Towards a Sustainable Bioeconomy

Innovative Methods and Solutions for the Agriculture and Forest Sectors

Sant Pau Art Nouveau Site in Barcelona, Spain

21–23 October, 2015

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Session 1: Transition towards bioeconomy: changing production systems and consumption patterns

Wednesday 21 October 10:30 -12:30
Rooms 3&4 (combined), 2nd floor
Session chair: Marcus Lindner, Head of Programme Sustainability and Climate Change, European Forest Institute

Salvatore Martire	European Forest Institute, Finland	Wood flow modelling for a more sustainable regional forest-based sector
Luc Pelkmans	VITO, Biobased Economy, Belgium	Strategies towards a resource-efficient biobased economy – benchmarking country approaches
Tiina Härkäsalmi	Aalto University, Finland	System design for circular Bioeconomy. Case: Biocycles of linseed flax reinforced biocomposites
Oludunsin Arodudu	Leibniz Centre for Agricultural Landscape Research (ZALF), Germany	Sustainability of agro-bioenergy land use: industrial agriculture vs. ecological agriculture
Elias Hurmekoski	European Forest Institute, Finland	Context, drivers and tensions for the market potential of wood construction in Europe
Gert-Jan Nabuurs	Wageningen University, the Netherlands	New perspectives on the role of the Dutch forest sector in the EU Bioeconomy
Philipp Sommerhuber	Thünen Institute of Wood Research, Germany	Cascading use potentials of post-consumer wood for Wood-Plastic Composites

Wood flow modelling for a more sustainable regional forest-based sector

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Research, policy and industry consider the transition to more efficient consumption and production patterns as crucial, especially to develop a sustainable bioeconomy. Bioeconomy development and consequent higher biomass mobilization require proper methods and tools to quantify environmental, social, economic implications of bio-based supply chains, especially in the light of the need of more efficient productions.

In order to test and further develop material flow oriented sustainability assessment, we conducted a study in the French region of Limousin, exploring challenges and needs of forest-based enterprises. We identified trends of biomass uses in the region, and we pictured the regional forest-based supply chains, focusing on important bio-industries of the area (paper, bioenergy, panels).

The different productions do not cause competitiveness between the different products, and the different productions generally use different types – in terms of quality – of biomass. The fast growing of wood energy plants could lead to competitive use of biomass between different industries (and production supplies). For example, harvesting of energy wood grew of about 4 times from 2005 to 2013 in Limousin, while the total amount of exploited wood is stable. Higher biomass demand can lead to higher prices for biomass, probably easier affordable for the bioenergy production due to subsidies for green energy. However, there is an interest of ensuring a local supply in order to develop the regional economy and to avoid higher costs and environmental impacts due to transportation of wood resources, as well as certified wood (FSC and PEFC) for the paper industry.

Picturing the regional wood supply chains can strengthen the forest-based sector because it can support in:

- Detecting potentials for (future) competitive use of biomass, and consequent higher costs of raw materials;
- Exploring potentials for a more efficient use of biomass, for example due to wood recycling and cascade use of biomass for different productions;
- Framing economic, environmental and social implications of wood-based supply chains, for example calculating positive or negative impacts of increasing bioenergy production.

We do not intend to purpose “definitive” solutions for the forest-based sector, but we expect that using a holistic approach can be a valuable basis to strengthen the bio-economy – designing better policy or having more collaborative enterprises. We would also contribute to further develop research on sustainability assessment in the bio-based sector. We expect that the approach and the designed supplies can be adapted in similar context and used to facilitate scenario analysis in the bio-based sector.

Strategies towards a resource-efficient biobased economy – benchmarking country approaches

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So far policy conditions have been extremely important for the deployment of the bio-based economy (i.e. the non-food applications of biomass). Different EU-wide and national/regional policies are playing a role in the mobilization, supply, conversion and end-use of biomass for energy as well as other purposes. To develop a robust bio-based economy, it will require both the access to renewable feedstock in sufficient quantities, of guaranteed quality and at a competitive price and stimulating the market demand, without disrupting food supply and other markets.

Biomass value chains touch on a multitude of sectors and topics which makes them much more complicated than other fields. This also implies a complexity to guarantee sustainability over the full value chain.

While there are considerable biomass potentials in the EU Member States, it will be important to implement balanced and integrated policies, taking into account different policy fields, aiming for a sustainable and resource efficient mobilization and use of these biomass resources, while keeping a level-playing field with other markets (i.e. avoiding market distortions through subsidies to one application).

Within the sister projects S2Biom (FP7, www.s2biom.eu) and BiomassPolicies (IEE, www.biomasspolicies.eu) different steps are taken to provide guidelines for these integrated policy frameworks and strategies towards a resource efficient biobased economy. Starting point is the mapping (at EU and MS level) of what regulations and financing mechanisms already exist in the field of energy, agriculture, environment, economy, etc., with relevance to important biomass value chains. Putting the approaches of different countries next to each other we will benchmark the different approaches for good practices and then feed into policy recommendations.

This paper will present first results of the benchmarking: which are typical country approaches, what was their impact on market and industry development We will also consider how resource efficiency as a principle was addressed. Resource efficiency aims at a more productive use of resources over their life cycle, and using resources in a sustainably way, within the planet's long term boundaries. In terms of country approaches this includes ensuring a sustainable production of resources, managing the cascaded use of resources (competition - level playing field), and stimulating the efficient use of biomass, … The opportunities to develop a biobased economy are clearly region dependent. We will consider which regional parameters (in terms of agriculture, forestry, waste management, knowledge, economy, strength of food industry, wood & paper industry, …) are determining these opportunities and what are the main lessons for future policy frameworks.

System Design for Circular Bioeconomy
Case: Biocycles of linseed flax reinforced biocomposites

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Introduction

Especially in emerging bioeconomies, agri-food residues such as linseed fibres can have significant potential as high quality raw materials, promoting resource efficiency, economic profitability and environmental performance [1]. Today, most linseed straw is either burned or chopped to be spread in the field or removed from the field and handled as waste [2,3]. In 2013 the global cultivation area of linseed covered over 2.2 million hectares [4]. The straw yields vary between 500–5000 kg/Ha and the fibre yield from 9 to 27% of the straw; linseed fibres thus provide a relevant raw material worldwide [3,5,6].

Fibres from linseed flax offer inexpensive raw material for natural fibre reinforced composites due to their high performance, versatile material mechanical properties, low cost of the processing technology, light weight and biodegradability [3,7,8,9]. Most flax reinforced thermoplastic composites are fabricated by injection moulding or compression moulding with non-renewable thermoset granulates or thermoplastic fibres as matrices [9,10]. Flax-fibre reinforced composites are mainly applied in technical applications in relatively low-value markets, such as the interior parts of cars and commercial vehicles [7,8,9]. The products consist of various renewable and non-renewable materials; the end-products are therefore difficult to recycle and are normally disposed of in landfill. In previous work the primary consideration has been paid to the technical properties of flax fibre reinforced biocomposites, whereas holistic and multidisciplinary approaches that encompass the material flows throughout the lifecycles and entire value systems are still relatively unexplored. The key aims of this multidisciplinary study were to reduce material flows, minimise and valorise waste, reduce toxics and maximise the value of these raw materials within continuous biocycles.

Materials and methods

This multidisciplinary design study focuses on the sustainable system development of linseed fibre and polylactid acid (PLA) commingled biocomposites to be used in various product applications. System design in the material development context refers to a holistic approach, where the environmental aspects and considerations were integrated early into the development processes and all the phases were designed to be applied in the framework of a circular bioeconomy.

Results and discussion

As a result, a model for continuous biocycles of linseed flax reinforced biocomposites was designed where the waste from one process/product can be turned into a valuable raw material for another industry, hence reducing disposal to landfill and the consumption of virgin materials. The model is illustated in Figure 1. The model is based on short-fibre methods and comprises the following stages: 1) Harvesting and decortication of linseed straw; 2) Integrated wet-processes (washing, cottonisation and dyeing); 3) Intermingling of PLA and linseed fibres together by carding and needle-punching into a non-woven fabric; 4) Compression moulding of the flax/PLA nonwoven into desirable shapes and products; 5) Crushing of cutting waste and disposed products to be used in injection or extrusion moulding of new products; and 6) Combusting for energy or composting of the degraded material.

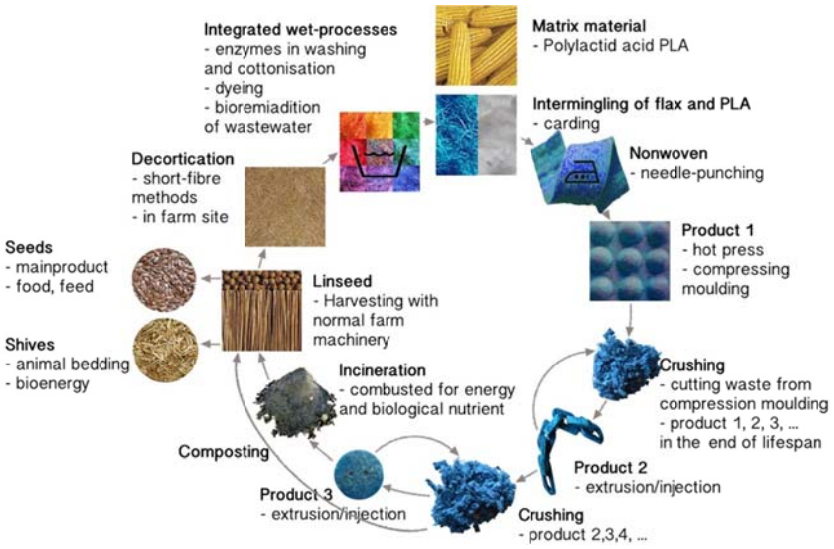

Figure 1: A circular model for continuous biocycles of flax reinforced PLA biocomposite materials.

Conclusions

Materials are fundamental from many perspectives: functional, economic, aesthetic, ethical and ecological. Material selection determines the processing technology to be used and hence affects the quality, the price and the environmental profile of the end product. This illustrative study was an attempt to combine material development and sustainable design practices in system design that can support the shift from linear and hierarchical value chains towards cross-sectoral value networks. In order for this concept to be realised in practice, collaboration between the stakeholders is needed, especially in collection, transportation, take-back services and recycling of materials and products.

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Sustainability of agro-bioenergy land use: industrial agriculture vs. ecological agriculture

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Bioenergy from agricultural sources (agro-bioenergy production) has often been heavily criticized and tagged unsustainable, especially within the context of transition to a bio-economy. Previous studies sharing this position were however based on the assumptions that (i) energy inputs are essentially fossil-fuel based, (ii) fossil-fuel resources will remain infinitely available and (iii) bioenergy-cropping must be ran on an industrial scale (i.e. as intensive mono-cultures) to be profitable. Conversely, if viewed from an ecological agriculture (agro-ecology) perspective, as a small-scale, family/community owned or rural-cooperative based enterprise, that is ran on organic farming principles, its long-term sustainability may be guaranteed. Bearing in mind, that food sovereignty (i.e. farming systems' capacity to produce enough food locally/regionally to sustain its teaming population) and energy sovereignty (i.e. farming systems' capacity to source enough energy locally or regionally to sustain continuous food production for its teaming population) are non-negotiable cornerstones for the sustainability of agro-ecological systems, this study considered the effects of often ignored local and regional agro-ecological factors such as alternative farm power (fossil-fuel powered tractor vs. human vs. animals), tillage (conventional vs. reduced vs. no-till), irrigation (rain-fed vs. surface vs. sprinkler vs. drip), pesticides (organic vs. synthetic), fertilizer (synthetic vs. animal manure vs. biogas digestate) and seed-sowing options (organic vs. hybrid vs. transgenic) on agro-bioenergy sustainability indicators (net-energy, energy-return, carbon-savings, water-savings, biomass-appropriated etc.) within a transport distance of not more than 20 km, using maize ethanol and maize biogas production systems as case studies.

We found that a lot more than accounted for under conventional (industrial) agriculture is accounted for by considering these agro-ecological factors (43.7-71.6% net-energy and 18.2-30.4% energy-returns from maize ethanol production systems; 27.4-49.5% net-energy and 43.1-47.6% energy-returns from the maize biogas production system). Consequently, it was concluded that organic farming principles (e.g. adoption of rain-fed/surface irrigation as against sprinkler/drip, animal manure/biogas digestate as against synthetic fertilizers, organic pesticides and seeds as against synthetic pesticides and transgenic/hybrid seeds, no-till/reduced tillage as against conventional tillage, crop rotation/mixed cropping/cover cropping as against intensive mono-cultures etc.) espoused by agro-ecology do not only take us closer to nature and promote social equity through reduction of farmland grabbing and rural livelihood loss incidences (which industrial agriculture promotes), but also has the potential to sustainably support agro-bioenergy production with higher energy-returns and carbon-savings, as well as better biomass-appropriation than those reported by conventional (industrial) agriculture.

Context, Drivers and Tensions for the Market potential of Wood Construction in Europe

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Introduction

Globally, construction and the use of buildings account for one half of the total resource use and energy consumption, one third of water consumption, and generate one third of all waste [1]. The GHG emissions from construction should be reduced by 90% by 2050, to effectively contribute to limiting the global warming to 2 °C [2].

Given the shown environmental benefits of substituting the most common building materials with wood-based products [3], the aim of the study is to explore the factors affecting the long-term market potential of wood construction in Europe by taking two complementary viewpoints: Top-down market pull factors and bottom-up technology push factors. The study focuses particularly on assessing the likelihood of, and prerequisites for, meeting the three long-term targets for the European wood construction sector towards 2030 set by the European Forest-based Sector Technology Platform [4]: Tripling the market share of wood construction; doubling the value added of the wood products industry; and reducing the embodied energy and CO_2 of construction products by a third.

Materials and methods

The conceptual framework of the study builds on the multi-level perspective (MLP) on systemic transitions [5], summarised in Fig. 1. The MLP is a simple framework for dividing the markets into three levels: (i) socio-technical landscape (trends and pressures in the operating environment), socio-technical regime (regulatory environment and industry structure) and niche level (new technologies and business models).

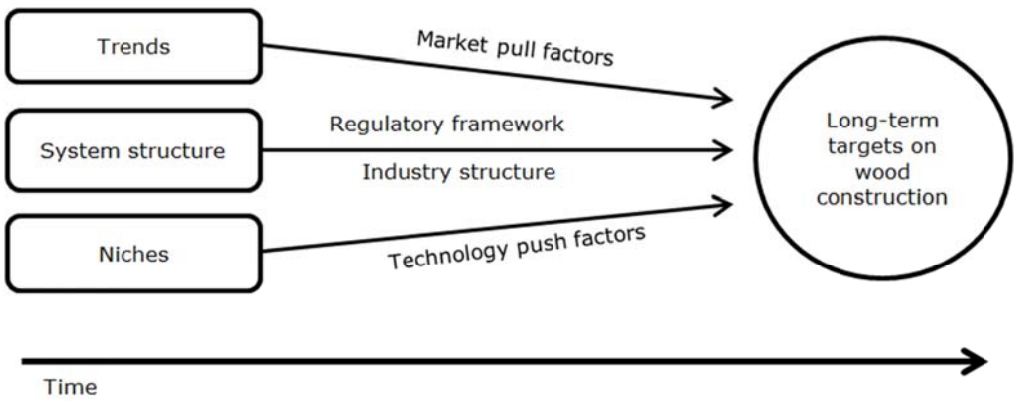

Figure 1. Conceptual framework of the study.

The empirical data were collected with a web-based questionnaire and semi-structured interviews. The survey was targeted at experts and stakeholders across the wood construction value chain, including civil servants, interest groups, industry representatives, non-governmental organizations and researchers from Finland, Nordic countries, and Central Europe. A total of 19 interviews were carried out, with the length of the interviews ranging from 45 minutes to two hours.

The study focuses particularly on the Finnish wood-frame multi-story construction (WMC) markets, owing to its high potential of contributing to green building. Nonetheless, the analysis aims to consider also other

European regions and other sub-sectors of the residential construction sector and to generalize the findings to the extent possible.

Results and discussion

The construction sector can be characterised as culture-dependent and risk-averse. According to the results, these path dependencies, added with the cautiousness of the stakeholder strategies in the wood construction sector, deem the target of tripling the market share of wood construction across Europe by 2030 unrealistic. That is, tripling the production capacity in fifteen years appears too risky for SMEs, whereas for large firms it may take half a decade to assess and prepare one single pilot project.

However, the construction sector is facing a growing number of pressures, culminating to the possible regulatory push for green building and the need for improving the low productivity of construction. Indeed, the market potential of wood construction appears to be to a significant extent dependent on the possible changes in the regulatory environment and in the strategic orientations of industries.

The public sector could contribute to the target by both explicitly supporting wood construction and by removing the regulatory hindrances for increased competition. The wood products industry could most effectively pursue the market share and the value added targets by taking more responsibility in the construction value chain. However, as the industry stakeholders regarded this strategic orientation as the least attractive, meeting these targets for 2030 seem likely only in certain niche sub-sectors and regions.

The environmental target was deemed as the most likely of the three to be achieved by 2030. However, policy measures based on information dissemination were seen to be insufficient for inflicting the desired changes in the environmental impact of construction. While policies promoting competition by removing the regulatory obstacles and cost burdens for the uptake of new construction practices would yield more credible solutions than stringent fiscal measures and norms based on obligation, they cannot be expected to have major impact in the short-run. Moreover, the direct support of single construction practices was seen to possibly turn against the initial objectives by reducing the credibility of the supported practices and by causing strong counter lobbying.

Conclusions

The probability of large scale diffusion of wood construction was questioned by the stakeholders, due to the structure and characteristics of both the construction and the wood products sector. Indeed, the results suggest that the diffusion of wood construction in Europe is likely to be a long-term and gradual process and that meeting the European industries' targets for the market share, value added and environmental impact by 2030 may be restricted to a few niche sub-sectors and regions. Correspondingly, also the impacts on wood resource demand are likely to remain limited, particularly in terms of volume. Evidently, strong policies and unforeseen technologies and business models are needed to reduce the GHG emissions in the scale of 80 % in the industrialised countries by 2050.

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New perspectives on the role of the Dutch forest sector in the EU bioeconomy

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The Dutch forest sector is a very open sector with large volumes (25 million m3) of internationally traded wood. The domestically produced wood from own forests suffices for only 10% of the consumption. Most (80%) comes from other European countries, and small shares from tropical countries and the USA.

Under the bioeconomy a larger demand is expected and with the infrastructure and harbours, the Netherlands foresees to play a large role in the bioeconomy, based on lignocellulosic sources. However, the Dutch forestry is not geared towards production and 2/3 of the domestically harvested wood ends up directly in a local wood stove. The question is where the wood for the bioeconomy has to come from, and whether it can be sustainably sourced without perverse effects on e.g. biodiversity.

