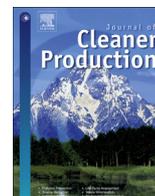




Contents lists available at ScienceDirect

Journal of Cleaner Production

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

Social life cycle assessment indices and indicators to monitor the social implications of wood-based products

A. Siebert^{a,*}, A. Bezama^a, S. O’Keeffe^a, D. Thrän^{a,b}

^a Helmholtz Centre for Environmental Research (UFZ), Department of Bioenergy, Permoserstraße 15, 04318 Leipzig, Germany

^b Deutsches Biomasseforschungszentrum (DBFZ), Bioenergy Systems Department, Torgauer Straße 116, 04347 Leipzig, Germany

ARTICLE INFO

Article history:

Received 9 June 2016

Received in revised form

1 December 2016

Accepted 21 February 2017

Available online xxx

Keywords:

Social life cycle assessment

sLCA

Social indices

Social indicators

Wood-based bioeconomy

Life cycle assessment

Bio-based products

ABSTRACT

Wood-based products will play a pivotal role in the development of German bioeconomy regions. This transition in production patterns should develop sustainably without negative effects to the environment and society. Therefore, appropriate assessment tools are required to measure and document (un)sustainable aspects. The use of life cycle thinking enables the assessment of sustainability issues relating to such wood-based products. However, life cycle assessment approaches assessing sustainability implications from a regional perspective have not been fully developed yet. A regional perspective is especially required when assessing products’ social implications as they are determined by the national and regional socio-economic conditions. In a previous work, we established the “RESPONSA” framework (i.e. a REgional SPecific cONtextualised Social life cycle Assessment) to assess a product’s social performance from a regional perspective, directly accounting to the organisations behaviour and therefore providing specific information to support producers’ decision-making. This paper focuses on developing a set of social indices and related indicators applicable to wood-based production systems in Germany. This was done in four steps: 1) screening of global, German and wood related sustainability standards; 2) analysis of sLCA case studies; 3) conducting of stakeholder interviews. This allowed the preselection of social aspects relevant to the socio-economic context of interest (i.e. wood-based production chains in German bioeconomy regions). To set up the final set of social indices and indicators, the preselected sets of social aspects, in a fourth step, were further screened regarding their feasible implementation. The established set provides a starting point for assessing and monitoring social implications from wood-based production systems in a regional foreground.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

Current debates promote a bioeconomy as a cornerstone for more sustainable production (Ingrao et al., 2016). The bioeconomy strategies aim to change current fossil-fuel based production activities into production processes based on biological renewable resources (BMBF, 2011; BMELV, 2013). Considering Germany’s leading position in woody biomass production (i.e. second in Europe and tenth in the world), wood-based products will play a pivotal role for this transition (BMBF, 2011; FAOSTAT, 2015; Raschka and Carus, 2012). It is not clear however, how adaptations and modifications of already established industries may evolve in a sustainable manner. Therefore, to accompany such a transition

process, the potential environmental, economic and societal implications have to be assessed and monitored. Life cycle thinking is promoted to effectively assess and monitor if these new modes of production will result in more sustainable, economic, social and environmental outcomes. Indeed such life cycle thinking has recently being expanded to assess the potential social implications of wood-based production activities (Siebert et al., 2016).

Siebert et al. (2016) proposed a context-specific social life cycle assessment (sLCA) framework in order to assess wood-based products from a German bioeconomy region. The framework focuses mainly on the potential social implications of foreground activities related to a wood-based production system within a particular study region (Fig. 1), whereas social effects outside the system boundary are considered, but not with the same level of detail. This paper focuses only on the development of particular social indices and corresponding indicators relevant to assess wood-based production activities from German bioeconomy

* Corresponding author.

E-mail address: anke.siebert@ufz.de (A. Siebert).

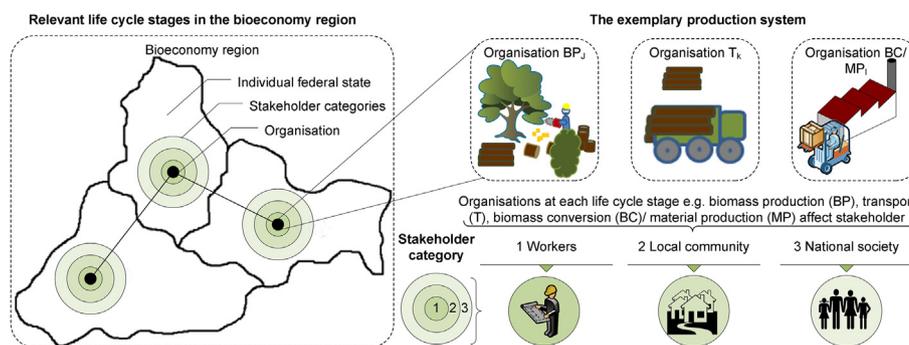


Fig. 1. A graphical representation of the scope of the RESPONSA framework. All relevant activities related to the main life cycle stages are assumed to be located in a geographic area smaller than a country. This area is referred to as the bioeconomy foreground. The location of the organisations associated to the activities determines the federal state that constitutes the regional system boundaries.

regions and thus within the regional foreground. This is a major step necessary to focus the establishment of the most appropriate social life cycle inventory (sLCI).

Unlike conventional LCA with relatively clear cause and effect chains, in sLCA the cause and effect chains are difficult to correlate, with regards to production activities and their potential social effects, making it often quite challenging to select appropriate indicators. Furthermore, there is currently no standardised indicator set established, and this has led to the huge variety of social indices and indicators applied in the literature, some of which have been implemented without proper indication or reason for their use.

Nevertheless, some guidance is provided by the sLCA guidelines that propose a comprehensive approach for conducting sLCA studies with major impact categories (UNEP-SETAC, 2009). Many authors applied their categories as well as indicators proposed in the corresponding methodological sheets (UNEP-SETAC, 2013). Other authors developed their own indicator sets with participatory approaches (Luca et al., 2015). However, as data availability is highly diverse, the indicators that can be applied also differ. Furthermore, many sLCA studies apply national data to set up the sLCIs and use global references for characterisation, or they use organisational site-specific data with a limited focus on one life cycle stage which is then compared to an alternative. To our knowledge there are no sLCA studies which collect indicator values from organisations along the production system and also characterise them, using primarily quantitative regional sector-specific references, as RESPONSA aims to do. The main reason for this is due to limited data availability. However, as the organisations within the focus bioeconomy region in Germany were amalgamated into clusters, this provided a better opportunity to access and structure the life cycle approach data at various different levels.

For a more comprehensive sLCA method, a limited set of indicators and indices relevant to the study context, (i.e. wood-based production chains in German bioeconomy regions) is required, selected in a transparent manner which can easily be outlined. Therefore, this paper aims to define the most appropriate and relevant social indicators that can be aggregated into a comprehensive set of social indices¹ which can be used to effectively assess the potential social implications of a wood-based product produced within a German bioeconomy region, as proposed by Siebert et al. (2016). This set will be the basis for establishing the social

inventories with the “RESPONSA” framework, (which stands for the acronym of a REgional SPecific CONtextualised Social life cycle Assessment). Thus, such a set of social indices also enables the assessment of social hotspots and opportunities relating to the foreground activities involved in wood-based production systems within a German bioeconomy region. Such indices also help to account for the social performance of all the organisations involved in the production chain within the study region.

2. Materials and methods

2.1. Screening criteria

Siebert et al. (2016) outlined the RESPONSA framework to assess the social performance of organisations involved in the production of wood-based products in a German bioeconomy region. Fig. 1 depicts the scope of the sLCA framework, the system boundaries and the definition of the production system. The focus of the study is within the boundaries of a producing region (O’Keeffe et al., 2016), assumed to be an area smaller than a country, thus all relevant life cycle stages of a wood product found within this boundary (e.g. wood harvesting, wood transport, pre-processing, and the production stage of the wood product) are considered. We refer to this geographic area as the *regional bioeconomy foreground*. The regional system boundaries are determined by the administrative level for which references (i.e. data and statistics) are available for characterising the indicator values collected from the organisations in the production system (e.g. the federal states of Germany). The social implications to be monitored are associated with the conduct of the organisations along the life cycle. The social aspects² considered affect: 1) workers employed in the organisations, 2) the surrounding local communities and 3) the national society of the country. An organisation’s conduct is highly influenced by national and regional socio-economic conditions, e.g. the cultural setting, the legislation or common societal norms (Hauschild et al., 2008; UNEP-SETAC, 2009; Zamagni et al., 2011).

