Int J Life Cycle Assess (2010) 15:247–259
DOI 10.1007/s11367-009-0148-7

SOCIETAL LIFE CYCLE ASSESSMENT

Characterisation of social impacts in LCA

Part 1: Development of indicators for labour rights

Louise Camilla Dreyer · Michael Z. Hauschild · Jens Schierbeck

Received: 27 April 2009 / Accepted: 23 August 2009 / Published online: 9 February 2010

Abstract
Background, aim, and scope The authors have suggested earlier a framework for life cycle impact assessment to form the modelling basis of social LCA. In this framework, the fundamental labour rights were pointed out as obligatory issues to be addressed, and protection and promotion of human dignity and well-being as the ultimate goal and area of protection of social LCA. The intended main application of this framework for social LCA was to support management decisions in companies who wish to conduct business in a socially responsible manner, by providing information about the potential social impacts on people caused by the activities in the life cycle of a product. Environmental LCA normally uses quantitative and comparable indicators to provide a simple representation of the environmental impacts from the product lifecycle. This poses a challenge to the social LCA framework because due to their complexity, many social impacts are difficult to capture in a meaningful way using traditional quantitative single-criterion indicators. A salient example is the violation of fundamental labour rights (child labour, discrimination, freedom of association, and right to organise and collective bargaining, forced labour). Furthermore, actual violations of these rights somewhere in the product chain are very difficult to substantiate and hence difficult to measure directly.
Materials and methods Based on a scorecard, a multi-criteria indicator model has been developed for assessment of a number of social impact categories. The multi-criteria indicator assesses the effort (will and ability) of a company to manage the individual issues, and it calculates a score reflecting the company's performance in a form which allows aggregation over the life cycle of the product. The multi-criteria indicator model is presented with labour rights as an example, but the underlying principles make it suitable for modelling of other social issues with similar complexity and susceptibility to a management approach.
Results The outcome of the scorecard is translated for each impact category through a number of steps into a company performance score, which is translated into a risk of social impacts actually occurring. This translation of the scorecard results into a company risk score that constitutes the characterisation of the developed social LCA methodology. The translation from performance score to risk involves assessment of the context of the company in terms of geographical location and industry and of the typical level of social impacts that these entail, and interpretation of the company's management effort in the light of this context.

Preamble: The present paper is the first in a series of two. The paper presents a characterisation model based on multi-criteria indicators representing fundamental labour rights, which is implemented in six company case studies and evaluated on this basis in the second paper (Part 2: Implementation in six company case studies).

Electronic supplementary material The online version of this article (doi:10.1007/s11367-009-0148-7) contains supplementary material, which is available to authorized users.

L. C. Dreyer · M. Z. Hauschild (✉)
Department of Management Engineering,
Section for Quantitative Sustainability Assessment,
Technical University of Denmark (DTU),
Produktionstorvet Bygning 426,
2800 Lyngby, Denmark
e-mail: mic@man.dtu.dk

L. C. Dreyer
e-mail: lcd@man.dtu.dk

J. Schierbeck
Saxo Bank A/S,
Smakkedalen 2,
2820 Gentofte, Denmark
e-mail: jsc@saxobank.com

Discussion The developed indicators in social LCA are discussed in terms of their ability to reflect impacts within the four obligatory impact categories representing the labour rights according to the conventions of the International Labour Organisation (ILO) covering forced labour, discrimination, restrictions of freedom of association and collective bargaining, and child labour. Also their feasibility and the availability of the required data are discussed.
Conclusions It is concluded that it is feasible to develop indicators and characterisation methods addressing impacts related to the four obligatory impact categories representing the labour rights. The developed indicators are judged to be both feasible and relevant, but this remains to be further investigated in a separate paper in which they are implemented and tested in six separate industrial case studies.
Recommendations and perspectives The suitability of multi-criteria assessment methods to cover other social impacts than the obligatory ILO-based impacts is discussed, and it is argued that the combination of indirect indicators measuring a risk of impacts and direct indicators giving a direct measure of the impacts requires an explicit weighting before interpretation and possible aggregation.

Keywords Corporate social responsibility (CSR) · Human rights · International labour organisation (ILO) · Labour rights · Multi-criteria indicator · Site specificity · Social LCIA

1 Introduction

Social life cycle assessment addresses the impacts that a product has on people who interact with the life cycle of the product. In an earlier paper (Dreyer et al. 2005), we presented a framework for social life cycle impact assessment (LCIA). We made the point that in contrast to environmental impacts, which are related to the physical input and output of the processes in the life cycle of the product, impacts on people are related to the conduct of the companies engaged in the product chain. While environmental LCA is focused on the processes as the fundamental elements of the product system, social LCA must be focused at a higher hierarchical level—on the companies in which the processes occur, as illustrated in Fig. 1. Impact categories and indicators in social LCA must thus reflect the conduct of the companies engaged in the life cycle, towards the main stakeholders who are affected by their actions.

The intended application of our social LCA methodology is to support informed business decisions in a company (the manufacturer of the product) which has the aim to minimise harmful impacts on peoples' lives from the activities in the company's product chains. For this application, the focus of the methodology must be on those types of impacts that the company has a possibility to influence, and our social LCA is developed to facilitate companies to conduct business in a socially responsible manner. A methodology developed from a societal perspective rather than a company perspective might thus look different.

The social LCA result will reflect the risk that a company conducts its business in an unacceptable manner concerning the stakeholders, which are directly affected by its activities. It will also tell whether the company acts in a way that may displease the stakeholders who are not directly affected, but have taken interest in the company on behalf of affected stakeholders, e.g. NGOs, and hereby the result will also reflect the risk that these will try to influence the conditions under which the company conducts its business.

