Journal of Cleaner Production 69 (2014) 34–48

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Application challenges for the social Life Cycle Assessment of fertilizers within life cycle sustainability assessment

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ARTICLE INFO

Article history:
Received 21 February 2013
Received in revised form
7 January 2014
Accepted 12 January 2014
Available online 23 January 2014

Keywords:
Fertilizer
Compost
Sustainability
S-LCA
UNEP/SETAC guidelines
SHDB
Working time

ABSTRACT

The paper explains and discusses the challenges confronted during the application of the Social Life Cycle Assessment (S-LCA) methodology defined by UNEP/SETAC S-LCA guidelines in a case study under the framework of Life Cycle Sustainability Assessment (LCSA). The environmental, economic and social aspects related to two mineral fertilizers and one industrial compost were assessed. The system boundaries of the LCSA study included fertilizer production and transportation and certain stages of cultivation. Regarding S-LCA, background and foreground processes were taken into account. The Social Hotspots Database (SHDB) was used to include social aspects related to background processes. Following the approach of Life Cycle Attribute Assessment – proposed, e.g., in the S-LCA Guidelines – the amount of working time that had been spent on each unit process was used to aggregate the social aspects over the life cycle. This work is one of the first examples for applying the S-LCA Guidelines within the LCSA framework, as well as for using SHDB in a real case study. The comparability and reliability of the S-LCA results were highly challenged by the definition of the functional unit and the system boundaries, the choice of stakeholders and indicators, the use of working time for aggregating social aspects and the data availability among others. Regarding the latter, it is necessary to find a balance between the use of site-specific primary data and generic data to include the entire life cycle. In addition, for many social indicators, no definition of the social targets to achieve is currently agreed upon in the international community. Thus, a complete and robust interpretation of the S-LCA results is not yet possible because of the many methodological obstacles faced. However, because the social dimension plays a major role in sustainability assessment, and as there is no commonly agreed methodology, every effort to advance the application for S-LCA is highly recommended.

1. Introduction

Sustainability describes development "that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Sustainability comprises three 'pillars' – environment, economy and society – which are addressed by Life Cycle Sustainability Assessment (LCSA) from a life cycle perspective (Finkbeiner et al., 2010). While LCSA is generally accepted conceptually (UNEP/SETAC, 2011), the application experience through real case studies is still very limited.

The maturity of methodologies and tools, under a life cycle framework, is different for the three sustainability dimensions. Whereas the environmental dimension can be covered quite well today with environmental Life Cycle Assessment (E-LCA) (ISO, 2006; JRC and IES, 2010), the economic and social methodologies still require fundamental scientific progress (Finkbeiner et al., 2010; Kloepffer, 2008).

Regarding Life Cycle Costing (LCC), the life cycle thinking methodology for evaluating of the economic dimension, a handbook and code of practice exists (Hunkeler et al., 2008; Swarr et al., 2011). However, only few case studies are available relating LCC to LCSA (e.g., Schau et al., 2011). Generally, three main challenges are

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http://dx.doi.org/10.1016/j.jclepro.2014.01.044

reported. First, different perspectives for the assessment can be used. Second, data are very volatile, and third, no agreements on external costs quantification have been made (Finkbeiner et al., 2010; Kloepffer, 2008; Swarr et al., 2011).

The Social Life Cycle Assessment (S-LCA) approach used here is described as "a social impact (and potential impact) assessment technique that aims to assess the social and socio-economic aspects of products and their potential positive and negative impacts along their life cycle" (UNEP/SETAC, 2009). According to the Guidelines for Social Life Cycle Assessment of Products (UNEP/SETAC, 2009) – henceforth, S-LCA Guidelines – the current challenges in S-LCA refer, e.g., to the selection and the analysis of social indicators, the definition of the functional unit and system boundaries, and the impact assessment. Indicators that are appropriate for a particular case study have to be identified from the numerous social indicators available in literature. The indicator analysis in S-LCA is generally challenging as databases comparable to those available for E-LCA are lacking. Moreover, on-site company data collection for processes along the life cycle of a product is highly time demanding and not always feasible (Ciroth and Franze, 2011; Finkbeiner et al., 2010; Jørgensen et al., 2008; Kloepffer, 2008; Swarr, 2009).

Jørgensen et al. (2008) stated that social impacts[1] are hardly determined by physical flows but instead mainly by the way company conduct toward its stakeholders. Therefore, it is the company rather than the process which is the fundamental unit (Hauschild et al., 2008). Consequently, a relation of social aspects to a functional unit and their aggregation over the entire life cycle of the product, as performed in E-LCA, is hardly feasible. The S-LCA Guidelines establish two different approaches for the evaluation of social aspects and for relating them to the product system (Parent et al., 2010). Following the Life Cycle Attribute Assessment approach, Norris (2006) among other authors, used an aggregation conducted by use of working time.

