Development of an Advanced Method for Conducting a Social Life Cycle Assessment

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Abstract: The value placed on the social sustainability of agricultural value chains has greatly increased in recent years. Although social life cycle assessment (SLCA) is often suggested as the appropriate method of evaluation, it continues to be characterized by two essential problems: First, the sets of indicators are insufficient to provide all the socioeconomic information requested by relevant stakeholders; second, there is no way to objectively measure qualitative socioeconomic aspects. This paper introduces a new survey-based approach to carrying out an SLCA and demonstrates its potential by referring to the biogas supply chain for the supply of electricity.

Keywords: Social Life Cycle Assessment, Life Cycle Sustainability Assessment, socioeconomic evaluation, biogas

1 Introduction

Anthropologically induced climate change is one of today's greatest challenges. It is important to face this challenge and find adaptation strategies [28]. In the course of the implementation of such strategies, aspects of sustainability must be considered. So far the evaluation of adaptation strategies has been carried out mainly by taking into account ecological and economic impacts. With regard to renewable energy production, a particular criticism has been that socioeconomic aspects have not been given enough attention [1]. For a comprehensive evaluation of sustainability, a holistic view ("people, planet, profit") is necessary. The idea of a holistic life cycle–oriented approach forms the conceptual basis of the life cycle sustainability assessment (LCSA), which collects data on the three pillars of sustainability (economic, social, and ecological aspects; [2, 3]) and evaluates products and production methods as well as entire supply chains according to these three criteria [4]. An analysis of life cycles with an ecological or economic emphasis can be carried out using a life cycle assessment (LCA) and a life cycle costing (LCC), both of which are established methods of evaluation. A number of approaches have been developed to evaluate social sustainability; these include such as certification systems (e.g., Fairtrade), codes of conduct and management system standards (e.g., ISO 26000). However, these methods provide only a very limited evaluation of the various aspects of social sustainability. For this reason, the social life cycle assessment (SLCA) has been suggested as a holistic method which could be applied as a third pillar of LCSA. However, due to methodological shortcomings, its application is far from established, and the method is still considered to be in its infancy [29]. In light of a geographically and temporally highly variable socioeconomic environment, two problems in particular hinder its application [5]: One involves the generation of sets of indicators that provide the necessary socioeconomic information meeting the needs of all relevant stakeholders; the other is the lack of methods by which qualitative socioeconomic aspects can be measured objectively.

This paper gives an overview of the development of a method for conducting a thorough SLCA. We first give an overview of other social management tools. In section three the paper continues by outlining the basic concept of the SLCA and then describing some of its methodological problems. The fourth section introduces the development of the modified method, and section five demonstrates an application of SLCA with the help of a case study.

The concluding section comments on the potential use of SLCA and offers suggestions for further research.

2 Social management tools

Prior to the development of SLCA, other tools for the assessment of sustainability and social aspects of products and processes were used. These instruments include labels, codes of conduct, management systems and the concept of corporate social responsibility (CSR) [6]. All these earlier social management tools are used to measure aspects of sustainability in a business context. They have in common that they cover only certain aspects of social sustainability.

The purpose of labels is to improve the terms of trade between developing and industrialized countries [6] or, more specifically speaking, the social conditions of workers and producers along the supply chain. The “fair trade label” issued by the Fair Trade Labelling Organizations International (FLO) is an example of this approach. Products that are certified as “fair trade” need to fulfill certain criteria; if they do so, they are awarded a label that is shown on the product. The fair trade label is frequently used for agricultural products generally associated with poor working conditions and low and often highly volatile prices for producers, such as coffee, cocoa and honey. The focus of the fair trade label is social aspects like conditions of employment, prohibition of child labor and compliance with the non-discrimination rule; economic aspects like advisory service, payment of minimum prices and long-term trade relations; and ecological aspects such as ecologically friendly cultivation, prohibition of genetically modified organisms and encouragement of wholefood products. The label addresses these problems and helps to improve payment and production conditions that lead to better health of workers and producers. Other social aspects are not involved [7].

Codes of conduct are another social management tool for companies. They provide guidance on how to behave as a business. In recent years, codes of conduct have been established by many organizations [6]. One example is the UN Code of Conduct. It is a global initiative that includes ten principles summarized under four main topics: human rights, labour, environment and anti-corruption. Through the implementation of the UN Code of Conduct, organizations commit themselves to complying with the principles [8]. Codes of conduct are often minimum standards that are also required by law. A company that has agreed to comply with the UN Code of Conduct has to publish an annual report on its activities, demonstrating its compliance. The report is effective only if combined with external independent monitoring of the reported information.