Negative as well as positive impacts are included in social LCA and may concern activities like violation of fundamental labour rights (e.g. working time, disciplinary actions and wage payment and health and safety of employees), corruption and bribery, company programmes

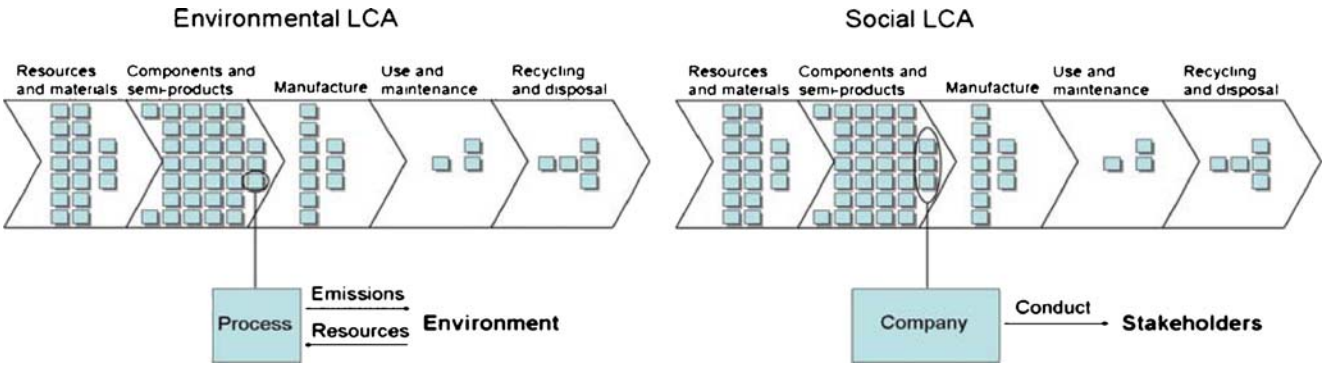

Fig. 1 In environmental LCA, focus is on the individual processes and the physical flows which they exchange with the environment. In social LCA, focus is on the companies engaged in the life cycle and the impact that their conduct has on the stakeholders who are affected by their actions (adapted from Dreyer et al. 2005)

for training and education or for health of employees, job creation and stimulation of economic development.

In an earlier paper (Dreyer et al. 2005), we suggested that social LCIA has two classes of impact categories, an *obligatory*, normatively based, class of predetermined categories expressing minimum expectations to conducting responsible business, and an *optional*, self-determined class of categories expressing interests specific to the product manufacturer, which are not already covered by the obligatory impact categories. We also argued that the obligatory impact categories should be based on the four issues of concern pointed out as fundamental by the International Labour Organisation (ILO), viz forced labour, discrimination, freedom of association and right to organise and collective bargaining and child labour (ILO 1930, 1948, 1949, 1951, 1957, 1958, 1973, 1999). These have earlier been identified for inclusion in social LCA or sustainability LCA by several authors, e.g. Mazijn (2004, 2005), Vanhoutte et al. (2004), Barthel et al. (2005), Schmidt et al. (2004), Griesshammer et al. (2006) and Manhart and Griesshammer (2006), and they are impacts that a company has a strong possibility to influence.

This paper presents a methodology for characterisation of social impacts belonging to the obligatory class of labour rights as defined by ILO. In Section 2, it is argued that violations of labour rights are complex and therefore difficult to measure using traditional quantitative single-criterion indicators, and in Section 3, we present a new methodology to create indicators suitable for modelling labour rights violations and other similar social issues in social LCA. In Section 4, we reflect on the significance of including considerations of the company's social context in the modelling of its social impacts, and in Section 5, we present a characterisation method for the labour rights impact categories. Finally, in Section 6, we discuss requirements to a category indicator, scope of assessment, data availability, weighting and other indicators in relation to the presented methodology.

2 Indicators for labour rights in social LCIA

Violations of labour rights may occur in many different ways, and they are complex to measure. Discrimination, for example, may occur through dismissal of female employees for getting pregnant, avoiding the hiring of persons with a different cultural background or assignment of the dirtiest jobs in the company to employees who belong to national minorities. Such aspects of discrimination must be included in the quantification of this type of labour right violation. Violations of labour rights are often difficult to substantiate: They may occur in a small and closed forum, e.g. when a manager punishes an employee, they are not necessarily the result of conscious acts, e.g. discrimination, the lines marking violations can be subtle, e.g. when overtime is considered voluntary, and the severity of some violations makes them too sensitive to disclose, e.g. when a company employs children in the workforce. This complexity and sensitivity make it difficult to quantify both the extent and severity of labour rights violations. Hence traditional quantitative indicators for LCA, which are typical one-dimensional in their representation of an issue and focused on direct measurement of the impact itself, have difficulty in producing meaningful results for some social issues. For example, the most simple, and often used, indicator for child labour 'number of employees below 15 years of age'[1] fails to consider the complexity of the child labour issue on several accounts[2]. Provided that information about the number of children working in the company below the minimum age is attainable from a company, it may be taken as an indication of exploitation of children. On the other hand, it may also be an act of social responsibility that a company introduces children to working life by letting them take on work that is appropriate to their age and maturity giving them the opportunity to gain skills and add to the well-being of their families. The ILO convention concerning child labour supports such initiatives by allowing children below the general minimum age to carry out light work (ILO 1973). This complexity of the issue can be dealt with by introducing more assessment criteria in the indicator model or by performing a qualitative assessment. The example also illustrates the necessity of such indicator results to be interpreted in the management context to be meaningful.

Another example illustrating shortcomings of traditional indicators concerns the measurement of work environmental impacts. Most companies register accidents at the workplace, but the registered number of working accidents may be a poor indicator of the quality or safety of the work environment. A company which has no active management of the work environment may have a low number of registered working accidents, simply because it has no systematic registration of them. Detached from its context of management effort, the number of reported working accidents will therefore not give an unambiguous assessment of the company's performance. Nevertheless, this type of *direct indicator* is frequently used in LCA as an indicator

[1] This type of indicator is used for assessment in LCA by Barthel et al. (2005) for modelling of labour rights issues by indicators concerning the humanity of working conditions measured, e.g. in 'seconds of actual child labour or forced labour' (Barthel et al. 2005). This measurement requires information about number of child labourers and persons working involuntarily.

[2] This example was also presented in a feasibility study about integration of social aspects into LCA (Griesshammer et al. 2006), where the authors briefly reflect on the complexity behind social indicators and the need of clear definitions.

of the work environment quality—in number of accidents per functional unit (Hauschild and Wenzel 1998), distinguished in lethal accidents and non-lethal accidents (Barthel et al. 2005) or further differentiated (Schmidt et al. 2004).

Instead, information about the measures taken to secure a safe and healthy work environment may serve as an *indirect indicator* of the quality of work environment, which can be expected. Examples of managerial measures that support a safe and healthy work environment in the company could be measures ensuring that the employees receive regular health and safety training, that safety instructions are placed on all machines in a language understood by the employees, that all employees have access to safety equipment and are instructed in the use of the equipment, that regular safety inspection rounds are conducted to ensure that safety instructions are followed and safety equipment is used and that all groups of employees are represented in a health and safety committee that meets frequently to discuss possible improvements in the working environment. All these measures help in reducing the risk that negative work environmental impacts occur—*provided that the implementation is effective*. The effectiveness of the implementation is crucial for the resulting work environment in the company, and the indicators for social impacts in LCIA are built upon this observation.