A sLCI should aim to incorporate these conditions and collect data directly from the associated organisations to assess social effects directly related to the product of interest. Therefore, several research steps were taken in order to select relevant social aspects

¹ We define the sLCA concepts of social impact categories as a social index, in order to acknowledge unknown cause effects relationships (Siebert et al., 2016). The indices should provide a single estimate of a social issue or opportunity and thus, make them easier to understand for decision makers. Each index is characterised by one or more social indicators.

² A social aspect is defined as anything related to human well-being. In the literature a diversity of terminologies is applied and the term social aspects may refer to any number of general topics, such as: objectives, social issues or opportunities, indicators, indices or impact categories. For simplicity and for ease of discussion we did not differentiate between them and named all relevant selected themes and topics as social aspects.

for setting up a context-specific set of social indices and corresponding indicators. To start the screening process the following criteria were used to review the literature for potential social aspects:

- Importance for the national socio-economic conditions (i.e. Germany)
- Direct accountability for the organisation's conduct (i.e. site-specific aspects)
- Descriptive relationship between the organisations' conduct and social implications for the relevant stakeholders
- Association with relevant stakeholder categories: workers, local communities, national society³
- Relevance at all life cycle stages found within the regional foreground

In order to avoid collecting unnecessary inventory data, and to support a more focused inventory collection the social aspects were reviewed with regard to their relevance to the national conditions and therefore, applicability to the production activities of the organisations located within the regional foreground (e.g. biomass production, transport and material production).⁴ Some sLCA approaches assess a product's potential social effects by determining the social conditions in the associated countries or sectors and applying indicators at a national level, such as a country's corruption or educational level. In cases of low data availability (e.g. in emerging countries) this approach is currently best practice. However, when reliable data is available, as in the case study used to develop RESPONSA, more site-specific approaches can be applied. Thus, this sLCA approach aims to assess site-specific social performances, directly related to an organisation's conduct. Therefore, social aspects which were identified to be directly attributable (e.g. linked) to the conduct of a specific organisation can be applied or generic social aspects (e.g. using national or regional level) were converted to be applicable at an organisational level. At best the relevant social aspects are measurable in a quantitative manner and address the potential implications for stakeholders as a result of the organisations' activities. Qualitative aspects should represent an action or measure (e.g. provision of safety equipment) from which the consequences are experienced by the stakeholders (UNEP-SETAC, 2013). The RESPONSA approach is derived for the producer perspective and takes all relevant social aspects into account from regional resource extraction (i.e. wood) until the final product (i.e. factory gate), use phase or end-of-life are not considered.

2.2. Overview of research steps

A top-down and bottom-up approach was applied to merge globally relevant social sustainability aspects⁵ with context-specific ones, as presented in Fig. 2.

In a first step, global sustainability standards were reviewed, as well as German sustainability strategies and national forest

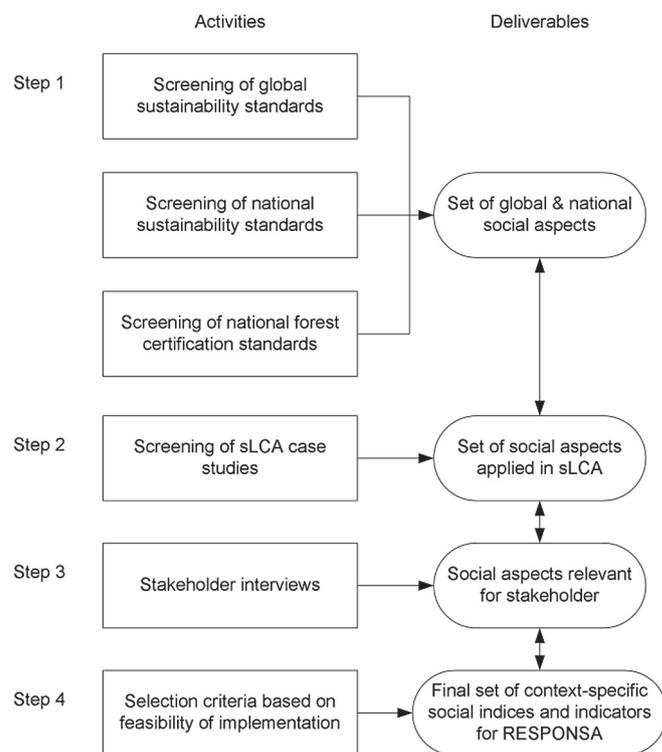


Fig. 2. Research steps taken to select and develop context-specific social indices and indicators to be used as part of the RESPONSA framework.

certification standards to determine a set of global and national social aspects (Section 2.3 and 2.4). In a second step, sLCA case studies were screened to crosscheck and complete the information generated from the literature analysis on sustainability standards and to develop a set of social aspects applied in sLCA case studies (Section 2.5). In a third step, the aspects preselected from the literature review were refined with more national specific information provided by interviewing stakeholders involved in bioeconomy activities, which enabled the generation of stakeholder preference aspects (Section 2.6). The fourth and final step screened and ordered the shortlisted social aspects with regards to: 1) available indicators, which had been found in the previous steps, 2) available data on organisational level, 3) reliability of available indicators and, 4) the availability of reference data on a national and regional sector-specific level (Section 2.7). This step resulted in a final set of context-specific social indices and their associated social indicators, which will be used to assess the social performance of wood-based production systems in a German bioeconomy region. These indices provide the basis for the sLCI required by the RESPONSA framework outlined in Siebert et al. (2016).

2.3. Screening of global sustainability standards

Based on the screening criteria outlined in Section 2.1 the social aspects selected from global sustainability standards are displayed in Table 1, although, due to space limitation only the main social aspects are presented. Two global standards focusing only on social responsibility aspects were reviewed, ISO 26000 and SA 8000, which are based on: the Universal Declaration of Human Rights, the Conventions and Declarations from the International Labour Organisation (DIN, 2010; SAI, 2008) and the Global Reporting Initiative standard (GRI, 2011), which encompasses social and environmental sustainability aspects.

The overall relevant social aspects in Table 1 are independent

³ When it comes to estimate social effects on other stakeholder groups such as consumers or value chain actors, this requires additional social indices or even different approaches (i.e. to assess social effects on consumers Dreyer et al., 2006).

⁴ This was necessary in view of the subjective well-being influenced by the national and regional socio-economic conditions (cultural setting, legislation or common societal norms) that influences the perception of relevant social aspects (i.e. in Germany other aspects are deemed to be relevant for good working conditions compared to other countries) thus, indicators have to be chosen that can assess aspects relevant to the geographic area.

⁵ We stick to the terminology of social aspects as an umbrella term to acknowledge the great diversity of terminology in the literature.

Table 1
Social aspects preselected from the screening process.

Level	Standards with preselected main social aspects in italics and corresponding examples ^a	
Global	ISO 26000^b/SA 8000^c/Global Reporting Initiative (GRI)^d	
	<i>Non-discrimination</i>	Fair opportunity for a job regardless of age, gender, origin, sexual orientation, disability or religion
	<i>Reasonable working hours</i>	A standard work week does not exceed 48h per week with at least one day off; overtime is voluntary and does not exceed 12h per week
	<i>Remuneration (payment)</i>	Should meet at least legal or industry minimum pay standards and is sufficient to meet basic needs (e.g. food, accommodation)
	<i>Freedom of association and right to collective bargaining/(social dialogue)</i>	The establishment of works councils and trade unions are permitted and recognised as a free collective bargaining for a balance of interests between employers and workers
	<i>Health and safety at work</i>	The employees have/maintain a bill of good health and there are preventative measures in place to protect against harm caused through working conditions
	<i>Training and education</i>	The employees have access to skills development, training and apprenticeships and opportunities for career development
	<i>Community involvement and development</i>	Opportunities within supporting communities for: consultation, employment creation and skills, technology development and access, wealth and income creation, health and social investments
National	Sustainability Code^e/National Sustainable Development Strategy^f	
	<i>Employment</i>	Job creation
	<i>Employment rights</i>	Employees should not be exposed to situations where, injuries, occupational diseases or work related fatalities may occur
	<i>Equal opportunities/(integration of non-nationals/prospect for families)</i>	Employment opportunities open to all; qualified non-nationals and people with disabilities, no discrimination as well as the provision of fair pay and a work-life balance
	<i>Qualification</i>	All employees take part in training irrespective of gender or employment category
	<i>Corporate citizenship/ stakeholder engagement</i>	Public engagement and transparency of organisations to report key topics and concerns that have been raised through stakeholder engagement
Sector	German Forest Stewardship Council (FSC)^g/Programme for the Endorsement of Forest Certification Schemes (PEFC)^g	
	<i>Employment</i>	Qualified employees as a matter of priority, employment for local communities, long-term employment
	<i>Training opportunities</i>	Employees have the possibility to take part in training courses
	<i>Health and safety measures</i>	Accident prevention regulations are met
	<i>Freedom of association and right to collective bargaining</i>	Employees rights of freedom of association and to bargain with the employer is guaranteed according to the ILO convention 87 and 98
	<i>Keep collective wage agreements</i>	The payments are deducted from current collective wage agreements
	<i>Participation</i>	Employees have the possibility to inform themselves and are provided with possibilities of participation

