Understanding positions and underlying motivations of stakeholder groups relative to their perceptions of bioenergy

Summary of findings under Objective 3 of the IEA Bioenergy inter-Task project "Measuring, governing and gaining support for sustainable bioenergy supply chains"

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Authors

Martin Junginger (Task and co-objective leader), Uwe Fritsche (co-objective leader), Thuy Mai-Moulin, Daniela Thrän, Evelyne Thiffault, Keith Kline, Virginia Dale

This summary and synthesis were based on several case studies, with the following additional authors:

T.L. Richard, D.L. Karlen, W.W. Belden (Iowa agricultural case study)

D. G. Hodges, B. Chapagain, P. Watcharaanantapong, N. C. Poudyal, (US forest case study),

B. Kulisic, I. Lakhdhar, L. Bouthillier,B. White, C. Krolik,S. Barnabé (Canadian biorefinery case study)

C. Sutor, K. Schaubach, T.Horschig, (German biogas case study).

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1. Introduction

Several systems to monitor progress toward sustainability of bioenergy have been developed and implemented (e.g. GBEP 2011; McBride et al. 2012; RSB 2015; ISO 2015; ASTM 2016; Dale et al. 2015). Even if much has been achieved, there are still challenges associated with understanding, defining, measuring, and gaining trust in assessing sustainability of bioenergy (IEA Roadmap 2017).

In light of these challenges, the IEA Bioenergy inter-Task project on "Measuring, governing and gaining support for sustainable bioenergy supply chains" was formed building on synthesised works of a number of IEA Bioenergy Tasks including Task 37, 38, 39, 40, 42 and 43[1]. The project aims at addressing the following questions:

1. How to measure and quantify progress towards more sustainable practices?
2. How to improve the input and output legitimacy of existing and proposed governance systems?
3. How to engage more successfully with the broad range of stakeholders so that policies and sustainability governance are perceived as legitimate and help build-up social capital, trust, and support among all stakeholders?

The project was started in 2016 and completed by the end of 2018. A multitude of studies were initiated focusing largely on the agricultural, forestry and biogas sectors. The main aim of this summary is to share final project results from the work carried out under the third question.

Objective 3: Stakeholder perception, positions and influence on bioenergy

The corresponding goal of the third objective is to understand the positions and underlying motivations of stakeholder groups relative to their perceptions of bioenergy in order to inform dialogues and discussions and thereby avoid misconceptions and gain trust in bioenergy. Within the frame of this objective, five case studies were carried out:

- *German biogas*: The first case study assessed stakeholder views on existing German biogas production from maize and other feedstocks (Sutor et al. 2018)
- *La Tuque biorefinery*: The second case study investigated stakeholder views and expectations towards a prospective Canadian biorefinery in La Tuque (northern Quebec) producing transport biofuels from forest residues (Thiffault et al. 2019)
- *US Southeast bioenergy*: The third case study focused on the views of forest owners in the US Southeast on the use of wood for bioenergy (Hodges et al. 2019)
- *Iowa ethanol*: The fourth case study investigated stakeholder views in the US state of Iowa on the production of cellulosic ethanol from agricultural landscapes (Dale et al. 2018)
- *Global position and vision towards bioenergy*: The fifth case study took a global view and investigated positions of supranational stakeholders towards bioenergy in general, and its sustainability in particular (Mai Moulin et al. 2018).

Each of these studies investigated the views and positions of stakeholders relevant for the respective value chains. They had different focus on land type (forestry or agriculture), geographic scope, and biomass end use (biogas, transport biofuels from starch and lignocellulosic biomass, heat and electricity from woody biomass). Some case studies focused on a key subset of the relevant stakeholders, e.g. the German biogas case largely focused on the biogas plant owners, while the US SE forestry case surveyed the perspectives of forest land owners. The other case

[1] For descriptions of IEA Bioenergy and its Tasks, see https://www.ieabioenergy.com/

studies took a more comprehensive approach and included stakeholders both directly involved in the value chains and from the larger public. These differences are depicted in Figure 1.

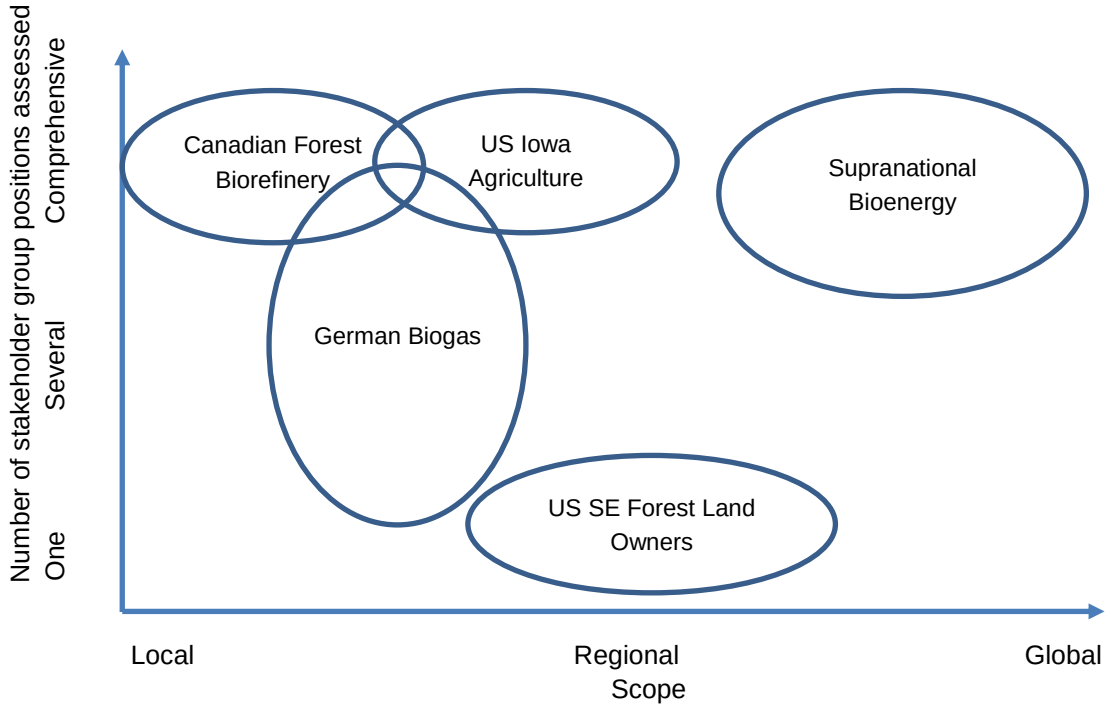

Figure 1 Overview of case studies, their geographical scope and assessment of stakeholder positions

While all case studies were linked to this project, most studies also received funding from other sources and, therefore, had varying objectives (e.g., the US agricultural case also evaluated the use of sustainability indicators). While methodologies varied, the case studies provide useful insights for a variety of bioenergy production systems and geographical settings.

This synthesis report first presents a synopsis of key findings from these case studies (Section 2), compares findings across studies (section 3), and discusses lessons and ways forward for a more fruitful stakeholder engagement in fostering progress toward more sustainable bioenergy (section 4)

2. Summary of the case studies

2.1 IMPLEMENTATION OF BIOGAS IN GERMANY

Biomass is an integral part in the energy system and used in the chemical industry and basis of the worldwide promoted bioeconomy. However, its potential can only be exploited sustainably if biomass is cultivated and governed appropriately. To accelerate the transformation, there was a need to install governance systems which support the installation of renewable energy plants and also ensure sustainability throughout the bioenergy value chain while maximizing the benefits and minimizing possible negative impacts. The biogas sector in Germany has grown steadily since the enactment of the Renewable Energy Act (REA) in 2000 aiming at an energy transformation.