3 Development of a multi-criteria indicator model assessing company performance

With their ability to reflect multiple aspects of an issue in one indicator, multi-criteria indicators can handle the complexity of labour rights issues. Instead of aiming at quantitative direct indication of the extent and severity of labour rights violations in a company in the social LCA, we suggest the use of a multi-criteria indicator, assessing a company's efforts (will and ability) to integrate managerial measures appropriate to the issue, to evaluate preventive actions and provide an indirect indication of risk of violation. This is based on the presumption that lack of a systematic management approach with dedicated preventive actions gives free rein to violate rights, which enhances the risk that violations actually occur. The main premise is thus that systematic management is preventive and that there is coherence between systematic management and responsible conduct.

3.1 Multi-criteria indicator model

For each impact category, the relevant managerial measures are identified. Next, the effectiveness of the integration of these measures in the management of the company is assessed based on three predefined assessment criteria: (1) the establishing of *guidelines and practices*, which support integration of the measure into daily work; (2) the *communication and delegation of responsibility* for the integration of the measure into daily work; and (3) the performance of *systematic active control* of the integration of the measure into daily work. The establishing of guidelines and practices (1) is an expression of conscious action based on the company's own ethical stance on the issue at hand, i.e. not the use of predefined or specific guidelines and practices. The criteria 2 and 3 must be considered in continuation of criterion 1. Simultaneous fulfilment of each of the three criteria is crucial for the effective implementation of a measure, and therefore they are assessed separately, and the results are combined into an aggregated score for a measure. The assessment is performed in a scoring matrix or scorecard as shown in Fig. 2. The elements of the assessment are described in the following sections, and Appendix A in the Electronic supplementary materials provides an excerpt of the scoring of a company's management effort for the impact category *Working Environment* and presents the basic rules for scoring the implementation degrees 1 to 3 for each of the management efforts 1, 2 and 3.

The data collection and inventory processing process of traditional environmental LCA is paralleled here by filling in the matrix for each of the companies engaged in the life cycle. The company assessment using multi-criteria indicators may be considered equivalent to the inventory processing for a unit process in environmental LCA.

3.1.1 Managerial measures

The managerial measures are listed in the first column of the matrix in Fig. 2 (A, B, C...). Within each impact category (e.g. work environment, forced labour or child labour) activities which can cause impacts are identified together with the measures that the company can take to manage these particular activities. The managerial measures may be interconnected and partly overlapping in coverage of the activities in order to provide an adequate description of a company's management efforts.

Managerial measures and their arrangement in the matrix are defined for each impact category in a three-step process (schematic overview is provided in Fig. 3):

1. Identify central aspects of the issue, i.e. identify the main elements or characteristics that can be used to identify a situation of negative or positive impact, which must be addressed by the indicator, based on qualitative links to the area of protection *human dignity and well-being*. For labour rights, negative impacts are synonymous with violations of these rights. Examples of central aspects for, e.g. forced labour, are exclusion

MULTI-CRITERIA INDICATOR MODEL		EFFORTS IN INTEGRATION								
		I The company has established a practice or issued a guideline, which addresses the criterion stated in the left column			II The company has communicated and delegated responsibility for compliance with the practice/guideline to relevant managers and employees			III The company performs continuous active control to ensure that managers and employees comply with the established practice or guideline		
IMPLEMENTION DEGREE		1	2	3	1	2	3	1	2	3
MANAGERIAL MEASURES	A									
	B									
	C									
	…									

Fig. 2 Scoring matrix applied for semi-quantitative assessment of management effort in handling a relevant social issue. The managerial measures (*A*, *B*, *C*,...), which can help improve the social performance of the company for the impact category in question, are listed in the in the first column of the matrix. The second, third and fourth columns of the matrix are used to score the company's efforts in integration of the measures into daily work in the company (*I*, *II* and *III*). Each of these three efforts is essential for effective management independent of the impact category. For each effort, the degree of implementation is scored (ranging from 1 to 3)

from future employment, withholding of wages and induced indebtedness.

2. Identify the activities in the company where impacts (identified in step 1) may occur and formulate the managerial measures necessary to ensure systematic and adequate management of each of these activities to minimise the risk that negative impacts actually can take place or promote the actualisation of positive impacts. In regard to, e.g. forced labour, handling of personal documents is a common activity during the hiring stage where the employer has the possibility, if permitted by circumstances, to retain identity documents or other valuable possessions belonging to the employee, which during the employment may be used as a mean to restrict the freedom of the employee to seek other employment. A managerial measure could be formulated like this: 'Birth certificate, passport, identity card, work permit or other original documents belonging to the employee are not under any circumstances retained or kept for safety reasons by the company neither upon hiring nor during employment'. In terms of labour rights violations it may be helpful to ask, where and when violations potentially could take place in a company and how the occurrence of these violations may be effectively prevented through systematic management.
3. Arrange the managerial measures in the matrix (see Fig. 2), presenting the management approach to the issue in a logic and coherent manner. This arrangement is an optional step, which may be applied to facilitate the data collection. Often a simple arrangement according to the three stages of employee lifecycle, viz recruitment, employment and end of employment, is beneficial, because it provides structure to the data collection.

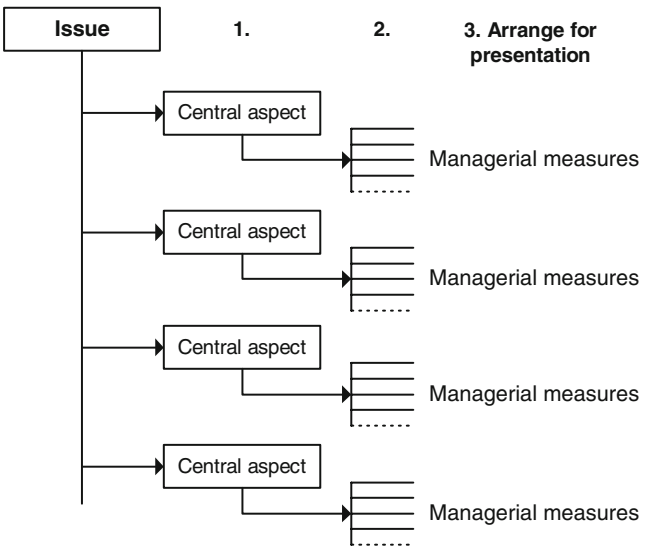

Fig. 3 The three steps to determine the subject dependent assessment parameters for an impact category indicator in social LCA

The indicator for the impact category *forced labour* is presented in Appendix B in the Electronic supplementary materials. Indicators for the other obligatory impact categories concerning labour rights in social LCA and the background for their development are presented in the Electronic supplementary materials, Appendices 1 and 2, respectively.