The paper will present new perspectives on the Dutch forest sector for 2030. It will show quantitative and semi quantitative what are the impacts of a) going fully for energy production from woody biomass, b) going for maximum added value from the sector based more on domestic wood, and c) going fully for a sustainable sector, i.e. only FSC wood and carbon neutral.

Impacts for the sector are quantified, but also effects on forest management, state of Dutch forests, biodiversity and forest management at some trading partners.

Cascading use potentials of post-consumer wood for Wood-Plastic Composites

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Innovative wood-plastic composites (WPC) find more and more acceptance due to their low moisture absorption, low density, resistance to biological attack, good dimensional stability, combination of high specific stiffness and strength. Wood particles used for WPC production constitute about 1% of the wooden raw material consumed by the wood-based panels industries in Germany. The market of WPC products is small but expected to grow steeply what could further increase the competition between alternative uses of wood. In this context the promotion of wooden products through the European Bioeconomy Strategy and wood as an energy carrier through the Renewable Energy Directive have to be mentioned.

Cascade use of biomass and the shift to a Circular Economy are intensively discussed as strategies to overcome resource scarcity. Both strategies point at utilizing secondary resources by valorisation of waste flows as potential substitution materials for virgin resources. Therefore, the feasibility of using recycled resources for WPC was investigated at given recycling activities, market conditions, and legislative frameworks.

Under experimental design conditions, WPC specimens made from recycled wood and high-density polyethylene (HDPE) (rWPC) were compared to WPC made from virgin resources (vWPC). Results indicated equivalent flexural and tensile properties of rWPC compared to vWPC. Impact strength properties were similar at 30% wood content. At 60% wood content, vWPC showed better results. Water absorption behaviour after 28 days and densities were similar for both rWPC and vWPC. WPC made from secondary resources were darker in colour. Differences in colour determined by using CIElab method would not lead to customers' dislike. Colour pigments can be added in the compounding process and surface homogeneity of wood-based products is the predominant visual aspect for customers.

Cascading use of wood for WPC is not an issue in terms of technical properties or customer acceptance. It is challenging in relation to political and legislative situations and economic aspects. Automated techniques for sorting waste wood into a clean fraction for material recycling and a lower quality fraction for energetic recovery are currently not feasible for economic reasons at the given prices for virgin wood particles.

The disadvantages associated with the possibility of diffusing hazardous substances through cascaded use of wood products is rated higher than the economic savings arising from using a somewhat cheaper wooden raw material resource. However, in the course of a competing demand for biomass, economic conditions are likely to change and legislative frameworks need to be adapted.

Session 5: Environmental challenges for the bioeconomy

Wednesday 21 October 10:30 -12:30
Rooms 1&2 (combined), -1st floor
Session chair: Tiina Pajula, Principal Scientist, VTT Technical Research Centre of Finland Ltd.

Genevieve Mortimer	Thünen Institute of International Forestry and Forest Economics, Germany	Unintended consequences in the context of corporate sustainability debate
Adam Felton	Swedish University of Agricultural Sciences	The implications of climate change mitigation and adaptation strategies for production forest biodiversity: Insights from Sweden
Anne Roedl	Thünen Institute, Germany	Extending LCA method to assess and compare water use of biological and technical production systems
Francesca Santaniello	The Forestry Research Institute of Sweden Skogforsk	Tree retention as a conservation strategy in managed boreal forest. Dead wood diversity, economic return and impact on logging productivity
Ottar Michelsen	University of Freiburg, Germany	Building consensus for assessing land use impacts on biodiversity: Contribution of UNEP/SETAC's Life Cycle Initiative
Alexandru Giurca	Wageningen University, the Netherlands	Towards a sustainable Bioeconomy: integrating environmental concerns in Germany's Bioeconomy discourse
Nicholas Clarke	Norwegian Institute of Bioeconomy Research	Influence of different tree-harvesting intensities on forest soil carbon stocks in boreal and northern temperate forest ecosystems

Unintended consequences in the context of corporate sustainability debate

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Unintended consequences are the result of a dilemma for firms acting on corporate sustainability. On the one hand, corporate sustainability requires business to take bold, timely and ethical action to address society's grand challenges. On the other, due to the complexity and unpredictability of people, societies and global systems, timely action by firms brings with it a higher risk of unintended consequences. Good intentions are not enough. As we act with good intentions in complex environments we should expect unintended consequences. This is a central paradox in the sustainability debate and one which is particularly present for the bioeconomy (both historically and today) given business activities are inherently interconnected with complex natural and social environments. This research will confine the discussion to a subset of unintended consequences – natural environmental changes that are perceived to be the negative impacts of actions motived by corporate sustainability. We define unintended consequences as changes that occurs in the external environment that were unforeseen at the time of action that in retrospect can be seen to be either fully or partially the result of deliberate action by a business or group of businesses. Based in the conclusions from complexity literature, we make the case that unintended consequences are real and of increasing importance for firms taking action and implementing innovative solutions in the bioeconomy.

Specifically, this paper explores the questions: What are unintended consequences in the context of corporate sustainability debate? And how do business leaders currently perceive and respond to unintended consequences of their good intentions? We develop a framework which positions unintended consequences among other business concepts and provide examples from the bioeconomy. Through a case study of a large enterprise in the forestry-wood industry we explore business perceptions and strategy for responding to unintended consequence.

Our contribution is, firstly, to explore the extent firms acknowledge the possibility of unintended consequences and the practical challenges for firms detecting and intervening when unintended consequences occur. Second, we construct a theory of the implication this has for sustainability action (or inaction). Research indicates that fear of unintended consequences is a challenge that can further impede corporate action on sustainability. However developing tools and processes to detect unintended consequences, respond innovatively and learn from them provides an opportunity for business to better manage action in uncertain and complex environments. This paper demonstrates why, in a complex world, a strategy for unintended consequences is needed to empower action on corporate sustainability strategy.

The implications of climate change mitigation and adaptation strategies for production forest biodiversity: Insights from Sweden

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Anthropogenic climate change is altering the management of production forests. These changes are motivated by the need to adapt to the uncertainties and risks of climate change, and by the need to enlist their carbon storage and sequestration capacity as part of global mitigation efforts. These changes do however raise concerns regarding the potential implications for forest biodiversity. We have evaluated these concerns by assessing the biodiversity implications of climate change adaptation and mitigation strategies (CCAMS) being implemented in the production forests of Sweden. We do so by identifying biodiversity goals aimed specifically at closing the existing gap between the habitat requirements of forest-dependent plant and animal species and the conditions provided by production forests, in terms of tree species composition, forest structures, and spatio-temporal forest patterns. Using the existing literature we have determined whether and by which pathway each CCAMS is likely to bridge or extend this gap. Our results indicate that CCAMS in Sweden will often come into direct or partial conflict with regional biodiversity goals and initiatives to restore habitat availability in production forests. Furthermore, the CCAMS which were most inconsistent with biodiversity goals are being implemented more extensively than those which were most consistent with biodiversity goals. We nevertheless challenge the necessity of pitting the preservation of forest biodiversity against climate change mitigation and adaptation. We can now clarify how CCAMS with negative biodiversity implications may still be implemented without adverse outcomes, if coupled with conservation interventions, or combined with other CCAMS deemed complementary in habitat provision.

Extending LCA method to assess and compare water use of biological and technical production systems

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Background

Fostering bioenergy production with the aim of reducing GHG-emission causes a growing demand on biomass crops. Land use changes might influence the water use regime within a region and further might have an impact on natural water regulation mechanisms like runoff, drainage and groundwater recharge. In general there is a close connection between water and energy demand. Water is needed for energy generation from renewable and non-renewable sources. On the other hand energy is needed for drinking water treatment, waste water treatment or desalination. It is also important to consider sufficient water supply when carbon sequestration in forests is discussed. All these interrelations put the topic water use and water quality as one of the sustainable development goals on the agenda of the United Nations.

Against this background methods for facilitating water use related decisions are needed. While one instrument for supporting environmental impact assessment is LCA (Life Cycle Assessment) no agreed methodology exists on water use assessment within this methodological framework. The contribution in hand therefore presents an new methodolocial approach to assess the impact category “Water Use” within Life Cycle Assessment studies.

Framework and Definitions

This contriubution works with Life Cycle Assessment methodology which is manly regulated by the standards ISO 14040 and ISO 14044 [1;2]. Life Cycle Assessment is a tool to address potential environmental impacts of the production, use, end-of-life treatment and disposal of a product. It consists of an inventory part (inventory analysis) and an assessment step (impact assessment). Both phases are addressed within the here presented methodology. For the impact assessment phase characterization factors are needed which convert an inventory result into the unit of the impact category which is representing the environmental issue of concern [2].

Within water use assessment usually blue and green water use is distinguished [3]. Blue water are water resources which can be easily extracted by humans like surface or ground water. Green water is water which is stored in soil and can only be extracted by plants. White water is introduced here to name water vapour.

Description of the new method

The presented method contains instructions for the life cycle inventory step to register the amounts of different water types going into the product system and coming out of it. Water which is not physically or qualitatively changed is not further considered. Just the changed amounts of water will be assessed in the impact assessment step and will be refered to “consumption” in the following desciption.

In order to make different water uses comparable e.g. for technical and biological production processes, the different water types have to be converted into one single unit. Therefore the unit “blue water equivalents” is introduced here. It indicates amounts of green or white water converted to a blue water amount. It is considered that green water is not completely consumed during biological production processes. Plants extract green water from the soil, evaporate it and thereby fuel the water cycle. Evaporated water returns to continents with rainfalls. According to Van der Ent et al. 2010 [4] on average 57% of evaporated water from continents return again to continents. Hereafter this share is called green water recycling factor (f_{GWR}). The factor differs depending on the exact position of a continent related to the ozean. Consumption of green water expressed in blue water equivalents is then calculated by wheighting the green water amount with the not-recycled proportion of evaporated water (1-f_{GWR}).

The rating in the characterization step of the new methodology is based on factors representing quantitativ and qualitative aspects of water use. Equation (1) gives an overview of the calculation rule to characterize the water consumption within the impact assessment step of a life cycle assessment study. The consumed amount of water (C_{ble}; reQ_c) is weighted with factors expressing the water conditions in the tapping region as well as its quality changes. Whereas anthropogenic index (Idx_{an}) is calculated by relating current water withdrawal to water availability from natural and secondary sources in the paticular region. Climatic index (Idx_{cl}) and storage index (Idx_{st}) reflect precipitation, potential evapotranspiration and water holding capacity of the soil in the particular region. Quality index (Idx_{qual}) is calculated by relating the difference between input and output concentrations of harmfull substances in the consumed water to a critical value. Critical values might be for example legal limits. In the end the impact indicator value will be compared to the water use registered in the inventory step. The impact indicator value exceeds the inventory result when water consumption takes place in a water scarce region or the quality is deteriorated. The impact indicator value falls below the inventory result if water is consumed in a region with abundand water resources or if the water quality is improved.

$$Ind_{WU} = [C_{ble} \cdot (Idx_{an} - Idx_{cl} - Idx_{st})] + (reQ_c \cdot Idx_{qual}) \quad (1)$$

C_{ble}	equivalent blue water consumption [*ble*], contains the consumed blue water and the weighted consumed amounts of green and white water
Idx_{an}	anthropogenic index
Idx_{cl}	climatic index
Idx_{st}	storage index
reQ_c	qualitatively changed blue water by consumption
Idx_{qual}	quality index

Conclusions

Different from most to date existing methodological approaches in this field the presented method can be applied to assess different types of water and therefore allows the assessment of water use by biological and technical production systems within the same framework. The method allows the joint assessment of green water flows as well as blue or grey water flows and makes them comparable to each other. Furthermore it is a methodological attempt which combines water use assessment from a quantitative and a qualitative perspective and allows to consider different spatial levels. At the same time it features rather modest demands on data availability and modelling.

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Effect of tree retention on economy and dead wood in boreal pine forest

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Introduction

Structural diversity and habitat heterogeneity has been shown to be important for maintaining species diversity (Tews et al. 2004). Intensive land use often leads to a simplification of the structural complexity and is considered a major threat to biodiversity (Hunter & Gibbs 2007). To counteract the simplification of forest structures associated with clear cutting, retention forestry was introduced, first in North America in the 1980's and then in Fennoscandia in the 1990's. Nowadays tree retention is required by the certification standards. Retention forestry implies that stands are only partially cut and single trees, tree groups, and dead wood are left on site. This study explores how different levels of tree retention affects biological and economic parameters in a boreal Scots pine forest. More specifically, it describes how logging productivity, economic return and structural diversity (dead wood amounts, diversity and conservation) vary over a gradient of tree retention and dead wood creation at the stand levels.

Materials and methods

Study area - The study area Effaråsen covers 140 ha and is located in the province of Dalarna in the southern boreal vegetation zone of Sweden. It is a relatively homogenous forest area dominated by Scots pine (Pinus sylvestris L.). Effaråsen is an experimental site, where 15 stands, with a mean area of 5 ha were randomly allotted to different levels of partial cutting. In each stand we retained four categories of trees: 1) green living trees, 2) girdled trees 3) high-cut stumps and 4) felled trees left on the ground.

Effaråsen forest. Green living trees, girdled trees, high-cut stumps and felled trees. (Photo: Francesca Santaniello, July 2013).

Data collection - Retained trees and dead wood were inventoried in 15 transects. For each tree and dead wood object we measured diameter, height or length, and bark thickness enabling calculations of stem

volumes for every object. Qualitative information, such as the conservation degree associated to the forest machineries damages, were also collected. Operational time from the harvester and forwarder was recorded during the cutting phase.

Data analysis - The dead wood objects were divided into different types according to their qualitative and quantitative characteristics. To calculate dead wood diversity and types' abundance we used Shannon diversity and Evenness formulas. Soil expectation values, logging productivity and opportunity cost that represents the income loss associated with tree retention, were calculated as well.

Results

The time spent for logging 1 m^3 of wood increased with increasing retention level, amounting to an overall c. 30% slower logging performance in the high retention stands. The soil expectation value were similar (c. 50 € per ha) for all stands. Accordingly, net present values were mainly dependent on the harvest net income. The opportunity costs were close to the cost associated with the loss of timber that was not harvested and increased linearly with retention level. Both number of dead wood types and Shannon diversity index increased with increasing level of retention up to c. 40%, but neither the number of wood types nor the diversity index continued to increase beyond 50% retention. The coarse woody debris volume showed a linear relationship with retention level. The conservation of old coarse woody debris increased by increasing the retention levels.

Discussion and conclusions

This study is the first to measure how logging productivity is affected by tree retention and creation of dead wood for biodiversity. It provides novel information about the effect of forest management on dead wood volumes, types and diversity, all being important components of structural diversity. Our results show that increasing the retention level from c. 5% to 50% will result in an increase in number of wood types and wood diversity. Old coarse dead wood conservation increase along the retention levels as well as the volume of the coarse dead woody debris, confirming the protection rule operated by the retained trees on the dead wood (e.g. retention patches are off-limits zones for the forest machines). The relationships found here between retention level and different components of structural diversity may change with time. It is likely that structural diversity will increase more in the high retention stands than in the low retention stands as wood volumes are higher and because there is a high degree of stochasticity in how wood decomposes (Renvall 1995, Weslien et al. 2011).

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Building consensus for assessing land use impacts on biodiversity: contribution of UNEP/SETAC's Life Cycle Initiative

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Introduction

The UNEP/SETAC Life Cycle Initiative has provided a platform for consensus finding in the area of environmental indicators in LCA. A flagship project was established in 2012 intended to run a global process aiming at global guidance and consensus building on a limited number of environmental indicators, including indicators for assessing impacts from land use (LU) and land use change (LUC) interventions on biodiversity. LU/LUC are some of the main drivers of biodiversity loss and degradation of a broad range of ecosystem services. The need for consensus arises from the fact that, despite substantial contributions to address biodiversity in LCA, no clear consensus exists on the use of specific impact indicator(s) to quantify land use impacts on biodiversity within LCA. This lack of consensus not only limits the application of existing models, but also imposes constraints on the comparability of results of different studies evaluating land use impacts based on applying different models.

Materials and methods

Two workshops with experts from the fields of land use impacts, biodiversity metrics, LCA and ecology, have been organized with the main goal to obtain inputs on the main aspects of methods for biodiversity assessment. The main focus on the workshops was on (a) concept of biodiversity and modelling strategies, (b) data availability and feasibility, (c) desired characteristics of indicators, usability and consensus and (d) concerns and limitations about using biodiversity indicators in LCA.

Following the advices from the workshops a deep review on which aspects need to be considered in the land use impact pathway is conducted. Only methods where the main description of the model is published in a peer-reviewed scientific journal and models characterized biodiversity in at least two different classes or intensities of land use (e.g. forest or agriculture, intensive orextensive) were included. This limited the number of models to 30; 19 developed specifically for impact assessment in LCA and 11 originated from non-LCA fields (environmental policy, ecology and conservation).

To evaluate the models, a review framework based on the approach used by the European Commission within the International Reference Life Cycle Data System, on the evaluation of LCIA models and indicators was adopted [1]. Evaluation criteria were grouped under the following categories: (i) "Completeness of scope"; (ii) "Biodiversity representation"; (iii) "Impact pathway coverage"; (iv) "Scientific quality; (v) "Model transparency and applicability"; and (vi) "Stakeholders acceptance".

Results and discussion

The experts who participated in the workshops highlighted the importance of the framework established by the Life Cycle Initiative and agreed that LCA should go beyond inventory data for LU/LUC and relate elementary flows to their respective impacts on biodiversity. There was also an agreement that a good LCA indicator for biodiversity necessarily has to include geographical location, several aspects that depict the state of ecosystems at that location, and a measure of land use intensity [2]. Changes in species richness is a potential starting point for assessing biodiversity loss, but complementary metrics need to be considered in modelling, such as habitat configuration, inclusion of fragmentation and vulnerability, and/or intensity-based indicators (NPP/HANPP).

There are a very complex pathway with several interconnections from the inventory flows on land use to endpoint damage on biodiversity loss. The most common pathway used in existing models is direct, local degradation and conversion of habitats. Regarding biodiversity representation most of the current methods are based on compositional aspects of biodiversity, namely species richness followed by spaces abundance, which show to be more sensitive to land use change [3]. Different spatial scales of assessment have been used and at present ecoregions are considdered having the best potential for consensus since it matches the requirements of available information with enough detail. Depending on the model, several taxonomic groups are covered, being plants the most common taxon assessed across models. As concerns to land use classes and the different use intensity, the variability is highly dependent on the purpose of the study. Uncertainity of the models is only partially and non-uniformly covered and the relative youth of all the models make them still not mature enough for stakeholders' acceptance.

Conclusions

Based on our revision of impact pathways , and how these are translated into modelling choices , there is clearly a need to model CFs in terms of both (i) local damage factor for land use linked to the functional unit, and (ii) regional "state and pressure" weight to reflect broader biodiversity patterns and processes surrounding the location of land use [2]. At present, only two LCA models [3, 4] provide global available CFs for use in LCA, but both have shortcomings.