In this study it is investigated how sustainability is put into effect with regard to the German biogas market being the largest biogas market worldwide.

The development of Germany's biogas market is structured according to a market phase model of Heuss` to categorize the different market phases during the development (see figure 2). This will also allow transferability of the approach to other countries. Within these market phases the most important national legislation for market development, the REA, and especially its repeated amendments, and associated legislation dealing with sustainability issues were analyzed. In this study, it is shown that an adaptive REA controlled and steered market development especially through incentivizing energy crops. Implementation of sustainability issues started during the transition from expansion to consolidation. While for greenhouse gas emission reduction the effects have been monitored and reported for more than one decade, the assessment for other sustainability aspects is diverse. In general, legislation regulating agriculture sector reacted with a certain delay to this.

Since then the sustainability of bioenergy and biogas in particular is subject to constant scrutiny, especially in the fields of economic and environmental sustainability. However, discussion on sustainability not only takes place in the scientific area but also in public, mainly via media. Public concerns about the sustainability of biogas started with the issue of energy crop cultivation for biogas production in the 2010´s. To steer sustainability in the biogas sector, a broad variety of regulations and acts were enacted, mainly via top-down legislation-making. But in order to govern sustainability in every step of the value chain, involvement of numerous stakeholders in the biogas sector is necessary. Therefore we took a closer look at the involvement of these various stakeholders at different stages of production and consumption of biogas, in order to improve their involvement and nurture an effective future development.

Following an instrumental approach for conducting the stakeholder analysis, three steps were initially undertaken for the systematic analysis of the stakeholder landscape, namely (1) stakeholder identification, (2) stakeholder categorization, and (3) investigation of stakeholder relationships. In addition, a theoretical mapping was performed to identify those actors, which most likely impact the implementation of biogas value chains or are strongly affected by this implementation. These were then subject to surveys via questionnaires and semi-structured interviews to gather information on their sustainability governance perception.

This study`s results indicate that a large proportion of the biogas plants are situated within agricultural production, which is why key players are farmers and biogas associations, along with environmental NGOs and policy makers. Furthermore, the surveyed stakeholders agree on regulating sustainability at national level, while tending towards neutral or even disagreeing for the local and international level. They also agree that certification and standards can be an effective tool for compliant sustainability governance. Concluding, this study revealed a clear gap

regarding an expectation management, how the current energy legislation (REA) shall be transferred in an encompassing bio-economy.

Therefore, both an adaptive legislation in the energy sector and monitoring elements, which regularly report the environmental effects and the developments in other areas of the agricultural sector (i.e. development of meat production), are needed. They shall point out the need for governance where necessary when deciding on the establishment of agricultural biogas. A rapid capacity growth in the biogas sector combined with a significant increase of meat production and thus fodder production fostered sustainability threats. It can be concluded that a sustainable development of biogas needs additional instruments, maybe a central one regulating the sustainability aspects of biogas apart from the agricultural sector, but also the better implementation of biogas in the further integration into the bioeconomy, i.e. by going beyond the supply of renewable energies.

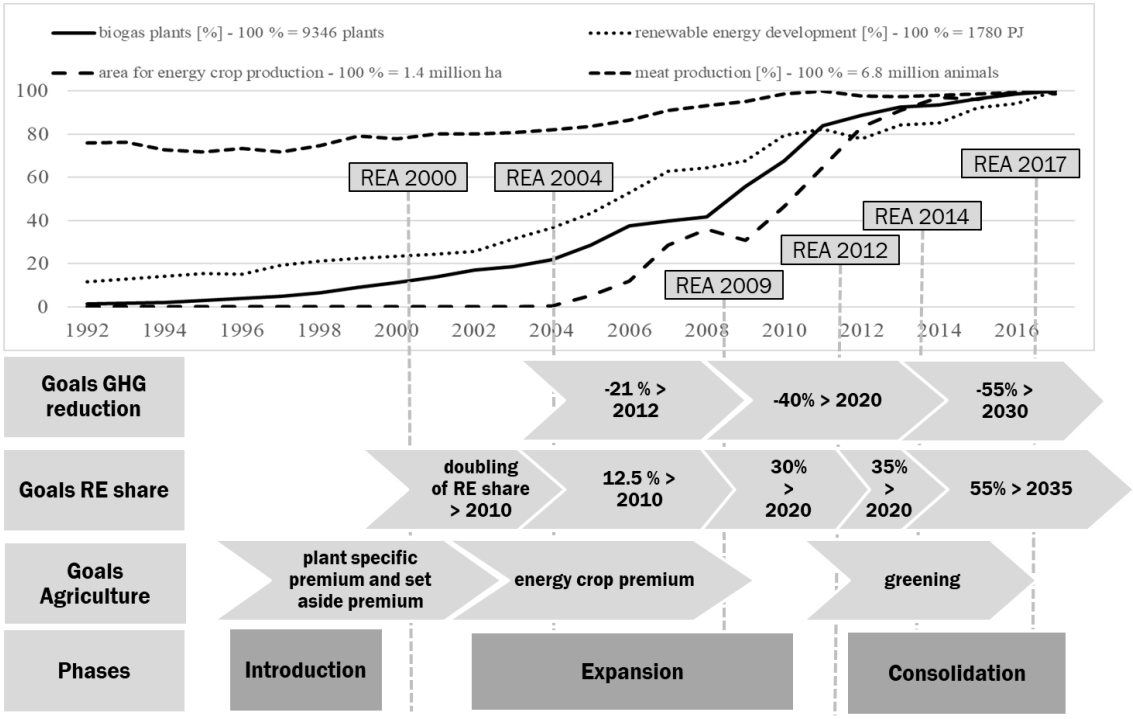

Figure 2 Different market phases of biogas sector implementation in Germany (data taken from Daniel-Gromke 2017; Bundesministerium für Wirtschaft und Energie 2018); Thrän et al 2019

2.2 SUSTAINABILITY OF FOREST BIOENERGY IN CANADA: EXAMPLE FROM QUEBEC

In Canada, the forest sector plays a key role in the social and economic development of hundreds of communities across the country. For example, in Quebec, the current forest industrial network is developed around sawmills and pulpmills. Bioenergy from forest biomass is still nascent, despite an abundance of forest resources across its mostly publicly owned, and largely third-party certified, boreal landscapes.

The municipality of La Tuque, located in the Mauricie region of Quebec, has been working to establish on its territory the first Canadian biorefinery producing renewable diesel from forest biomass. Since its foundation in 1909, La Tuque's development has been largely based on hydropower and forestry. However, bioenergy in the form of liquid biofuels represents a new

product. The feedstock envisioned for this production would be clearcut harvest residues, which were historically left unused on forest cutblock sites or by roadside. The acceptability of such a project within La Tuque, and the willingness of its inhabitants to be actively involved in the establishment and operation of the biorefinery, partly hinges on the local perceptions and expectations towards the future biorefinery.

As a case study towards exploring social acceptability of forest bioenergy in Canada, expectations (both positive and negative) of La Tuque community members (including the general public, stakeholders with various experience and links to the forest sector, and First Nations) towards the planned forest biorefinery, were collected, compared and weighed. The list of collected expectations consisted of 13 statements classified under each of the main criteria of sustainable development, i.e. social, economic and environmental (Figure 3). When ranked and weighed against each other, almost half of the overall weight was attributed to the following expectations:

- Creation of an additional source of income for individuals and companies (economic);
- Creation of new business opportunities (economic);
- Recovering and valuing forest residues (environmental);
- Keeping youth within their communities (social).