3.1.2 Efforts in integration

For each managerial measure taken by the company, guidelines and practices (I); delegation of responsibility and communication about guidelines and practices (II); and monitoring (III), which supports integration of the measure into daily work, are surveyed (second, third and fourth column of the matrix in Fig. 2). The three efforts are elaborated further in the following sections, and the basic principles for scoring of them are described in Appendix A in the Electronic supplementary materials.

Practice established or guideline issued A *guideline* provides the user with written step-by-step guidance to carry out a certain task, e.g. recruitment, whereas a *practice* is a general way of carrying out a task, which is not written down. For example, an employee may describe the practice of announcing open positions in the company like this 'when we have an open position, I always draft an announcement for the newspaper, which I send to the manager of hiring, for approval'.

Management style may vary significantly from company to company, so the quality of the individual practice or guideline must be assessed with respect to (1) its ability to fulfil the intent of the measure to minimise the risk of negative impacts or promote positive impacts and (2) its viability in the organisation.

For example, behind a measure about broad announcement of open positions lies the intent of ensuring applicants equal access to employment, which is a central aspect of non-discrimination. If the company's practice regarding announcement of open positions excludes a group of applicants, e.g. advertisement in youth magazine excludes elder applicants, it does not fulfil the intent of the measure.

Communicated and delegated responsibility A guideline may be developed for carrying out a certain task, but if the people involved in the task do not know that the guideline exists, do not know how to use the guideline or disagree with the guideline, it is unlikely that it will be followed in daily work. Therefore, for a practice or guideline to work effectively in an organisation, it is important that all concerned employees and managers have been informed about the practice/guideline in such a way that they can act accordingly and that responsibility for compliance has been explicitly delegated. It is not enough that written guidance has been sent out to the relevant employees and managers; it must also be ensured that they actually have acquainted themselves with the content and accepted its implications including the delegated responsibility for compliance.

The relevant employees and managers must be identified for each measure by asking, firstly, who is responsible for ensuring daily integration; secondly, whose behaviour is affected by the measure taken; and thirdly, who has interest in being informed in general.

Active control to ensure compliance Without control, it is not possible for the management to ensure the actual use of a guideline or practice in the daily work. *Active control* means that the company has established a system to monitor and survey that concerned employees and managers comply with the issued guidelines and practices. This involves systematic control on a regular basis by a superior or other qualified person in the company, who is impartial to the outcome of the control, or by a third party independent of the company. In order for the indicator to reflect both will and ability of the company to manage an issue, control should be company initiated, e.g. annual internal audit, internal anonymous employee survey. Yearly labour inspection by the national Labour Department does hence not constitute active control. In some organisations and for some measures, third party control may be the only type of effective active control. Active control can involve random check (sampling) with documented outcome for some measures.

An example of active control, which will be very efficient for most measures concerning the working environment, is regular safety rounds in the factory.

4 Contextual adjustment of indicator scores

Assessment with the multi-criteria indicators does not allow us to say whether impacts take place or not, only whether the circumstances in the company may permit or facilitate them to do so. The multi-criteria indicators measure the management effort of a company in regard to a particular issue. The importance of a strong management effort to avoid negative impacts or promote positive impacts taking place depends on the issue's topicality in the given context of the company compared to that of the reference context. The reference context represents the external conditions of the company for which the managerial measures of the indicator have been defined as a desirable management effort to ensure a minimum risk of negative impacts or a maximum possibility of positive impacts. In order to interpret the results of the multi-criteria indicators into a probability that social impacts actually take place, we therefore introduce a contextual adjustment as a part of impact assessment, assessing the need for good performance in light of the given context of the company. The contextual adjustment is valid for both positive and negative impacts, but for simplification of the discussion, the focus is in the following on negative impacts exemplified by labour rights violations.

By context, we mean the external environment characterising the risk of negative impacts. For labour rights issues, the external risk environment is typically influenced both by the geographical location of the company and the industry it belongs to. The external risk environment is the background on which the management of the company must be judged. If the company does not take specific measures to manage a particular issue, the internal risk environment of the company must be expected to resemble this background situation, whereas a dedicated effort may reduce the risk of social impacts compared to the level of the company's context. Depending on nature of the social issue and the scope of the LCA, the location may be specified as region (e.g. South America), country (e.g. Brazil), national macro-region (e.g. southeast of Brazil), state (e.g. Sao Paulo state) or even city (e.g. Sao Paulo).

The assessment of the context depends on the social issue and may be based on (1) existence and enforcement of national legislation concerning the issue, and social, cultural, economic and political practices at the location, and (2) the practices of members of the industry. The frequency and severity of violations reveal the topicality of the issue in the actual context, since they are the product of norms and customs in the concerned environment. Frequency and severity of violations at a particular location and in a specific industry may thus serve as an indicator of the context risk. If the context risk is high, i.e. violations are widespread or common, the company needs to make a very strong management effort in order to ensure/demonstrate low internal risk of violations, and vice versa. For example, the demands to a management system to ensure that children below minimum age are not hired are higher in a country where child labour is culturally accepted and therefore widespread, than in a country where this is not the situation. A company in Brazil must thus work harder to ensure a minimum age restriction for hiring than a company in Germany.

The managerial measures (introduced in Section 3.1.1) are defined in a way so they together describe a desirable company performance in a context where the issue is of maximum topicality. In regard to labour rights, this translates to desirable company performance in a very high risk context, i.e. where violations are common or systematic at a regional level and in the concerned industry. In order to assess the likeliness of negative impacts actually taking place in a company, the company's indicator result must be adjusted for the deviation of the context of the company from the reference context for which the indicator assessment criteria were developed. A parallel from environmental LCA is the inclusion of site dependent considerations (e.g. Potting and Hauschild 2006), but in social LCA, the need is more extreme. The social impacts of a company are determined by the way it behaves towards its stakeholders, and this may vary between two otherwise very similar companies applying the same technologies and operating in the same region. This means that it is difficult to apply general default data for social LCA with the purpose of supporting a company's management of its product chains (see Weidema 2005; Dreyer and Hauschild 2005), and as also the case for the implementation of spatial differentiation in environmental LCA, data availability may be a limiting factor.

5 Characterisation for obligatory impact categories

For the obligatory impact categories on labour rights, a characterisation model is described to calculate category indicator results based on the scoring of company management efforts in the scorecard shown in Fig. 2.