One pragmatic way of building consensus would be to construct a weighted average of available indicators from the reviewed models for a particular region for both local and regional biodiversity damage based on the following steps:

1. Match the land use classifications in the model to the typology of Koellner et al. [5]
2. Extract reported biodiversity indicator scores from publications or communication with authors, linking these to the reclassified land use types, taking account of the level of detail in land use classification
3. Express biodiversity scores on a relative scale to the chosen reference (ideally ranging 0–1, but exceeding 1 if the reference is the current state/impacts are positive)
4. Construct indicator weights based on literature review or expert interviews of how well a given indicator reflects local biodiversity change (precision, accuracy)
5. Calculate the weighted average for the relevant land use types.

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Towards a Sustainable Bioeconomy: Integrating Environmental Concerns in Germany's Bioeconomy Discourse

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Background and Objectives

Shifting towards Bioeconomy (BE) has become a top priority on Germany's political agenda. The main objective is for Germany to become a world-renowned innovation center with a competitive and leading global economy [1]–[3]. The approaches for achieving these objectives are mainly expressed in the national research strategy [1] and in the national policy strategy on BE [2]. The BE strategies mainstream numerous other related policy strategies and build upon the Federal Government's Sustainable Development (SD) strategy [4]. Accordingly, SD in this regards is partly already renamed to "sustainable economy".

The concept of SD is repeatedly highlighted in the German strategies as the overarching goal of the shift towards BE. It promises to address major societal and economic challenges and at the same time to create a more favorable environment. However, the BE in itself cannot be considered as self-evidently sustainable. In fact, research shows that there are different visions about the relationship between BE and sustainability [5]. The main driving force for shifting towards BE seems to be mainly motivated by growing the economy and reaching a world leading position in the field [3], [5]. How SD is approached and ensured in BE strategies remains therefore an empirical question.

An essential part of the concept of SD is Environmental Policy Integration (EPI) [6]. EPI mainly focuses on prioritizing environmental protection in all governmental decision making [7]. However, as pointed by Jordan and Lenschow [8], there is an ambiguous political relationship between EPI and SD within the European Union's (EU) shift towards a 'new economy'. Despite the widespread political commitment to EPI at a general discursive level in most industrialized states, environmental concerns are integrated only in an incomplete and unsatisfactory way into policies at national and European levels [8]. Particularly, traditional "economic" sectors such as forest sector have been identified for being resistant when it comes to integrating environmental concerns [9].

Studying the integration of environmental concerns into BE strategies and related policies is therefore of outmost importance in order to understand whether and as to how SD plays a role. This allows us also to study indirectly the relationship between SD and EPI, and understand how this is influencing Germany's discourse on BE. Thus, the objectives of this paper are twofold: firstly, to identify weather and how the concepts of SD and EPI have been integrated in Germany's political BE discourse, and secondly, to determine whether the forest sector discourse on BE integrates environmental concerns, and if so in which way.

Theoretical framework and Empirical approach

We take on the general theoretical concept of policy integration focusing on idea based integration - across different political levels (from the EU to Germany - and the other way around) and across different policies (Environmental, Sustainable Development policy and bioeconomy policy).

Empirically this paper is based on qualitative document analysis and interviews with key stakeholders. The analyzed documents cover Germany's national and EU political strategies concerning and/or related with BE, as well as political strategies of the forest sector dealing with BE. Additionally, qualitative interviews with key stakeholders are carried out in order to achieve in-depth understanding of the complex interplay between SD, EPI and BE.

Preliminary Results and Conclusions

The ambiguous relationship between SD and EPI seems to prevail also in Germany's discourse on BE. The reviewed national BE strategies and related documents partly integrate elements from the national SD strategy and repeatedly acknowledge the importance of considering environmental issues. Although this offers some indication of environmental learning it cannot be considered that EPI has been consistently and unambiguously integrated in the BE strategies. Indeed, the concept of SD affects EPI by broadening the notion of what should be integrated [7]. This seems to be the case for Germany's BE strategies where mainstreaming SD-related concepts into the national BE strategies has diverted attention from EPI. In order to diminish the gap between policy and practice, more concrete steps towards achieving EPI are needed.

The importance of forests is repeatedly highlighted together with their role in climate change mitigation. Challenges associated with the provision of sufficient biomass and with the intensifying competition for land use for agriculture and forestry are acknowledged. Whereas environmental considerations and the principle of sustainability (especially that of sustainable forest management) are frequently advocated, no concrete integrations pathways for EPI are suggested.

Indeed, Germany's understanding of SD is generally associated with ecological modernization, characterized as a combination between economic growth and ecological concerns. However, quite often there is a blurry line between the promoted values in the BE strategies. Promoted values generally favor economic aspects while environmental concerns are secondary, and seen as directly dependent on economic growth.

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Influence of different tree-harvesting intensities on forest soil carbon stocks in boreal and northern temperate forest ecosystems

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Introduction

Effective forest governance measures are crucial to ensure sustainable management of forests, but so far there has been little specific focus in boreal and northern temperate forests on governance measures in relation to harvesting effects on soil organic carbon (SOC) stocks. We reviewed the findings in the scientific literature concerning the effects of harvesting of different intensities on SOC stocks and fluxes in boreal and northern temperate forest ecosystems to evaluate the evidence for significant SOC losses following biomass removal, discussing how the scientific findings could be incorporated in guidelines and other governance measures.

The scientific basis

Experimental results indicate increasing SOC loss with increasing harvest intensity or increasing soil disturbance at some sites but little or no effect at other sites (Fig. 1), and there is no basis for firm generalisations. Although differences in the results may to some extent be due to differences in the experimental setup, a likely site specific vulnerability to SOC loss is implied that needs to be characterized and understood.

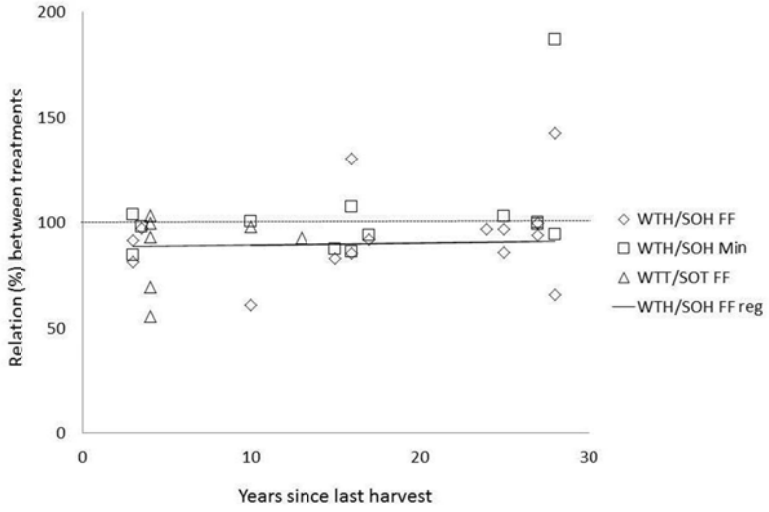

Figure 2: Effects of harvest intensity expressed by the relative change in % of SOC with whole tree harvesting or thinning relative to stem only harvesting or thinning (SOH=stem-only harvesting, SOT=stem-only thinning, WTH=whole-tree harvesting, WTT=whole-tree thinning) in the forest floor (FF) and upper mineral soil (Min), based on field studies. Dashed line = 100%. Solid line (WTH/SOH FF reg) is a linear regression for WTH/SOH in the forest floor, omitting one outlying study. From Clarke et al. (2015).

Limited availability of long-term experimental data currently precludes firm conclusions about the long-term impact of intensified forest harvesting on SOC stocks in boreal and northern temperate forest ecosystems, suggesting a need for continuation of existing long-term experiments.

Although experimental results show variable effects of harvesting on SOC, models generally predict losses of SOC, though less in the long term. The reasons for the discrepancy between field studies and modelling results are unclear. Understanding of the SOC balance implemented in the models may be lacking some inputs or processes important for SOC accumulation; however, the difficulties involved in determining small differences in SOC stocks in the field, where there is large spatial variability, may also play a role.

Even where there are clear negative effects of harvesting on SOC stocks, it is important to note that this may be mitigated or indeed completely outweighed by improved tree growth in the next rotation. At the same time, it is important to evaluate the net effects of biomass production at the expense of SOC accumulation in relation to the potential for long-term storage of C.

Governance

Although many countries have produced national recommendations and guidelines for biomass extraction to encourage this taking place in agreement with the principles of sustainable forest management, there has been little specific focus so far on SOC stocks. Regarding certification systems, harvesting effects on SOC have until recently not often been explicitly included in Programme for the Endorsement of Forest Certification (PEFC) or Forest Stewardship Council (FSC) certification systems, although some mainly newer standards do include requirements focussing on the forests' contribution to the C cycle

Although there is great site-to-site variation, science-based and operationally practical management guidelines might be developed with the help of expert judgement. Comparison of different countries' guidelines may help to identify broad areas of agreement that should be included, while leaving details to be worked out nationally or even at a more local level. This would increase local empowerment, and also emphasises the importance of training of forest managers.

It is vital that governance measures are accepted by stakeholders. 'Soft' governance measures, e.g. management guidelines and certification systems, may often be more adaptable to changes and local conditions, and more inclusive of stakeholder inputs, than legislation, and thus more easily accepted.

Discussion

Current governance measures may state that SOC stocks are to be protected during forest operations, but often little or no direct guidance is given as to how this is to be achieved. Partly this is due to the diverging results from various experiments, which is connected to the complexity of the processes involved, the difficulties associated with measuring the changes, and the number of factors that affect the SOC stock. Effects are species-, soil-, site- and practice-specific. Both well-designed new experiments and continuation of existing long-term experiments are therefore very important. Until more knowledge is available, the gap of uncertainty between the scientific results and the need for practically useable management guidelines and clear indicators can only be bridged by expert opinion given to authorities and certification bodies.

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Acknowledgements - This work was funded primarily by the Nordic Council of Ministers through the Forest Soil C-sink network and through the CenBio and Triborn projects funded by the Research Council of Norway.

Session 4: Optimal forest operations for a sustainable biomass supply

Wednesday 21 October 13:30 -14:30
Rooms 3&4 (combined), 2nd floor
Session chair: Richard D. Bergman, Research Forest Products Technologist, USDA Forest Service

Richard D. Bergman	USDA Forest Service, USA	Keynote presentation, tbc.
Frank Müller	Technological Institute for Forest Cellulose, Construction-wood and Furniture (FCBA), France	Collaborative logistics in the French forest based sector (FFBS) – opportunity or dead end?
Teresa de la Fuente	The Forestry Research Institute of Sweden Skogforsk	Fuel consumption and greenhouse gas emissions of wood supply chains to future biorefineries in Northern Sweden: A comparative analysis between innovative and conventional systems
Celia Martínez	Forest and Wood Technology Research Centre (CETEMAS), Spain	Evaluation of biomass supply chain in terms of operating costs and GHG emissions in Northern Spain
Dmitriy Danilov	State Research Enterprise, Leningrad Research Institute for Applied Agricultural Science	Growing tree plantations of pine and spruce on the grounds postagrogenic Northwest Europe

Collaborative logistics in the French forest based sector (FFBS) – opportunity or dead end?

Frank Müller

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A high share of transport costs in raw material prices and adverse externalities induced by the transport of wood between its source and industrial transformation challenge the FFBS towards tapping its full potential within the bioeconomy. Taking a supply chain management (SCM) perspective, this study looks at inter-organisational logistics collaboration in the FFBS to address these issues. Academia and consultancy promote collaboration as a promising approach to improve transport and logistics performance, predominantly emphasising a focal company and its vertical and horizontal relations. Businesses involved in wood exploitation, transport, and transformation in the FFBS typically structure as clusters, an economic phenomenon describing a set of interlinked companies in related industries in spatial proximity. Yet, such set of actors in its entirety finds little attention in collaboration related research, limiting the view on the multi-directional flows and ties between the actors and on potential collaborations and their antecedents.

This study aims to shed light on the relevance of and potentials for collaborative logistics in the FFBS. It explores the current state, barriers, drivers, and facilitators of logistics collaboration in the context of the content, structure and governance schemes characterising clusters in the FFBS. Furthermore, the study tests a SCM literature based collaboration framework in the context of clusters.

To this end, semi-structured expert interviews have been conducted face-to-face and by phone and analysed qualitatively. The experts represent FFBS-specific applied research organisations and businesses.

The results show that the experts consider logistics collaboration necessary for eliminating transport related inefficiencies. However, collaboration initiatives in practice remain rare. While IT and information standardisation are considered to facilitate collaboration, information sharing as such appears to be the most critical collaboration element, with barriers being inherent to prevalent structures and governance schemes within the clusters. Driving factors for logistics collaboration are seen in new market actors, in increasing economic pressure, and in regulatory measures.

The study widens the theoretical perspective on collaboration by extending the predominant analysis scope from supply chains to clusters and identifies common logistics collaboration antecedents in practice. Moreover, the interviews revealed controversial expert perceptions regarding the perceived interest of businesses in, and their awareness of potential benefits resulting from collaborative logistics, highlighting the case specific character of this subject. Consequently, further methodological development and case study based research is intended to more comprehensively analyse and understand logistics collaboration and its practical implications in the context of selected clusters in the FFBS.

Fuel consumption and GHG emissions of energy wood supply chains in Northern Sweden: a comparison analysis between innovative and conventional systems

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Introduction

The 2020 European Union (EU) targets promote an increase of renewable energy, establishing mandatory national targets for the overall share of energy from renewable sources. For Sweden this share is 49%.

Today forest energy is one of the most important sources of energy in Sweden [1].Taking into account that most of the by-products from paper, pulp and timber industries in Sweden are used for energy, more forest biomass will be needed to satisfy the bioenergy market [2] [3] [1], future biorefineries, and the EU targets mentioned before.

Although bioenergy systems can provide environmental benefits in comparison with fossil fuel systems, reducing greenhouse gas (GHG) emissions into the atmosphere and fossil fuel extraction [4], forest operations, forest biomass processing and transportation from forest to industry involve GHG emissions due to the high diesel consumption of heavy machinery and trucks. These emissions should be also taken into account when considering bioenergy systems.

The current interest in forest bioenergy production, future biofuels, and their potential to mitigate climate change make this study relevant. In this context, it is essential to compare different wood supply chains in order to promote those with the lowest GHG emissions. In this study the conventional system is compared with an innovative system, biomass dedicated, where harvesting of roundwood is integrated with energy wood.

Materials and methods

A Life cycle perspective was used to calculate the fuel consumption and GHG emissions of all the processes from harvesting to delivery to industry of each supply chain in three locations in Northern Sweden. The functional unit chosen to analyze the different forest fuel production and procurement systems was oven dry tonne (ODt) of wood chips delivered to the industry.

The conventional system, where roundwood and residual assortments were treated separately, was compared to an alternative system (biomass dedicated) which integrated roundwood and residual assortments. A conventional forestry regime was considered where a forest cycle of 95 years included four silvicultural treatments to reduce tree density and increase growth of the remaining trees: pre-commercial thinning – manual thinning of small and non-commercial trees- (PCT), first thinning (FT), second thinning (ST) and final felling (FF). The main assortments extracted from the forest in the conventional forestry regime were pulpwood (PL) in FT, sawlogs (SL) and PL in ST and FF (Table 1). In addition, logging residues

(LR) and stumps (SP) were harvested in FF. The biomass dedicated forestry regime included energy thinning – thinning that takes place 15 years later than PCT in order to provide trees with economic size for mechanized logging- (ET); FT, ST and FF. The assortments extracted were bundled whole small trees (BWT) in ET, tree sections (TS) in FT, long tops (LT) in ST and FF, and sawlogs with stump core (SPC) and LT in FF (Table 1). SPC were separated in SL and stump core (SC) at the terminal.

Table 1. Assortment definitions

Assortment	Definition	Silvicultural treatment
Pulpwood (PL)	Delimbed small-diameter logs with bark with a top diameter ≥ 5cm under bark (u-b)	FT, ST, FF ST, FF
Sawlog (SL)	Delimbed logs with bark with a top diameter >12 cm u-b.	
Logging residues (LR)	Tree-tops (diameter ≤5 cm u-b) and branches removed from the stem at conventional round-wood harvest.	FF
Stumps (SP)	The stump left when a tree is cut including part of the roots.	FF
Bundled whole trees (BWT)	Small trees from thinning operations with top and all branches still attached cut into sections which are compressed and tied together into ca. 0.5 m^3 solid bundles at the harvest.	ET
Rough-delimbed tree sections (TS)	Partly delimbed stemwood cut into sections (50% branches mass is included).	FT
Long tops (LT)	The pulpwood part of a stem (diameter u-b ≤12 cm) with the tree-top and branches still attached.	ST, FF
Stump core (SPC)	The prolongation of the stem into the stump, which can be cut out together with the lower part of the stem.	FF

Results and discussion

The total fuel consumption and GHG emissions of the operations considered in the study were lower in the biomass dedicated system than in the conventional system in all three locations. The total average amount of $kgCO_2$-eq/ODt varied between 35 and 37 in the biomass dedicated system, and between 43 and 45 in the conventional system (sawlogs excluded).

In the conventional and biomass dedicated systems the key contributors to GHG emissions were transport, forwarding, harvesting, and chipping. In the conventional system excavating for stump extraction was another relevant contributor. A significant reduction of fuel consumption in forwarding was observed in the biomass dedicated system when comparing to the conventional system. This was due to the high diesel consumption in forwarding of logging residues and stumps in the conventional system.

Conclusions

The calculation showed that a biomass dedicated system where harvesting of industrial roundwood is integrated with energy wood can reduce the fuel consumption and GHG emissions by around 13% when comparing with the conventional harvesting and procurement system in Northern Sweden. This result was similar in the three locations analyzed.

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Acknowledgement - The research leading to these results has been supported by the EU through the Marie Curie Initial Training Networks (ITN) action CASTLE, grant agreement no. 316020. The contents of this publication reflect only the authors' views and the European Union is not liable for any use that may be made of the information contained therein."

Evaluation of biomass suply chain in terms of operation costs and GHG emissions in Northern Spain

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The use of renewable energy based on woody biomass has become increasingly important in European countries. Forest-fuel systems show great potential in this respect but they require study in order to find out and develop efficient forest operations from a technical, economic and environmental point of view. As a result, this study aims to evaluate the costs and the greenhouse gas (GHG) emissions of different pine forest-fuel systems in Northern Spain. In the study, harvesting, forwarding and chipping and transportation to consumer points were considered in the analysis. One of the most common approaches for the analysis of the supply chain is the calculation of biomass supply and the analysis of the logistics and costs of harvesting through the use of GIS technology. Here biomass transport by road was optimized through a network analysis using Network Analyst ArcGis. A combination of GIS methods and time study data was used to calculate biomass supply flow and its estimated costs.