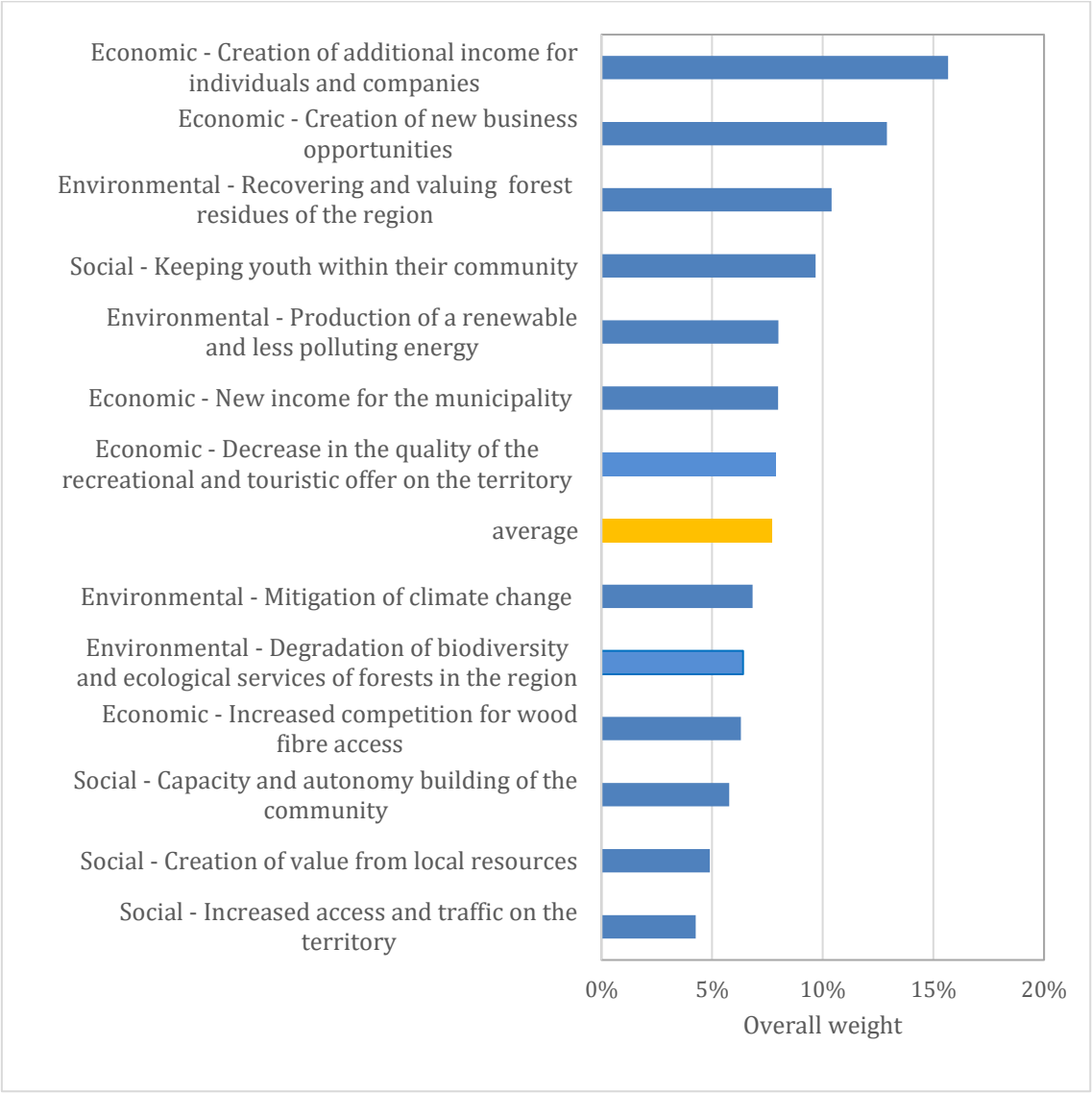

Figure 3 Ranking and relative weight of expectations towards the La Tuque biorefinery. Sum of all weights is 100%

Four out of the five economic expectations were given an above-average weight relative to other expectations. The two environmental expectations with above-average weight were positive ones: recovering and valuing forest residues (getting rid of decaying residue piles is likely seen as an improvement of forest landscapes) and production of a renewable and less-polluting energy source. Mitigation of climate change (also positive), was however ranked lower than the average. La Tuque community members perceived as more important the concern that the establishment of the forest biorefinery might degrade the quality of their (forest-dominated) territory for recreational and touristic use, than the concern that it might degrade biodiversity and ecosystem services. The territory is heavily used for hunting, hiking and motorized activities. The local economy of La Tuque, the vitality of which ranks highest among expectations, also heavily relies on exploitation of forest resources, which need to be sustained for the long-term well-being of the community. La Tuque stakeholders did not appear to perceive forest biomass procurement for the biorefinery as a threat or particular concern to the ecological health of forest ecosystems; they are however concerned about their quality as their own living environment and playground. This suggests that concepts such as preservation of biodiversity might be too abstract for most of the stakeholders, whereas indicators that directly relate to their well-being might be easier to grasp. This points to the importance of adapting communication of global issues so that local communities can see how they relate to their own life, well-being and living environment.

The planned forest biorefinery in La Tuque is an example where forest bioenergy will be integrated within existing forest management systems. Forest biomass procurement will occur on managed public forest areas that are already under forest certification; governance of sustainability should (at least partially) be ensured by these certification systems, in addition to existing governmental forest regulations for public forest lands. The most recent Sustainable Forest Development Act in Quebec (in force since 2013) relies on the concept of ecosystem-based forest management, which goal is to reduce the differences between managed and natural forests in order to create or maintain landscapes that can support biodiversity. The high level of naturalness that this type of management maintains also causes a large variability in the quality of wood supply, forcing the industrial network to adapt to such variability. As such, polyvalent fibre-takers such as bioenergy developers can play a key role for silviculture by recovering residues and trees with fibre characteristics considered undesirable by the sawmills and pulpmills. In some instances, biomass procurement can serve as an important silvicultural practice either by:

- reducing residue loads on clearcut areas and accelerating the establishment and growth of the regenerating stand;
- allowing the harvest of stands that have a high proportion of undesirable trees (and were previously left untouched), and thus unlocking/mobilizing their portion of timber-quality volume.

2.3 SURVEY OF FOREST LANDOWNERS IN THE SOUTHEASTERN UNITED STATES REGARDING USE OF WOOD-BASED PELLETS FOR BIOENERGY

Wood-based pellets are currently being produced in the southeastern United States (SE US) and a large part is shipped to Europe for generation of power. Because sawtimber, pulp, and paper have higher value, biomass is typically sold for wood pellets only if wood quality or market conditions make it difficult to sell the material at a higher price to those markets. Wood used to manufacture pellets in the SE US comes from private forests, and the majority derives from residuals associated with forest management for other products. In recent years, an increasing share of the feedstock for pellets is classified as roundwood or pulpwood and may be sourced from forest thinning and economically stranded timberlands (i.e., areas that previously supplied pulp but now have no other market after mills have closed or reached capacity).

In 2017, a mail-based survey was conducted targeting 2,900 non-industrial, private forest landowners in the SE US regarding their perspectives on supplying wood for pellets used for energy. This survey targeted areas from which wood is sourced for the two major pellet-export ports in the SE US: Savannah, Georgia, and Norfolk-Newport News, Virginia. The survey methods and results are presented in two articles in preparation by Donald Hodges, Binod Chapagain, Pattarawan Watcharaanantapong, Neelam Poudyal, Keith Kline, and Virginia Dale.