There are some management systems that help to provide guidance and certification in a sustainability context, for example, ISO 26000 and SA 8000 [6]. The ISO 26000 Standard provides guidelines for social behavior. The Social Accountability Standard SA 8000 is based on the conventions of the International Labor Organization (ILO). The standard was developed in the USA by Social Accountability International (SAI). Its general aim is to improve working conditions and products can be certified according to this standard. The criteria of SA 8000 are similar to those of the UN Code of Conduct but the criteria are more clearly defined and evaluated by external independent auditors. SA 8000 is widely spread among companies. It is advantageous that the same criteria are applied to all companies,

independent of local conditions, and that the criteria are fixed and cannot be modified. Thus, they are comparable and using the standard is effective if social impacts are kept in line with the criteria used in SA 8000 [9].

Corporate social responsibility (CSR) is the commitment of firms to behaving ethically and contributing to economic development while improving the quality of life of the workforce and their families as well as of the local community and society at large [10]. CSR is a broad and not yet consistently defined concept. The various definitions agree that it is the goal of CSR for firms to voluntarily behave with greater social responsibility in order to contribute to sustainable development [6]. CSR is commonly broken down into three areas: internal responsibility (company), medium responsibility (supply chain of the company) and external responsibility (not related to supply chain, society as a whole).

Independent of the social management tools mentioned above, there are various industry initiatives that promote and evaluate social attributes. The Seebalance® programme by BASF, for instance, is a tool for eco-efficiency and social impact analysis. It assesses the environmental, economic and social impact of industry products and processes [12]. Another BASF approach is AgBalance, which is a holistic method for life cycle assessment in agricultural and food value chains based on the three pillars of sustainability. For each pillar 69 indicators are defined. AgBalance helps to reduce social complexity to enable clear conclusions and arrive at a sustainability score. A more recent sustainability initiative, developed by the German retailer REWE, is PRO PLANET, which addresses ecological as well as social aspects of food production.

3 Process and Problems of Social Life Cycle Assessment

Efforts to develop a concept for a holistic socioeconomic evaluation have been advanced not only by researchers but also by the aforementioned business initiatives. Often the time-tested parameters from the LCA (ISO 14040: Environmental Management – Life Cycle Assessment – Principles and Frameworks) are suggested as guidelines for an SLCA. The Life Cycle Assessment—also known as eco-balance or ecological balance sheet—comprises three steps.

The first step is to determine the goal and parameters of the research. The research goal serves as a guideline during the design of the research study. The preliminary considerations include the definition of the functional unit, the determination of the process chain to be analyzed and the selection of informative environmental indicators. The functional unit is the measure to which the collected ascertained outcomes will be applied, for example, a kilowatt hour of electricity. The determination of the functional unit is the key to guaranteeing the comparability of various products, for instance, electricity from fossil, nuclear and renewable sources. Similarly, the definition of the process chain enables differentiation between the product system and the natural environment. In this way, it determines the parameters of the study [14]. Indicators for describing environmental effects can include climate-relevant gas emissions, various water pollutants or other effects on the environment.

The resulting life cycle inventory analysis serves to detect specific environmental effects of the process chains under analysis. This second research step requires by far the greatest effort, for the raw material and energy flow requirements must be determined for each

individual process. The total balance can then be gained by adding the values of the individual processes [15].

The third stage is the so-called assessment of effects, during which the effects on the environment are evaluated. In this step, environmental indicators with a similar effect are aggregated in order to reduce complexity [14]. The depiction and evaluation of the results of the individual stages include all phases of the process chains. The presentation and evaluation of the results must conform with the goals and recipients of the study [16].

The most comprehensive SLCA approaches are the social components of the holistic balancing methodology PROSA (Product Sustainability Assessment of the Institute for Applied Ecology) in Freiburg, Germany, as well as the guidelines of the UNEP for the implementation of SLCA. Both approaches are oriented on the above-mentioned standardized procedure of LCA [17]; therefore, they comprise the determination of goal and research parameters, the compilation of a life cycle inventory analysis and the evaluation and interpretation of this analysis [4]. Unless otherwise indicated, the study below follows the UNEP guidelines for carrying out an SLCA [18]. They clarify the procedure as well as the methodological difficulties of carrying out an SLCA.