For the study of GHG emissions the system boundary considered comprised: harvesting, forwarding, chipping and transportation phases. The amount of CO2e emitted was estimated based on the productivity and the fuel consumption data of each machine involved in the processes analyzed. Additionally, the energy input-output ratios between the fossil fuel energy inputs (machines) and the bioenergy produced were evaluated. Studies such as this are essential to identify the factors that affect and influence costs and GHG emissions, and thus generate knowledge for improving forest-fuel systems and aiding forest managers in planning and decision making.

Growing tree plantations of pine and spruce on the grounds postagrogenic Northwest Europe

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Presently a substantial amount of land released from agricultural use (more than 20 million hectares) has accumulated in the North-West of the European part of Russia. Compared with forest soils, organic horizon of which is insignificant in its depth, and which contains the main bulk of absorbing trees roots, the root zone on former agricultural lands has a length of up to 30-40 cm along the arable horizon, and, therefore, woody plants have a greater opportunity for root nutrition. In forest soils, in the most productive forest types of the North-West region, humus content amounts to 1.5-2%, and acidity pH is of 3.5-4.0, whereas postagrogenic lands have a more neutral reaction pH of 4.5-5.0, and humus content of up to 5%.

The experience of growing coniferous tree plantations on these lands shows that such forest stand in its stock and performance is superior to similar plantations growing on forest lands. Thus, in the setting of the Leningradskaya Oblast region, naturally appearing spruce forest on old arable lands forms a growing stock of 300-400 m^3 by the age of 60-70 years (Sennov, 1999; Alyatin, 2006). The majority of the naturally formed pine tree stands on former agricultural lands are characterized by high productivity, while growing in accordance with Ia-I class of site quality of forest.

Plantations of spruce and pine, created on old arable lands a century ago, as well as natural forest stands which appeared during serai process on the former haylands and ploughlands, so far have formed timber stock exceeding the stock of naturally growing stands on forest lands by a factor of 1.5-2. Double cropping of spruce and pine trees created on postagrogenic lands, at 60 years of age have the following stock of wood per 1 hectare: in spruce and pine plantations – 500-520 m^3/ha; in pine and spruce plantations – 480-600 m^3/ha; and in pine plantations of 110 years of age with further regeneration of spruce the total standing volume is 650 m^3/ha (Lokhov, 2013; Danilov, 2014). The results obtained in research allow us to conclude that joint cultivation of pine and spruce on the former ploughlands of the Northwest of Russia should be regarded as a biologically justified silvicultural activity.
Plantation crops of pine and spruce, created in Pskovskaya and Leningradskaya Oblast regions on the former lands of agricultural use, which are being cultivated in accordance with intensive technology, by the age of 40 years, presently can boast a timber reserve of 250-500 m^3 , whereas natural stands have a reserve of less than 120 m^3/ha. In these plantations massive large-sized usable timber constitutes up to 20% of the stock of commercial timber (Danilov,2013; Zhigunov,2014).

Table 1 - Performance of Forest Plantations on Lands Released from Active Agricultural Use under Optimal Growth Mode

Region	Area Baseline Characteristics	Year of Plantation Establishment	Species	Plantation Age	Plantation Density/ thousand pcs./ha	Reserve, m^3/ha
Leningradskaya Oblast	Abandoned Hayland	1975	Spruce	36	1775	360
		1975	Pine	35	2095	316
		1980	Spruce	30	2145	419
		1980	Pine	30	1606	328
Pskovskaya Oblast	Abandoned Ploughland	1975	Pine	22	1409	392
	Abandoned Hayland	1975	Pine	35	1435	399
		1975	Spruce	35	1839	462

Established as of today experimental planting of pine and spruce on fallow lands in Leningradskaya region, at the age of 5 years, demonstrate its advantages in concern to the rate of growth of plant biometric indicators, which is 1.5-2 times higher than that of forest plantations grown on forest soils.

Table2 - Dynamics of Plantation Growth of Spruce and Pine Trees on Postagrogenic Lands

Soil cultivation method	Planting material				Year of growth													
					1(2010)			2 (2011)			3 (2012)			4 (2013)			5 (2014)		
	Species, Age	d_0, mm	H_c, m	d_0^2H, cm^3	d_0, mm	H_c, m	d_0^2H, cm^3	d_0, mm	H_c, m	d_0^2H, cm^3	d_0, mm	H_c, cm	d_0^2H, cm^3	d_0, mm	H_s, sm	d_0^2H, cm^3	d_0, mm	H_c, m	d_0^2H, cm^3
Virgin land+chemical tending	Spruce, 3 years, BareRS	3,6	19±0,8	2,46	4±0,2	27±0,9	4,3	6±0,2	36+1,1	13,0	9±0.4	55±2.0	44,5	14±0,4	78±2,9	153	17±0,5	109±4,1	315
	Spruce, 4 years, BareRS	4,0	31±0,7	4,96	5±0,2	40±0,9	10,0	8±0,2	45±1,0	28,8	11±0.4	60±1.4	72,6	17±0,7	84±2,7	243	21±0,9	116±4,3	512
Surface+ chemical tending	Spruce, 4 years, BareRS	4,0	31±0,7	4,96	6±0,2	37±0,8	13,3	9±0,2	45±1,0	36,4	14±0.4	66±1.9	129,4	20±0,5	99±2,8	396	23±0,6	123±3,7	651

Soil cultivation method	Planting material				Year of growth														
					1(2010)			2 (2011)			3 (2012)			4 (2013)			5 (2014)		
	Species, Age	d_0, mm	H_c, cm	d_0^2H, cm^3	d_0, mm	H_c, cm	d_0^2H, cm^3	d_0, mm	H_c, m	d_0^2H, cm^3	d_0, mm	H_c, cm	d_0^2H, cm^3	d_0, mm	H_s, sm	d_0^2H, cm^3	d_0, mm	H_c, m	d_0^2H, cm^3
Virgin land+chemical tending	Pine, 3 years,	5,0±0,3	37±1,2	9,25	6±0,2	44±0,9	15,8	10±0,5	51±1,7	51,0	17±0.8	81±0.9	234	25±1,1	116±4,5	725	29±1,7	158±7,1	1329
Surface+ chemical tending					8±0,2	40±0,8	25,6	15±0,3	61±1,7	137,2	23±0.7	96±2.5	508	35±0,1	141±3,2	1727	45±1,4	192±5,1	3888
Surface					8±0.2	41±0.9	26,2	13±0.5	60±1.2	101,4	17±0.6	86±1.8	249	26±0,2	114±2,2	771	35±1,0	160±3,6	1960

BallRS-ball-rooted system; BareRS– bare-rooted system Spruce, 3 years,Pine

With the establishment of forest plantations on forest soils the task of creating microelevations to improve the soil and hydrological conditions for planting spots is of prime importance. When creating plantations on

postagrogenic lands, the task of timely elimination of competition from herbaceous vegetation for the successful growth of the created plantations comes in the first place.

As it was already noted above, previous human impact on the soil and created ploughed horizon allow getting pine and spruce wood biomass on such plantations within a more accelerated term of 30-40 years compared to the term of 80-100 years observed on the forest lands.

Qualitative and quantitative indicators of pine and spruce growing on postagrogenic land are not below the average ones for the region. The given data on basic wood density in plantations on postagrogenic lands of the Northwest region show that density of pine and spruce in most cases is higher than the average numbers for the region of study which are 370-380 kg per m³ for spruce, and 400-410 kg per m³ for pine. The average base wood density of pine averages from 380 to 420 kg per m³, and of spruce – from 360 to 400 kg per m³ in the North-West region of Russia. It is also worth noting that under the conditions of the mentioned region, increase of pine wood density can occur until the age of 100 years, and, in case of spruce, until the age of 120 years and even after that.

Table3 - Pine and Spruce Wood Density on the Postagrogenic Lands of Northwest Region

Region	Species	Age, in years	Average Base Wood Density, kg/m^3
Leningradskaya Oblast	Spruce, forest plantations	110	383
	Pine, forest plantations	110	420
	Spruce, planted species	40	402
	Pine, planted species	40	422
	Spruce natural stands	120	460
	Pine natural stands	120	480
Pskovskaya Oblast	Spruce, planted species	40	380
	Pine, planted species	40	360

Growing wood for the needs of the pulp and paper industry presents a number of requirements to the quality of raw wood – content of resins, the proportion of cellulose and lignin.

The study of the component composition of the pine wood from planted species grown on postagrogenic land shows that it is quite uniform in its performance compared to that of older natural timber stands. Particularly, cellulose content usually averages 53% of the total pine pulp, and in natural forests it does not exceed 50%, which is also important when using it as raw material for the needs of the pulp and paper industry. The content of resins in such wood is also lower than what can be observed in the older pine stands, where resin-richer heartwood has been formed.

Table4 - Chemical Composition of Pine Wood Plantation on Postagrogenic Lands

Trunk height, m	Number of Annual Growth Rings, pcs.	Kurschner-Hoffer Cellulose, %	Cellulose after deduction of pentosans, %	Lignin, %	Pentosans, %	Pentosans in Kurschner-Hoffer Cellulose, %	Substances Extracted in Acetone, %	Substances Extracted in Water, %	Ash Content %
10	8	49,20	45,73	29,73	10,18	7,06	1,60	2,73	0,08
8	8	51,21	47,68	26,71	10,70	6,90	2,65	3,70	0,10
6	13	51,63	48,32	27,20	10,12	6,40	3,29	2,61	0,10
4	17	53,31	50,26	27,76	10,05	5,73	1,65	3,03	0,09
1,3	23	51,58	48,10	27,26	8,44	6,74	3,22	3,16	0,09
0,05	29	54,83	50,97	26,23	7,69	7,03	2,66	2,88	0,11

Growing pine and spruce plantations on postagrogenic lands allows involving them in economic turnover and maintaining natural forest ecosystems.

Accelerated growth of coniferous plantations enables us to get high-quality wood raw materials for the customer in shorter terms, making it a cost-effective and economically expedient venture. Creation of mixed plantations of pine and spruce will increase the volume of wood grown per hectare of yield area.

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Session 6: Economic and social challenges for the bioeconomy

Wednesday 21 October 13:30-15:30
Rooms 1 & 2 (combined) Floor -1
Session chair: Jean-Luc Peyron, Managing Director, ECOFOR

Alessandro Paletto	Council for Agricultural Research and Economics (CREA), Italy	The Communication of European Commission concerning the Strategy for "Innovating for Sustainable Growth: A Bioeconomy for Europe"
Päivi Pelli	University of Eastern Finland	Rethinking service logics in forest-based Bioeconomy
Nadine Pannicke	The Hemholtz Centre for Environmental Research, Germany	The political economy of fostering a wood-based Bioeconomy in Germany
Katja Huenecke	Institute for Applied Ecology, Germany	Global bioenergy demand and food security
Irmeli Mustalahti	University of Eastern Finland	Responsive Bio-economy: Interaction of states, citizens and corporations in everyday practices of forest governance
Anna Harnmeijer	MHG Systems, Finland	Interface between new sustainability legislation and the current initiatives within the UK bioenergy industry
Elena Gorriz	Forest Sciences Centre of Catalonia (CTFC), Spain	Tbc
Mihail Hanzu	National Institute for Research-Development and Forest Management "Marin Drăcea", Romania	Holistic indicator for optimal forest governance
Sabaheta Ramcilovic-Suominen	University of Eastern Finland	Sustainability – A 'selling point' of the emerging EU Bioeconomy?
Maxim Trishkin	University of Eastern Finland	Root-identification of bioenergy conflicts in developing countries

The Communication of European Commission concerning the Strategy for "Innovating for Sustainable Growth: A Bioeconomy for Europe"

Alessandro Paletto

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The Communication of European Commission concerning the Strategy for "Innovating for Sustainable Growth: A Bioeconomy for Europe" (COM(2012)60) stressed as a responsible bioeconomy calls for participatory models that engage citizens and end-users in order to reinforce the relationship between science, society and policy making. The bioeconomy can play an important role in the sustainable economic growth of the European Union (EU) Member States through reducing dependence on non-renewable resources and managing natural resources sustainably. In order to achieve these objectives it is fundamental that collective stakeholders (public institutions, private organizations and non-governmental organizations-NGOs) and single citizens are engaged in an open and informed dialogue throughout the research and innovation process. This study focused on the analysis of the stakeholders' preferences and opinions about the different aspects of bioeconomy using the cognitive mapping approach (Axelrod, 1976). The cognitive mapping is an approach to strategic thinking, particularly in exploring values, issues, perspectives, goals, concerns, and objectives (Eden, 1988). The cognitive map is a model congenial to formal analysis that is designed to mimic the way a person or a group perceives an issue. In other words, it is a casual-based mapping technique in which the elements of a complex problem are organized as a set of concepts framed as a network of nodes and links to represent the relationships of the concepts (Paletto et al. 2014). In the present study, the cognitive maps of the stakeholders were analyzed in order to identify the best political strategy (objectives and actions) to promote the bioeconomy at the local level. This method was applied and tested to a case study in Southern Italy (Calabria Region) characterized by a high socio-economic importance of the forest sector for the development of the local economy. The data for the analysis of stakeholders opinions and preferences were collected through the administration of a semi-structured questionnaire at about 50 local stakeholders divided into four categories of interest (public administrations, private actors of forest-wood-energy chain, associations-NGOs and universities and research centers). The cognitive maps drawn up for each category of stakeholders shown that the strategies can change from category to category highlighting potential conflicts in decision-making process. In addition, the overall results of all stakeholders shown that the most appreciated strategies are: (1), to promote forest certification of timber and woodchips; (2) to promote cultural activities related to the environment (eco-tourism, environmental education); (3) to improve collaboration between local economic actors.

Rethinking Service Logics in Forest-based Bioeconomy

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Introduction

The increasing role of services has been recognized as an emerging phenomenon in the forest sector [1,2]. Companies shift from product and production orientation to more customer-focused approaches and also new business models are appearing. These developments have already been evidenced for example in machinery and engineering industries and their business-to-business services, but similar advances can also be found in a number of forest sector companies [3].

During the recent years, bioeconomy, biobased society and green economy have appeared as framework concepts for the sectoral visions and strategic orientations in the forest-based sector (FBS), including the new EU forest strategy (2013). The core message in these documents is that the forest-based sector is one of the key sectors contributing to bioeconomy. Yet, the bioeconomy conceptualizations are under evolution, reflecting the different emphasis given to it by various actors at international and national levels, and whether it is industrial, technological or socio-economic changes that are central [4]. This study asks: how the bioeconomy strategies and forest-based sector programmes take on board the increasing role of services?

Taking stock on the business research on services, three angles to services in bioeconomy are used: services activities either as inputs to production or as business on their own; services outputs either as separate offerings or as embedded in the products, and; service as process. A system view to service as process is elaborated through the lens of Service Dominant Logic (SDL) by Vargo and Lusch [5]: rather than producing services and/or goods, the focus is in rethinking the concept of value. First, a review is made of the bioeconomy strategies and the forest-based sector related programmes at EU level. Second, the SDL foundational premises are tested vis à vis the bioeconomy and forest-based sector strategies.

2. Results and discussion

2.1 Bioeconomy strategies largely ignore services, but they are in the radar of other FBS partnerships

In bioeconomy strategies and programmes services refer to various *support services* needed to ensure production processes. Similar conclusion can be drawn from the FBS strategies; there are few *business opportunities* recognized in services activities. Services outputs, in turn, tend to be performance of materials, such as biodegradability, and functionalities *embedded in the products*, such as diagnostics or smart elements. Even if the strategies refer to solutions to customers, it is not explained how or by whom such processes would be developed. The aspect of service sector companies and their contribution to innovation in primary production and supply chains are lacking from the analysis.

	Services activities:		Service outputs:	
	support services	services business	services	embedded
EU bioeconomy strategy (incl. PPP BBI, EIP AGRI)	x			x
EU forest strategy (incl. F-BI); UNECE/FAO	x			(x)
Forest-based sector (FTP, CEPI, BECOTEPS…)	x	(x)	(x)	x
Other European Innovation Partnerships, public-private partnerships (SPIRE, E2B, EFFRA…)	x	x	(x)	x

Table 1: Review of bioeconomy and forest-based sector strategies and programmes

The forest-based sector documents refer to a number of other than bioeconomy-related public-private partnerships and innovation partnerships, such as construction sector (E2B), processing industry (SPIRE) or manufacturing (EFFRA). Their strategies tend to take a wider view on technological change and the possibilities that enabling technologies open up for production and throughout the whole product service life. These strategies also elaborate more about services as activities, outputs and new business models.

2.2 Systems view to transition towards a bioeconomy: service as process

The forest-based sector strategies underline the multiple products and services that forests and the sector provide to society. The same is repeated in bioeconomy strategies with emphasis on the high potential of bio-based solutions. Yet, the focus is in product development, production processes and substituting fossil-based materials with renewable ones. Breakthrough innvoations are expected to yield to environmentally sound, energy- and resource efficient production. In other words these strategies do not seek to address changes in product uses or to define alternative ways of satisfying the customer or consumer needs. *In SDL terms, customers and users are not perceived as value co-creators but remain passive recipients for the company value propositions.* The inconsistency becomes even more evident, if the loop of linear value-added chain is closed, and the resource flows are not only from production to consumption but also back. There is potential in involving customers and users in design of future solutions, as already addressed in the above mentioned public-private partnerships which go beyond the current bioeconomy strategies.

Value-added chains are the prevalent approach in bioeconomy strategies. SDL looks into company operations in a systems view: While forest-based companies, forestry organizations and various stakeholders comply with requirements set by national and EU legislation, they at the same time use the bioeconomy strategies to highlight and improve their offerings. They enact and re-define bioeconomy in interaction with their suppliers, customers as well as the overall network of stakeholders. Bioeconomy projects direct companies towards cross-sectoral collaboration, such as pulp production / biorefineries connecting with several use-field industries. The process is not as controllable and predictable as a linear value chain for traditional products has been. *In SDL terms, resource integration is an opportunity to reach also more radical innovations.* Opportunities should be sought to involve users and service providers to design solutions towards bioeconomy.

3 Conclusions

Bioeconomy strategies and related forest-based sector documents focus mainly on biomass and production processes, keeping the focus too narrow to enable assessment of wider technological and socio-economic developments, including the increasing role of services. New tools are needed to envisage systemic changes beyond mere incremental improvements in the existing products. SDL as a framework provides new vocabluary to elaborate how the new windows of opportunity can become recognized and utilized.

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The political economy of fostering a wood-based bioeconomy in Germany

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Sustainability of economic processes (use of resource inputs as well as products) requires a transition from the hitherto predominant fossil-based "throughput economy" towards a circular flow economy based on renewable resources, the so-called bioeconomy. As an example, this paper analyses the technological as well as socio-economic potential of Germany's wood-based bioeconomy to support such a sustainable path transition.