The survey results indicate that most private forest owners are aware that environmental benefits of bioenergy outweigh the costs. A majority of the 707 private land owners who completed the survey are willing to provide woody biomass for energy. Factors affecting willingness to supply biomass for energy include the right price, noninterference with traditional sawtimber income, and compatibility with the owners' land management and conservation goals. The survey also found that aesthetic and conservation values are among multiple reasons for keeping land in forests. Interestingly, while only 44% of the survey respondents reported knowledge of best management practices (BMPs) being applied in their forestry operations, other sources suggest that a far larger share of total timber is harvested under BMPs due to requirements of purchasing mills. Since harvest operations are conducted by third party professional loggers, small private landowners may not be well-informed.

A wide variety of perspectives were offered by respondents in response to questions about the potential costs and benefits of bioenergy. Hence, survey results (see Figure 4) indicate that work remains to be done so that forest owners can be more fully informed about the issues that determine net benefits of using woody biomass to offset fossil fuels. A key need is to better document the conditions under which bioenergy markets can help land owners meet multiple goals such as wildlife conservation, provision of aesthetic benefits, and increased income while reducing risks of insect outbreaks and destructive wildfires.

Given the number and diversity of private forest landowners in the Southeast US, systematic monitoring of forest conditions, as is currently performed by the US Forest Service, appears to be a more effective option to monitor compliance with sustainability goals than attempting to have each individual land owner complete certification requirements.

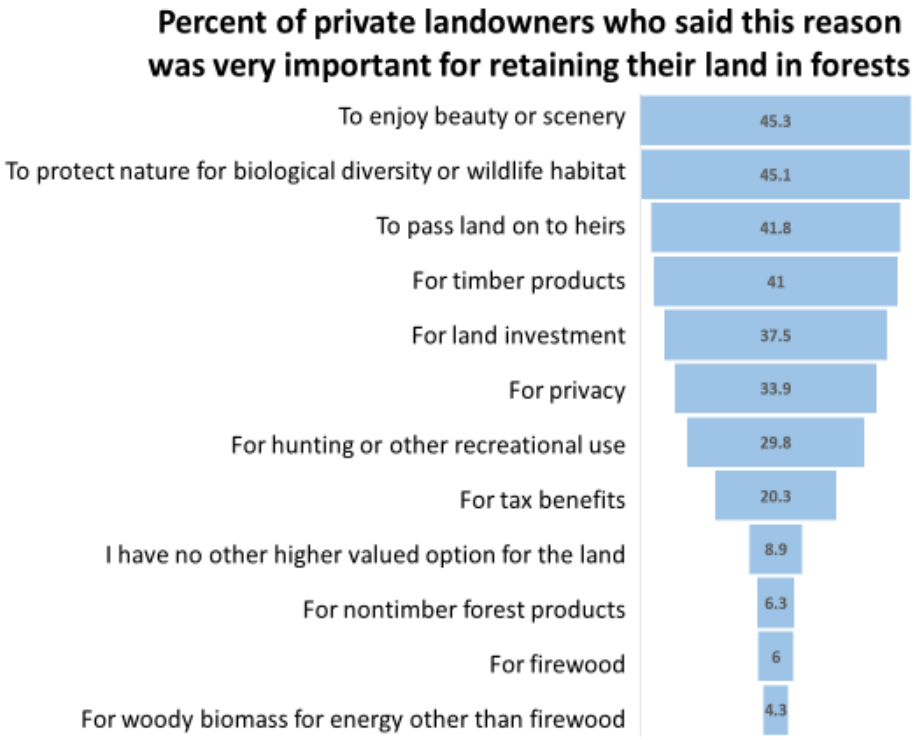

Figure 4 Overview and ranking of reasons for private landowners to maintain land in forests

2.4 BRIDGING BIOFUEL SUSTAINABILITY INDICATORS AND ECOSYSTEM SERVICES THROUGH STAKEHOLDER ENGAGEMENT - – PRODUCING CELLULOSIC ETHANOL IN IOWA (US)

Continued development of cellulosic-based biofuels can help provide renewable energy while improving the provision of ecosystem services such as soil conservation and control of nutrient runoff, while simultaneously strengthening rural investment in the United States (US). To foster development of sustainable pathways for producing biofuel and reduce negative effects on ecosystem services, stakeholder input is necessary to identify sensitive and meaningful indicators. However, substantial differences in terminology, perspectives, and methods used to quantify sustainability exist among different stakeholders. And the values placed on different ecosystem services with regard to processes, biodiversity, and socioeconomic effects can also vary widely among stakeholders. There is not a practical list of indicators that is appropriate for all contexts. Hence the objectives of this study (Dale et al. 2018) were to identify relevant indicator categories using a case study from the US state of Iowa.

Building from a scientific literature review, stakeholders were asked to identify indicator categories associated with production, harvest, storage, and transport of cellulosic feedstocks. The stakeholders consulted included farmers, land owners, nongovernmental organizations, university researchers, and staff from government agencies. Information came from 175 attendees at the November 2015 meeting on "Sustaining Our Iowa Land," 61 participants of the December 2015 meeting of the Biomass Landscape Design Project, 34 attendees of the Dec 2015 "Capital Crossroads" workshop, and 15 other stakeholder groups. Most stakeholders focused on two Iowa watersheds which produce feedstock to support a local biorefinery.

Cellulosic feedstocks in this region consist either of corn stover (*Zea maise L.*) or increased cultivation of perennial crops such as switchgrass (*Panicum virgatum*). Removal of some stover can facilitate no-till agriculture and help address residue management problems in these watersheds. Furthermore, efforts such as the Conservation Reserve Program help fund the establishment of perennial grasses in order to reduce soil erosion and enhance wildlife habitat. Together these two feedstock options can promote ecosystem services in this region.

The stakeholders identified 11 sustainability categories for biofuel feedstocks (see Figure 5). Five of those categories focus on environmental concerns (soil quality, water quality and quantity, greenhouse gas emissions, biodiversity, and productivity), and six categories focus on socioeconomic concerns (social wellbeing, energy security, external trade, profitability, resource conservation, and social acceptability). The stakeholders prioritized profits, productivity, and soil and water quality, reflecting the importance of good management to support ecosystem services. While these indicator categories reflect sustainability concerns of these stakeholders, additional monitoring and stakeholder engagement are needed to support continual improvement through adaptive management.