The characterisation operates on the scored company management effort from the inventory, and interprets it in a company risk perspective to generate a score which can be interpreted as the potential impact within the social impact category. Similar to inclusion of site specific consideration in environmental LCA, the consideration for context in social LCA entails that calculation of the potential impacts must occur separately for each process (company) before aggregation for the product system can take place (Potting and Hauschild 2006). The steps in characterisation are summarised in Fig. 4 and further elaborated in the following: The company assessment using multi-criteria indicators may be considered equivalent to the inventory processing for a unit process in environmental LCA.

Step I: Company performance (CP) The company performance is here defined as a score representing a company's efforts and ability to manage a particular issue through integration of appropriate managerial measures. The company performance score for an impact category is calculated using the filled in scorecard (see Fig. 2), attributing values to the three implementation degrees (1, 2 and 3) within each effort (I, II and III), multiplying the implementation degree values per management measure and summing them across management measures to arrive at one score for the impact category. The attribution of values determines the relative weight which is assigned to each of the individual efforts and implementation degrees in the scoring matrix, i.e. how the three efforts must act together for an efficient management of the issue in a very high risk context. The effectiveness of management increases markedly in a company, when responsibility has been clearly communicated and delegated (II) for existing guidelines and practices (I), and this effort again becomes even more effective, and reliable, when it is combined with systematic active control (III). In the value attribution to company

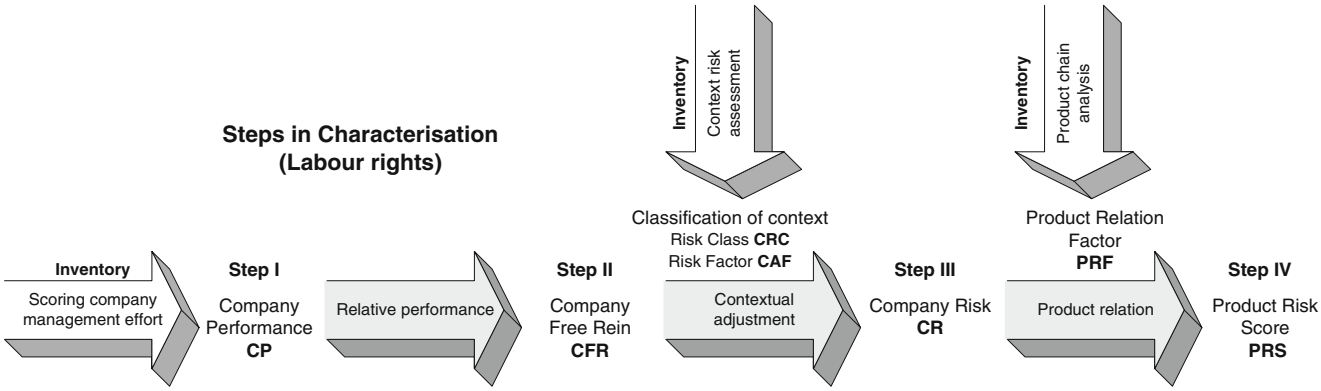

Fig. 4 Four steps of characterisation in social life cycle impact assessment for obligatory impact categories. The illustration is for one company and one impact category. *White arrows* signify inventory process, and *grey arrows* signify characterisation process

scoring, this amplifying relationship between the three integration efforts of the multi-criteria indicator is expressed through multiplication of the effort scores for each managerial measure of the indicator in the formation of the company performance score. The higher the total score, the better the management of the issue in question. The value attribution is elaborated further in Appendix 3 in the Electronic supplementary materials, where the values shown in Table 1 are developed to ensure the necessary differentiation between different performance levels.

Steps in calculating company management performance score (refer to Table 1 and Fig. 2 for terminology):

- Determine scores for each effort (AI, AII, AIII, BI, BII, BIII,...) by attributing values from Table 1 to implementation degrees 1, 2 and 3.
- Calculate scores for each managerial measure (A_{tot}, B_{tot}, C_{tot},...) by multiplication of the three effort scores (Eq. 1):

$$A_{tot} = \mathrm{AI} \times \mathrm{AII} \times \mathrm{AIII} \quad (1)$$

- Calculate total company performance score (CP) as the sum of the scores for all managerial measures (Eq. 2):

$$\mathrm{CP} = A_{tot} + B_{tot} + C_{tot} + \ldots \quad (2)$$

Step II: Company free rein (CFR) The difference between the measured company performance score (CP) and the ideal performance (CP_{max}) in a context of very high risk makes up the free rein to violate labour rights; the greater the distance, the greater the free rein and hence the stronger the presence of circumstances allowing violations to take place. Through indexation relative to the ideal company performance, the value of company free rein ends up in the interval between 0 and 1 regardless of the variation in the number of possible management measures in the impact category enabling comparison between scores of different impact categories (which have different numbers of management measures). The indexation also provides a

Table 1 Values for the implementation degrees of each of the three management efforts to be applied in the processing of management measure scores for all obligatory impact categories

Multi-criteria indicator model	Efforts in integration								
	I			II			III		
	The company has established a practice or issued a guideline, which addresses the criterion stated in the left column			The company has communicated and delegated responsibility for compliance with the practice/ guideline to relevant managers and employees			The company performs continuous active control to ensure that managers and employees comply with the established practice or guideline		
Implementation degree	I_1	I_2	I_3	II_1	II_2	II_3	III_1	III_2	III_3
Managerial measures A, B, C,...	0	0.7	4	1	1.2	2	1	1.2	2

Value attribution is developed in Appendix 3 in the Electronic supplementary materials

more comprehensible scale of the results, and the new scale facilitates contextual adjustment (Eq. 3):

$$CFR = (CP_{max} - CP)/CP_{max} \qquad CFR \in [0;1] \tag{3}$$

Step III: Company risk (CR) The indexed company free rein is adjusted by a contextual adjustment factor (CAF), which represents the relevance or importance of performance when considering the context of the company. The contextual adjustment enables comparison between scores of same impact category for different companies by compensating for differences in the context within which they operate. The adjustment is performed downwards to compensate for lower relevance/importance of performance than in the chosen reference context (Eq. 4):

$$CR = CFR \times CAF \qquad CR \in [0;1] \qquad CAF \in [0.4;1] \tag{4}$$

Contextual adjustment factor A context risk classification has been developed for labour rights violations on the basis of reported frequency and severity of labour rights violations in different geographic locations and industries. The classification considers five generic risk classes each of which is assigned a contextual adjustment factor with a value between 0.4 and 1, where a factor value of 1 signifies very high risk in present context. Based on a desk study of violations for the relevant geographic location and industry, the context of the assessed company is placed in a risk category and assigned the corresponding contextual adjustment factor. The context risk classification is described in Appendix 4 in the Electronic supplementary materials. The meaning of the different contextual adjustment factors is given in Table 2, and the meaning of the resulting CR scores is explained in Table 3.