^a The terminology, the structure and the scope of themes differs between the standards although core subjects associated with human rights and labour practices are found in all standards therefore these umbrella terms are not listed.

^b Guidelines for social responsibility (DIN, 2010).

^c Certification standard for socially acceptable practices in the workplace (SAI, 2008).

^d Guidelines for sustainability reports (GRI, 2011).

^e In contrast to the GRI, the ISO 26000 and SA 8000 the Sustainability Code exclusively focus on social responsibility themes which are based on the Universal Declaration of Human Rights as well as Conventions and Declarations from the International Labour Organisation (ILO) (German Council for Sustainable Development, 2015; The Federal Government, 2012). It must be noted that the guidance provided by the standard is universally applicable for all types of organisations no matter what size, geographic location or industry sector and therefore is not specific enough for an sLCA approach focusing on the social sustainability aspects of a German bioeconomy region.

^f Framework to report on sustainability management system.

^g Forest certification standards for Germany (FSC Deutschland, 2016; PEFC Deutschland e.V., 2014).

from national socio-economic conditions. However, the extracted aspects must be specified further, if they are to be applicable to a more case specific sLCA which focus on the social performance of organisations related to a German bioeconomy region.

2.4. Screening of national sustainability and forest certification standards

The national standards include the same aspects as the global standards, but are specified further to German conditions. Social aspects identified as relevant from the national sustainability standards are outlined in Table 1. The “Sustainability Code” developed in Germany contains standards to guide organisations on sustainability (German Council for Sustainable Development, 2015). Furthermore, the “National Sustainable Development Strategy” was reviewed (The Federal Government, 2012). The strategy outlines the social aspects, independent from organisations’ conduct, which are to be monitored in Germany and therefore, provides insight into sustainable development objectives for Germany. It also helps to identify the aspects relevant for the stakeholder category “national society”.

To further specify the themes and indicators for the wood-based bioeconomy, certification standards from the PEFC (Programme for the Endorsement of Forest Certification Schemes) and FSC (Forest

Stewardship Council) for Germany were also reviewed (Table 1). It can be seen from Table 1 that there are many similar and often overlapping social aspects found in the different standards. For this reason, as presented in the next section, sLCA case studies were screened in order to determine which social aspects should be selected.

2.5. Screening of sLCA case studies

In order to make the previous shortlisted selection of social aspects more compatible with the RESPONSA framework of Siebert et al. (2016), the next step focused on screening available sLCA case studies. An overview of the social aspects applied in the available sLCA case studies (at time of writing) is provided in Table 2. It was determined that certain social aspects which were relevant for other studies were not deemed to be relevant here, as discussed in Section 2.2. Social benefits, for example, is a category proposed by the guidelines (UNEP-SETAC, 2009). In Germany, such rights are legally implemented by the German government through social insurance contributed by the salaries of the employees.⁶ This in turn should enable a social welfare payment to be

⁶ In Germany the majority of employees work in jobs where social security contributions are mandatory to be paid by the employer.

Table 2
Set of social aspects applied in sLCA case studies.

Social aspects ^a	sLCA case study ^b											
	1	2	3	4	5	6	7	8	9	10	11	12
Working conditions					x		x	x				
Discrimination/equal opportunities		x	x	x	x	x	x	x	x	x		x
Working hours/time		x	x	x	x	x	x	x				x
Fair salary/wages	x	x	x	x	x	x	x	x		x	x	x
Health conditions/health & safety	x	x	x	x	x	x	x	x		x	x	x
Freedom of association & collective bargaining		x	x	x	x		x	x	x		x	x
Education					x			x				
Local community acceptance (complaints)											x	
Safe & healthy living conditions		x	x	x			x				x	x
Community engagement		x		x	x		x			x		
Local employment		x	x	x			x				x	
Transparency on social & environmental issues							x					
Public commitment to sustainability issues		x		x	x		x					
Contribution to economic development		x	x	x	x					x	x	
Technology development/transfer		x	x	x	x		x				x	

^a Since most sLCA case studies apply social impact categories proposed in the UNEP-SETAC guidelines, please refer to (UNEP-SETAC, 2009) for more information. Relating indicators can be found in the methodological sheets (UNEP-SETAC, 2013).

^b We reviewed major sLCA case studies mainly focusing on those using data on an organisational level. For more information on the case studies (e.g. the study object etc.), please refer to (Chhipi-Shrestha et al., 2015); 1 (Chang et al., 2015); 2 (Ekener-Petersen and Finnveden, 2013); 3 (Franze and Ciroth, 2011); 4 (Ciroth and Franze, 2011); 5 (Revéret et al., 2015); 6 (Traverso et al., 2012); 7 (Halog and Manik, 2011); 8 (Aparcana and Salhofer, 2013); 9 (Dreyer et al., 2010); 10 (Foolmaun and Ramjeeawon, 2013); 11 (Hosseiniyou et al., 2014); 12 (Martínez-Blanco et al., 2014).

provided to every worker in Germany, in the event of illness, invalidity and retirement. Therefore, this is expected to be the standard condition for workers and as one would not expect infringements, it is taken as a baseline for the German condition and is not considered within the RESPONSA framework here.⁷ While these aspects were deemed to be irrelevant for the production chain in the regional foreground, it has to be noted that they could become relevant when assessing the social implications from production activities outside the region. Therefore, we suggest to apply generic indicator sets such as proposed in the methodological sheets (Benoit-Norris et al., 2011) from the sLCA guidelines or to apply the “Social Hotspot Database” (Benoit-Norris et al., 2012) in order to screen these production activities. The social indices which were found to be applicable to the socio-economic conditions in Germany are outlined in Table 2.

2.6. Stakeholder interviews

A key feature of this research is the use of semi-structured⁸ stakeholder interviews that explored social opportunities and challenges related to a wood-based (German) bioeconomy. The results were used to refine the previous selected social aspects relevant to wood-based production chain in German bioeconomy regions.

In Germany workers, local communities and the society as a whole are represented by various institutions. Trade unions for example represent workers' rights and NGOs represents societies' interest (e.g. concerns, view points and norms). Accordingly, we selected representatives from a wide range of institutions, to generate information about workers, local communities and national society's interest, in order to create social indices and indicators “that make sense for the stakeholder” as suggested by

⁷ Additionally, aspects such as child labour, forced labour, food security, prevention and mitigation of armed conflicts and access to material and immaterial resources were considered not to be relevant, because they are more relevant for emerging countries. Furthermore, indigenous rights, as defined in the UNEP-SETAC guidelines are assumed not to be relevant for Germany, as such groups no longer exist in Germany.

⁸ The semi-structured interview is a method of research applied in social science that allows a free exploration of topics (Flick, 2016).

(Mathe, 2014). In a first step a list of approx. 23 potential stakeholders were compiled and contacted via email or phone to request an interview. Although most stakeholders contacted (Table 3) had an initial response of being interested in participating, many of them declined to take part in the official interview process. Consequently, approx. 50% of those initially contacted agreed to participate in the interviews.