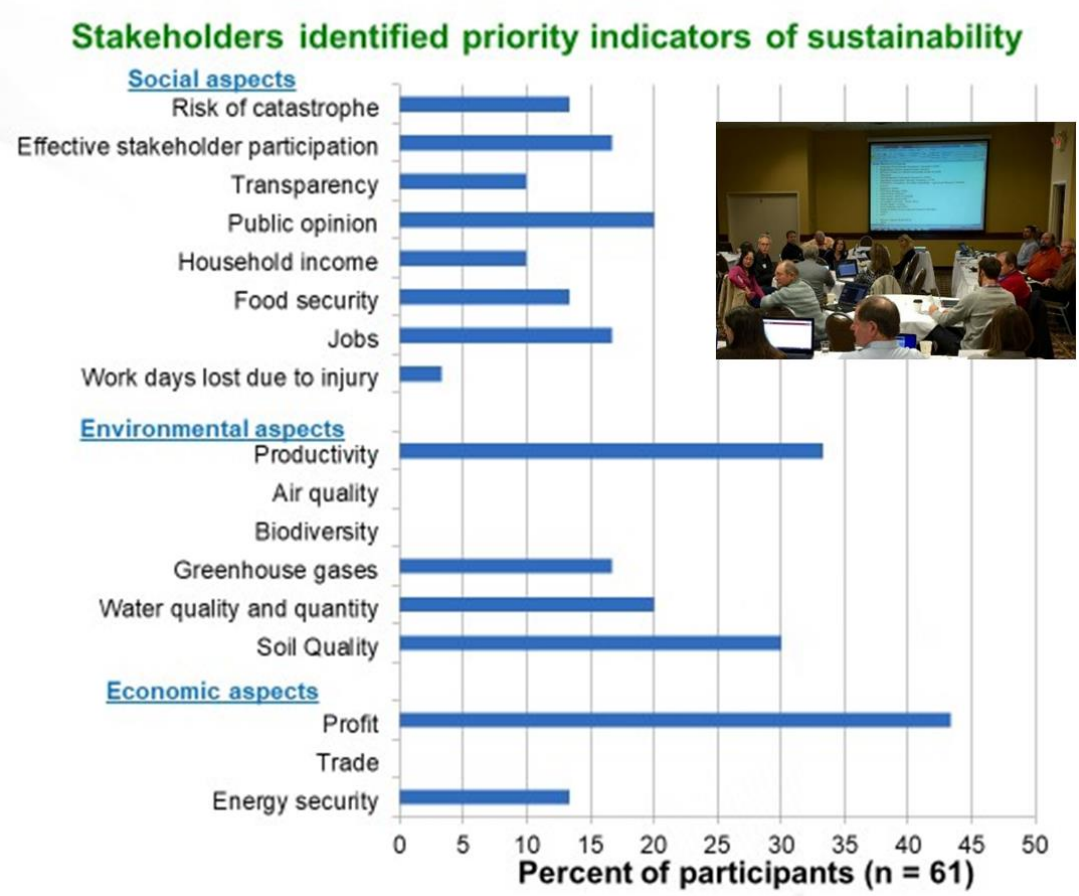

Figure 5. Example of the results from a landscape design project meeting where stakeholders were asked to identify their top three priorities for more sustainable agricultural production in Iowa (Dale et al. 2018)

Fig. 5 illustrates feedback collected in a project kick-off meeting where profits, productivity, soils and water were top priorities among direct project agricultural sector stakeholders. None of these stakeholders identified air quality or biodiversity as one of their top three priorities given current conditions in central Iowa. However, subsequent meetings were organized with focus groups and biodiversity was identified as being an important indicator for several local parties interested in recreation and conservation.

With support from the US Department of Agriculture and the US Department of Energy Bioenergy Technologies Office, field work is expected to continue through 2020 to document improved practices and measure actual and projected effects across multiple indicators of social, economic and environmental sustainability. For more information see https://www.energy.gov/eere/bioenergy/sustainability

2.5 PERCEPTION, POSITIONS AND VISION OF STAKEHOLDERS TOWARD BIOENERGY - GLOBAL VIEW

Bioenergy has an important role in the current and future energy landscape as recognised by the European Union and many other regions / countries. However, the potential role that bioenergy should play in the energy transition in the short-, medium- and long-term is seen differently by various stakeholder groups. This study consulted various stakeholder groups (general public, biomass producers, biomass users for energy, biomass users for other purposes, non-for-profit organisations, academia and consulting, policy makers) and supranational[2] stakeholders towards bioenergy. It aimed to understand the positions and underlying motivations of diverse stakeholders relative to their perception of bioenergy; inform dialogues/discussion to avoid misconceptions as well as provide neutral and comprehensive knowledge on the bioenergy development.

To achieve the goals, three approaches were considered to receive feedbacks from stakeholders. One online survey was designed and included various aspects of bioenergy. The online survey was disseminated via the project participants to their networks, to several websites of IEA Bioenergy and its members, was also announced in a number of events and conferences. 199 stakeholders have provided answers on the online survey. The questionnaire received most contributions from the academia and consulting group, which accounts for 35% of the total answers. Other active contributions included NGOs (17%), policy makers (15%) and biomass users for energy (12%). Lower participation included biomass producers (8%), general public (7%) as well as biomass users for other purposes (6%). This constitutes a representative mix of stakeholder groups and thus it is expected that the results reflect interests and involvement of stakeholder groups in the bioenergy sector. Also, two dialogues were organized in April and May 2018 with a number of stakeholders having interests and expertise on bioenergy to receive feedback on questionnaire results, and to reflect further stakeholders' vision on future pathways and strategies for sustainable bioenergy development. Interviews with supranational stakeholders were also carried out. In addition to response to the online survey, they also answered key questions to clarify further how bioenergy could move forward sustainably. There were 11 supranational stakeholders provided inputs for this study. For more details, see Mai-Moulin et al. (2019).

The online survey, dialogues and interviews showed that the position of the general public needs to be recognised in designating policy and in implementation of bioenergy projects. Public involvement in bioenergy projects also needs to be increased. The NGO groups demonstrated concerns about environmental impacts of feedstock sourcing and mobilisation; they also have relatively high influence in both informing and changing viewpoints of other groups. Some of them have critical views towards bioenergy. Certain biomass users for other purposes (bio-materials) indicated issues of resource competition between bioenergy and their own sectors. They saw a minor role for bioenergy to contribute to global energy production, but they have limited influence on bioenergy development. Biomass producers and biomass users for energy in principle support bioenergy development and are positive about the growth of the bioenergy sector. The academia and consulting group has generally a positive view on bioenergy and their role is important to inform the bioenergy sector's activities to external stakeholders. However, there are also a number of scientific reports which show contradicting assessments of the sustainability of the bioenergy sector, demonstrating that there also scientists with negative views of bioenergy. It is therefore necessary to involve scientists and consultants in discussing and communicating perspectives of bioenergy development. Policy makers have generally a positive view on bioenergy

[2] i.e. active and interested in bioenergy on an international level, rather than on a specific case study level.

but need appropriate information for their decision making. They have the most important role in designing energy policies which influence the bioenergy development. The dialogues and interviews with the supranational stakeholders revealed their perceptions about the bioenergy sector. Communication among stakeholders can change individual perceptions and ultimately influence opinions towards bioenergy, see Figure 6.

Bioenergy market uncertainties and unresolved sustainability issues are identified by the respondents as the two main barriers to further bioenergy development. Social acceptance of bioenergy projects is also a real challenge to the bioenergy industry. Moreover, large-scale sustainable mobilisation of biomass feedstocks and governing increasing global trade are further challenges for the bioenergy sector to overcome over in the medium- and long-term future.