Step IV: Product risk score (PRS) The company risk scores for the companies in the product chain must be related in a quantitative way to the product for which the LCA is performed in order to arrive at an impact score for the product. Each company risk score is related to the product chain by multiplication with a product relation factor PRF (Eq. 5):

$$PRS = PRF \times CR \qquad CR \in [0;1] \qquad PRF \in [0;1] \tag{5}$$

PRF[3] The product relation factor expresses which weight the social risk profile (consisting of one company risk score for each impact category) of a company in the life cycle shall be given in the social LCA of the product. The product relation factor has a value between 0 and 1, where 1 signifies that the product must carry the entire risk profile of the company in question. There is not one objectively correct way of calculating the product relation factor, but different approaches are possible (Dreyer et al. 2005). The choice of product relation principle will inevitably introduce a bias to the LCA study as regard to how it places emphasis in the life cycle, and it will influence the importance of the individual company impact in the overall impact profile for the product. The range of variation of the product relation factor (in particular the ratio between highest and lowest value it can take) in comparison to the possible range of the company risks is of importance. The product relation step therefore constitutes a value choice in the characterization method (Dreyer 2009).

Since this step is not necessary in traditional LCA, where the product relation is implicit, and hence not considered by ISO terminology (ISO 1997), it can be debated as to whether this should form part of characterisation or be

[3] Product relation factors is the same as what is referred to as share factors in Dreyer et al. (2005).

Table 2 Contextual adjustment factors to be applied in characterisation of labour rights indicators in social LCA

Contextual adjustment factors		
Contextual risk class (CRC)	Contextual adjustment factor (CAF)	Probability of occurrence in context
1	1.0	Very likely
2	0.9	Likely
3	0.7	Possible
4	0.5	Unlikely
5	0.4	Very Unlikely

Contextual risk classes are described in Appendix 4 in the Electronic supplementary materials. Typical risk situations applying to the different classes may be identified using Table 4.1 and Table 4.2 in Appendix 4 in the Electronic supplementary materials

Table 3 Interpretation of company risk

Company risk classification	
Company risk score	Definition of company risk
$0.9<CR\leq1.0$	Very high risk
$0.6<CR\leq0.9$	High risk
$0.4<CR\leq0.6$	High to medium risk
$0.2<CR\leq0.4$	Medium risk
$0.0\leq CR\leq0.2$	Low risk

The company risk classification defines five classes of company risk (CR). The classification is described further in Appendix 3 in the Electronic supplementary materials

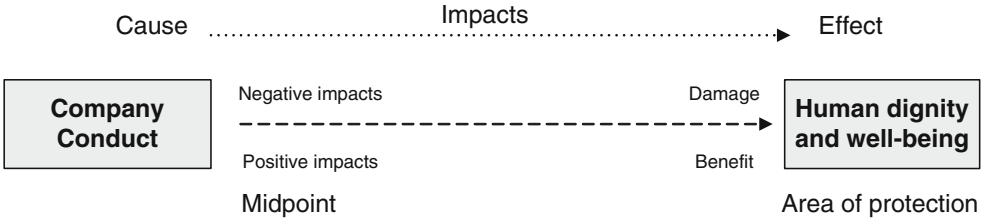

Fig. 5 Impact pathway model of the social LCIA framework. The goal of social LCA to support the company's management decisions naturally places the development of category indicators at midpoint of the impact pathway

viewed as a separate step similar to normalisation and weighting.

6 Discussion and outlook

6.1 Requirements to the impact category indicator

In environmental LCA, the inputs and outputs of a process in the inventory are quantified, and on the basis of assessment by environmental models (characterisation), the resulting (negative) impact on the environment is expressed by a score of the impact category indicators. As an alternative to assessing the social impacts of a company's operation directly in social LCA, it is here proposed to operate with impact category indicators, which express the probability that impacts occur as a result of a company's operation, through assessment[4] of the company's will and ability to manage its activities (multi-criteria indicators) considering the context which the company forms part of (contextual risk adjustment factors).

The requirement of an impact category indicator (category indicator) in the ISO standard for LCA (ISO 1997) is that it must be a quantifiable representation of an impact category, which is achieved in the suggested characterisation method.

The discussion of where in the impact pathway the category indicator should be located is well known from environmental LCA, and it is equally relevant in social LCA. The choice should respect the goal of the LCA. The goal of supporting the company's management decisions thus requires that the methodology addresses the expectations and demands from the main stakeholders of the company. The results of the social LCIA must be meaningful to the company, it must be easy to trace them back to tangible managerial measures, and they must be sufficiently sensitive to reflect changes in the management practice. Due to the uncertainty of the causal relationships, damage modelling may cloud the understanding of the causal links between the conduct of the company and the damage upon the area of protection. Furthermore, the expression of the product's social impacts in terms of damage, e.g. as disability or quality adjusted life years (DALY or QALY),[5] will be undesirable in the business context for many companies, implying that the company's product is dangerous compared to other products, which do not communicate their social impacts in this way. The use of the social LCA methodology for management decision support in companies thus point to the use of category indicators defined at the midpoint level. See overview of the impact pathway model of the social LCIA in Fig. 5.

6.2 The scope and aim of the assessment: labour rights violations

The proposed indicator model is focused on the will and ability of a company to manage an issue of concern (here developed for labour rights), rather than on direct impact, and this has consequences for the type of conclusions which can be drawn and therefore also the type of violators and violations it is likely to detect.

In principle, the method is developed to detect the risk of company violations of any severity. However, in reality, it will predominately detect violations of the more moderate character, which you can expect to get information about when conducting interviews in a company. In the situations where violations may be of a more serious character, the access to information will normally be limited. The type of violations indicated through the method may consist of many smaller violations or isolated cases of severe violations, such as:

- Unintentional as well as intentional discrimination of employees during recruitment, employment or termination of employment.

[4] In the process of scoring company performance, some personal judgement may be necessary to determine management efforts and the degree of implementation, and therefore the scoring step may include elements of assessment.

[5] Disability adjusted life years (DALY) is a metric developed by Murray and Lopez (1996) for the WHO and the World Bank. The original purpose was to have a tool to analyse the rationale of health budgets. DALY aggregates mortality and morbidity using weighting factors for the latter in the assessment of damage. Modelling of damage in life cycle impact assessment was introduced by Hofstetter (1998) and applied to the impact category Human Health in the Eco-indicator methodology (Goedkoop and Spriensma 2000). The QALY metric, which is the inverse of the DALY metric, has later been suggested applied in social LCA by Weidema (2006).