The statements made during the interviews were grouped according to the three stakeholder categories (Table 3) and their relation to overall social aspects which were shortlisted: qualification, health & safety, remuneration, working conditions, participation and regional development (Fig. 3). One major social issue identified from the survey was the conflicting objectives in forest management (e.g. forestry (for wood products), conservation, recreation etc.) due to competing interests from stakeholders, which is seen to increase in the future due to higher wood demands generated by a wood-based bioeconomy. Furthermore, interviewees indicated that the development towards a bioeconomy should address other issues such as the climate change or demographic change, and take into account people's preferences. With regards to workers, several issues related to the private forest management⁹ in Germany were raised, such as: the low health and safety standards, high accident rates due to low qualification, low payment and low organisation of workers. These aspects were taken into account during the conversion of general aspects (from the previous step) into a set of social indices and related indicators, which are more context specific.

2.7. Selection based on feasibility of implementation

Finally, the relevant social aspects identified were screened and sorted based on criteria determined for the implementation of the RESPONSA framework. Thus, the previous shortlisted social aspects are converted into a set of context-specific indices and indicators (Table 5) for the sLCA approach. The selected social aspects were then screened for the following criteria:

⁹ In Germany forest is owned privately by the municipalities or the state.

Table 3
Organisations interviewed and associated stakeholder category.

Stakeholder category	Interview partners affiliation	Explanation
Workers	Industriegewerkschaft Bau Agrar Umwelt (IG B.A.U.)	Trade union affiliated to the forest sector in Germany
	Sozialversicherung für Landwirtschaft, Forsten, Gartenbau (SVLFG)	Employer's liability insurance association in Germany
Local community	Regional Ministry for Science and Arts	Governmental department
	Local Ministry for Science and Economy	Governmental department
National society	Regional planning organisation	Organisation for regional planning
	Friends of the Earth Germany (BUND)	Association for environmental protection and nature conservation in Germany
	Forest Stewardship Council (FSC)	Forest certification organisation in Germany
	Programme for the Endorsement of Forest Certification Schemes (PEFC)	Forest certification organisation in Germany
	State forest organisation	Forest organisation owned by the government
	Nordwestdeutsche Forstliche Versuchsanstalt	Research institute for forest owners, forest companies and politics from several federal states
	Helmholtz Centre for Environmental Research	Environmental research institute

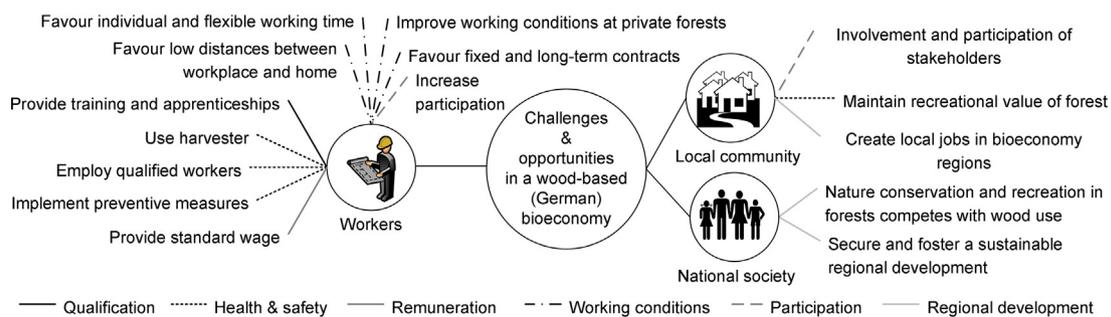


Fig. 3. Social aspects extracted from the stakeholder interviews on the central question on potential challenges and opportunities in a wood-based bioeconomy in Germany. The statements are grouped according to the associated stakeholder categories. The Figure does not represent the actual number of times the aspects were named during the interviews.

- measurability, either with a quantitative or qualitative indicator
- parameters to be calculated require data that is easily available in the organisations
- can provide an accurate measurement based on reliable information
- available indicators can be matched with available sector-based reference data on a national or regional scale (i.e. performance reference points (Fig. 4))

In Table 4, the main social aspects determined were grouped and analysed using these four selection criteria. The indicators available to assess the social aspects were found to be very heterogeneous. Although they address the same social aspect, such as wages, they could be used to assess national or sectoral levels (e.g. minimum wage in the country/sector) or at an organisational level (e.g. lowest payment in the organisation) or the numerical unit may differ and thus, comparability is limited (e.g. the average payment in the organisation or the percentage of employees receiving a certain amount of payment). Furthermore, the social aspects could be assessed using indicators of engagement (e.g. documented payment of workers) or of organisational measures (e.g. financial participation means for employees). This also has consequences for data availability, which therefore, differs respectively between the social aspects (Table 4). Additionally, the reliability of the information generated for the indicator assessing the social aspect of interest has to be taken into account. For example, information about working hours found in workers contracts does not provide information about the real hours worked. A final screening criterion for the definition of a social indicator set was the availability of sector-specific reference data on a national or regional scale for the particular indicator that are applied in the social life cycle impact

assessment (sLCIA), in order to calculate the relative social performance (Siebert et al., 2016). An employment survey conducted by the Institute for Employment Research (IAB)¹⁰ was selected as the main statistical source for reference data. The results of a national survey, the IAB Establishment Panel (i.e. a representative employer survey of employment parameters), conducted once a year across a diversity of organisations in Germany is made available for scientific research. Therefore, potential indicators are adapted (i.e. the type of indicator and its unit) in order to match the data found in this statistical source.

3. Results and discussion

The purpose of this paper was to select social indices and indicators which can be used to assess the relative social performance of wood-based products produced in a German bioeconomy region. Although the set is only applicable to assess activities in the German foreground it becomes a powerful tool, through the broad variety of social concerns taken into account, to screen wood-based production chains in Germany and to provide a comprehensive overview of social hotspots and opportunities for regional producers. Additionally, available generic indicator sets (e.g. from the Social Hotspot Database or the methodological sheets of the sLCA guidelines) can be applied for a better understanding of the social effects occurring outside the region although they cannot assess social effects with such a high level of detail.

The indicator values are directly collected from the

¹⁰ The IAB is a special office from the Federal Employment Agency. For the panel please see <http://www.iab.de/en/erhebungen/iab-betriebspanel.aspx/>, 20.05.2016.

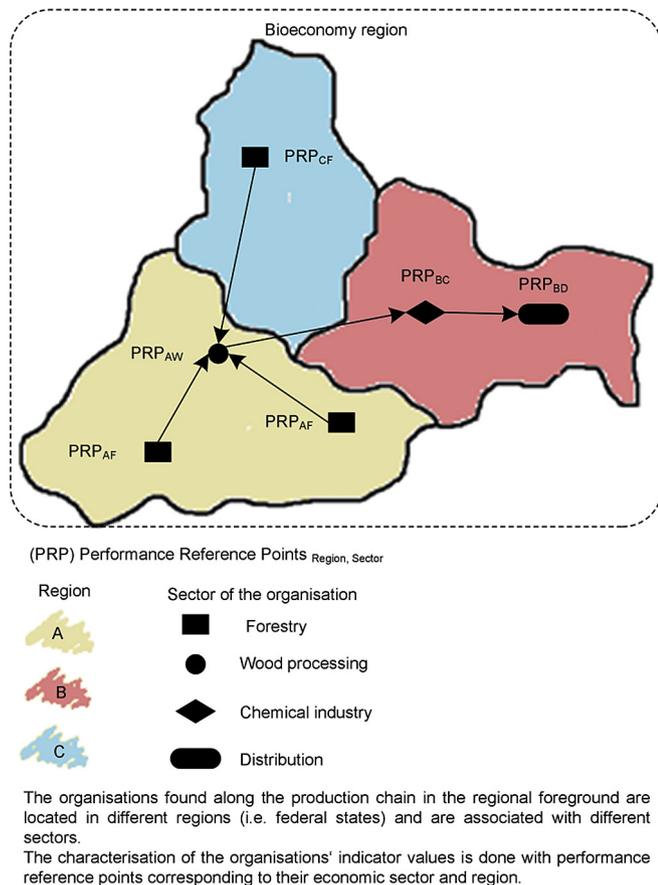


Fig. 4. RESPONSA framework.

organisations (e.g. average remuneration level) and characterised with regional sector-specific reference data (e.g. average remuneration level in the forestry sector in a federal state). This enables the calculation of relative social performances that are directly related to a product and the organisations affiliated with the production activities found in the regional foreground. The results can be used by organisations to compare their behaviour to the status quo of their particular sector and/or region in which they are operating. This information can encourage decision makers to make more sustainable courses of action.