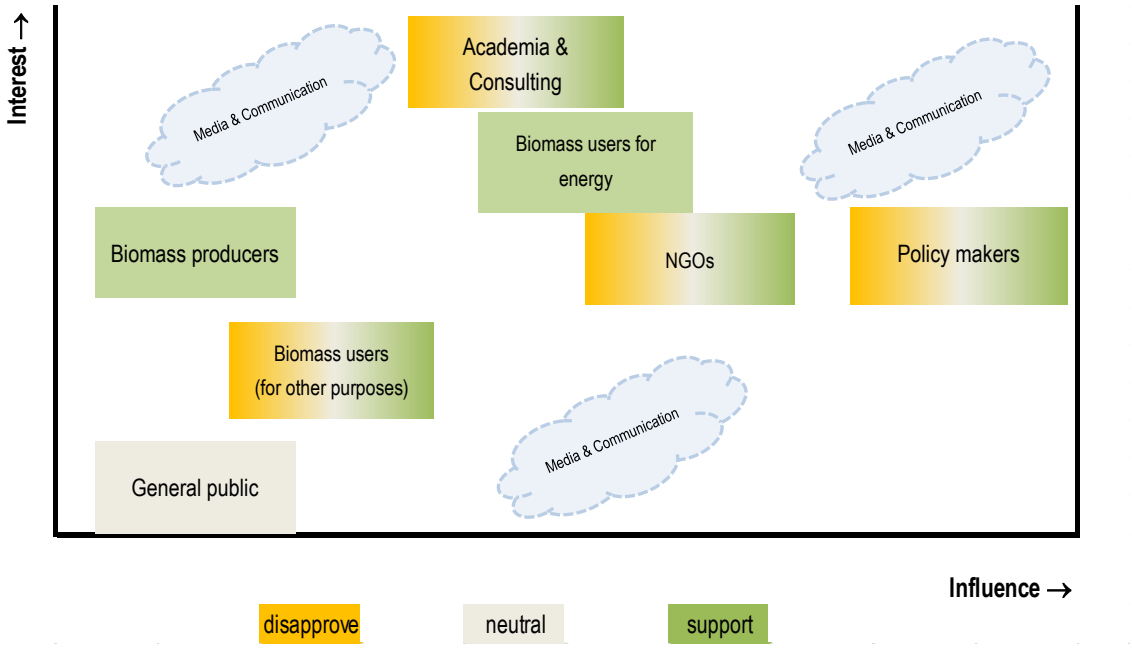

Figure 6 Conceptual sketch of interest & influence of stakeholder groups

In general, most of the stakeholder groups agreed to support bioenergy development if the six identified aspects shown on Figure 7 were fulfilled. One of the main possible drivers to enhance the bioenergy development was the potential introduction of binding sustainability requirements for all types of biomass, i.e., for feedstocks used for both bioenergy and for other end-use sectors. Another driver would be if bioenergy policies were based increasingly on scientific information.

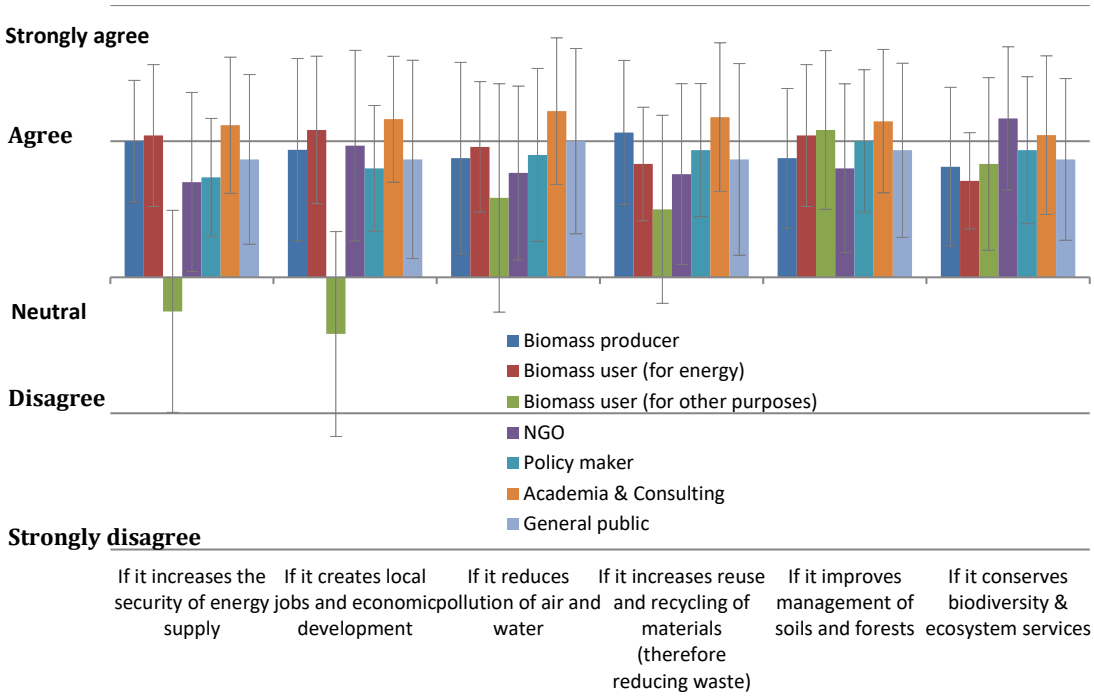

Figure 7 Aspects to support bioenergy development

To enhance and gain further support for the bioenergy sector, sustainability requirements covering social, and additional economic and environmental aspects should be implemented for all types of biomass regardless of specific bioenergy end use. In addition, third party sustainability certification needs to be transparent to prove that sustainability compliance is assured. Certification cost would make the bioenergy price higher but the cost challenges would also include possibilities for bioenergy to grow in terms of pressures for technology innovations as well of feedstock potential (supplementary quantity might be added once sustainability is verified).

A continued dialogue and improved communication of scientific evidence of bioenergy impacts and benefits with external stakeholders could help identify stakeholder priorities and find solutions acceptable for all parties. The potential benefits of bioenergy and its contribution to climate change mitigation, environmental improvements, social and economic enhancements, if shown by scientific evidence, need to be translated into simple and clear messages to assist long term decision making for the bioenergy sector as well as to inform the general public and other stakeholder groups. Also, involving external stakeholders in the communication of bioenergy development and engaging them to find mutual solutions not only for the bioenergy industry but also for other sectors using similar feedstocks would be very important for the bioenergy sector.

This study has new findings on the perception, positions and vision of stakeholders toward bioenergy, but it also bears some limitations. The studied results were received from self-selected respondents, and therefore, averages for each stakeholder group were taken as general opinions from those who chose to respond. Thus, these groups should not be considered as statistically significant representation of any group. The number and geographic distribution of respondents may also vary widely by category. Likewise, not all stakeholders from whom interviews were requested chose to respond. Future studies are recommended to address these limitations and investigate further the positions, viewpoints and influence of additional group representatives to better reflect their opinions and vision towards bioenergy.

3. Overarching insights from the case studies

In this section, the outcomes of the five case studies are compared. While they cover different bioenergy supply chains, unique geographical settings, and varying numbers of stakeholders, similarities and differences are pointed out below.

All local case studies focused on systems in which **bioenergy is a small part of larger forestry or agricultural systems**. Even in the German biogas case (Thrän et al. 2018) where it could be argued that maize is an energy crop for biogas production, the associated cultivation impacts (e.g. monocultures, water pollution, etc.) are closely related to general agricultural practices in the region. Depending on the dedicated frame condition in agriculture the provision of biomass can increase existing problems (i.e. monocultures, water pollution etc.) or contribute to reduce them (i.e. diversification of crop rotation, providing natural habitat infrastructure, better use of agricultural residues, introduction of improved nutrient management practices, etc.). Yet, debates often center around crop use for bioenergy, as this option is viewed as a marginal addition to the system. Others argue that bioenergy markets, with their attention to indicators of sustainability, bring welcome innovation and improvements to conventional productive sectors. Solutions to reduce and mitigate negative impacts are not end-use specific. Also, they need to be implemented in the wider agricultural/forestry setting (or "landscape").

Stakeholders also indicate that they would support bioenergy if additional benefits accrue from bioenergy deployment, e.g., in the case of forest land owners in the southeastern US, if bioenergy reduces risks of wildfires and diseases. From the supranational stakeholder case study (May-Moulin et al. 2019) similar opinions were expressed: bioenergy supply from forestry and agricultural systems in the form of residues from existing activities receiving wide support, whereas dedicated use of (high quality) agricultural land for energy crops was not favored by a large majority of the respondents to the questionnaire: on average by 79%, ranging from 68% (policy makers) to 100% (biomass users for purposes other than energy) and 7 out of 11 supranational stakeholders interviewed (May-Moulin et al. 2019).

