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Social sustainability assessments in the biobased economy: Towards a systemic approach

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ABSTRACT

The majority of impact assessments for the biobased economy are primarily focused on the environmental and (techno-)economic aspects, while social aspects are rarely considered. This study proposes a modified systemic approach for a social sustainability impact assessment of the biobased economy, based on a review on the common methodologies for assessing social impacts. Accordingly, the proposed approach follows the four general iterative steps of social life cycle analysis (SLCA) as it considers all life cycle phases of the biobased economy. The systemic approach considers the potential social impacts on local communities, workers, and consumers as the main three groups of the stakeholders. The review showed that the most common social indicators for inventory analysis within the biobased economy include health and safety, food security, income, employment, land- and worker-related concerns, energy security, profitability, and gender issues. Multi-criteria decision analysis (MCDA) was also highlighted as the broadly utilized methodology for aggregating the results of impact assessments within the biobased economy. Taking a life cycle perspective, this study provides a holistic view of the full sustainability of research, design, and innovation in the biobased economy by suggesting the integration of the social aspects with techno-economic and an environmental life cycle assessment. Our proposed systemic approach makes possible to integrate the social impacts that are highly valued by the affected stakeholders into the existing sustainability models that focus only on environmental and techno-economic aspects. We discuss the steps of the proposed systemic approach in order to identify the challenges of applying them within the biobased economy. These challenges refer mainly to the definition of the functional unit and system boundaries, the selection and the analysis of social indicators (inventory analysis), the aggregation of the inventory to impact categories, and the uncertainties associated with the social sustainability evaluation. The result of this review and the proposed systemic approach serve as a foundation for industry and policy makers to gain a better insight into the importance of social sustainability impacts assessment within the biobased economy.

1. Introduction

The biobased economy is one that utilizes 'green' materials instead of fossil-based materials to generate energy, chemicals, transport fuels, and other biobased products [1]. Within such an economy, sustainability and the efficient use of resources are the key components of social and industrial implementations [2]. In this regard, production of bioenergy and biobased products and services is expected to increase.

Abbreviations: AHP, Analytic Hierarchy Process; ETEA, Environmental Techno-Economic Assessment; ESMAP, Energy Sector Management Assistance Program; FAO, Food and Agriculture Organization; GBEP, Global Bioenergy Partnership; IUCN, International Union for Conservation of Nature; LCA, Life Cycle Assessment; MCDA, Multi-Criteria Decision Analysis; ORNL, Oak Ridge National Laboratory; PET, Polyethylene terephthalate; PSILCA, Product Social Impact Life Cycle Assessment; SEIA, Socio-Economic Impact Assessment; SHDB, Social Hotspots Database; SIA, Social Impact Assessment; SLCA, Social Life Cycle Analysis; UNEP-SETAC, The United Nations Environment Programme (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC); TOPSIS, Technique for Order of Preference by Similarity to Ideal Solution; TRL, Technology Readiness Level

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Also, the European Commission identified the biobased economy as a sector that has the potential to bring benefits for both the private sector and society [3]. In the present study, biobased products are defined as those that are entirely or partly extracted from biomass and converted using chemical, physical, and/or biological processes [4]. Biobased products may vary from high-value-added specialty chemicals used in cosmetics, pharmaceuticals, or food additives, to high-volume substances like bulk chemicals or fertilizers [5]. The biobased economy has helped Europe meet its target of an actual sustainable economy by creating a total of 520,000 direct and indirect jobs and a yearly turnover of around €78 billion [6]. If we want to further change a fossil-based economy into a biobased economy, we must take into account that production location, storage, refining, and transportation need to be restructured [1]. This restructuring implies that new investments in infrastructure will have to take place. In order to convince the society that these costs are justified, we should assess the sustainability of the biobased economy.

