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Indicators of bioenergy-related certification schemes – An analysis of the quality and comprehensiveness for assessing local/regional environmental impacts

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ABSTRACT

Bioenergy is receiving increasing attention because it may reduce greenhouse gas emissions, secure and diversify energy supplies and stimulate rural development. The environmental sustainability of bioenergy production systems is often determined through life-cycle assessments that focus on global environmental effects, such as the emission of greenhouse gases or air pollutants. Local/regional environmental impacts, e.g., the impacts on soil or on biodiversity, require site-specific and flexible options for the assessment of environmental sustainability, such as the criteria and indicators used in bioenergy certification schemes.

In this study, we compared certification schemes and assessed the indicator quality through the environmental impact categories, using a standardized rating scale to evaluate the indicators. Current certification schemes have limitations in their representation of the environmental systems affected by feedstock production. For example, these schemes predominantly use feasible causal indicators, instead of more reliable but less feasible effect indicators. Furthermore, the comprehensiveness of the depicted environmental systems and the causal links between human land use activities and biophysical processes in these systems have been assessed. Bioenergy certification schemes seem to demonstrate compliance with underlying legislation, such as the EU Renewable Energy Directive, rather than ensure environmental sustainability. Beyond, certification schemes often lack a methodology or thresholds for sustainable biomass use. Lacking thresholds, imprecise causal links and incomplete indicator sets may hamper comparisons of the environmental performances of different feedstocks. To enhance existing certification schemes, we propose combining the strengths of several certification schemes with research-based indicators, to increase the reliability of environmental assessments.

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Abbreviations

CSBP	Council on Sustainable Biomass Production
C&Is	criteria and indicators
DPSIR	driving forces – pressures – states – impacts – responses
ESS	ecosystem services
EU RED	EU Renewable Energy Directive
FSC	Forest Stewardship Council
GBEP	Global Bioenergy Partnership
GlobalGAP	Global Good Agricultural Practice
GGL	Green Gold Label
IWPB	Initiative Wood Pellet Buyers
ISCC	International Sustainability and Carbon Certification
LU/LUC	land use and land-use change
NTA	Netherlands Technical Agreement
PEFC	Programme for the Endorsement of Forest Certification
RSB	Roundtable on Sustainable Biomaterials
SAN	Sustainable Agriculture Network
SEM	standard error of the mean
SOC	soil organic carbon
SFI	Sustainable Forestry Initiative

1. Introduction

Bioenergy is receiving increasing attention because it is assumed to be associated with the following major advantages over fossil fuels [1-4]:

- Reduction of greenhouse gas (GHG) emissions and strengthening of the environmental sustainability of energy provision
- Securing and diversifying the energy supply
- Positive socioeconomic impacts such as increased energy access in developing and jobs in developed countries

The arguments in favor of bioenergy can be summarized under the concept of sustainability as defined by the Brundtland Commission [5]. The aspects listed above show that several dimensions of sustainability are of importance, namely the economic, environmental and social dimensions [6]. According to neoclassical theory, economic sustainability is ensured through market mechanisms [7]. Environmental and social sustainability are often not ensured through these mechanisms and require government interventions, for example, quotas for bioenergy or subsidies to overcome market failures [8]. Even if environmental and social sustainability are considered for bioenergy, Robbins [9] stated that it is currently unclear how to assess the sustainability of bioenergy from both environmental and socioeconomic perspectives.

The major environmental impact categories of bioenergy feedstock production have been summarized to GHG emissions, air pollutants, soil quality, water quality, water availability or quantity, biodiversity and land-use and land-use change (LU/LUC) based on scientific literature [10–13] and broader stakeholder panels [14]. To a great extent, the environmental sustainability of bioenergy production systems is evaluated with well established life-cycle assessments (LCAs), assessing large-scale or globally occurring environmental effects, such as GHG emissions or air pollutants, along the major steps of the supply chain [10,15]. The highly site-specific and locally/regionally occurring environmental impacts of feedstock production in the first step of most of the bioenergy supply chains are difficult to assess in LCAs. Impacts on soil quality, biodiversity and land use change, water availability and water quality [16,17] are often insufficiently covered. These limitations comprise necessary but missing regional thresholds to ensure the stability of the ecological system. Such thresholds are not easily integrated into highly standardized LCAs. Existing LCAs assessing environmental impacts often disregard the interaction for example between different regulating ecosystem services (ESS) and biodiversity, such as the buffering capacity of environmental impacts of agriculture or forestry [18,19]. In the context of bioenergy feedstocks and sustainability, this type of assessment of interactions is supposed to extend the EU RED, i.e., the provision of "basic ecosystem services" such as erosion control should be accounted for if biomass is produced for bioenergy [20]. Dale et al. [21] recommend to determine water quality and soil quality impacts of bioenergy feedstock production in addition to LCAs, e.g., nutrient export to water bodies or soil loss. A regional water quality assessment will more likely allow to determine, whether regional thresholds of nutrient exports that ensure good ecological status of water bodies are met.

Site-specific and flexible options for the assessment of local/regional environmental impacts and other aspects of sustainability could be sets of criteria and indicators (C&Is) as used in certification schemes. Such a site-dependent audit approach allows assessing the environmental impacts and their interactions mentioned above. C&Is are currently under development or are at an early stage of implementation for bioenergy but have been extensively applied for a longer period to other products from forestry or agriculture. Examples of C&Is are the Forest Stewardship Council (FSC) for timber or the Sustainable Agriculture Network (SAN) as a label for Good Agricultural Practices [2]. Especially FSC provides nationally or regionally adapted indicator sets [22]. Several bioenergy certification schemes are used to demonstrate compliance with the EU Renewable Energy Directive 2009/28/EC (EU RED) [23].

Despite the common aim of EU RED compliance for most of the bioenergy schemes, an increasing number of alternative schemes may contribute to confuse stakeholders and decrease the acceptance of certification schemes in general [24,12]. On the one hand, comprehensive and clearly defined requirements may exclude producer groups [2], e.g., in developing countries, and augment certification costs due to increasing effort, such as audits. On the other hand, vaguely defined and less comprehensive schemes may allow for a higher market penetration, but more likely disregard major environmental or social impacts and are not acknowledged by NGOs [25,26]. An increase in EU imports of biomass for bioenergy might induce or enhance deforestation in countries