To this end, the paper provides an economic analysis of transition processes using dynamic theories of lock-in effects and lock-out options. From this perspective, the current economy might be described as locked into a fossil equilibrium. Thus, a successful transition requires a new twofold equilibrium: an economic sustainability equilibrium described by a different pathway of the economy and a corresponding "political equilibrium" providing the required transition policies to manage the transition, which results from policy demand of e.g. voters/consumers, industries and other pressure groups meeting policy supply on political markets. With adequate transition policies in place, a critical economic threshold towards the bioeconomy may be crossed. Afterwards, the transition process might be self-sustaining.

Against this theoretical background, a positive analysis of current bioeconomy policy supply and demand in Germany is carried out. The analysis shows that a range of wood-based bioeconomy-related policies currently exists. However, R&D support, at present the dominant bioeconomy policy, does not suffice to trigger the required transition. Furthermore, politicians are not inclined to initiate significant path changes due to high political costs (innovative policies do not pay off in elections). On the policy demand side, few actor groups have substantial interest in strong bioeconomy policies, whereas fossil interest groups successfully promote the further use of fossil resources.

Based on this analysis, we formulate recommendations how to develop appropriate transition policies. To begin with, innovative niche products and processes need to be identified and promoted. Complementary policies that reduce the use of fossil resources need to support the transition process. Once a critical threshold towards the bioeconomy is crossed, a market-induced selection of the most sustainable and cost-effective bioeconomy products and technologies might be conceivable.

In sum, our analysis delivers both a theoretical framework of sustainable transition processes and specific policy advice for fostering Germany's wood-based bioeconomy.

Global Bioenergy Demand and Food Security

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Guaranteeing food security is one of the fundamental challenges of our times. At the same time the world is facing the challenges of climate change, desertification and habitat destruction. All challenges require immediate political action and more or less binding targets have been set at national level to counter them. There is the danger on conflicting targets and trade-offs of political action towards the one or the other target. Such conflicts become most apparent regarding food security and bioenergy use. The availability of agricultural land is limited. In addition to growing global demand for food and bioenergy the conflict is fueled by unequal global distribution of biomass use.

We will present results of the project “Milestones 2030 - Elements and milestones of the development of a sound and sustainable bioenergy strategy” funded by German Federal Ministry for Economic Affairs and Energy. We evaluated the risk of food insecurity by biomass cultivation for bioenergy use. We developed a food security model that puts bioenergy use and inadequate nutrition into relation. A min-imum requirement of 2.300 calories (10 percent animal food and 90 percent vegetal food) per day and person was assumed. Based on current and future diets at national level, countries with the risk of food insecurity were identified. To balance an unequal distribution, the model adjusts consumption of bioenergy in countries with a high GDP (gross domestic product) to a defined level that allows a reallo-cation of biomass to countries suffering from scarce resources for food.

Results show that missing calorie quantities are about seven percent of the current bioenergy demand in countries with high GDP. However, bioenergy demand in these countries is rather expected to in-crease, which is also due to targets set by policy to combat climate change. We show also that the gap can be filled by a change of diets: reducing meat consumption and other animal food products within industry and emerging countries we consider a more viable option towards global food security, climate and habitat protection at once.

Responsive Bioeconomy: Interaction of states, citizens and corporations in everyday practices of forest governance

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Introduction

Climate change and the transition to the bioeconomy are creating new challenges for natural resources management. Current national and international natural resource policy reflects current challenges of multi-level governance: Scholars argue that there is a shift from 'government' to 'multi-actor' or 'network governance', as all kinds of new (private) actors have entered policy arenas and co-determine policy processes; there has also been a (partial) shift from 'intergovernmentalism' to 'transnationalism', 'supranationalism' (EU) and 'multilevel governance' (Van Kersbergen and Van Waarden 2001 in Arts and Tatenhove 2004:340). This type of policy of strategic interaction aims to promote multi-actor dialogue and participation of various actors in policy arenas. But such interactions also reflect influential vested interests and can lead to creation of so-called discourse coalitions (Hajer, 1995; Dryzek, 1997) and advocacy coalitions (Sabatier, 1987). In this paper, I argue that these types of coalitions are very visible in relation to policy arenas promoting transition to the bio-economy. Current bioeconomy strategies have been criticized for being based on the assumption of unlimited resources and the optimistic belief that (bio)technology can foster sustainable economic growth (Pülzl et al., 2014). Despite these critical discourses, the bioeconomy in Finland for example is still seen as the new path towards a sustainable green economy (Finnish Bioeconomy Strategy 2014). My current study aims to identify interactive forms of governance and citizens' inclusion for the creation of multi-actor dialogue and participation of various actors in so-called bioeconomy discourses and advocacy coalitions in Finland. The ideal of responsive bioeconomy governance raises the questions: what kinds of involvement and participation are sufficient when bioeconomy strategies are developed and implemented at the international, national or local level? Several scholars (e.g. Arnstein 1969; Thomas, 1995; Konisky and Beierle, 2001; Mustalahti et al. Forthcoming) have identified different participation ladder, levels and degrees, but the meaningful participation of citizens, however, remains a challenge. I argue that the bioeconomy cannot be a way towards a sustainable green economy without citizens' participation in responsive bioeconomy governance.

Case study and methods

In this paper, I use Finland as a case to discuss the bioeconomy discourse and advocacy coalitions in relation to current strategies towards a forest-based bioeconomy. Currently, the Finnish Bioeconomy Strategy (2014) promotes interactions between citizens, bioeconomy operators and decision-makers both as concerns policy processes as well as in management and use of natural resources. The current strategy aims to engage citizens in combating climate change, and the objectives of the actions related to forest-based bioeconomy in particular seek to engage citizens. In reality, the multi-level bioeconomy governance in Finland is an example of the 'policy arrangements' approach which is contextual and problem oriented: Arts and Tatenhove (2004:341) argue that "the key assumption is that policy decisions and policy making processes within *policy arrangements* (referring to the ordering of a specific policy field in terms of agents,

resources, rules and discourses) are the result of the interplay of contextual processes of structural political and social change on the one hand (*political modernisation*) and problem-oriented renewal of policy making by agents in day-to-day practices on the other (*policy innovation*)." However, in Finland, the bioeconomy advocacy coalitions are very visible in relation to policy arenas promoting transition to the bio-economy.

My current study addresses multi-level and responsive governance in the context of the Finnish forest-based bioeconomy. I discuss the advantages of responsive bioeconomy governance, and highlight the challenges of so-called discourse coalitions in a forest-based bioeconomy. My current study addresses multi-level and responsive governance in the context of the Finnish forest-based bioeconomy. I discuss the advantages of responsive bioeconomy governance, and highlight the challenges of so-called discourse coalitions in a forest-based bioeconomy. Finally, I draw some conclusions and present recommendations regarding responsive bioeconomy governance and, in particular, discourses which enable wide representation of climate change concerns and provide a platform for local considerations of forest conservation and utilization to be taken into account.

Results and discussion

Recently, the public debate has noted bout slow Finnish efforts to fight climate change while at the same time Finland has been developing forest-based bioeconomy strategies and programs. For example, combating climate change is not possible without the involvement of citizens and the inclusion of citizens' in public decision making (Rask et al. 2011; Mustalahti et al. Forthcoming). Collaborative approach represents a radical democracy based on ordinary people's abilities and participation. This type of multi-level governance is not possible once influential actors protect their vested interests and can create discourse coalitions (Hajer, 1995). In Finland, participatory and responsive multi-level governance is considered challenging (Ahokas et al 2010; Wiberg 2013). Wiberg (2013) emphasizes limits of deliberation and participation: Citizens' panels and other forms of deliberative administration can also be used to manipulate the multi-level democratic decision-making processes. Ahokas et al. (2010) raise the issue of the trend in Finnish democracy in which participation and activity of strong coalitions come to reflect age, education and wealth for example. The elites network and operate independently, regardless of the opinions of the people (Korvela 2012: 148). Multi-level governance, in principle, should implement democratic values such as justice and moderation, and promote a sense of community and civil society (cf. Wiberg 2013 above). An interactive debate between civil society and forestry sector-driven actors' coalition is a challenge for Finland's current forest-based bioeconomy strategies and program. The fight against climate change and the role of the bioeconomy in economic growth is further emphasized in current forest law and the national forest program. For example, public debate and strategy planning have not considered how significantly the forest-based bioeconomy impacts the livelihood of citizens and multi-purpose forest management and conservation. Based on evaluation of forestry sector strategy papers and programs, I argue that coalitions based on forestry actors such as the sector ministry, private sector and forest owners' organizations are very visible in relation to policy arenas promoting transition to the bioeconomy.

Conclusions

This paper argues that multi-level and responsive governance has a crucial role to play in the success of the current bioeconomy transition. In Europe, with its concern about climate change, the bioeconomy will challenge previous conceptualizations about how states, citizens and corporations interact in everyday practices of forest governance. Finland's forest governance reform efforts attempt to respond to local circumstances and simultaneously mitigate global climate change. At the same time the current forest-

based bioeconomy transition will also have impacts. Therefore democracy, sustainability, effectiveness, inclusiveness and engagement of the citizen need to be put at the center of governance. For example, forest owners are not automatically able to sustainably manage, protect and exploit natural resources that they own and control. Forest ownership does not make a forest owner automatically a forest management professional, environmentally friendly decision-maker and bioeconomy minded forestry expert. Multi-level and responsive governance requires a strong counseling, advisory and support network. At best, multi-level and responsive governance will for example be able to support the forest owners' transformation from forest resources 'consumers' towards multi-users and guardians of forests, who can influence strategy plans and programs. However, this will require a change in current discourse coalitions and clear laws to guide multi-level and responsive governance. It will be important to try to develop information systems, financial programs and legislative initiatives that can support interactivity between professionals and the general public and forest-based bioeconomy actors, from design to the various interactions of states, citizens and corporations in everyday practice of forest governance.

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Interface between new sustainability legislation and the current initiatives within the UK bioenergy industry

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This paper explores the interface between new sustainability legislation and the initiatives currently being undertaken within the UK bioenergy industry to understand, monitor and limit the direct and indirect social and environmental impacts of production. We collect data on change initiatives undertaken by a cross-section of firms in the heat, CHP and power sector, and classify them broadly according to level of innovation. Three case studies were selected based on their variable ability to adapt to 'the sustainability dilemma' posed to them by new UK legislation and were analysed in detail with respect to strategising and organising processes, resources and relational qualities. The results open up a discussion on if and how enterprises are able to address the contingencies on which bioenergy is a sustainable and climate neutral technology, revealing the challenges and opportunities of managing effective firm and network level change initiatives in response to complex global environmental problems.

Non-Wood Forest Products and their role in rural economies

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Non-Wood Forest Products (i.e. berries, mushrooms, moss) constitute a valuable resource which is often ignored in bioeconomy approaches due to the lack of institutional settings that allow the internalisation of their value in rural economies. This calls for analysing the adequacy of institutional reforms allowing land managers to take into account the production of NWFP, and NWFP users/harvesters to assume their contribution against the recreational or commercial benefit they get from the forest.

However, social factors play a crucial role in the acceptance of new governance modes. Here we focus on social capital emerges as a key aspect for analysing how networks of actors interact in decision-making and implementation of policy processes. We analyse the design and implementation of a governance reform over the rights on wild mushroom picking in a protected forest in Catalonia (North-East Spain). In 2012 a picking permit was established in the protected area of Poblet, acting as a pilot case for the whole Catalonian region. It affects an extension of 3,000 hectares, which has been signalled. A permit fee is implemented, giving 90% discount for locals. Locals are those living in one of the four municipalities with territory affected by the mushroom regulation. 2,170 permits were emitted during the first season, 80% to locals.

We study social capital dimensions (cognitive, structural and relational) within the park decision-making body, a technical commission and local stakeholders in order to understand possible key actors, coalitions, alignment in discourses, and evolution of relationships along the policy process of introducing a picking permit. Through in-depth interviews and Social Network Analysis, we find that the decision-making constituted a comprehensive network encompassing all relevant stakeholders, from which some actors stand as crucial for influence and information flows in the decision-making. These agents share in a large extent the mushroom picking-related problems and also agree in their preferred solutions. This is likely to have had an effect in the large engagement of local pickers to the permit.

Holistic indicator for optimal forest governance

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Introduction

Historically, the main criteria considered when decisions are to be taken regarding forests and forestry are either related to: i) a sustainable maximum timber production, either related to ii) a maximum income or rent. Even if these two main directions of thinking seem to be antagonistic, the first leading to long rotation cycles while the second to the idea that long rotations are not economically feasible (Samuelson 1974), they both have in common a very important feature: they neglect all the other positive outputs of the forests.

Because modern forestry appeared in a crisis situation, a timber crisis, its governance structure had and continues to have, in most of the world, a rather pyramidal structure, in order to ensure the control on the system. But the needs of the human society are changing in time, therefore it is expected that forest governance decission process addapt itself to this social change and new needs.

The scope of this work is to present a indicator that can be used to optimize the structure of forest governance models. For achieving this scope, the main ojectives are:

1. to design a structure of an indicator that will allow it to be adaptable in any particular context,
2. to integrate non-homogenous valuations of the forests outputs into an ecosystem efficiency indicator.

The scope of this article is to present an alternative governance indicator to the pyramidal top-bottom model of forests governance.

Materials and methods

The approach is based on statistical, cybernetic and fractal based methods in order to construct a forest ecosystem efficiency integrative indicator. The indicator is a modular one, one module being used for each dimension of the forest-society system. One module of the indicator has the following logical scheme:

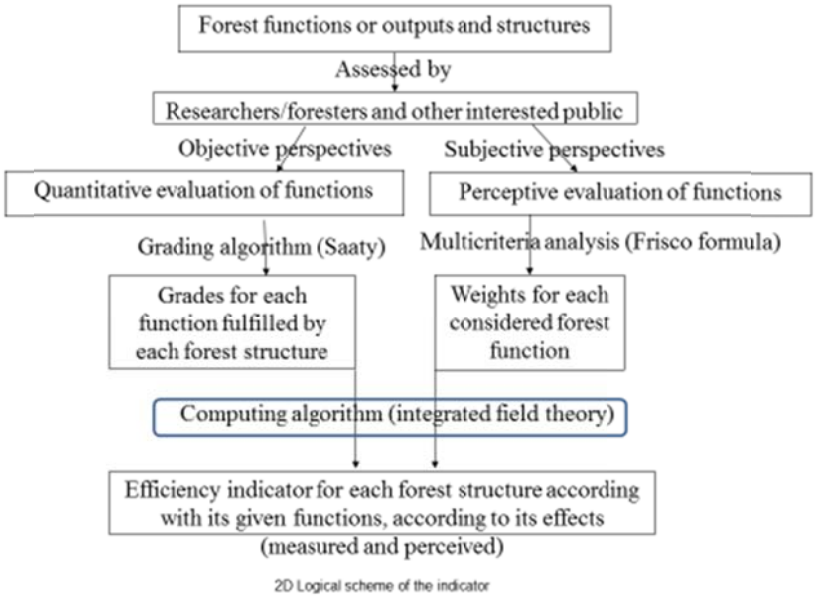

Figure 3: Logical scheme of one module of the indicator

The reason why general public is involved in shaping the forest governance is the fact that in democratic countries forest governance is not optimal if it is not supported by the public.

Using a similar rationality all the modules are integrated into a numeric indicator. The most challanging part of this process is given by fact that even if very different by their nature, the dimensions are not linear independent. For instance, the augmentation of the wood production by spruce plantations in a beech site leads to a decrease of the aesthetic effects and to soil acidification therefore a decrease of soil fertility.

Results and discussion

Results of implementing the method

The method was tested to estimate the efficency of different possible forest stand structures from Cindrel Mountains in Romania´s Meridional Crpathians, in mixed forest sites. So far, only three criteria are taken into account, namely: (1) the productivity of the forest which is estimated by the average height; (2) the protective effect of the forest which is estimated by the stability of the forest stand for climatic hazards and (3) the aesthetic effect of the forest which is estimated by the people's perceptions and preferences for different forest structures. The inetnt of this experiment was to test the algorithms involved in the computation of the indicator.

The study showed that the mixed forest stands are most efficient in the given sites, even if from protective effects they are surpassed by mixed stands.

		Possible composition for the forest stand							
		Spruce stand		Fir stand		Beech stand		Mixed stand	
criterion	w_k	G_k	G_k*w_k	G_k	G_k*w_k	G_k	G_k*w_k	G_k	G_k*w_k
1	0.138889	8	1.111112	8	1.111112	6	0.833334	9	1.250001
2	0.722222	5	3.61111	6	4.333332	7	5.055554	9	6.499998
3	0.138889	4	0.555556	4	0.555556	8	1.111112	9	1.250001
		Total	5.277778	Total	6	Total	7	Total	9
		Rank	4	Rank	3	Rank	2	Rank	1

Where: w_k – weight of criterion k, computed using Frisco multicriterial analysis; G_k – garde of criterion k from a 1 to 10 linear scale; criterion 1 – productivity; criterion 2 – protective effect; criterion 3 – aesthetic effect

Table 2: efficency of different possible forest stand compositions from Cindrel Mountains in Romania´s Meridional Crpathians, in mixed forest sites

Conclusions

The indicator can be applied for any perceived dimension of the forest-society system, due to the generality of the mathematics behind the computing algorithms. Even so, the results will need to be carefully interpreted, due to the fact that once the scale of the system increases, new properties of the system appears. In order to deal with this properties of the systems, further research needs to be done.

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Sustainability – A 'selling point' of the emerging EU Bioeconomy?

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Sustainability is often used by policy-makers, stakeholders and the private sector, as a 'selling point' of their existing agendas and goals. Thanks to its wide, but also self-interpretive definition, the concept allows various actors to make sustainability pledges without necessarily undertaking significant changes in their respective policies, strategies and actions. It is in this context that an emerging bioeconomy policy is being placed. While bioeconomy has been characterized as a "mixed-source" discourse based on the assumption of limited resources and the relevance of (bio)technology to foster sustainable economic growth, sustainable development aims at securing economic growth, while reaching social equity and environmental protection. Whether an emerging EU bioeconomy policy places sustainable development on an equally important level, has to be investigated empirically, however. This is important since bioeconomy has been identified as a (meta-)discourse particularly by the OECD, the European Union (EU), and some countries worldwide, but also found its way into sector strategies, such as forestry.

The aim of this paper is to critically analyse the meaning of and approaches to sustainability, which are being adopted and/or reformulated in the newly emerging bioeconomy policy debate of the European Union (EU). For this purpose we first review literature on sustainability, identifying the main sustainability approaches, pillars and principles. Secondly, we analyse the key policy documents where the European Commission (EC) defines and presents the bioeconomy for Europe, identifying those sustainability principles promoted in this policy debate. Thirdly, by applying a discourse analysis approach we analyse the meaning of sustainability in the EU bioeconomy policy and critically discuss how sustainability notion is understood, defined and whether it is being reframed in the EU policy debate.