In Table 5 we depict social effects delineated by the social performance indicators that were consolidated into comprehensive

sub-indices (i.e. accidents and sick-leave) and related to an individual social index, such as “health & safety”. Every indicator listed in Table 5 was identified as highly relevant for the socio-economic context of interest (i.e. wood-based production chains in German bioeconomy regions). Each sub-index is assessed with one or more indicators. While these indicators assess potential social effects affiliated predominantly with the stakeholder category, workers, they also encompass social effects on local communities and the national society (Figs. 1 and 3). The first three social indices are primarily associated with workers, whereas the index “knowledge capital”, for instance, is relevant for workers (i.e. on-the-job training), for local communities (i.e. vocational training) and the national society (i.e. research and development). It has to be noted that these relationships overlap to various extents, and thus that many social effects on workers or the local communities may have potential social effects for the national society too (e.g. occupational diseases affect a workers well-being and at the same time the health system and in turn the national society). The main affiliation to the stakeholder categories is indicated through letters at the sub-indices.

We further depict the format of the indicators that may be numerical, a currency, percentage or a category and its calculation (e.g. the categories, time period etc.), thus the format of data required from the organisations. This makes the set directly applicable for collecting primary data from each relevant organisation in the regional foreground. This effort of data collection is one major limitation of the RESPONSA framework, however the reference data required for characterisation is easily available from IAB.

When it comes to the social effects indicated by the defined indices it has to be noted that they can only constitute those effects determined through the applied social performance indicators. Thus, the presentation of the inventory results and their interpretation should be done with great care and always in view of the indicators providing the information for the social indices. The social index “health & safety”, for example, does not indicate potential health and safety effects on local communities, as the indicators only address occupational accidents and workers' health issues. Additionally, some indicators are ambiguous because they could indicate either a “good” performance or a “bad” performance, at the same time depending on the reality being assessed. One example of where this occurs relates to marginal employment (e.g. positions remunerated with 450€ per month), which could have a positive social effect if people intend to have such a position, or negative effects if people do not intend such a position. Therefore, these underlying stakeholder preferences, as well as the specific social impacts on human well-being, cannot be denoted with this

Table 4
Screening criteria applied to the social aspects selected.

Social index	Indicators	Data	Reliability	Reference	Source
Health & safety	✓ ^a	✓	✓	✓	[1–5,7]
Adequate remuneration ^b	✓	✓	(✓)	✓	[1,3]
Adequate working time	✓	✓	(✓)	✓	[1,6]
Employment ^c	✓	✓	✓	✓	[2,3,4,5,6,7]
Knowledge capital	✓	✓	✓	✓	[1,4,5]
Equal opportunities	(✓)	✓	(✓)	✓	[1,3,4,5]
Participation ^d	(✓)	(✓)	(✓)	–	[1,3,5]

[1] (Aparcana and Salhofer, 2013); [2] (Busset et al., 2014); [3] (Foolmaun and Ramjeeawon, 2013); [4] (German Council for Sustainable Development, 2015); [5] (GRI, 2011); [6] (Traverso et al., 2012); [7] (Vinyes et al., 2013).

^a ✓ fulfilled (✓) fulfilled with restrictions.

^b Without equal remuneration of men and women as found in (GRI, 2011; Aparcana and Salhofer, 2013).

^c Aspects besides the named aspects such as the description of the employees (total, fulltime, part-time, gender, age, locally hired, educational status etc.).

^d [1,5] Collective bargaining, [3] Stakeholder involvement (Percentage of Corporate Social Responsibility fund spent on community projects).

Table 5
Final set of social indices and their associated indicators.

Index	Indicator	Unit	Equation/Measure
1. Health & safety			
Accidents ^a	Occupational accidents	Nr	Number of accidents per year per 1000 employees
	Occupational fatal accidents	Nr	Number of fatal accidents per year per 1000 employees
Sick-leave ^a	Sick-leave days	Nr	Sick-leave days per year per employee
	Preventive health measures	Cat.	Health measures (e.g. sick-leave analysis, health activities)
2. Adequate remuneration			
Payment ^a	Payment according to basic wage ¹	y/n	Payment of basic wage
	Average remuneration level	€	Average payment per month per full-time employee
Financial participation ^a	Capital participation ²	y/n	Existence of a capital participation model
	Profit-sharing and bonuses ³	y/n	Existence of a profit-sharing and bonuses model
3. Adequate working time			
Working time ^a	Contractual working hours	h	Average contractual working hours per week per full-time employee
	Compensation for overtime	Cat.	Compensation measures (e.g. exclusively payment, payment and free-time, exclusively free-time, any)
Work-life-balance ^a	Access to flexible working time agreements	y/n	Access to flexible working time agreements (e.g. working time accounts etc.)
	Rate of part-time employees	%	Percentage of part-time employees per total employees
4. Employment			
Job conditions ^a	Rate of qualified employees	%	Percentage of employees with professional training per total employees
	Rate of marginally employed (earning max 450€ per month)	%	Percentage of employees earning max 450€ per total employees
Duration of employment ^a	Rate of fixed-term employees	%	Percentage of fixed-term employees per total employees
	Rate of employees provided by temporary work agencies	%	Percentage of employees provided by temporary work agencies per total employees
Job creation ^b	Rate of recruitment	%	Percentage of new hired employees per year per total employees
5. Knowledge capital			
On-the-job training ^a	Employees participated in training	%	Percentage of employees participated in training per total employees
	Support for professional qualification	y/n	Assumption of cost or exemption for training programs
Vocational training ^{b,c}	Rate of vocational trainees	%	Percentage of trainees per total employees
	Rate of vocational trainees hired	%	Percentage of trainees employed permanently per total trainees
Research & development ^c	Rate of employees in research and development	%	Percentage of employees working permanently or temporarily in the research and development section per total employees
6. Equal opportunities			
Gender equality ^c	Rate of female employees in management positions	%	Percentage of female employees in management positions in relation to all employees in management positions
	Measures to improve gender equality	Cat.	Measures for family support (e.g. support for child care, support for female employees)
Older employees ^{a,c}	Measures to support older employees	Cat.	Measures for older employees (e.g. offer of part-time contracts, special equipment of the workplace)
Minorities ^c	Rate of disabled employees	%	Percentage of disabled employees per total employees
	Rate of foreign employees	%	Percentage of foreign employees per total employees
7. Participation			
Workers participation ^a	Works' council	y/n	Existence of works' councils in the organisation
	Other measures for participation	y/n	Measures to participate in the organisation

Nr: number, Cat.: category, % per cent, y/n: yes and no, h: hours.

^a workers; ^b local community; ^c national society.

1 In Germany basic wages are based on sectoral collective agreements between management (i.e. representing the organisation) and trade unions (i.e. representing the workers). The agreements are valid for one sector (e.g. forestry) and are legally binding.

2 With capital participation employees provide financial means for the organisation and became shareholders (e.g. GmbH shares, employees shares or cooperative shares) (Bellmann and Möller, 2006).

3 With profit-sharing or bonuses employees receive in addition to their regular wage an additional profit-based or performance related pay (Bellmann and Möller, 2006).

approach. This is an area which requires further research, especially in relation to potential cause-effect relationships between an organisation's activity and its social impacts (Feschet et al., 2013; Macombe et al., 2013). The set of social indices and indicators is discussed individually in the succeeding sections.

3.1. Index: health and safety

In view of the relatively high accident rates associated with the sectors of biomass production (e.g. forestry and agriculture) in Germany (Knieps and Pfaff, 2014), health and safety aspects become a key social issue to integrate, in order to assess the social performance of the associated wood-based products. Thus, production activities should not harm or have negative effects on the workers' health. We selected four common indicators to assess the status of these issues, which were then aggregated into two sub-

indices, "accidents" and "sick-leave", which should be accounted for in a specified time period (Table 5). Implemented health and safety measures were chosen to evaluate the engagement of the organisations to prevent or improve the health status of their employees.