Sustainability is comprised of environmental, economic, and social aspects [7,8]; all three aspects should be taken into account when assessing the sustainability of the biobased economy. There are numerous concerns with regard to the social (such as labor and human rights, health issues, and food safety), economic (such as local welfare and job creation), and environmental (such as biodiversity, global warming, and water quality) impacts of producing biomass on large scales [9]. Therefore, a suitable sustainability impact assessment approach is required. However, most existing sustainability impact assessments assess only the environmental [10–13] or economic impacts [14–16] of the biobased economy. Although some efforts have been made to integrate social aspects into the sustainability impact assessment of the biobased economy [17–21], there is no consensus on a standardized approach with which to evaluate the social impacts at different scales [22]. Also, social issues are not always measurable in quantitative terms, so they have been dropped from many sustainability evaluation studies. Importantly, there is a lack of social data regarding the use of biomass in comparison with data available for the environmental aspect of sustainability [23,24]. A precise sustainability evaluation calls for an evaluation of the balance between biomass usage in, for example, biorefineries and the need for safe food and feed, along with the conservation of natural resources, mainly water, soil, and biodiversity [25]. Furthermore, the indicators that are considered in some existing social sustainability impact assessments of the biobased economy vary along with the goal and scale of the study. For example, Elghali et al. [26] developed a sustainability approach for evaluating the life cycles of bioenergy systems at the system level, only taking into account social acceptance as an indicator of social impact. Assefa and Frostell [27] considered only three social indicators (acceptance, fear, and knowledge) in their evaluation of the sustainability of energy technology systems. An example at the local level is Foolmaun and Ramjeeawon's [28] study of four disposal alternatives of PET bottles in Mauritius, with seven social indicators for the analysis and comparison of its life cycle social and environmental impact.

Based on the above, we can conclude that there is a need to develop a general social sustainability impact assessment approach that allows integration with existing economic and environmental assessment approaches in order to result in an overall sustainability impact assessment approach (that is, one that includes economic, environmental and social aspects). Therefore, as a first step, we developed such a general social sustainability impact assessment approach for future research in different scales, whether internationally, nationally, locally or company-focused. The intention is to integrate this approach with an environmental techno-economic assessment (ETEA), which is based on the integration of a techno-economic assessment and an environmental life cycle assessment as proposed by Thomassen et al. [29]. Integrating the social aspects with an ETEA provides a holistic insight into the full sustainability related to research, design, and innovation in the biobased economy. Accordingly, the main goal of this study is to provide a modified systemic approach for evaluating the social impacts, in order to incorporate them into the ETEA. A comprehensive review process to achieve this goal is explained further in the following section.

There are three main goals for this study, which also reflect the structure of this paper: (i) provide an overview of the main methodologies for assessing social impacts and identify which of them has the most promising methodological features to be applied in the biobased economy, (ii) define a modified systemic approach for evaluating the social impacts in order to incorporate them into the ETEA, and (iii) identify the challenges for each step of the proposed systemic approach in the context of the biobased economy. The main focus for these challenges is on the inventory analysis. We consider a range of frameworks that have already been applied in order to identify and classify the main social indicators along the entire life cycle for the assessment of the social impacts in the biobased economy. We then compare some recent empirical studies that have applied these frameworks within the biobased economy in order to identify the main elements that need to be taken into account throughout data collection for inventory analysis of the biobased economy. We conclude with recommendations for future research.

2. Methodology for constructing the literature review process

To address the goals of the study, we searched a number of databases, including the ISI Web of Knowledge, Web of Science, Google Scholar, and Science Direct, to identify review papers and original publications between 1990 and 2016 on social impacts evaluation, and sustainability assessment frameworks for the biobased economy. The searching process also included grey literature such as academic theses and dissertations, and official reports on (social) sustainability impact evaluation methodologies, both on a general level and specifically within the biobased economy. We identified a total of 103 studies and reports from the databases. The topics and abstracts of the papers and documents were first reviewed to exclude the duplicates and to identify whether they are suitable for meeting the mentioned goals of this review paper. The decision for including papers was based on two criteria: (i) the focus on 'social aspects' of the biobased economy and (ii) the focus on sustainability assessment frameworks and methodologies. Accordingly, 44 studies were identified as relevant and included for further analysis. Afterwards, we also screened the reference lists of the selected publications for additional suitable publications, based on which 15 peer-reviewed articles were included in the review study. Finally, we included 59 papers and documents to conduct a comprehensive review on the social sustainability assessment within the biobased economy.

3. Review of the main methodologies for assessing social impacts

This section starts by discussing the social sustainability concerns within the biobased economy, highlighting the need to develop methodologies for monitoring the potential social impacts to help decision-makers evaluate their industry's performance. We then compare different methodologies applied for evaluating social sustainability impacts in order to identify a suitable approach for conducting social sustainability assessment within a biobased economy.

3.1. Social sustainability within a biobased economy

There is no universally accepted definition of social sustainability. As Valente et al. [30] stated, it is quite challenging to define social sustainability since its meaning is not obvious. According to Black [31], social sustainability is "the extent to which social values, social identities, social relationships and social institutions can continue into