- Unintentional hiring of children; hiring of children under false pretence (e.g. as apprentices); work of children inconsistent with their physical and mental development.
- Work on involuntary basis and under menace of penalty.
- Suppression, restriction or obstruction of employees' right to freedom of association, right to organise and collective bargaining.

In this group of violators, we will find the companies that violate rights, because they lack systematic management, are ignorant of labour rights, have opportunity to take advantage of employees' less fortunate situation and may gain economically (in a small scale) by doing so, have individual persons hired showing poor judgement, etc. The method will primarily expose companies operating in the grey zone in regard to observance of labour rights. Hence disclosure of severe violations, such as physical confinement and physical punishment of employees, children in prostitution, disappearance and liquidation of union representatives, etc., is not directly considered by this approach. Even so, these labour rights aspects are indirectly considered by the social LCA through the context risk assessment, which considers labour rights violations of any severity. The presence of severe violations in the environment of the company is reflected through the adjustment of company free rein, as a demand of extra management effort from the company in order to minimise the risk of violations of less severe character, i.e. the need for management effort to prevent smaller violations from occurring is enhanced. When the extent of the management effort rises beyond a certain level, it also becomes preventive in regard to more severe violations, simply because these cannot coexist with the high awareness level accompanying the management effort. Social auditing often finds that behaviour leading to severe violations like physical abuse of employees is very unlikely to occur in a company which has employment contracts and training programmes for its employees. So the company risk scores obtained in characterisation may indirectly also express the risk of more severe violations.

The multiple assessment parameters of the labour rights indicators are developed to ensure that it can be said with reasonable certainty that violations do not take place if the company performs maximum regardless of the context. The contextual adjustment is thus carried out in the characterisation in such a way that it leaves a good performer unaffected, whereas a bad performer is affected by the adjustment to the degree that labour rights violations in the surroundings of the company give rise to concern and pose requirements to conscious management effort to ensure a low risk of violations in the company. Implicitly it is thus our perception of company risk that the influence of the external risk environment is less important than a conscious company management, meaning that a company's conduct does not necessarily have to be a product of its surrounding environment, but may be a result of a conscious management effort.[6] Hereby we emphasise that even a strong prevalence of violations in the settings of the company (country, industry) does not necessarily result in violations in the company. This preventive management paradigm is the backbone of the social LCA method presented with its focus on spotting the improvement potential(s) of the individual company in the small perspective (unit process level) and the improvement potentials in product chain in the larger perspective (life cycle level).

6.3 Data availability

The multi-criteria assessment method demands a site-specific data collection, which will often also require a high level of validation. It is not always possible to obtain specific information and may therefore sometimes be necessary to supplement by more simplified indicator models for companies with reduced access to data. Simplified indicator models could be reduced versions of the multi-criteria indicator, applying more accessible types of information and information sources, or models relying on information of more general character. In general, when simplified indicator models are used, it is very important to consider the consequences that this has for the reliability of the LCA. For example, assessment relying on use of generic data, such as assessment of country risk to represent internal risk environment of a company when considering negative impacts, can result in erroneous assessments and in the worst case a misleading conclusion of the LCA, e.g. identifying the wrong hot spots. Furthermore, in order to apply indicator models of different sophistication in the same LCA, they must be able to produce results that are compatible with the results produced with those of the multi-criteria indicator model. This also implies that the LCA method must be able to handle the different uncertainties connected with the chosen models in the aggregation in a way that enables comparability of the results ultimately in the interpretation of the LCA.

In social LCA, the issues which are addressed are of a particularly sensitive character. The structure of the multi-criteria indicators makes it difficult for a company—intentionally as well as unintentionally—to give a misleading image of their conduct and hence the risk of violations. This

[6] This is also reflected in the relative importance of the CAF, which in the extreme can move a company no more than two risk classes (see Table 3).

is one of the major strengths of the model as opposed to more simplified models.

6.4 Weighting of obligatory impacts

The contextual adjustment carried out in the characterisation is not to be confused with the weighting step of traditional LCA. The context risk is important for how large a management effort is needed to ensure that violations do not take place. The contextual adjustment does thus not evaluate whether observance of a given labour right is of more or less importance in the context, only the relevance of performing the determined managerial measures of the multi-criteria indicator. Regarding weighting between the different impact categories that represent the labour rights, in our work, we consider observance of the eight fundamental labour rights (four issues) to be by definition of equal importance, and therefore do not suggest any explicit weighting of the obligatory impact categories in case of comparison across the impact categories.

6.5 Derived indicators

Social LCA is a new discipline, and there are many different topics to work with at this stage of methodology development.

Fundamental labour rights are social aspects that have caught our particular interest, because even though it is widely accepted that these constitute minimum standards to which companies must apply, they are also aspects which are difficult to make tangible and actionable for companies. In terms of LCA, they are also social aspects, which are particularly difficult to quantify. The labour rights indicators presented in this paper (Appendices B and 1 in the Electronic supplementary materials) are therefore quite comprehensive involving many aspects in order to meet these challenges. Other social aspects may be represented by more simple multi-criteria indicators that constituted of few managerial measures; see the example of measures for indicator on working hours in Table 4. For social aspects related to the employer–employee relation, several simpler indicators may be derived from the labour rights indicators presented in this paper, because they, in their attempt to encompass central aspects of labour rights violations, touch upon many different aspects of working conditions. Derived indicators may for example include overtime, wage (remuneration in general), equal remuneration, grievances, employment contracts, training and education. Examples are given in Table 6 in Appendix C in the Electronic supplementary materials. Indicators along this line on labour practices and decent work conditions have been suggested by several authors; see overview presented by Jørgensen et al. (2008). Some of these derived indicator scores can also be submitted to a contextual risk adjustment, which may then be more specific when data on conditions relating to the issues are available. Data on occurrence of overtime, and on wages and equal remuneration, are thus sometimes available from common sources on labour rights violations. What concerns examination of grievances, contextual adjustment on the basis of risk of labour rights violations in general, is very relevant, because the need for grievances systems is highly dependent on the topicality of labour rights violations in the context. Equal remuneration may be adjusted by contextual risk of discrimination in the lack of specific data.