3.2. Index: adequate remuneration

In Germany the remuneration of employees differ greatly between regions. However, if the wages and salaries paid by organisations along a product's life cycle cover the basic needs of employees, cannot be assessed due to data limitations. Nevertheless, remuneration has to be taken into account in the assessment of wood-based products from Germany. This index is broken down into two sub-indices, "payment" and "financial participation" each of them characterised by two indicators. The sub-index "payment"

has indicators examining if an organisation pays the basic wage¹¹ (i.e. based on a sectoral level) and the average remuneration level in the organisation. However, the cost of living differs between regions. Therefore, the remuneration level should be characterised with the average remuneration level of a region and sector, a step carried out during the sLCIA phase (Siebert et al., 2016). In addition, the “financial participation” of employees in the organisation is associated with a fair payment, too. On the one side organisations become more attractive to qualified workers and on the other side, workers get an additional (financial) reward for a successful work which motivates them. An additional effect is the more equal distribution of wealth and thus, to oppose the concentration of assets within certain sections of society (Beyer et al., 2013).

3.3. Index: adequate working time

In Germany one major social concern of workers is their working time. In this regard the hours worked per week and the form of compensation is particularly relevant. In the last years overtime that is not compensated financially or with free time has increased in Germany. Therefore, the sub-index “working time” has indicators on the contractual working time and the overtime and its compensation. While, exact amounts of overtime are difficult to gather we focus on the form of compensation according to the employees’ preference thus, with free time or extra payments (Table 5).

Additionally the organisation of the working time effects well-being. Part-time employment,¹² for example, can help to combine family and working life. However, long-term part time employment in Germany is associated with negative impacts for income, career development and retirement planning. The sub-index “work-life-balance” consists of an indicator that describes the ability of workers to choose their presence at the workplace in a flexible manner. Additionally, while preferred working hours cannot be anticipated, the amount of part-time workers is assessed in order to estimate the ability of workers to decide on their preferred working time per week. However, it has to be noticed that this indicator is rather difficult to interpret as part-time employment can be associated with both negative and positive effects. Thus, stakeholder that are willing to work full-time but only get a part-time position, because of increased demand for part-time workers in Germany, would experience negative effects. In contrast, especially women are willing to reduce their working time, for example during motherhood, would experience positive effects for their work-life balance (Vogel, 2009; Wanger, 2015).¹³

3.4. Index: employment

This index assesses social aspects that are key conditions for a good quality of life that go beyond aspects of working time. In Germany several working conditions are defined as atypical and are often described as precarious (i.e. employees earning less than 450€ per month, employees from work agencies, or employees with fixed-term contracts) and are associated with higher social risks such as insufficient payment or a higher risk of

unemployment compared to permanent full-time positions. While the sub-index “job conditions” assess the rate of qualified employees (associated with “good” working conditions) and of marginally employed¹⁴ (“bad” working conditions) the range of job demands on the employees is displayed.

Additionally, positions for qualified employees (e.g. requiring vocational training or a university degree) should be fostered to prevent precarious working conditions. This sub-index is complemented by the sub-index “duration of employment” which provides insights into affiliated social aspects. Duration of employment is correlated with quality of life, as it impacts social participation due to its association with several risk factors, such as income insecurity (Gundert and Hohendanner, 2011). Therefore, we assess the rate of fixed-term employees and additionally the rate of employees provided by temporary work agencies.

The sub-index “job creation” assesses employment aspect affiliated to the stakeholder category “local communities”. A sustainable bioeconomy can contribute to the development of rural areas and local communities through the establishment of employment opportunities for workers in these areas. In this way providing an incentive to stay preventing migration away from such rural areas and support local communities. Thus, numbers on the annual recruitment in organisations can give insights into a regional product’s supply chain’s contribution to the economic development of the associated production region.

3.5. Index: knowledge capital

To maintain society’s productivity, potential knowledge capital has to be maintained and extended in order to provide the same opportunities for future generations. In this work the term knowledge capital is defined as “ones skills and capacities”. The bioeconomy is also named as knowledge-based bioeconomy which implies that its development requires innovation. Therefore, the sub-index “research and development” examining the amount of employees working in this area can serve as a proxy to assess organisations engagement in the development of new knowledge, as well as their innovation capacity. Furthermore, the research and development activities are important to maintain competitiveness of the industries involved in the bioeconomy which has major influences on the employment level in Germany. The sub-index “on-the-job-training” assesses the organisations effort to maintain or increase the knowledge capital of their employees calculated through their regular participation in training programmes. This can also enhance the organisations economic performance, as educated workers can do more diverse work to a higher standard and be more creative and innovative. It also relates to the workers themselves with regard to their employability and self-perception. Furthermore, new knowledge has to be set up by vocational training that maintains the stock of knowledge in the local communities and society. Thus the sub-index “vocational training” evaluates the amount of apprenticeships offered. The vocational training furthermore increases employment opportunities for local communities and prevents a future shortage of skilled workers in a society.

3.6. Index: equal opportunities

If each member in a society has access to education, information, the labour market or social and political positions, then equal opportunities are provided. Additionally, everybody should be

¹¹ The reason for this indicator is that while a minimum wage was implemented in 2015 in Germany, we assume that the basic wage (i.e. a wage agreed upon between management and trade unions on a sectoral level) to be higher and therefore, closer to an adequate remuneration.

¹² Part-time employees work less than 31h per week.

¹³ In Germany the proportion of part-time workers increases constantly due to the demand from the employees as well as from the organisations itself. Most of the part-time employees are women which increases the social inequality between men and women.

¹⁴ In this work we use the term marginally employed for employees who’s working contract is on max 450€.

treated the same, irrespective of their sex, age, race, religion, marital status or political beliefs and they should not be hampered by discrimination. Access to the labour market can, in some cases, be especially challenging for disabled and foreign people (Kaas and Manger, 2012). Therefore, to examine the sub-index “minorities” the proportion of disabled and foreign employees was selected as relevant indicators.

Another area of inequality relates to gender bias. The gender pay gap reflects the difference of payments between men and women. However, as the gender pay gap is difficult to calculate and to interpret due to complex cause and effect chains, it was not selected as an index for the sLCA method. Instead, we selected indicators that provide information on the engagement of organisations to increase gender equality through implementing different management measures. For example, the proportion of women within leadership positions was used within the sub-index “gender equality”. Additionally, due to the demographic change in Germany and a demographic skewed with an aging population, more employees in organisations of an older age category can be expected and this has increased the attention given to the fair treatment of older employees in the last decade, therefore, an indicator which assess the support of older employees was assigned to the sub-index “older employees”.

3.7. Index: participation

Equal participation and the right to voice one's concerns, is a fundamental right of workers (International Labour Organization, 1998) that includes all types of negotiation, consultation or exchange of information between representatives of the organisation and its employees on matters of concern (DIN, 2010). This right should be assessed by the social index “participation”. Works' councils are a powerful medium for workers participation in Germany. Employees may legally elect a works' council from five permanent employees in order to exercise their rights of representative participation (Addison, 2001). The works' council right of information, consultation and codetermination is formally prescribed by law. However, works' councils are only found in one in five organisations and in particular are rarely found in small organisations (Addison, 2001). Despite these limitations, the existence of works' councils is still a measurable and reliable proxy to examine workers participation in a particular organisation and was therefore assigned as an indicator to the social index “participation”. The power of a works' council cannot be calculated, if organisations restrict freedom of association or if a works' council simply has not been set up. Therefore, an additional indicator, “other measures for participation”, that indicates if organisations provide other means to involve employees was consolidated into the index in order to acknowledge that 61% of the organisations embrace other participative forms (Addison, 2001).

3.8. Outlook

This paper described the research steps taken and outlines the developed comprehensive set of social indices and corresponding indicators for the RESPONSA framework. The proposed set of indices is the first available to assess relative social performances related to a product and the organisation found along wood-based production chains in German bioeconomy regions. Thus, the design of the indicator set support the collection of site-specific inventory to link to such indicator values directly from the organisation and guarantees a benchmarking with regional sector-specific generic data available in Germany. Encompassing seven main indices several sub-indices and 29 mainly quantitative indicators, the set can depict a broad picture of social performances across different

relevant social topics, enabling simultaneous and comprehensive monitoring of our wood-based bioeconomy production systems.