Definition of Goal and Determination of Study Parameters

The first step of the UNEP approach is to determine the goal and parameters of the study. As in the LCA, the general parameter, functional unit and balancing depth must be defined [17]. In addition, relevant indicators must be chosen. In practice, this means that, due to the frequent lack of existing valid and reliable social indicators, the indicators must be derived from regulated minimal standards or international agreements on social standards. Due to the large number of potential indicators—a result of the holistic perspective—it has been proved valuable to aggregate the indicators into influence categories. For example, the UNEP guidelines and the PROSA methodology differentiate between the various effects on society, consumers, the regional populace, employees and future generations [18]. The meta-analysis of corresponding collections of indicators conducted by JØRGENSEN et al. [19] clearly shows that these groups are also considered by most of the other approaches. Existing sets of socioeconomic indicators are found not only in the PROSA approach [13, 17] but also in the SEEbalance approach developed by BASF [20] and in the sustainability label described by SPILLEMAECKERS et al. [21].

Life Cycle Inventory Analysis

In a life cycle inventory analysis, the product system is modelled and determined with regard to the goal and study parameters, considering where and under which conditions (socioeconomic environment, participating organizations) the process flow occurs. The determination and life cycle inventory analysis of individual indicators is easy when only quantitative indicators such as work hours are concerned, but much more complicated when meaningful and operational indicators for qualitative aspects such as corruption or transparency have to be identified. Quantitative data, such as the number of job-related accidents, can simply be taken from employers' records—as is usual in Life Cycle Assessment—and applied to an individual functional unit. In contrast, for the measurement of

qualitative indicators, which often comprise the majority of socioeconomic indicators, a considerable need for research remains [18]. The value of qualitative indicators is often determined through the examination and inspection of company documents, reports from governmental agencies and non-profit organizations, investigations on site, interviews and surveys. More recent approaches have heavily relied on expert interviews [30]. The various sources of data can provide a comprehensive, but also contradictory, picture. In any case, stakeholders must be involved in this process in order to critically discuss conflicting research results and evaluations [22]. A severe disadvantage of qualitative data is that it is difficult to apply it to a functional unit. For example, it is difficult to relate corruption to a single product. Because of this problem, the PROSA instrument has attempted to accurately determine qualitative data and place them in groups on a scale under the label *Sociograde* [13].

Estimation of Effect and Evaluation

The estimation of effect is based on the information gathered during the previous steps. There is no definite recommendation as to how the steps estimation of effects and evaluation should be carried out; however, there is a widespread orientation towards the procedural guidelines of the LCA [18].

4 Development of an Advanced Social Life Cycle Assessment

Especially in regard to the selection of relevant socioeconomic indicators and their evaluation/measurement, there is an extensive need for further development of the SLCA methodology. The approach described below solves the problems which have widely prevented the large-scale application of the SLCA approach up to now by using quantitative empirical studies in order to identify relevant socioeconomic indicators and measure the value of individual indicators while maintaining the established phases of the LCA. In addition, it is recommended to also conduct an empirical study to determine reference value chains in order to provide a basis for interpreting and assessing results.