Table 4 Example of managerial measures for working hours indicator based on ILO convention 1 (ILO 1919)

Managerial measures	
	Working hours
1	Employees are never required to work more than 48 h per week
2	Employees have at least 1 day off in every 7-day period on average
3	Regular working hours do not exceed 8 h a day
4	Overtime does not exceed 12 h per week
5	Overtime is only used under exceptional business circumstances
6	Overtime is always compensated by time off or at a premium rate
7	Work is organised to accommodate paid rest breaks
8	Working hours for all employees are recorded

The ILO has published a series of conventions addressing working hours for specific industrial undertakings and workplaces. The indicator is based on the general rule for working hours, as stated by ILO convention 1. There are exceptions to this rule, which the managerial measures may be slightly adjusted to take into consideration, when the indicator is applied in these situations

6.6 Other social impacts

This paper has mainly focused on the modelling of labour rights issues in social LCA (obligatory impacts), but the multi-criteria indicator model presented earlier will also be suitable for modelling other social issues in social LCA when these comprise multiple aspects, which can be handled through systematic management and when systematic management of the issue will be preventive for negative impacts or conducive for positive impacts. *Corruption and bribery* and *stimulation of local economic growth* are examples of social issues with a direct relation to the company's conduct towards internal as well as external stakeholders, which successfully can be subjected to systematic management and for which a multi-criteria indicator model would also be suitable.

Other social impacts may be covered by single-criterion indicators and measurement of direct impacts, e.g. *money spent on education programmes for employees*. If indicators

directly measuring impacts are combined with the multi-criteria indicators measuring risk, it is necessary to consider this different in the measurement approach in an explicit weighting.

Acknowledgements The work has been performed as part of the Industrial PhD 'Inclusion of Social Aspects in LCA' carried out at Brødrene Hartmann A/S, Denmark, and Department of Management Engineering, Section for Quantitative Sustainability Assessment, at the Technical University of Denmark. Financial support for the study from Brødrene Hartmann A/S and the Danish Ministry of Science, Technology and Innovation is gratefully acknowledged.

References

Barthel L, Wolf MA, Eyerer P (2005) Methodology of life cycle sustainability for sustainability assessments. 11th Annual International Sustainable Development Research Conference (AISDRC), 6–8 June 2005, Helsinki, Finland

Dreyer LC (2009) Inclusion of social aspects in life cycle assessment of products—development of a methodology for social life cycle assessment. Industrial PhD Thesis. Technical University of Denmark, Kgs. Lyngby, 2009

Dreyer LC, Hauschild MZ (2005) Scoping must be done in accordance with the goal definition, also in Social LCA. Int J LCA 11 (2)

Dreyer L, Hauschild MZ, Schierbeck J (2005) A framework for social life cycle impact assessment. Int J LCA 11(2):88–97

Goedkoop M, Spriensma R (2000) The Eco-indicator 99—a damage oriented method for life cycle impact assessment. Methodology report. Second edition 17 April 2000. PRé Consultants B.V., Amersfoort, The Netherlands

Griesshammer R, Benoît C, Dreyer LC, Flysjö A, Manhart A, Mazijn B, Méthot A, Weidema BP (2006) Feasibility study: integration of social aspects into LCA. Discussion paper from UNEP-SETAC Task Force Integration of Social Aspects in LCA meetings in Bologna (January 2005), Lille (May 2005) and Brussels (November 2005). Freiburg, Germany, 2006

Hauschild MZ Wenzel H (1998) Environmental assessment of products. Vol. 2 - Scientific background, 565 pp. Chapman & Hall, United Kingdom, 1998, Kluwer Academic Publishers, Hingham, MA. USA

Hofstetter P (1998) Perspectives in life cycle impact assessment; a structured approach to combine models of the technosphere, ecosphere and valuesphere. Kluwer, Dordrecht

ILO (1919) Hours of Work (Industry) Convention No.1. Adopted and proclaimed by the General Conference of the International Labour Organisation. November 28, 1919

ILO (1930) Forced Labour Convention No. 29. Adopted and proclaimed by the General Conference of the International Labour Organisation. June 28, 1930

ILO (1948) Freedom of Association and Protection of the Right to Organise Convention No.87. Adopted and proclaimed by the General Conference of the International Labour Organisation. July 9, 1948

ILO (1949) Right to Organise and Collective Bargaining Convention No.98. Adopted and proclaimed by the General Conference of the International Labour Organisation. July 1, 1949

ILO (1951) Equal Remuneration Convention, No. 100. Adopted and proclaimed by the General Conference of the International Labour Organisation. June 29, 1951

ILO (1957) Abolition of Forced Labour Convention No. 105. Adopted and proclaimed by the General Conference of the International Labour Organisation. June 25, 1957

ILO (1958) Discrimination (Employment and Occupation) Convention, No.111. Adopted and proclaimed by the General Conference of the International Labour Organisation. June 25, 1958

ILO (1973) Minimum Age Convention No. 138. Adopted and proclaimed by the General Conference of the International Labour Organisation. June 26, 1973

ILO (1999) Worst Forms of Child Labour Convention, No. 182. Adopted and proclaimed by the General Conference of the International Labour Organisation. June 17, 1999

ISO (1997) Environmental management—life cycle assessment—principles and guidelines. ISO 14040. International Organization for Standardisation (ISO), Geneva

Jørgensen A, Le Boqc A, Nazakina L, Hauschild M (2008) Methodologies for social life cycle assessment. Int J LCA 13 (2):96–103

Manhart A, Griesshammer R (2006) Social impacts of the production of notebook PCs—contribution to the development of a Product Sustainability Assessment (PROSA). Öko-Institut e.V.Freiburg, Germany, p 1006

Mazijn (2004) Minutes of workshop on the integration of social criteria into LCA: analysis of existing methodologies, Ghent, Belgium, 15–16 November 2004, Chairman Bernard Mazijn

Mazijn (2005) Minutes of the UNEP-SETAC life cycle initiative, taskforce 'Integration of social aspects into LCA', Brussels, Belgium 10–11 November 2005, Chairman Bernard Mazijn

Murray CJL, Lopez AD (1996) The global burden of disease. WHO, World Bank and Harvard School of Public Health, Boston

Potting J, Hauschild M (2006) Spatial differentiation in life cycle impact assessment—a decade of method development to increase the environmental realism of LCIA. Int J LCA 11(Special Issue 1):11–13

Schmidt I, Meurer M, Saling P, Kicherer A, Reuter W, Gensch CO (2004) SEEbalance®: managing sustainability of products and processes with the socio-eco-efficiency analysis by BASF. Greener Management International (Issue 45):79–94

Vanhoutte G, Heyerick A, Mazijn B, Spillemaeckers S, Vanbraeckel D (2004) Ecological, social and environmental aspects of integrated product policy—development of two instruments (Report). Ughent-CDO and Ethibel, 2004

Weidema B (2005) ISO 14044 also applies to social LCA. Int J LCA 10(6):381

Weidema BP (2006) The integration of economic and social aspects in life cycle impact assessment. Int J LCA 11 (1) (Special Issue) 89–96