However, its application is limited to the foreground activities in Germany. It has to be noted the indicator set cannot be applied to assess the social implications of production activities outside the region because of its specificity to the German socio-economic context. However, the approach itself can be adjusted for application in other European countries (i.e. with similar socio-economic conditions) for a social hotspot screening. Another additional drawback is the exhaustive data collection required; as each foreground organisation has to deliver data, the majority quantitative indicators can be clearly and easy be measured by the organisations itself. Despite this draw back the advantages could be worth the effort, as the approach facilitates the characterisation of each indicator with regional sector-specific performance reference points (conducted in the sLCA phase), thus, enabling regional producers to evaluate their social performance in view of their competitors. This may improve their decision making towards more sustainable production (Drew, 1997). Consequently, it can inform producers on the social effect of the overall product in the region in general and on their contribution to the social effects of the product in particular. Therefore, it supports producer's decision making to mitigate negative social effects and to accelerate positive ones.

4. Conclusion

The form of indicators applied in sLCA inventories differ respectively. Current sLCA approaches are powerful tools to screen global supply chains or compare production alternatives. However, when we become interested in the social implications directly related to a product produced in a specific region, the use of RESPONSA provides the benefit of a better insight into the social performance of the affiliated organisations in relation to their competitors in the region and sector. Consequently, it enables to inform producers of the potential social effects of the overall product in the region in general and on their contribution to the social effects of the product in particular. Therefore, it support producer's decision making which could mitigate negative social effects and to accelerate positive ones. Regional context specific sLCA approaches will become even more important as bioeconomy evolve at a regional level (Bioeconomy Congress EBCL, 2016). In a subsequent paper the regional sector-specific characterisation (sLCA) of RESPONSA will be outlined.

Acknowledgements

The authors thank the support of the project “Leading Edge Cluster Bioeconomy” (BMBF FZK 031A078A), and of the following Programs of the Helmholtz Association of German Research Centres: “Cross-Programme Initiative ‘Sustainable Bioeconomy’”, and “Technology, Innovation and Society”.

References

- Addison, J.T., 2001. Works councils in Germany. Their effects on establishment performance. *Oxf. Econ. Pap.* 53 (4), 659–694. <http://dx.doi.org/10.1093/oeq/53.4.659>.
- Aparcana, Sandra, Salhofer, Stefan, 2013. Application of a methodology for the social life cycle assessment of recycling systems in low income countries. Three Peruvian case studies. *Int. J. Life Cycle Assess.* 18 (5), 1116–1128. <http://dx.doi.org/10.1007/s11367-013-0559-3>.
- Bellmann, Lutz, Möller, Iris, 2006. Gewinn- und Kapitalbeteiligung der Mitarbeiter. Die Betriebe in Duetschland haben Nachholbedarf. Institut für Arbeitsmarkt- und Berufsforschung der Bundesagentur für Arbeit (IAB Kurzbericht, 13). Available online at. <http://doku.iab.de/kurzber/2006/kb1306.pdf>. updated on 2006, checked on 5/24/2016.
- Benoit-Norris, Catherine, Aulisio Cavan, Deana, Norris, Gregory, 2012. Identifying social impacts in product supply chains: overview and application of the social