We argue that the EU bioeconomy policy debate adopts a narrow technocratic, technology and efficiency oriented approach to sustainability; and in that way reframes the original discourse and notion of 'sustainability'. Possible implications of the emerging EU bioeconomy discourse on the existing related discourses (e.g. sustainable development and sustainable forestry), as well as the implications on the emerging bioeconomy sector, in general and forestry sector in particular, are thoroughly thereafter discussed.

Root-identification of bioenergy conflicts in developing countries

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Root-identification of bioenergy conflicts in developing countries The role of bioenergy in many countries is increasing, especially in European countries, where current strategy is aiming at promotion of renewable sources, particularly woody biomass etc. However quite often the raw material for bioenergy purposes is coming from developing countries in Africa, Asia and Latin America, where the climatic conditions are favorable for fast growing species and raw available at reasonable price. Cost competitiveness of imported to EU raw material for bioenergy purposes make the transportation profitable. However, high demand for raw material and low law enforcements in many developing countries cause the potential conflicts on the ground. The aim of this study is to make a root-identification analysis of the main causes for bioenergy conflict in these areas and map them on global map. Moreover a set of possible barriers and forums for conflict resolution will be pointed out.

Session 3: Assessing sustainability in forestry, agriculture and related bioenergy systems

Wednesday 21 October 14:30-18:00
Rooms 3&4 (combined), 2nd floor
Session chair: Ottar Michelsen, Senior Adviser, Norwegian University of Science and Technology

Hannes Böttcher	Institute for Applied Ecology, Germany	Assessing direct and indirect environmental impacts of alternative EU bioenergy policy scenarios
Tommi Suominen	European Forest Institute, Finland	An application of ToSIA for Life Cycle Sustainability Assessment of biomass utilisation in alternative forest-based value chains
Jakob Hildebrandt	The Hemholtz Centre for Environmental Research, Germany	Identification and evaluation of overriding goals in a sustainability monitoring system for a wood-based bioeconomy region.....62
Leire Iriarte	International Institute for Sustainability Analysis and Strategy (IINAS)	Approach to evaluating sustainability of lignocellulosic biomass delivery pathways within the S2BIOM project
Martha Demertzi	University of Aviero, Portugal	Carbon footprint of the cork oak sector
Spartak Koci	University of Padua. Italy	The impacts of legality constraints on international timber trade patterns
Qianyu Li	VTT Technical Research Centre of Finland	Evaluating land use impacts on bioproductive land depletion in life cycle assessment
Heather Davidson	Technological Institute for Forest Cellulose, Construction-wood and Furniture (FCBA), France	Assessing business sustainability practices: Methodological guidance in simplifying LCA and evaluating triple bottom line principles using parametric modelling
Alexandra Langner	University of Natural Resources and Life Sciences Vienna, Austria	Value-based trade-offs between ecosystem services from European mountain forests
Alessia Portaccio	Tbc	Assessing interactions between renewable energies and ecosystem services according to a sustainability perspective
Giuseppe Cardellini	KU Leuven, Belgium	A new Dynamic Life Cycle Assessment methodology to deal with biogenic carbon fluxes and temporary carbon sequestration
Anke Siebert	The Hemholtz Centre for Environmental Research, Germany	Developing a LCA approach to assess wood-based production system in a bioeconomy region in Germany
Salvatore Martire	European Forest Institute, Finland	A widely usable framework to calculate indicators for sustainability assessment of bio-based supply chains
Eva Meier	Thünen Institute, Germany	Forestry in sustainability measures – From sector specific to national
Oludunsin Arodudu	Leibniz Centre for Agricultural Landscape Research (ZALF), Germany	Sustainability assessment of agro-bioenergy land use: a combined life cycle-participatory approach

Assessing direct and indirect environmental impacts of alternative EU bioenergy policy scenarios

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The world is facing an unprecedented demand for biomass. All existing studies on projections of the future demand of biomass as energy carrier or material for EU countries but also the rest of the world show increasing trends, often with rapidly increasing rates. The increased use of biomass will have impact on the environment in the EU but also abroad because more and more biomass is imported. Single process chains and options have been analysed regarding their environmental performance and scenario analysis of certain indicators, such as net GHG emissions, exist. But integrated studies looking at all relevant environmental indicators at once are missing. Global trade of biomass goods, indirect effects caused by a high degree of substitutability of feedstocks, branched process chains and the competition for land make an estimation of net impacts a challenge.

We use a partial equilibrium land use model (GLOBIOM) and a forest sector simulation model (G4M) to assess the environmental impacts of alternative scenarios of EU bioenergy policies. A set of more than 50 indicators is analysed including general land use, GHG emission, biodiversity, soil and water related variables. The scenarios describe – besides a baseline scenario of current policies – various alternative developments until 2050 (i.e. bioenergy demand in EU stagnates, bioenergy demand in EU is largely met by imports and bioenergy demand in the rest of the world increases more strongly). The development over time of all indicators in the baseline is followed and then deviations of the alternative bioenergy demand scenarios are evaluated.

Preliminary results show that differences between scenarios in 2050 can be as large as differences observed over time in the baseline until 2050. This indicates that the policy scenarios – all based on realistic assumptions – have a significant influence on the environment. Different assumptions of biomass produced in EU affect the intensity of land management, especially forest management. Also in the rest of the word increasing biomass imports to EU might lead to more forest taken into production. This has implications for net GHG emissions and biodiversity in those forests. Water impacts are limited due to the fact that more and more biomass will come from forests instead of cropland. At global level impacts might be limited but there can be strong implications at regional and national level.

An application of ToSIA for Life Cycle Sustainability Assessment of biomass utilization in alternative forest-based value chains

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ToSIA (Tool for Sustainability Impact Assessment) has been initially developed for the sustainability impact assessment (SIA) of changes in forest-based value chains. ToSIA inherently includes a harmonised framework covering the ecological, economic and social dimensions of sustainability. Efforts have recently been made to improve compatibility of ToSIA with Life Cycle Sustainability Analysis. An allocation methodology has been implemented into ToSIA which allows for picking out products from a larger value chain and looking at its share of the value chain indicators and impacts. Work has also been carried out in mapping the ToSIA indicators' relevance to environmental LCA impact categories such as acidification potential, global warming potential, photochemical ozone creation potential, and eutrophication potential.

ToSIA offers a robust framework tailored at looking at the bigger picture beyond environmental product declarations of a single product. A thorough economic analysis is attained by utilising the integrated Cost Benefit Analysis, which uses the economic sustainability indicators and monetary values for externalities (e.g. emissions). Due to its tracking of material flow through a value chain, ToSIA natively uses a "cradle to grave" approach which is suitable for holistically assessing impacts of alternative forest-based value chains. ToSIA allows for accounting of carbon sequestration in forest and primary and secondary harvested wood products. Considering all three sustainability dimensions, the impacts of varying material flow into a cascade use value chain can be assessed. This functionality will be illustrated with a case study on alternative use of construction waste wood. We will demonstrate how cost assumptions and net fossil fuel savings constitute tipping points t hat change the preference of stakeholders for the studied value chain alternatives. The developed ToSIA framework is well placed to address the challenge of a Life Cycle Sustainability Assessment with harmonised system boundaries and one that is integrated with ready and usable decision support tools. The presentation will highlight how this approach can provide decision support to guide land use management and policy implementation.

Identification and evaluation of the overriding goals in a sustainability monitoring system for a wood-based bioeconomy region

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Introduction

The production of high added value product portfolios out of biomass resources, which at the same time create external benefits rather than negative external impacts is a decisive element in the current bioeconomy strategies. For a successful implementation of these strategies, a major integration of energy and material flows between production and conversion systems is necessary. However, this integration must go beyond traditional "industrial ecology"and must be implemented not only at the waste stream level, but through extended cross-sectoral cooperations, integrating products and by-products in cascade and coupled production schemes. The analysis and monitoring of such integrations faces however several challenges. They must include the evaluation of the whole supply chain and process networks for the production of the evaluated goods. Moreover, the assessment should be based on a detailed picture of the regional material flow systems, complemented with the monitoring of stakeholder preferences as well as opportunities and risks resulting from the emerging options for cross-sector integrations. Goal of this work is to present the identification and assesment of the attainment degree of the overriding goals for the-stakeholder involved in wood-based bioeconomy networks, as a first step in the establishment of a Multi-Criteria Decision Analysis (MCDA) for the assessment of the sustainability level of bioeconomy regions.

Materials and methods

Two main activities were carried out: (i) a material flow based assessment, and (ii) a preference-based assessment. The first step of the material flow assessment was the identification of relevant production chains related to traditional and emerging wood-based industrial sectors, such as the production of engineered wood products, biorefinery products and wood fibre boards. The identified production chains were characterized from a life cycle perspective, in terms of their material and energy flows and socio-economic performance profiles. In a second step, alternative options for emerging cross-sectoral process chain integrations were identified and characterized [1]. The specification of the parameters for the individual process chains are operationalized through the collection of companies' inventory data, the evaluation of publically available company data, as well as from business statistics and regionalized social databases.

For the formulation of a goal system for sustainability monitoring a combined top-down + bottom up approach was implemented. The first step, i.e. the top-down approach, consisted in reviewing literature information on the potential goals for sustainability strategies of bio-based industries, and by the organization of workshop sessions for the validation of the identified goals as well as for the weighting of the resulting goal system. The bottom up approach consisted on a stakeholder analysis. This was carried out considering the stakeholder-specific perceptions of the chances and threats triggered by bioeconomy strategies in their fields e.g. administrative constraints, nature and resource protection issues and innovation management. Furthermore the stakeholders from industry were contacted to perform an individual selection and elicitation of potential sustainability goals for bioeconomy regions [2].

Results and discussion

The results from the contextualization of the MCDA procedure for a regional wood-based bioeconomy system showed that the most appropriate and context-specific definition of goal system is achieved by categorizing it accordingly to the following three dimensions: 1.) the maintance of the resources basis encompassing the efficient resource mobilization and sustainable ecosystem management; 2.) the increase of resource productivity, encompassing the efficient process operation and optimized added-value creation; and 3.) the enhancement of regional wealth and external benefits, which is encompassing emission reductions, enhanced end-of-life management options and regional added value creation.
In Table 1 the three overriding dimensions of the sustainability goal system are broken down into sub-goal specific criteria and measurable indicators.

Dimension of the goals	**Selected criteria for achieving sub-goals**	**Indicators**	**Production systems**	**Involved stakeholders**
Maintanance of the resources basis	–Increasing share of sustainably produced forest biomass –Increasing heat self-supply –Increase in high-qualified workforces	–Certified sustainable forest management (% of raw material input) –By-products' use rate for process heat (% of total heat demand)	–Wood and fibre-drying –Biorefinery heat supply –Workers in entire industrial network	–Harvesting service providers –Forest managers –Regional workers –Plant managers and investors
Increasing the resource productivity	–Increasing the material efficiency –Reducing cumulative energy consumption	–Input/output ratio of specific properties –Cumulative energy consumption	–Engineered wood production –Entire industrial networks	–Plant managers –Material scientists –Architects –Process engineers
Enhancing regional wealth and minimizing external impacts	–Tax income of local communities –Enhanced production costs –Increasing (total/ regional)value added –Increased recyclability of the product portfolio	–Tax income of the communities (€/a per t/a) –Value-added shared along the upstream processes (€/t ouput)	–Entire industrial networks –Wood mobilization in upstream chains	–Regional communities –Companies –Consumers –Harvesting service providers

Table 3: Examples of selected criteria for assessing the attainment degree of the three overriding sustainability goals

Conclusions

The establishment of a goal system for a MCDA of wood-based value-added chains has to aggregate performance data from all relevant scales, from the process scale to the scale of the regional industrial production networks. The identification of sustainability benefits cannot be operationalized without quantifiying the deficits and progresses which are attained through the transition of wood biomass uses from conventional state-of-the art production chains towards highly integrated production networks This requires to combine ex-post monitoring informations with trade-offs and synergies identified through ex-ante evaluation of emerging production systems. The material use of wood resource for building materials with a high material efficiency has to be combined with energy-efficient production of bio-based resins and polymers in order to enhance the value-added from stem wood and industrial wood. The extended resource use efficiency through cascading use of the regional product portfolio has to be monitored already for the early product design stage in order to identify the best performing product alternatives.

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Approach to evaluating sustainability of lignocellulosic biomass delivery pathways within the S2BIOM project

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The bioeconomy is expected to significantly contribute to the objectives of the Europe 2020 flagship initiatives "Innovation Union" and "A Resource Efficient Europe". Given this prominent role of the bioeconomy, the demand of biomass for bioenergy and bio-based materials is anticipated to increase in the future. Whether domestic or imported biomass resources will be used depends on several factors, including sustainability requirements, efforts towards mobilization, and cost. Furthermore, integration of “energy” and “material” uses through biorefineries, and wider cascading use of biomass are expected.

This implies increasing pressure on biodiversity and soils and might pose social risks, but there are also opportunities. To safeguard against risks and deliver on the opportunities, a sound and coherent approach to sustainability challenges is needed which requires consideration of not only environmental criteria and indicators, but also social and economic ones.

The S2Biom project - Delivery of sustainable supply of non-food biomass to support a “resource-efficient” Bioeconomy in Europe - supports the sustainable delivery of non-food biomass feedstock at local, regional and pan-European level (EU28, Western Balkans, Moldova, Turkey and Ukraine) through developing strategies and roadmaps that will be informed by a computerized and easy to use toolset. As part of this, the sustainability of value chains across the biobased sectors is addressed, and a sustainability framework with respective criteria and indicators is developed. The particular goals of this paper are twofold:

a) Provide an overview of different points of view to be acknowledged when delinea-ting the approach to sustainability (i.e. scope, sustainability sets or type of indicators) , and

b) Introduce the set of sustainability criteria and indicators (C&I) for non-food biomass that consolidate different EU-level sustainability C&I into a practical approach.

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

The sustainability C&I draft proposal has considered the three “pillars” (dimensions) of sustainability, i.e. environmental, social and economic. In total, 12 criteria and 27 indicators are included. This set aims to serve as an all-encompassing umbrella of sustainability to the bioeconomy from which more specific indicators could be derived.

Carbon footprint of the cork oak sector

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Introduction

Cork oak (*Quercus Suber L.*) is a slow-growing, evergreen tree, mainly located in the western and central Mediterranean region. Cork, the outer bark of the cork oak tree, is its most important product and it is an extraordinary and unique material. Portugal is the world leader of cork production, with a 50% share of the global annual raw cork production [1]. Cork can be used in a variety of sectors (e.g. wine industry and construction) for the production of various products. Environmentally, cork oak forests can contribute to climate change mitigation due to their ability of carbon dioxide (CO_2) sequestration from the atmosphere and storage for very long periods in their perennial tissues and in the soil as organic matter. Furthermore, part of the sequestered carbon is stored in the cork products delaying its return to the atmosphere since they can stay in use for many years [2, 3].

The main objective of the present study is to develop a simulation model to assess the carbon footprint (CF) of the cork oak sector and to apply this model to Portugal as a case study. The cork flows throughout the forest and industrial cork sector are tracked and the greenhouse gas (GHG) emissions of the various stages are assessed, namely forest, manufacturing, use and end-of-life stages. Furthermore, the contribution of the most representative cork products to the total CF is assessed. The application of the simulation model can support the decisions on how to perform changes in the supply chain and production processes of the cork sector in order to minimize the CF. Additionally, the present study includes a comparison between the results when accounting for and when excluding the biogenic carbon in the total CF. This is the first simulation model addressing the entire cork sector and the calculation of its CF. Thus, the present study can provide a more complete insight on the sustainability of the cork oak sector.

Materials and methods

A cradle-to-grave LCA approach was adopted in the model, allowing the identification of the stages where GHG emissions occur and the cork products with a greater CF. Four different cork types were assessed: virgin cork (first cork extraction), second cork (second cork extraction), reproduction cork (third and following cork extractions) and 'falca' cork (from cork oak tree brunches). The virgin and second cork types, due to their low quality, are destined to the trituration and agglomeration industries for the production of agglomerated cork products (e.g. isolation slabs). The reproduction cork is destined to the preparation and then the transformation industry for the production of natural cork stoppers and natural cork discs. The cork wastes are sent to the trituration and agglomeration industries for the production of agglomerated cork products. 'Falca' after its separation from the wood, is sent to the trituration industry and is then used for the production of expanded cork slabs for acoustic and thermic isolation (with a characteristic black color and without addition of resins).

For the case study applied in the model, raw cork quantities were used as input data referring to the year 2013 as simulated by the SUBER stand simulator (assesses the evolution of cork oak stands and estimates the stand's biomass) [4, 5]. SUBER was used since there are no specific statistical data for the different cork

types but for the total raw cork produced annually. Primary data from Portuguese cork companies were used for the distribution of the different cork types among the different cork products and for the CF of the manufacturing processes.

Results and discussion

Table 1 presents the results obtained from the developed simulation model for the CF of the cork sector per stage and in total, both when considering and excluding the biogenic carbon.

Stages	CF without biogenic C	CF with biogenic C	Units
Forest	10,375	-190,980	t CO_2 eq.
Manufacturing	227,618	324,587	t CO_2 eq.
Use	0	0	t CO_2 eq.
End-of-life	-3,739	31,427	t CO_2 eq.
Total	234,254	165,034	t CO_2 eq.

Table 4: Carbon footprint of the cork sector per stages and in total

From the 104,205 tons of total raw cork produced (6% moisture) in 2013, a total CF of 234,254 and 165,034 tons of CO_2 eq. was calculated for each case. When biogenic emissions are excluded, the greatest influence derived from the manufacturing stage mainly due to the reproduction cork type, since this is the main cork type weight input (68% of the total raw cork input). The manufacturing stage was dominated by the production of champagne, technical and agglomerated cork stoppers (39%, 19% and 17% of the total stage impact, respectively). The process for the production of the cork body (called body agglomeration) is the main reason for the high CF of those products. The body of the champagne, technical and agglomerated cork stoppers contains a mix of small particles of triturated cork and adhesives as a binding agent. In this process, the consumption of electricity is high and also the use of adhesives has an important role for those impact levels. The rest of the cork products represent a lower range of the total CF of the cork sector (1%-9%). Thus, environmental improvements of the production of the aforementioned agglomerated products must be focused on these operations. It should be noted that the value of the end-of-life stage is negative since in the case of incineration there is energy recovery with production of electricity (substituting electricity produced from the country's mix).

When biogenic emissions are considered, the total CF change considerably due to permanent carbon accumulation when cork products are disposed of in landfills.

Conclusions

The most influential stage of the cork sector for all the cork types is the manufacturing stage due to the production processes performed for the production of the various cork products. More specifically, it was noticed that the production of the agglomerated cork products and namely, the champagne, technical and agglomerated cork stoppers, influenced the total CF of the cork sector due to the consumption of electricity and adhesives for the production of the stoppers body. Furthermore, information regarding the CF of the stages and the various cork products can be obtained in order to focus on the high impact stages and products and attempt to decrease the CF of the entire cork sector.