In two out of four local case studies, **stakeholders assigned high priority to economic sustainability** :

- In the Canadian Biorefinery case (Thiffault et al. 2018), creation of additional income for individuals & companies and creation of new business opportunities are the highest two priorities.
- In the Iowa agricultural case (Dale et al. 2018), profit was the indicator receiving the most votes as a high priority among agricultural sectors stakeholders involved in a multi-institutional landscape design project. When asked to identify their top three priorities, 45% of the participants included profit. The second most commonly cited priority was productivity, which was labelled as an environmental indicator due to a definition emphasizing the maintenance or increase of Net Primary Productivity on a landscape without the need to increase inputs. For many stakeholders, however, productivity also has obvious economic ramifications.
- A random sample of US forest owners (707 completed surveys) in the areas supplying wood for bioenergy pellets, showed that while income from various timber products, heritage for children, and future income opportunities (a bank account that can be drawn upon in times of need) were all important criteria for owners to maintain their land as forest, these factors were surpassed in importance by nature protection and scenic values (Hodges et al., 2019). Income from fuelwood or other energy options was deemed the least important reason to maintain land in forest. The forest owners surveyed did not perceive the sale of forest residues for energy as a major factor of value. However, while owners are aware of stumpage fees (price per volume of wood harvested), they may not know or care about the final uses of biomass harvested from their land.
- In the German biogas case, the reduction of GHG emissions is, together with energy security, ranked the most important driver for bioenergy, whereas making a profitable business is deemed the lowest priority, both according to the biogas plant owners and a wider set of stakeholders (Sutor et al. 2019). This characteristic may reflect the economic

context: biogas in Germany is highly subsidized and affluent compared to the rural and economically rather depressed Southeastern US setting.

- The German biogas case (Sutor et al. 2019) is in line with the findings from the SE US (Hodges et al. 2019) and global survey (May-Moulin et al. 2019), where economic viability of the supply chain plays a less important role than environmental considerations.
- Impacting the economic viability of other biomass users was also a concern. Among the interviewed supranational stakeholders, the role of bioenergy for climate change mitigation was still in question by three of the eleven interviewees. They questioned whether biofuels/biomaterials could deliver climate benefits, even if provisions (such as minimum GHG reductions in the supply chain) were in place to safeguard such benefits.
- All North American cases also indicated opinions that bioenergy should contribute to **social criteria** such as using land for recreational purposes and hunting (US Forestry), jobs (Iowa agriculture, US Forestry and Canadian biorefinery), and keeping youth in the local community (Canadian biorefinery). These aspects and the stakeholders advocating them are typically **underrepresented** in the current public and political discussions, as taking place in the media, which are typically dominated by the environmental impacts. Another underrepresented aspect is **rural development** for which bioenergy can be an important driver. Engagement with civil society organizations, e.g. land owner organizations or labor unions, and communicating information on positive effects along with risks, negative impacts and tradeoffs, may help to balance the dialogue in the future.

Local stakeholders tend to focus more on local rather than global impacts. Most notably, climate change mitigation is missing as a key priority in the North American case studies, while respondents of the global survey identified reduction of greenhouse gas emissions as the most important driver for bioenergy development and reciprocally indicated a potential failure that bioenergy will reduce GHG emissions as second-most important reason for opposing bioenergy. In both the Canadian and the US cases, local environmental conditions are ranked higher than those related to less tangible goals for biodiversity conservation and climate change mitigation. For example, the Canadian stakeholders were more concerned that a proposed biorefinery might degrade the potential for forest-based recreation and tourism, rather than the potential for biodiversity conservation and environmental ecosystem services. On the one hand, this makes perfect sense, as local stakeholders are typically confronted with these impacts on a regular basis in their daily lives. Region- and case-specific, local stakeholders tend to prioritize local issues. For example, in the US Iowa agricultural case, agricultural sector participants did not identify biodiversity loss as a top priority because, in the context of a landscape dominated by intensive agriculture where lawsuits over water quality were highly publicized, water quality, soil conservation, and maintenance of productivity without the need to add more nutrients, were higher priorities. However, biodiversity was identified as a priority by civil society groups representing recreation and hunting interests. This highlights the need to provide timely and reliable data about the linkages and feedbacks among local interventions (land management), indicators that are locally a priority (productivity), and larger scale phenomena (climate, pollinators).

We suggest that this result partially links to the **role of media in the provisioning of information to and communication among stakeholders**. From the global online survey, it was clear that internet and social media were the most frequently used sources of information for stakeholders. Other important information sources included local news, television and traditional journals and papers, whereas academic sources, e.g., scientific papers and conferences, are least used. Interestingly, the trust in these sources is the inverse of their use: social media and internet sources are least trusted, whereas academic sources are trusted the most. For the German biogas case, the lack of communication between the general public, especially local residents, and farmers and plant operators was also identified as a major obstacle for societal acceptance, in conjunction with negative "sensational" depiction of bioenergy in the local media.

The German biogas and supranational stakeholder case studies addressed the question **how sustainable bioenergy systems should be governed**[3] and whether **governance structures should be mandatory, voluntary, or a mix of both.** This was not a priority issue for the three North American case studies. For example, forest owners in the southeastern US were neutral concerning the certification of forest and are not necessarily informed of the practices employed by contractors who typically supervise management and harvesting activities. Nevertheless, North American mills that export pellets to the European Union require feedstocks to meet specific criteria with compliance assured through various voluntary certification mechanism and through employing certified professionals trained in best management practices (BMPs) for harvests (southeast US forestry case). In the Canadian Biorefinery case, issues related to the deployment and sustainability governance of forest bioenergy were not mentioned (or perceived as important enough to mention) by the interviewees. This is possibly due to the fact that bioenergy from forest residues can be perceived as just one additional product within an existing basket of wood products sourced from forest areas; current residue harvesting activities are also still somewhat limited and have therefore not raised any specific concerns. Moreover, forest certification and comprehensive public regulation are already prevalent across Canadian forests, which are largely public; therefore, additional standards/certifications might not be perceived as needed. This is distinct from the US, where the largest share of timber production comes from privately owned forests, especially in the southeastern US.

Governance strongly differed for the two agricultural case studies. The Iowa case was set within a context of a law suit over impaired water quality associated with historical agricultural land use. Against this backdrop, the Landscape Design Project aimed to integrate more herbaceous ground cover and the case study engaged stakeholders to develop a set of voluntary indicators for assessing progress toward more sustainable production. The results of the German biogas case point in a different direction: both plant owners and a wide set of stakeholders agreed that **mandatory** sustainability requirements should be applied equally for **all** biomass types, regardless of end use. On the other hand, the majority of biogas plant owners indicated that compliance with all forms of bioenergy sustainability standards should preferably be voluntary, whereas the stakeholders outside the supply chain indicated that they would prefer mandatory implementation, ideally linked to independent certification with third party auditing based on sustainability standards. Above all, plant owners seem especially interested in obtaining a "level playing field", so if mandatory implementation is preferred, then harmonisation of such requirements for all stakeholders might be key.

Questions that arise from these examples include: Will more mandatory sustainability requirements (as opposed to voluntary schemes and BMPs) increase trust and legitimacy (see also Stupak et al. 2019), as was advocated by external stakeholders in the German biogas case? Or could measures of observed conditions across landscape (e.g., detailed forest inventory data, water quality measures, acreage in perennial cover) provide more trust and confidence? How much additional cost are consumers willing to pay for assurances of sustainability? And at what point do additional requirements become counterproductive, simply increasing paperwork and time and energy spent on consultancies? Transparent and verifiable systems that provide timely information to stakeholders about the actual conditions on the ground would be a helpful start. For example, in Germany the incentives for the development of biogas provision came along with an adaptive law and included continuous monitoring of the development of the biogas production.