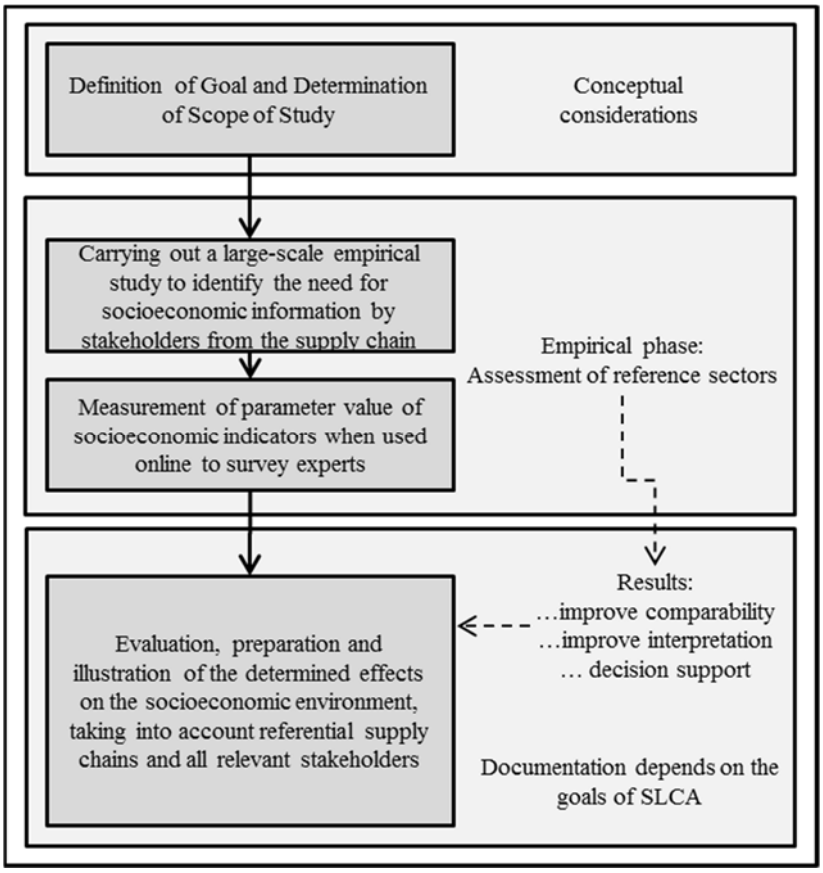

Figure 1: Advanced Social Life Cycle Assessment Approach

Definition of Goal and Determination of Scope

After defining the goal and parameters of the study, the first step is to determine the purpose of the research and the recipients of the study. The selection of such study guidelines is an important preliminary decision; depending on the purpose of the study, a regionally differentiated view of hypothetical value chains can be as much the focus of the study as the evaluation of an actual value chain. The establishment of a functional unit in the development of the process model supports the determination of the study parameter and, as necessary, the identification of the participating enterprises.

Identification of socioeconomic indicators

The next step involves deciding on the relevance of socioeconomic indicators. This step can be omitted if there is a validated set of indicators from a previous study available, for example, one that was used to evaluate the same value-added chain in another region. If no validated set of indicators exists, all potential indicators are collected that might be relevant to the aim of the research. Potential sources of information include legal minimum standards and international agreements on social standards, the literature, criteria from examining organizations and existing SLCA approaches. Additional socioeconomic indicators may be derived from the demands of citizen's initiatives, cooperatives, political representatives, or preliminary studies. Those indicators which would obviously have no application in the product life cycle under observation in the particular case at hand (e.g., child labour in Germany) are then expunged from this collection of potentially relevant indicators. The

resulting compilation of indicators is aggregated for reasons of research economy, reducing them to the number to be used in the life cycle inventory analysis. To do so, the indicators are first ordered according to the stakeholder group influenced by them (e.g., employees). Within these categories of influence, individual indicators (e.g., work hours, vacation benefits) are grouped together in subcategories (e.g., here: free time). Then, using the final selection of individual indicators, a survey is developed that can be used for sample testing in the context of a large-scale study in order to validate the indicators identified as well as to test the reliability of the devised subcategories.

Measurement of parameter value

The measurement of the strength of the subcategories deemed relevant occurs in the actual life cycle inventory analysis. Since it is currently impossible to objectively measure and evaluate qualitative indicators, an empirical study is carried out. In the context of this research, the subcategories are given to a sample of experts for evaluation. Experts are defined as persons qualified because they reflect a certain level of knowledge about or have definite experience with specific aspects of the product life cycle in question. In the sample testing, experts are asked to evaluate the chosen socioeconomic subcategories of the product life cycle under observation using a Likert scale. The questionnaires are statistically assessed, and the results are used in the evaluation of the product life cycle or value chain. Furthermore, in order to facilitate subsequent ordering of the results of the analysis, the life cycle inventory analysis can include a description of a socioeconomic environment that was discovered as a result of internet research (desktop screening). An example might be enterprises in developing countries, which, generally speaking, cannot begin to fulfil the minimal standards of industrial nations in regard to working conditions, but which, in light of the socioeconomic reality in their own country, must receive a positive rating simply due to the fact that they provide employment for the local population.

Evaluation of reference chains

At the same time, the evaluation of up to two reference supply chains or value-added chains is requested in order to provide a foundation for comparison and assessment in the later interpretation step. The evaluation of reference chains also makes it possible to better order and interpret the results gained from the questionnaires. Generally speaking, it is possible to create a comparative evaluation and a graphic representation, perhaps in form of network diagrams, of the socioeconomic effects of products, production methods and entire value chains.