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The impacts of legality constraints on international timber trade patterns

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This study was focused on the impacts of legality policies/programs on international timber trade patterns, with special focus on tropical timber trade by using a mixed research approach. Combining literature reviews and trade data analyses, this study assess the impacts of the Forest Law Enforcement Governance and Trade (FLEGT) Action Plan (with its Voluntary Partnership Agreements system and a new piece of legislation known as European Union Timber Regulation (EUTR) on the timber trade between tropical countries and Europe. These instruments have the potential to reduce the amount of illegally sourced timber being placed on the market, stimulation both legal timber production and good forest governance. A detailed analysis of recent development trends patterns for some timber groups it was performed. Furthermore, was analyzed to what extent these trade patterns have changed and influenced by the introduction of legality constraints by some key timber importers over the last two decades. The findings demonstrate that, there has been a significant decrease of timber imports coming from tropical countries to the European Union (EU) in the last years, where many commodities have been following a similar trend (continuously declining). A decrease that has redefined the role of the EU in the global timber import flows in front of a trade diversion lead by the new emerging economies. However, there is no clear evidence whether these trends are the result of the implementation of the FLEGT Action Plan or the consequences of other factors such as opening economies, a decrease in demand from the wood processing industry or the recent economic crisis. In conclusion, with the sole global trade analysis approach, it is difficult to assess and evaluate the role of legality constraints on the international timber trade patterns. Further research should have a more deep focus on specific trade flow impacts.

Evaluating land use impacts on bioproductive land depletion in life cycle assessment

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Introduction

The life cycle assessment (LCA) method is still under development in terms of impacts caused by the use of biotic resources, and well-accepted approach is lacking. However, when assessing the sustainability of bio-based products, and for example evaluating the substitution of fossil fuel-based products by them, unambiguous and robust methods are required. According to United Nations Environment Programme-Society for Environmental Toxicology and Chemistry (UNEP-SETAC)'s guideline for land use impact assessment in LCA framework, three key pathways should be included: biodiversity, ecological soil quality, and land productivity (i Canals, 2007). In LCA, five different types of land use are recognized: agriculture, forest, grazing, infrastructure and industrial area, and remaining untouched area; each of them can be categorized under two different activities, land occupation and land transformation respectively (Thomas, 2003). This paper will concentrate on impact on land productivity from land occupation activity.

Along with the on-going world population growth trend and increasing consumption of raw material, the earth's biologically productive land is becoming a limited resource. Human appropriation of net primary production (HANPP) is a widely used indicator for reflecting impact on bioproductive land from land use. NPP is the key factor for ecosystem functioning, which can be linked to biodiversity, water flow, soil erosion and the provision of ecosystem services. To be integrated in LCA, HANPP has a solid environmental mechanism, but its application in LCA is not straightforward. For example, it does not be fully covered forest biomass production (Haines-Young & Potschin, 2013). This paper will assess land use impacts from forest biomass cultivation, and discuss the need of having tailor-made method for forest.

Materials and methods

The life cycle impact assessment (LCIA) method of land use impact on bioproductive land depletion used in this paper is under HANPP approach. This impact is evaluated by comparing the difference between NPP of baseline scenario ($HANPP_{pot}$) and NPP of current occupied land use type ($HANPP_{act}$), represented by $HANPP_{LUC}$ as a midpoint level characterisation factor (CF) shown in Equation 1. In the equation, i indicates location and j indicates land use type. The unit of $HANPP_{LUC}$ is gram carbon per square meter per year.

$$CF_{i,j} = HANPP_{LUC_{i,j}} = HANPP_{pot_{i,j}} - HANPP_{act_{i,j}}$$

Baseline scenario here is the natural potential vegetation (NPV), which was evaluated by three different approaches respectively: LPJ model, Miami model, and results from previous literature. The effects caused by forestry i.e. the current land use situation have not been previously modelled. We applied Finnish forest as a case study and computed the actual NPP by using data from Finnish Meteorological Institute, Finnish National Forest Inventory and many other sources, with specification on tree species in regional level.

Results and discussion

$HANPP_{pot}$

The $HANPP_{pot}$ of Finland from LPJ model is 398.8 g C/ m^2a, and from Miami model is 388.3 g C/ m^2a. The

HANPPpot result of the Miami model is lower than the one from LPJ. These results coincide with Del Grosso (2008) assertion that the Miami Model underestimates the NPP for boreal forest.

$HANPP_{act}$

$HANPP_{act}$ is calculated by data from Finnish National Forest Inventory data, IPCC and literature (Gower, 2001). $HANPP_{act}$ here includes biomass production of aboveground whole tree, belowground part and aboveground understory part. Due to the data availability, the biomass production of young and small trees is excluded in this paper. The $HANPP_{act}$ results can be explicit in 13 region and tree species (Norway spruce, Scot pine and deciduous). In average, the HANPPact for Finland is 221.2 g C/ m^2a.

$HANPP_{luc}$

Till now, there is no other source of CF for forest available to compare with our results. But in Rodrigo (2015) the CF for cropland in Finland is 193.5 g C/ m^2a. Comparing with our results both from LPJ and Miami model (177.6 g C/ m^2a and 167.1 g C/ m^2a), it indicates that the forest do have impacts on bioproductive land depletion and it should be considered carefully.

Applied model	$HANPP_{pot}$	$HANPP_{luc}$
LPJ	398.8	177.6
Miami	388.3	167.1

Table 5 $HANPP_{pot}$ and $HANPP_{luc}$ results for forest based on different models, with unit as g C/ m^2a.

Conclusions

The application of HANPP approach is enriched into LCA field with a bottom-up perspective. On the other hand, it illustrates that managed forest practice do have impacts on environment and should not be neglected. But it is much more complicated for forest other than agriculture to have a satisfied capture of land use impacts by LCA, considering its relative long rotation period. Lacking sound LCIA method is due to the lack of sufficient and systemic forest data for all kinds of forest. Thus the calculation method of forest NPP is still immature. More researches are needed for LCIA methodology development on other types of forest, instead of boreal forest only. A global-scaled set of characterization factors for forest biomass production together with current methods for agriculture can make LCA more capable to illustrate impact on bioproductive land depletion.

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Assessing business sustainability practices: Methodological guidance in simplifying LCA and evaluating triple bottom line principles using parametric modelling

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Introduction

The life cycle suite of assessments (LCA, LCC, SLCA) can be extremely valuable tools in gaining insight into the sustainability effects of business' production practices [3]. Many companies and organizations rely on environmental, economic and social data and their analysis to make decisions in identifying areas for improvement or comparing life cycle scenarios against one another. However, small-medium enterprises (SMEs), Benefit Corporations and other company configurations are often presented with difficult decisions in how to allocate their limited time and resources to obtain thorough analyses [1].

Global sensitivity analysis (GSA) is starting to be established as a viable alternative to performing a full environmental LCA [4]. The majority of environmental impact can be explained by reducing the number of life cycle parameters via simplified parametric modelling. Here, GSA methodology is expanded and a framework is developed for calculating a full triple bottom line assessment by enveloping a life cycle costing (LCC) component and a social life cycle assessment (SLCA) into a simplified parametric LCA model. In this context, a methodology is developed to identify of the top parameters that comprise the environmental, economic and social systems of the wood product, glue laminated timber (glulam). Results are analyzed according to the highest ranking parameters.

Materials and methods

A method is developed to reduce the overall number of parameters needed to obtain robust results for LCA, LCC and SLCA studies that contain a large number of input parameters. The methodology was first developed as applied solely to LCA. In the next step, LCC parameterized data should be added to the original number of input parameters from the LCA and finally, SLCA parameterized data is added.

Using the glulam case study, the definition of the parametric model of the full environmental life cycle inventory is based on 86 independent parameters. Exploring a suitable methodology to determine key parameters involves researching new techniques in combining amplification factor calculations (AFCs) and global sensitivity analysis (GSA). Sobol and Morris methods are chosen to accomplish a ranking of the most impactful parameters and the interaction between parameters, respectively.

The methodology first uses a completed parameterized LCA model as a reference to assess the environmental impacts of the functional unit, in our case, one m^3 of glulam. Next, key parameters are identified by those which have the highest influence on the impact variability for each indicator category. Three methods are used to make this identification and compared in identification: amplification factor calculations, the Morris Method and the Sobol Method (Figure 1). In essence, key parameter identification is contingent on the few parameters that demonstrate the highest variability for each impact category. The methodology is adapted to be a generic approach to investigate how triple bottom line evaluations could

be simplified (using environmental, economic and social concerns as the investigative goal, instead of midpoint impact indicators) related to a wide array of products or concerns in the forest industry.

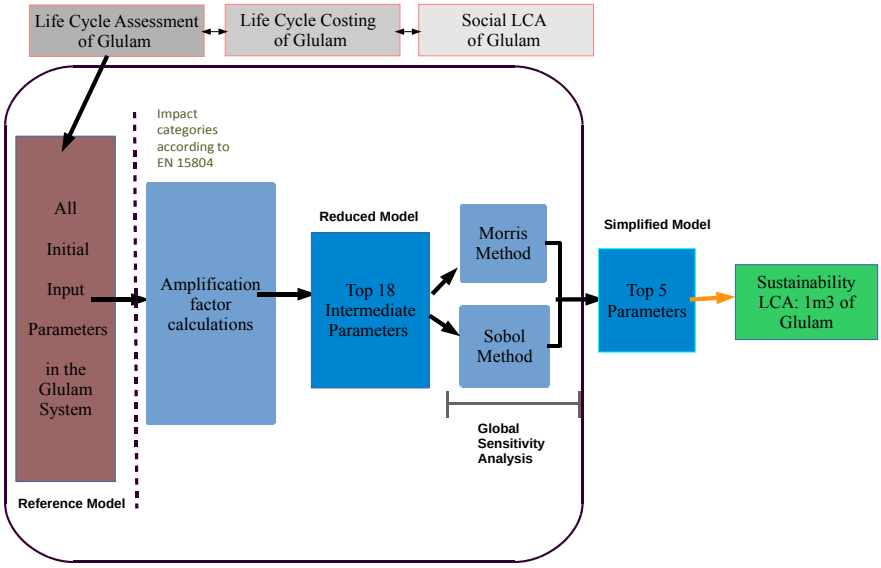

Figure 4: Schematic of the methodology developed to identify the key parameters in a triple bottom line sustainability assessment of glulam using simplified parametric modelling.

Discussion

Reducing parameters

Amplification factor calculations reduce the original 86 parameters of the glulam LCA down to 18 main parameters. GSA principles are then applied by building a reduced model, which shows interactions between parameters and the model system as a whole. Next, a simplified parameterized model is realized by extracting the simplified parameterized model from the reference parameterized model. The aim is to further reduce the number of parameters so that SMEs can concentrate on these parameters to lessen their overall impact on the environment, the economy and society.

Conclusions

A generic method is developed that adds to the current body of LCA interventions while also expanding the definition of a proper assessment that is relevant for companies to use after a full LCA has been established. While LCA standards and practices have been used reliably since its European inception in 1997 [2], the lack of a streamlined way to account for scenarios with a large number of parameters, and the omission of economic and social indications of relevant sustainable factors, has hindered the triple bottom line assessment's development potential as a robust tool for business.

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Value-based ecosystem service trade-offs in multi-objective forest management under climate change in Europe

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1. Introduction

The provision of ecosystem services (ES) in mountain forest landscapes across Europe and related trade-offs is affected by climate change as well as forest management approaches (Bennett et al. 2009; Raudsepp-Hearne et al. 2010). To support sustainable land use management decisions, this study evaluates current and potential alternative forest management practices with regard to four ES (timber production, carbon sequestration, biodiversity and nature conservation and protection against gravitational hazards) under changing climate conditions in three different mountain forest regions across Europe. We focus on multifunctional ES utility and related trade-offs under various forest managements and a range of climate conditions.

2. Materials and methods

The three study regions are mountain forests located in Valsain (Spain), Montafon (Austria) and Shiroka laka (Bulgaria) representing distinct biophysical and governance settings featuring different demands for ecosystem services. In each of the regions the forest ecosystem model PICUS (see Seidl et al. 2005) is used to generate trajectories of ES indicators for the period 2000-2100 under a set of management regimes and climate scenarios (c0: current climate, c1-c5: climate change scenarios) for representative forest types. Generic preference functions are calibrated for each ES indicator and aggregated to performance indices for timber production (TP), carbon sequestration (CS), biodiversity and nature conservation (BDNC), and protection against gravitational hazards (PGH). Overall utility from the four ES is calculated from an additive utility model. Trade-offs among ES are assessed using the root mean square deviation (RMSD) which identifies the deviation of each ES from the mean benefit. Summing the RMSD for all ES within a portfolio of ES indicates the involved trade-offs and allows for putting ES utility and trade-offs in perspective (Bradford & D'Amato 2012).

3. Results and discussion

ANOVA and Tukey tests revealed no significant influence of climate change on any of the ES in Spain, while in Austria and Bulgaria there is a general significant effect of climate change on ES provisioning, however, only at the end of the assessment period (2066-2100). In all three case studies there is a significant effect of management on all ES which in most cases is already significant in the first decades of the assessment period. Also, in all study regions the no-management scenario was significantly better for CS, BDNC and PGH regardless of climate scenario. In Austria, however, the extensive management regimes with long turnover periods and small-scale cutting pattern performed good as well. PGH was maintained at very high achievement levels independent of management and differences between management regimes were rather small. In the Austrian case the best management regime for TP was the stripcut regime with a reduced turnover of 150 years, in Bulgaria the unevengaed regime based on patch cuts while in Spain mixed shelterwood and irregular shelterwood approaches has highest preference values for TP.

RMSD varied greatly among the different ES pairs. However, large trade-offs in all three case studies were always related to TP under the no-management alternative (Figure 1).

In all study regions, the contrast between the no-management scenario and all other active management regimes becomes visible. The no-management approach achieves high overall utility values from the portfolio of four ES but at the cost of substantial trade-offs. Actively managed scenarios achieve high overall utility but at much lower trade-off values.

In Spain (not shown), the best compromise is achieved with a combined system of irregular shelterwood for Pinus sylvestris and shelterwood for Quercus pyrenaica. In the Austrian study region most management regimes (except no management and extensive strip cut with 250 years turnover) are clustered around similar trade-off and utility values. In Bulgaria the highest overall utility is achieved with an uneven-aged patch cut system.

There were only small differences for overall utility and trade-offs between climate scenarios.

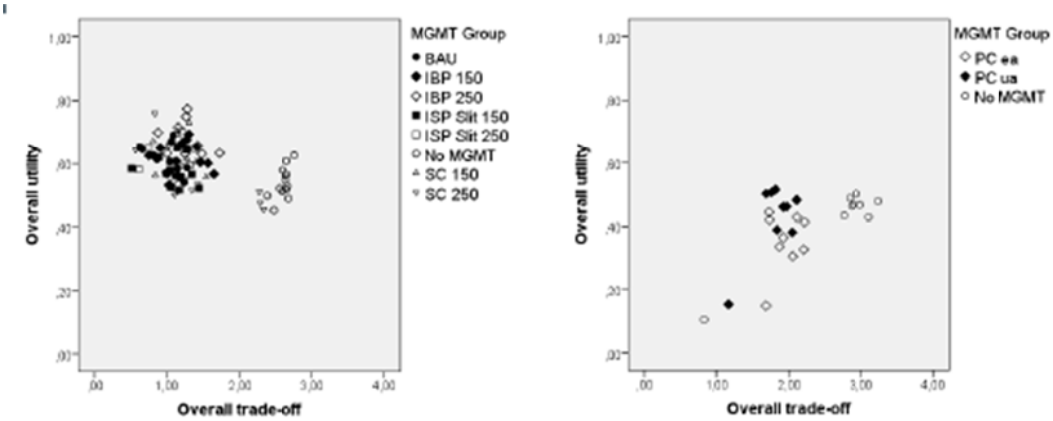

Figure 1: Overall utility from four ecosystem services and related trade-offs for representative forest types by management regimes in Austria (left) and Bulgaria (right) under climate change scenario c5. BAU = business as usual management, IBP = irregular big patches, ISP Slit = irregular small patches or slit, SC = strip cut regime (numbers indicate rotation length in years), No MGMT = no-management regime, PC ea = patch cut evenaged, PC ua = patch cut unevenaged;

4. Conclusions

The results indicate that climate change effects depend on the region and affects the analysed ES differently but all ES are highly sensitive to changes in management regimes. High trade-offs are always related to the no-management approach due to forgone timber production values. All actively managed scenarios substantially reduce trade-offs at likewise high overall utility for a portfolio of four ES.

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Assessing interactions between renewable energies and ecosystem services according to a sustainability perspective

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The Alpine area is supposed to have a great potential for the development of renewable energy plants, in the perspective of the European Union 2020 goals. However, this means also increasing pressures on nature. In order to help decision makers evaluating the synergies and trade-offs between renewable energies and ecosystem services (ES), the Alpine Space 'recharge.green' project aims at setting some guidelines and best practices while assessing and managing energy plans. The University of Padova contributed to the project with the assessment and evaluation of ES related to water resources, for the micro- and mini-hydroelectric power production, and to forest biomass, for energy purposes. The potential energy plants are conceived according to the rationalization of the systems and the promotion of short local supply chains, mostly based on principles of economically and environmentally sustainable management of timber resources, for the case of the forest biomass. The evaluation of ES requires a spatial analysis, of which outputs are thematic maps of the surveyed areas. We developed a multi-criteria approach for the geographical assessment of ES, basically considering the site capability and forest type suitability of the patches characterised by homogeneous forest typology. According to this, we produced three alternative maps on the study areas of the Mis and Maé Valleys (North-East of Italian Alps) considering the following services: hydro-geological regulation and hazard protection, ecology and biodiversity conservation, landscape and recreation. The level of locally perceived importance of the ES has been expressed through a Likert-type scale. For both the study areas, maps representing a ranked distribution of the services have been produced, in order to identify the prevalent service, according to the different sites. Such maps have been compared to the ranking of ES categories made by the local stakeholders during the focus groups organized in the frame of the project activities. In fact, social inclusion is a main issue to tackle while pursuing a decision process about land management. The association with an economic evaluation of the ES allows adding a quantitative connotation, which is useful in case of compensation activities.

A new Dynamic Life Cycle Assessment methodology to deal with biogenic carbon fluxes and temporary carbon sequestration

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Life cycle assessment (LCA) and carbon footprinting are becoming popular tools for assessing the environmental impact of the entire life cycle of products and activities. Although LCA has been widely used in the forest and wood production sector, this tool poses several methodological problems when applied in this context. One of the main limitations is that LCA has been conceived as a static, steady-state tool, where all emissions are treated identically, regardless their time of occurrence, a limitation that becomes of particular relevance when long life cycles of trees or wood products are involved. For example the conventional approach does not consider the difference in timing between the emissions of forest ecosystems and the moment in which the carbon is sequestered back during forest growth is not taken into account and consequently this temporary carbon sequestration effect is neglected, underestimating the potential climate mitigation benefits arising from the use of wood based products. Furthermore several authors already pointed out that the distribution over time of the GHG exchanges with the atmosphere should be taken into account and any carbon neutrality assumption should not be considered to avoid inconsistencies and misestimations in LCA.