- hotspot database. *Sustainability* 4, 1946–1965.
- Benoit-Norris, Catherine, Vickery-Niedermann, Gina, Valdivia, Sonia, Franze, Juliane, Traverso, Marzia, Ciroth, Andreas, Mazjin, Bernard, 2011. Introducing the UNEP/SETAC methodological sheets for subcategories of social LCA. *Int. J. Life Cycle Assess.* 16.
- Beyer, Heinrich, Stracke, Stefan, Wilke, Peter, 2013. Die Praxistauglichkeit finanzieller Mitarbeiterbeteiligung verbessern. Gestaltungsoptionen für Sondervermögen. Studie im Auftrag der Abteilung Wirtschafts- Hans Böckler Stiftung, Friedrich Ebert Stiftung (Wiso Diskurs).
- Bioeconomy Congress EBCL 2016, 2016. Lodz Declaration of Bioregions. Available online at: http://bioeconomy.lodzkie.pl/wp-content/uploads/dekl_en.pdf.
- BMBF, 2011. In: Federal Ministry of Education and Research (Ed.), National Research Strategy BioEconomy 2030. Available online at: http://www.bmbf.de/pub/Natinal_Research_Strategy_BioEconomy_2030.pdf. checked on 6/6/2015.
- BMELV, 2013. In: Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz. BMELV (Ed.), Politikstrategie Bioökonomie. Wachsende Ressourcen und biotechnologische Verfahren als Basis für Ernährung, Industrie und Energie. Available online at: http://www.bmbf.de/pubRD/Politikstrategie_Biooekonomie_barrierefrei.pdf. checked on 1/12/2014.
- Busset, G., Belaud, J.-P., Montréjaud-Vignoles, M., Sablayrolles, C., 2014. Integration of social LCA with sustainability LCA: a case study on virgin olive oil production. In: Macombe, Catherine, Loeillet, Denis (Eds.), *Social LCA in Progress*. FruiTrop, Montpellier, France.
- Chang, Ya-Ju, Sprosser, Gunther, Neugebauer, Sabrina, Wolf, Kirana, Scheumann, René, Pittner, Andreas, et al., 2015. Environmental and social life cycle assessment of welding technologies. *Proc. CIRP* 26, 293–298. <http://dx.doi.org/10.1016/j.procir.2014.07.084>.
- Chhipi-Shrestha, Gyan Kumar, Hewage, Kasun, Sadiq, Rehan, 2015. 'Socializing' sustainability. A critical review on current development status of social life cycle impact assessment method. *Clean. Technol. Environ. Policy* 17 (3), 579–596. <http://dx.doi.org/10.1007/s10098-014-0841-5>.
- Ciroth, Andreas, Franze, Juliane, 2011. LCA of an Ecolabeled Notebook. Consideration of Social and Environmental Impacts along the Entire Life Cycle. GreenDeltaTC GmbH, Berlin.
- DIN ISO 26000, 2010. Guidance on Social Responsibility.
- Drew, S.A.W., 1997. From knowledge to action: the impact of benchmarking on organizational performance. *Long. Range Plan.* 30, 427–441.
- Dreyer, Louise Camilla, Hauschild, Michael Z., Schierbeck, Jens, 2006. A framework for social life cycle impact assessment. *Int. J. Life Cycle Assess.* 11 (2), 88–97. <http://dx.doi.org/10.1065/lca2005.08.223>.
- Dreyer, Louise Camilla, Hauschild, Michael Z., Schierbeck, Jens, 2010. Characterisation of social impacts in LCA. Part 2. Implementation in six company case studies. *Int. J. Life Cycle Assess.* 15 (4), 385–402. <http://dx.doi.org/10.1007/s11367-010-0159-4>.
- Ekener-Petersen, Elisabeth, Finnveden, Göran, 2013. Potential hotspots identified by social LCA – part 1. A case study of a laptop computer. *Int. J. Life Cycle Assess.* 18 (1), 127–143. <http://dx.doi.org/10.1007/s11367-012-0442-7>.
- FAOSTAT, 2015. Forestry. Available online at: <http://faostat3.fao.org/download/F/FO/E>. checked on 10/20/2016.
- Feschet, Pauline, Macombe, Catherine, Garrabé, Michel, Loeillet, Denis, Saez, Adolfo Rolo, Benhad, François, 2013. Social impact assessment in LCA using the Preston pathway. *Int. J. Life Cycle Assess.* 18 (2), 490–503. <http://dx.doi.org/10.1007/s11367-012-0490-z>.
- Flick, Uwe, 2016. *Qualitative Sozialforschung. Eine Einführung*, 7. Auflage. Rowohlt Taschenbuch Verlag, Reinbek bei Hamburg.
- Foolmaun, Rajendra Kumar, Ramjeeawon, Toolseeram, 2013. Comparative life cycle assessment and social life cycle assessment of used polyethylene terephthalate (PET) bottles in Mauritius. *Int. J. Life Cycle Assess.* 18 (1), 155–171. <http://dx.doi.org/10.1007/s11367-012-0447-2>.
- Franze, Juliane, Ciroth, Andreas, 2011. A comparison of cut roses from Ecuador and The Netherlands. *Int. J. Life Cycle Assess.* 16 (4), 366–379. <http://dx.doi.org/10.1007/s11367-011-0266-x>.
- FSC Deutschland, 2016. *Deutscher FSC-Standard 3.0*, Freiburg.
- German Council for Sustainable Development, 2015. The Sustainability Code. Benchmarking Sustainable Economy (47). Available online at: http://www.nachhaltigkeitsrat.de/uploads/media/RNE_The_Sustainability_Code_Text_no_47_January_2015.pdf. checked on 3/15/2016.
- GRI: Global Reporting Initiative, 2011. Sustainability reporting guidelines.
- Gundert, Stefanie, Hohendanner, Christian, 2011. *Leiharbeit und befristete Beschäftigung. Soziale Teilhabe ist ein Frage von stabilen Jobs*. Institut für Arbeitsmarkt- und Berufsforschung der Bundesagentur für Arbeit.
- Halog, Anthony, Manik, Yosef, 2011. Advancing integrated systems modelling framework for life cycle sustainability assessment. *Sustainability* 3 (12), 469–499. <http://dx.doi.org/10.3390/su3020469>.
- Hauschild, M.Z., Dreyer, L.C., Jørgensen, A., 2008. Assessing social impacts in a life cycle perspective – lessons learned. *CIRP Ann. - Manuf. Technol.* 57 (1), 21–24. <http://dx.doi.org/10.1016/j.cirp.2008.03.002>.
- Hosseiniyou, Seyed Abbas, Mansour, Saeed, Shirazi, Mohsen Akbarpour, 2014. Social life cycle assessment for material selection. A case study of building materials. *Int. J. Life Cycle Assess.* 19 (3), 620–645. <http://dx.doi.org/10.1007/s11367-013-0658-1>.
- Ingrao, Carlo, Bacenetti, Jacopo, Bezama, Alberto, Blok, Vincent, Geldermann, Jutta, Goglio, Pietro, et al., 2016. Agricultural and forest biomass for food, materials and energy. Bio-economy as the cornerstone to cleaner production and more sustainable consumption patterns for accelerating the transition towards equitable, sustainable, post fossil-carbon societies. *J. Clean. Prod.* 117, 4–6. <http://dx.doi.org/10.1016/j.jclepro.2015.12.066>.
- International Labour Organization, 1998. *Declaration on Fundamental Principles and Rights at Work*.
- Kaas, Leo, Manger, Christian, 2012. Ethnic discrimination in Germany's labour market. A field experiment. *Ger. Econ. Rev.* 13 (1), 1–20. <http://dx.doi.org/10.1111/j.1468-0475.2011.00538.x>.
- Knieps, Franz, Pfaff, Holger (Eds.), 2014. *Gesundheit in Regionen. Zahlen, Daten, Fakten mit Gastbeiträgen aus Wissenschaft, Politik und Praxis*. BKK (BKK Gesundheitsreport, 2014), Berlin. Available online at: http://www.bkk-dachverband.de/images/bkk/gesundheitsreport/2014/BKK_Gesundheitsreport_2014.pdf.
- Luca, Anna, de, Irene, Iofrida, Nathalie, Strano, Alfio, Falcone, Giacomo, Gulisano, Giovanni, 2015. Social life cycle assessment and participatory approaches: a methodological proposal applied to citrus farming in Southern Italy. *Integr. Environ. Assess. Manag.* 11 (3), 383–396. <http://dx.doi.org/10.1002/ieam.1611>.
- Macombe, Catherine, Leskinen, Pekka, Feschet, Pauline, Antikainen, Riina, 2013. Social life cycle assessment of biodiesel production at three levels. A literature review and development needs. *J. Clean. Prod.* 52, 205–216. <http://dx.doi.org/10.1016/j.jclepro.2013.03.026>.
- Martínez-Blanco, Julia, Lehmann, Annekatrin, Muñoz, Pere, Antón, Assumpció, Traverso, Marzia, Rieradevall, Joan, Finkbeiner, Matthias, 2014. Application challenges for the social life cycle assessment of fertilizers within life cycle sustainability assessment. *J. Clean. Prod.* 69, 34–48. <http://dx.doi.org/10.1016/j.jclepro.2014.01.044>.
- Mathe, Syndhia, 2014. Integrating participatory approaches into social life cycle assessment. The SLCA participatory approach. *Int. J. Life Cycle Assess.* 19 (8), 1506–1514. <http://dx.doi.org/10.1007/s11367-014-0758-6>.
- O'Keeffe, Sinéad, Majer, Stefan, Bezama, Alberto, Thrän, Daniela, 2016. When considering no man is an Island - assessing bioenergy systems in a regional and LCA context: a review. *Int. J. Life Cycle Assess.* 21 (6) <http://dx.doi.org/10.1007/s11367-016-1057-1>. S. 885–902.
- PEFC Deutschland e.V., 2014. *Deutscher PEFC-Standard. PEFC Standards für nachhaltige Waldbewirtschaftung. PEFC-D 1002-1:2014*, Stuttgart.
- Raschka, Achim, Carus, Michael, 2012. *Stoffliche Nutzung von Biomasse: basisdaten für Deutschland*. nova-Institut GmbH. Hürth, Europa und die Welt.
- Revéret, J.-P., Couture, J.-M., Parent, J., 2015. *Socioeconomic LCA of milk production in Canada*. In: Senthilkannan Muthu, Subramanian (Ed.), *Social Life Cycle Assessment. An Insight*. Springer, Singapore (Environmental footprints and eco-design of products and processes).
- (SAI) SAI SA8000, 2008. *Social Accountability 8000*.
- Siebert, A., Bezama, A., O'Keeffe, S., Thrän, Daniela, 2016. Social life cycle assessment in pursuit of a framework for assessing wood-based products from bioeconomy regions in Germany. *Int. J. Life Cycle Assess.* <http://dx.doi.org/10.1007/s11367-016-1066-0>.
- The Federal Government, 2012. *National Sustainable Development Strategy, 2012 Progress Report*. Available online at: http://www.bundesregierung.de/Content/DE/_Anlagen/Nachhaltigkeit-wiederhergestellt/2012-06-07-fortschrittsbericht-2012-englisch-barrierefrei.pdf?__blob=publicationFile. updated on 5/26/2016.
- Traverso, Marzia, Asdrubali, Francesco, Francia, Annalisa, Finkbeiner, Matthias, 2012. Towards life cycle sustainability assessment. An implementation to photovoltaic modules. *Int. J. Life Cycle Assess.* 17 (8), 1068–1079. <http://dx.doi.org/10.1007/s11367-012-0433-8>.
- UNEP-SETAC, 2009. *Guidelines for Social Life Cycle Assessment of Products*. United Nations Environment Programme, Paris, France.
- UNEP-SETAC, 2013. *The Methodological Sheets for Subcategories in Social Life Cycle Assessment (S-LCA)*. France, Paris.
- Vinyes, Elisabet, Oliver-Solà, Jordi, Ugaya, Cassia, Rieradevall, Joan, Gasol, Carles M., 2013. Application of LCSA to used cooking oil waste management. *Int. J. Life Cycle Assess.* 18 (2), 445–455. <http://dx.doi.org/10.1007/s11367-012-0482-z>.
- Vogel, Claudia, 2009. *Teilzeitbeschäftigung – Ausmaß und Bestimmungsgründe der Erwerbsübergänge von Frauen*. ZAF 42 (2), 170–181. <http://dx.doi.org/10.1007/s12651-009-0015-9>.
- Wanger, Susanne, 2015. *Frauen und Männer im Arbeitsmarkt. Traditionelle Erwerbs- und Arbeitszeitmuster sind nach wie vor verbreitet. Aktuelle Analysen aus dem Institut für Arbeitsmarkt- und Berufsforschung (IAB Kurzbericht, 4)*. Available online at: <http://doku.iab.de/kurzber/2015/kb0415.pdf>. updated on 5/24/2016.
- Zamagni, Alessandra, Amerighi, Oscar, Buttol, Patrizia, 2011. Strengths or bias in social LCA? *Int. J. Life Cycle Assess.* 16 (7), 596–598. <http://dx.doi.org/10.1007/s11367-011-0309-3>.