There has been much theoretical discussion about how to perform a S-LCA, but there are few practical studies applying it in a comprehensive manner. Several studies dealing with methodological and practical questions for S-LCA have been published (e.g., Dreyer et al., 2010; Hunkeler, 2006; Jørgensen et al., 2008, 2012; Lehmann et al., 2013). To the best of our knowledge, apart from the current paper, only a few other S-LCA studies have assessed agricultural systems (Andrews et al., 2009; Franze and Ciroth, 2011). A S-LCA case study of fertilizers has not been conducted yet, and more importantly, no case study thus far considers all background processes or, at least, not all the relevant ones. Although Ciroth and Franze (2011) and Ekener-Petersen and Finnveden (2013) provided a detailed explanation of a complex product during its entire life cycle, they did not include many relevant background processes such as energy generation, distribution and transportation. Including background processes is crucial as LCSA ideally intends to have the same system boundaries for the three dimensions.

Similarly, few attempts can be found for LCSA application (Lindner et al., 2010; Basurko and Mesbahi, 2013; Lehmann et al., 2013; Vinyes et al., 2013). Traverso et al. (2012a) proposed Life Cycle Sustainability Dashboard (LCSD) for representing the results of the environmental, economic and social performance[2] of a product within a LCSA framework. This tool was applied in few examples (Capitano et al., 2011; Traverso et al., 2012b) and also recommended by the publication "Towards a Life Cycle Sustainability Assessment" by UNEP/SETAC (2011).

Regarding the environmental and economic performance of fertilizers, studies are already available by Martínez-Blanco et al. (2010, 2011a, 2011b, 2013b) for both mineral and organic fertilizers production and use in the Mediterranean area. From an environmental perspective, fertilization decisions are claimed to be very relevant, especially in agricultural system with low energy consumption, which are very common in temperate areas. From an economic perspective, little effect is detected when fertilizer decisions are assessed (Martínez-Blanco et al., 2013b; Torrellas et al., 2012). To reflect all dimensions of sustainability, this paper focuses on the social aspects of fertilizer production and use.

The paper examines and discusses the challenges of applying the S-LCA methodology proposed by UNEP/SETAC (2009, 2010) in a real case study and with the specific questions resulting from its use within the LCSA approach. Apart from discussing the challenges, the goal is to suggest possible solutions. We would like to note at the outset that the paper does neither intend to present a complete (i.e., including all the processes of the life cycle and all the subcategories defined by the S-LCA Guidelines) and robust (i.e., where all the challenges of S-LCA are solved) social assessment of fertilizers nor to provide S-LCA results that are strong enough for a clear decision support regarding alternative fertilizers. The paper explains and discusses step by step the potential application of S-LCA to three different type of fertilizers[3] and proposes possible solutions. This is performed under the umbrella of the LCSA framework (UNEP/SETAC, 2011), and thus, existing E-LCA and LCC studies on fertilizers are integrated as well. All of these constraints and the existing studies were considered when defining the scope of the S-LCA and LCSA.

2. Methodological approach

This part first defines the scope of the LCSA study (Section 2.1). In the following Sections (2.2–2.4), considerations for E-LCA, LCC and S-LCA are described. Finally, Section 2.5 presents the approach for LCSA.

2.1. Scope of the LCSA

More detail is provided here for the three fertilizer alternatives considered, and the functional unit, system boundaries and data sources for LCSA are presented, with a special focus on S-LCA.

2.1.1. Fertilization alternatives

Aiming to integrate social aspects into previous environmental and economic assessments of fertilizers (Martínez-Blanco et al., 2011a,b, 2013b), the same three fertilizer alternatives were compared here: compost, nitric acid and potassium nitrate. These fertilizers were applied by a farmer whose fields were located in Catalonia (Barcelona region, Spain). The two mineral fertilizers are common in Catalan horticulture, and interest in compost application is growing in the region.

Compost from the source-separated organic fraction of the municipal solid waste (OFMSW), which was collected from nearby municipalities and the area main market, was produced in an in-vessel composting plant with biofiltration of decomposition

[1] The term social impact is understood to be the actual experiences of an individual or community. As described in Vanclay (2002), some of the social aspects described by social indicators are already impacts (for example, 'Occurrence of occupational lethal accidents per year'), whereas other social aspects may lead to impacts when they undergo a change (for example 'Potential of sector not adopting labor conventions').

[2] The term social performance is used when indicator results (social aspects) are presented using certain criteria (see Section 2.4.3).

[3] The general term 'fertilizer' is used along the paper to refer to both compost and mineral fertilizers. Whenever we want to refer to mineral fertilizers the adjective 'mineral' is used.