[3] Which is in fact the main objective of another part of this project focusing on how to improve the input and output legitimacy of existing and proposed governance systems (Stupak et al. 2019).

This monitoring was the basis for the adaption of the incentives, but agriculture effects were considered only partially. Early warning systems need to be improved to promote action and accelerate adaption by politicians which is why results of regional studies have to be summarised in a national monitoring system of sustainability indicators, especially, for water and soil contaminants and air emissions (Thrän et al. 2019).

A second question addressed in the German biogas and supranational stakeholder case studies was whether **governance systems should be tailor-made for specific local conditions or, in contrast, be generic on national or even international levels**. In the German biogas case, the main preference of both plant owners and all other stakeholders was for regulation at the national level. From the interviews with supranational stakeholders, the view emerged that sustainability requirements could be designed at a global level, but, as each region has a different context, sustainability measurements and applications should "translate" general requirements to the local level. This approach also would fit the philosophy of a sustainability indicator framework as presented in the Iowa agricultural case, with a generic framework, but local prioritization and measures to meet specific criteria. For the US Forestry case, this question was not specifically addressed, but current BMP's are defined on a state level within the US and are thus fairly location specific, while federal laws are applicable to protect biodiversity, clean water, coastal zones, and to govern the management of forests on public lands. In Canada, a combination of local, provincial and national policy approaches, along with third-party certification systems, are applied. In most provinces, including Quebec, forest management is under the responsibility of registered professional foresters (RPF): all management and silvicultural activities need to be prescribed or recommended by RPFs, which are required by law to ensure sustainability of forest practices. These include forest biomass procurement practices. The professional decision-making of RPFs in addition to forestry regulations and certification systems are already important and may be considered sufficient layers of governance to achieve sustainability goals.

4. General conclusions, recommendations and way forward

Include social stakeholders and increase stakeholder awareness

The results of the case studies indicate that public awareness of bioenergy in general is rather low, and information from academia and consulting is most trusted. For new (local) bioenergy projects, (better) informing and involving the public in advance could help identify concerns and expectations and thereby generate more support for projects. Information about economic benefits and participation/inclusion in bioenergy projects seems to be often neglected, yet these aspects are typically of high priority for many local stakeholders. It also became clear that stakeholders outside of bioenergy supply chains concerned with social topics are typically less involved than those focusing on environmental aspects (such as eNGOs). Engagement with and inclusion of civil society organizations (e.g., land owner organizations and labor unions) in the discourse, and communicating information on positive effects (without neglecting negative tradeoffs or risks) through their networks, may help to balance the dialogue.

Use best practice examples

From the local projects, the German biogas case met most resistance from many stakeholder groups in recent years. Conflicts between the stakeholders included especially landscape aesthetics. One approach suggested to reduce conflicts between the stakeholders is given by so-called best practice examples. Farmers have been able to reduce local conflicts without certification and standards by finding a compromise between local perceptions of undesired impacts and the profitability of a commercial biogas plant operation. An example included plantings at the edge of the energy crop field with the purpose of improving the perception of landscape aesthetics by the residents and to promote biodiversity in the region. Other examples creating win-win situations for operators and residents included biogas plants delivering heat to nearby households and giving the residents the possibility to discard their bioorganic wastes at the plant. Sharing of economic benefits and fostering communication and good relationships has been shown to increase trust and understanding among stakeholders.

Establish and implement sustainability safeguards

The analysis of supranational stakeholder views underlined that bioenergy market uncertainties and unresolved sustainability issues are the two main barriers to further bioenergy development. Social acceptance of bioenergy projects is also a real challenge to the bioenergy industry. Moreover, large-scale sustainable mobilisation of biomass feedstocks and governing the sustainability of the increasing global trade are further challenges for the bioenergy sector to overcome in the medium- and long-term future.

The establishment and implementation of sustainability safeguards thus remains important for a diverse stakeholder group, as a condition for granting support for the development of the bioenergy sector. Critical sustainability issues include the reduction of GHG emissions, under stringent criteria with regard to air and water pollution; high levels of reuse and recycling of materials; appropriate soil and forest management; and the conservation of biodiversity and maintenance of ecosystem services. Sustainability criteria addressing these issues have already been implemented for the energy sector in some EU Member States and can be relevant also in other countries if existing governance systems are considered insufficient. The respondents of the online survey indicated that in order to enhance and gain further support for the bioenergy sector, sustainability requirements covering social, and additional economic and environmental aspects should be mandatorily implemented for all types of biomass regardless of end use. However, it remains to be seen whether mandatory implementation will ultimately lead to more stakeholder acceptance, generally, and how realistic and rapid implementation for other end-uses is. The views of traditional wood product industries, and novel biochemical and biomaterial industries, are different, as they partly consider competition with bioenergy for feedstocks as problematic, especially due to subsidies available for bioenergy.

View on potentials of energy crops versus residues

The survey also indicated low support for energy crops on agricultural land. This may reflect common concerns about food production for an increasing global population in coming decades. Or it may be linked to negative perceptions of direct and indirect land use change caused by bioenergy, or to negative perceptions of intensive agriculture in general. The issues have been popularized by media campaigns. The low support for energy crops is problematic, as the world desperately needs investments in land management to improve soil, water, forests and related ecosystem services (e.g., Fargione et al. 2018; Woods et al. 2015) and energy crops could contribute to these goals in some parts of the world (Kline et al. 2017). Some marginal agriculture lands are valuable from biodiversity and landscape aesthetics points of view (Shortall et al. 2019). But there are extensive areas of degraded and marginal agricultural lands where establishment of appropriate cultivation systems can provide biomass for bioenergy while helping to restore land productivity (e.g., Woods et al., 2015). It is important to communicate that the outcome of planting energy crops will always depend on the local conditions and priorities. This includes to highlight examples of beneficial land use change where establishment of suitable crop cultivation systems can provide biomass while mitigating environmental impacts of current land use. The indirect effects triggered by bioenergy, as well as possible ways to reduce risks and rather assure achievement of benefits, need to be explained and communicated better.

Many respondents of the global survey indicated that they preferred the use of forestry and agricultural residues, rather than decided energy crops or plantations, presumably because the environmental impact is perceived as lower. However, forestry stakeholders in the US indicated that the economic benefits of harvesting and selling residues are low, showing that it is often difficult to reconcile different sustainability objectives.

Further work on stakeholder engagement, involvement and perceptions should address the following issues.

1) The measurement of trust for specific purposes, e.g. trust in government, social license to operate etc.; how should this be done?
2) The role and modes of communication for creation of trust and confidence among different groups of actors, and the role of researchers for communication; which role and modes are most effective for which groups, depending for example if communication takes place at local, regional, national or international levels.
3) The extent to which sustainability standards and respective certification systems promote, incentivize and communicate continuous improvement in a transparent and effective manner should be investigated. Monitoring data at all levels are useful for documenting sustainability of bioenergy production and use and should be part of the assessment and communication with stakeholders.
4) Supranational stakeholders' recognition of local governance systems already in place; it is desirable to avoid overlapping systems as this implies unjustifiable burden. However, views on specific sustainability issues may differ between producing and importing regions. In such situations, producers may decide to meet additional requirements to get access to export markets.
5) There is no one single approach to assessing progress toward sustainability in any particular setting, but there are common patterns. These general attributes include active stakeholder engagement throughout the bioenergy production process; transparent sharing of information about the social, economic, and environmental costs and benefits; ongoing monitoring; and working together towards identifying and implementing better practices.

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