Thus, various sources of data can be utilized in carrying out the actual socioeconomic evaluation. In this way, determining relevant indicators also provides a selection of socioeconomic indicators that reflect the socioeconomic demand profile of the society and the object of study. In addition, data retrieved through online and other research as well as the results of the expert survey are available.

5 Case Study

The main research goal of the case study is to demonstrate the applicability of the advanced SLCA approach. It includes a socioeconomic evaluation of the biogas supply chain for the

supply of electricity. The study examines the agricultural production of the biomass, its transportation to and fermentation in a biogas production facility, and the subsequent conversion of the biogas into electricity. In addition to the production of biogas, the socioeconomic aspects of short rotation coppices and wheat supply chains will be evaluated. The reference chains should improve the interpretation and comparison of results.

In this particular case, the 19 criteria for evaluation of biogas production are based on a qualitative study of the relevant literature on renewable energy production. The proposed preliminary socioeconomic indicators were then tested [23] in an empirical survey conducted at the end of 2012 with 307 participants who represented relevant stakeholder groups. The process of evaluation takes place within the SLCA, which is based on expert feedback. To this end, a partially standardized online survey is utilized. Experts are found via online research in connection with trade associations, industry experts and enterprises, as well as regulatory bodies and scientific communities. Keeping equal representation in mind, a total of 88 responded to the survey, which was carried out between February 2013 and July 2013. The expert survey consisted of two parts: The first focused on localization and self-appraisal of the experts' own expertise regarding the supply chains being studied. The second was the actual evaluation. This part was divided into thematic sections (e.g., employees, society, regional population) and requested a comparative judgment of socioeconomic criteria using seven-step Likert scales. It also offered the opportunity to add a qualitative verbal socioeconomic evaluation of the supply chains under analysis. The standardized survey portion was analyzed using descriptive statistical methods (means comparison, significance test [Tamhane-t2]) [24]. (See Table 1.) The qualitative part of the survey was subjected to a qualitative content analysis [25, 26, 27].

Table 1: Example of evaluation of renewable energy sources from the perspective of the regional population (expert survey)

Perspective of the regional population (n=68-86)[1]	Biogas	SRC	Wheat
Effects on the environment ***a c	-0.34	1.05	-0.10
Relationships with regional population ***a **b	-0.13	0.43	0.35
Changes to the landscape ***a b	-0.79	0.49	0.21
Effects on the lifestyle of neighbours ***a b **c	-0.88	0.51	0.09
Regional economic effects	0.55	0.51	0.39
Potential for conflict ***a b	-1.00	0.14	0.38
Effects on tourism ***a ** c	-0.48	0.39	-0.05

*Test of significance between groups: a= biogas – SRC, b= biogas – wheat, c= wheat SRC, *p ≤ 0.1; ** p ≤ 0.05; *** p ≤ 0.01. -3= negative influence to +3= positive influence.*

[1]= Fluctuations due to missing data

6 Perspectives for Further Research

The biogas case study has demonstrated the practicability of the advanced SLCA approach for the socio-economic evaluation of products and processes. The proposed method for carrying out an SLCA guarantees that a profile of social demands will be addressed by carrying out a large scale empirical study to identify relevant socioeconomic evaluation criteria. In a second step, it also uses expert knowledge gained through a survey of experts to measure the actual values of the indicators identified in the first step. A further innovation is the parallel analysis of reference chains, which facilitates the assessment and interpretation of the empirical results. The newly introduced methodological elements (stakeholder survey, expert interviews) have already proven themselves in the social assessment of energy systems [30] outside the context of an SLCA (or other lifecycle-based methodology).

In the long run, it is possible to develop a computer-based SLCA tool that integrates a database. The database stores evaluation results that can be retrieved for further socioeconomic analyses of products and processes. This would significantly reduce the efforts and expenses required for future SLCA analyses. It would also allow cross-sectional and longitudinal studies of socioeconomic effects. Furthermore, the results stored in the database could be used as the basis for evaluation and comparison in further SLCA. In addition, the results of empirical studies for the identification of relevant socioeconomic indicators of diverse value chains could be stored in the database. When a sufficient number of products or processes with the corresponding socioeconomic indicators have been collected, further studies can largely forego the step of empirically determining appropriate indicators.

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