In order to tackle the issues related to the static behaviour of conventional LCA, we developed a new, computationally efficient, methodology for dynamic LCA that enables the use of both dynamic inventory and dynamic impact assessment. In our methodology the total characterization factor can change depending on the time of emission, is spread over time and can be calculated for any time horizon. This dynamic LCA methodology is conceptually transparant, easy to implement and has been developed as open-source software.

In this presentation we illustrate the proposed methodology with a case study applied to production of Glulam in France, where we calculate the climate change impact for the cradle-to-grave life cycle of the product considering the carbon fluxes in the forest as well as the climate impact of production, use and end use of it.

Developing a LCA approach to assess wood-based production system in a bioeconomy region in Germany

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In a bioeconomy in Germany, wood will be increasingly used for producing high value added materials and chemicals besides its current energetic use, due to its national availability as a resource, as well as due to its highly developed and industrial infrastructure. Indeed, the estimated intensification of local biomass harvesting processes will affect the environment and people living near to biomass catchment areas and production sites.

In this context, social responsibility constitutes a central element for success or failure of the future development of the pretended bioeconomy system. Social Life Cycle Assessment (sLCA) is a method under development that can assess potential social effects of a wood-based production system on different stakeholders. In general, sLCA approaches may be divided in generic and specific analysis, one assessing global value chains the other focuses on most relevant foreground processes and organisations involved. Such assessments could support decision making by providing information on improvement potential of organisations' conduct towards social responsibility.

Within the framework of an ongoing project in a bioeconomy region, a sLCA method has been developed to assess production activities in a wood-based bioeconomy region from a regional perspective. It consists of the establishment of a goal system, including the definition of relevant social issues and most appropriate indicators to measure their accomplishment. The goal system was developed combining a top-down and bottom-up perspective thus integrating national social sustainability goals with stakeholder preferences conducted from in-depth interviews. To assess potential social effects along the life cycle a characterisation method was developed, relying on sectoral (best practice) performance reference points from statistical databases to assess the relative performance of organisations involved in the product's life cycle.

Goal of this work is to present the sLCA method developed to assess wood-based production systems in a bioeconomy region in Germany. The overall sLCA approach is introduced and the goal system with the indicator set is discussed.

A widely usable framework to calculate indicators for sustainability assessment of bio-based supply chains

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Sustainability Assessment (SA) aims at providing useful information to one or more stakeholders regarding a process or a plan. Methodological development for SA in bio-based systems is required to make SA a common used practice to design sustainable systems: there is a need for decision support tools that quantify and optimize the economic, environmental and social aspects of the forest-based supply chains. A more consistent and holistic approach for SA could be beneficial not only for policy support, but also for the private sector, if it is capable to provide comprehensive information that are useful for different stakeholders. However, procedures to calculate multi-dimensional indicators are not standardized, and data collection and elaboration on environmental, social and economic aspects are time demanding operations.

In order to have a big picture of the state of the art of SA in real application, we reviewed relevant case studies, where SA was applied to assess multi-dimensional implication of processes or products. As result, we identified some economic, social and environmental indicators that are more often used for SA.

On the basis of the case study review, we propose a framework to interlink certain economic, social and environmental indicators and parameters in order to minimize data collection and to facilitate scenario analyses focusing on bio-based supplies and energy productions. It is well known that several indicators are linked each other, e.g. increasing the fuel consumption in a process also the air emissions increase. Despite the high variability of systems and calculation methods that can be used in a SA, it is possible to identify universal interdependences between different indicators.

In most of the cases, an explicit calculation structure of the indicators is not defined. We expect that defining an explicit structure of interdependences between some specific indicators, and the related indicator calculation scheme, can bring three main benefits to future SAs: more efficient data collection (reducing the needed primary data, and the data collection time); more transparency for the users (clarifying assumptions and the limitations of the results); more consistency of the results (giving more consistency to the indicator values).

Finally, we test the calculation framework on existing datasets, with the aim of expanding the information provided by the original dataset, using existing data, and the defined calculation flow. With the present work, we aim at contributing to further develop SA for improving methods and tools for ensuring a sustainable bioeconomy.

Forestry in sustainability measures - From sector specific to national

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Today the goal of sustainability is in the center of attention on political and corporate levels. Not only will the UN Millennium goals be replaced by the UN Sustainable Development goals in 2015, also the number of e.g. certification schemes for sustainability and corporate sustainability strategies are constantly and rapidly growing. But even though sustainability is of such great importance in people's minds and actions, there is a lack of conformity in the meaning of it. Scientists estimated some three hundred definitions of sustainability or sustainable development just focusing in the field of environmental management.

The question at stake is, if and if yes, how different perceptions of sustainability result in diverging judgements of e.g. products, projects, companies or sectors.

To examine how the forest sector can be judged with different approaches of sustainability assessment, we exemplify congruent and incongruent sustainability indicators and quantify sustainability based on these indicators. Precisely, we will compare the development of the German forest based industry between 2000 and 2010 from a sectoral sustainability point of view to the sectoral performance in a national sustainability framework. This will show similarities and differences in sustainability understanding from varying points of view. It will also reveal possible supplements for sector specific sustainability measures, as well as shortcom-ings on general national sustainability criteria. This will help to gain better understanding of sustainabil¬ity ideas and to promote the forest sectors impact on sustainable development in general.

Several key questions are addressed: Is the scope of sectoral measures wide enough to address sus¬tainability sufficiently? Are sectoral measures consistent with society's sustainability goals or are there any hints for conflicts? And what does that mean for forest specific sustainability measures? On the other hand: are the multiple benefits of forests considered adequately in public sustainability crite¬ria or do they underestimate the impact of forestry for a sustainable development in general?

The quantification of the sustainability of Germany's forest sector with examples of sectoral and national sustainability indicators proofed, that the indicator sets share similar perceptions of sustainability. However, it is also shown, that due to different approaches in measuring and evaluating sustainability aspects, different judgements of the sectors sustainability can be concluded.

Sustainability assessment of agro-bioenergy land use: a combined life cycle-participatory approach

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Sustainability assessments are often either seen as a political negotiation or brokerage process, or an entirely scientific enterprise. While the outputs of sustainability assessment as a political negotiation/brokerage process is usually purely stakeholder based, qualitative and lacking in scientific depth (not evidence-based), the outputs of sustainability assessment as a scientific enterprise is usually quantitative, evidence-based but less practicable in reality. Circumspectly speaking, elements of both are important and needed to bridge the gap between society and science in policy making. With regards to agro-bioenergy land use (which is a hot topic globally), this study attempts to bridge the gap between sustainability assessment as a political negotiation/brokerage process, and sustainability assessment as a scientific enterprise by suggesting a methodological pathway for adapting highly quantitative, evidence-based life cycle assessment indicators to mostly qualitative, stakeholder-chosen but difficult-to-quantify ecosystem services or land use function indicators (i.e. depending on the choice of the land use assessment framework deployed-ecosystem services vs. land use functions). This methodological pathway can be operationalized by (i) taking an inventory of stakeholder's most valued or cherished environmental, economic, social and/or cultural priorities (defined in accordance with ecosystem services and/or land use function framework boundaries), (ii) identifying the relevant agro-bioenergy related life cycle assessment indicator frameworks (namely the energy return on energy invested-EROEI, greenhouse gas accounting-GHG, human appropriation of net primary production-HANPP and resource footprint-RF indicator) that touch on identified environmental, economic, social and/or cultural stakeholder priorities, (iii) creating acceptable life cycle thinking templates, for integrating often ignored or generalized local and regional agronomic factors that touch on stakeholder priorities, into relevant agro-bioenergy related life cycle assessment indicator framework (e.g. inclusion of human and animal labour touches on local and regional employment, consideration of irrigation and tillage effects and incorporation of alternative agricultural input supply chains-fertilizers: synthetic fertilizer vs. biogas digestate vs. animal manure , seed sown-organic vs. hybrid vs. transgenic, pesticides-organic vs. synthetic etc. touches on energy, environmental and financial costs of production), (iv) adoption of derivable or derived indicators from the new system boundaries created (as a result of the assimilation of relevant local and regional agronomic factors) for subsequent connection of qualitative, stakeholder-chosen, ecosystem services/land use function indicators to quantitative, evidence-based life cycle assessment indicators.

Session 2: Innovative climate change mitigation strategies for the forest-based sector

Wednesday 21 October 16:00-18:00
Rooms 1 and 2 (combined) Floor -1

Session chair: Gert-Jan Nabuurs, Special Professor European Forest Resources, Wageningen University

Gediminas Jasinevičius	European Forest Institute, Finland	Carbon storage in harvested wood products to mitigate climate change
Raghu KC	Lappeenranta University of Technology, Finland	Impact of forest management regimes and forest supply chain on carbon emissions
Pau Brunet Navarro	Leibniz Centre for Agricultural Landscape Research (ZALF), Germany	Introducing cascade use in wood product models
Giuseppe Cardellini	KU Leuven, Belgium	The climate impact and mitigation potential of the European forestry-wood chain
Anna Liza Bais	Alpen-Adria University, Austria	Assessment of impacts of cascading in the wood sector based on global wood biomass flows account

Carbon Storage in Harvested Wood Products to Mitigate Climate Change

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After forest harvest, a significant share of carbon is removed and stored in harvested wood products (HWPs), including building materials, furniture, paper and other wood products. Harvested wood is incorporated into products that have lifetimes ranging from months to centuries.

In 2011, the UNFCCC Conference of the Parties in Durban decided that Annex I Parties should account for and report carbon changes in their HWPs pools for the second commitment period of the Kyoto Protocol, before that carbon in HWPs was regarded as oxidised at the time of harvest.

So nowadays, carbon storage in harvested wood products is seen as a measure to mitigate climate change. The increased use of long-life wood products, however, should be thoroughly analysed before being promoted as a climate mitigation strategy.

In order to estimate climate mitigation potential, we analyse existing and developing new models for carbon accounting in HWPs. We have found that carbon pool of harvested wood products is very dynamic, due to changing patterns of wood product consumption and trade.

Carbon accounting methods and the input data has the largest impact on the estimates of the pool of HWPs. Different methods provide different pools estimates. In our model we apply material flow analysis. Material flow is tracked over actual processes, in order to estimate the carbon pool in HWPs by using country-specific data. The model has a possibility of including recycling and decomposition processes in the value chain, which could result in a significant reduction of greenhouse gas emissions. In addition, this model could assist in the analysis of “what-if” alternative process chain scenarios and thereby support decision making in the forest-based sector.

This innovative method we already applied for a case study. We select relatively small Central European country (Czech Republic). We used country-specific data and traced the carbon from the forest harvest until the use of different wood products. The results have shown that carbon inflow into the pool of HWPs significantly differs while applying different accounting methods.

Impact of Forest Management Regimes and Forest Supply Chain on Carbon Emissions

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Introduction

In 2012, the city of Helsinki, Finland committed an ambitious environmental policy as a 2020 target to increase renewable energy by minimum of 20% and lower its heat and power related greenhouse gas (GHG) emissions by 20% from the level of 1990 [1]. These ambitious targets evidently need proactive solutions. Thus, Helsingin Energia (Helen), which is a city owned power company, has put forward multiple alternatives such as building a new power plant, or increase the share of biofuel by 40% in Hanasaari and Salmisaari B power plant or to replace coal by biofuel in Hanasaari or Salmisaari power plant with necessary retrofits [2]. In any circumstances, Helen would need to look for biomass feedstock and local forest biomass is a most likely solution. In this study, we have studied the sustainability of supply chain alternatives for forest biomass originated in different management regimes and locations of Finland and delivered to Helsinki.

Various studies have been conducted on ideal forest management regimes for optimal economic and environmental values but there has been lack of research on the impact of location and subsequent supply chain of biomass for energy production. In this study, we attempt to compare the life cycle GHG emissions from varying supply chain of small-diameter wood generated in different forest management regime according to the density of stand. The reason behind analysing different forest management regimes is to identify varying forest removal and productivity in different locations in Finland. Moreover, the main aim is to identify the difference in supply chain related emissions of biomass brought from northern, central and southern Finland to Helsinki region. Availability of small-diameter wood from young pine stands is the most potential either industrial or energy purposes [3]. On the other hand, the competition and demand of small-diameter wood will be increasing because of potential investments of pulp and energy user-sites.

Materials and methods

Three locations; northern, central and southern Finland are taken as reference forest of Scots pine (Pinus sylvestris L.) stands, with each having 4 different forest management regimes mainly with different tree densities; 4000, 3000, 2000 and 1500 trees/ha before first thinning [4]. The forest stand is simulated using MOTTI forest stand simulator. The small-diameter wood from first thinning are delivered to Helsinki either as wood chips (roadside chipping) or as round wood to be chipped in the terminal, located in the vicinity of power plant. The biomass from second thinning and final harvesting are not taken into account because it is believed that biomass from these harvesting phases is more suitable and economically beneficial for other purposes, such as, timber production than bioenergy. Additionally, biomass residues and stumps are also out of the study.

The lifecycle assessment (LCA) of biomass supply chain is modelled using product sustainability software GaBi 6 and databases, such as, ecoinvent v3.1 and thinkstep (formerly known as PE International). The initial point of system boundary is set at harvesting with multitree cutting [5]. The harvested wood is then

forwarded to roadside. After leaving biomass on the roadside for drying, the wood is chipped by mobile chippers ;traditional and hybrid [6] chipper and transportated to a biomass terminal located near the plant via electric driven trains or chips trucks depending on the locations [7]. The wood chips are then transported to plant via chips trucks from terminal ending the system boundary of the study; leaving storage and combustion outside of the boundary.

Results and discussion

The study showed that an average of 90% more carbon emissions for northern Finnish small-diameter wood compared to wood from southern Finland, but the corresponding figure is only 16% in case of central Finnish wood. On the other hand, traditional road-side chipping and hybrid road side chipping have 9% and 7% respectively more emissions than terminal chipping. This is because the terminal chipping is operated by grid mix electricity while roadside chippers are diesel driven and the grid mix electricity contains renewable energies.

Conclusions

Study showed minimal difference in carbon emissions per unit energy basis according to the density of forest stand but in total hectare based emissions, the removal and tree size of small-diameter wood from first thinning would have effect on total emissions due to the varying productivity in different stand densities. From the analysis, it was realized that the emissions from transportation is highly sensitive of payload, utilization factor and type of roads, thus, for the future analysis more precise information regarding transportation is recommended.

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Introducing cascade use in wood product models

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Wood Product Models (WPM) are employed to estimate carbon dynamics of wood products and evaluate their climate change mitigation effect. Their increasing complexity allows for advanced analysis of industrial efficiency, product lifespan or recycling rate, although very often data availability for these analyses is problematic. The product's lifespan, the recycling rate and substitution effect have been identified as determining factors to estimate climate change mitigation of wood use. Although the recognized importance of wood use cascade chains, they are only represented in current WPMs by consecutive usage loops of the original logs through re-use and recycling. A new generation of WPMs will need to incorporate predefined cascade chains to estimate the cradle-to-grave mitigation effect and be able to compare alternative scenarios.

We present preliminary results applying this new generation of WPMs. We employ amount of harvested wood under different management scenarios estimated by the forest growth model Biome-BGC. Then, we use life cycle inventory data together with environment product declaration data to analyse potential future wood use. The results presented here identify increases in wood products carbon stock and reductions of industrial emission per forest hectare due to introduction of long cascade chains and due to substitution of high-energetic alternative materials, mainly in the construction sector, by wood products. Data accuracy is the big obstacle also for the new generation of WPMs. To promote wood products and highlight their competitiveness against other sectors, the wood sector will need to intensify its investments in research and information sharing.

The climate impact and mitigation potential of the European forestry-wood chain

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Among the multiple objectives forest management has to achieve, mitigation of climate change is one of the increasingly important ones. This objective can be achieved by (i) increasing carbon storage in the terrestrial biosphere (soils and biomass), (ii) increasing the use of renewable forest products as material and (iii) substituting fossil fuels with biofuels. While the direct role that forest and forest management can play in sequestering carbon is known and studied since long time, still very uncertain is the extent to which wood products can contribute to mitigate climate changes due to the temporary carbon storage effect and the substitution of more greenhouse gases (GHG) emitting products and materials.

To capture the full mitigation potential of the European forestry-wood chain we developed the Time and Space explicit (TiSpa) LCA methodology and combined it with forest growth model simulation and the EFI-GTM partial equilibrium model to assess the future mitigation potential of the overall European forest sector. In the analysis we considered all the greenhouse gases fluxes occurring along the chain, including the ones due to forest regeneration and management, harvesting, trade, industrial transformation, use and disposal. In addition to this, also carbon storage and substitution effects have been considered for the portfolio of long and short living wood products in use in European countries, together with the impact of the trade of this wood material within EU.

Assessment of impacts of cascading in the wood sector based on global wood biomass flows account

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Wood biomass is an important natural resource of the society. Since the pre-industrial times, wood is widely used as raw materials for various processes in industrial sectors for the production of wood products and construction materials. It is also the major source of energy for heating, cooking and other domestic use. However, the extraction of wood in the past has led to substantial environmental tradeoffs in many world regions, especially in tropical countries, related to forest degradation, loss of biodiversity, depletion of carbon stocks as well as to the release of massive carbon pools to the atmosphere. The increased use of fossil fuels in industrialized regions in the past led to an increased atmospheric CO2 concentration. Furthermore, we are now facing the situation of dwindling fossil resources. Due to this concerns (i.e. climate change and energy security), in recent years wood energy has entered into a new phase of high importance. The provision of bioenergy is regarded as a key technology for the mitigation of climate change. Wood biomass is increasingly promoted by governments as a carbon-neutral source of energy, based on the idea that for biomass, only the amount of carbon that previously absorbed in the course of plant growth will be released at the atmosphere. The projected growth of bioenergy sectors due to ambitious renewable energy target, alongside the growing population with a more pronounced increase in less developed countries that are highly dependent on traditional woodfuel and increasing interests on biomaterials due to the adoption of bioeconomy strategy will significantly increase global demand for the services of wood. A substantial rise in wood harvest in meeting future demands for wood-based products and energy might put additional pressure to climate and forest. This heightens the importance of adopting a cascade use of wood biomass, i.e. a mechanism when biomass is used for material products first and the energy content is recovered from the end-of-life products. The aim of this research is to assess the impacts of applying cascade use in the wood sector based on the established global wood biomass flows account, focusing on GHG emission reduction and resource efficiency.