A SOCIAL SUSTAINABILITY ASSESSMENT MODEL FOR MANUFACTURING COMPANY BASED ON S-LCA

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ABSTRACT
Generally, sustainability analysis should include the aspects of the environmental, social, and economic assessment. The development of social sustainability assessment for manufacturing company however has been paid little attention currently, and previous studies are not appropriate due to the complex information and the unbefitting indicators. This study presents a new social sustainability assessment model based on social life cycle assessment (S-LCA) methodology to assess the social sustainable performance for manufacturing companies, in this method, four groups of stakeholders and social impact categories are involves and product social risk score (PSRS) is employed to quantitatively expressed the sustainability indicator of the company. Through detailed social inventory investigation, Fuqiang Power Company as the research case is put to assess the social sustainability and verify the validity of this model.
Keywords: manufacturing company, social impact category, social life cycle assessment (S-LCA), social performance, social sustainability assessment.

1 INTRODUCTION

Sustainability was adopted by United Nations Environment Programme (UNEP) as the main political goal for the future development of humankind, while developing the sustainability analysis of the environmental and economic assessment for the company products or services, the social impact assessment should also be considered [1]. With the high development of economy, people pay more attention to occupational health and work safety; however, some manufacturing companies are always with a bad working environment, which brings more harm to workers' physical and mental health, therefore, the workers' labor rights as a factor of company social sustainable assessment must be paid more attention. In addition, the employment opportunities brought by manufacturing activities to the society, and the contributions made to the social economy should also be an important criteria for the evaluation of social sustainability. However, the social sustainability performance assessment is not always considered adequately due to the complex data and the lack of effective assessment method.

Recent years, social sustainability assessment has been brought to the forefront, Hossain *et al.* [1] presented a single score-based social sustainability-grading model to estimate and compare the social sustainable performance of construction materials. Sierra *et al.* [2] put forward a stochastic method for the evaluation of social sustainability to assess the infrastructure projects, this method provided procedures to estimate the social sustainability of infrastructure projects under uncertainty conditions. At the same time, Sierra *et al.* [3] also developed a deterministic method for estimating the social sustainability, this method can distinguish the contribution to social sustainability of different infrastructure projects and location contexts. Cooper *et al.* [4] focused on the UK context, proposed a first and most comprehensive social impacts assessment method of shale gas production and utilization for electricity generation. Rafiaani *et al.* [5] conducted a systemic approach considering the

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potential social impacts and three main stakeholders of local communities workers, and consumers were involved. Siebert *et al.* [6] developed a set of social indices and related indicators applicable to wood-based production systems in Germany. Rajak and Vinodh [7] provided a systematic approach to measure and analyze the social sustainability performance; to assess social sustainability of capture fisheries.

S-LCA (Social life cycle assessment) is taken as a social sustainable analysis method based on the way the business affects human well-being [8]. There are numerous and diverse methodologies in S-LCA literatures. During the past decade, most debates have focused on impact categories and measurements [9]. Many efforts have been spent in defining this methodology and the indicators [10-13]. Resent years, the methodology of S-LCA have also been made tentative applications study, e.g. Hosseinijou *et al.* [14] presented a method and a case study of S-LCA specialized for comparative studies; Nemarumane [15] conducted a social life cycle assessment method from the aspects of health and safety, gender equality, and wages for the south African sugar industry; Chang *et al.* [16] applied S-LCA in evaluating possible social impacts of the state-of-art welding technologies; Lehmann *et al.* [17] discussed the applicability of the S-LCA guidelines for a comparative technology analysis and two case studies were taken as the examples in developing countries; Hannouf and Assefa [18] developed and tested the applicability of a new subcategory assessment method for social life cycle assessment using a case study on high-density polyethylene production in Alberta, Canada. Dong and Ng [19] developed a social life cycle impact assessment method for building construction projects in Hong Kong.

Many methods of social sustainability evaluation have been put forward and achieved fruitful results, the evaluation framework is becoming clearer in specific products or industry, however, the quantitative method of social sustainability assessment for manufacturing company are not yet cleared, and the detailed characteristics associated social performance are not considered. The typical characteristics for a manufacturing company are that, the company have produced a variety of products for profit; the basic process include: raw material purchase – manufacturing processing – product sales; the products would be produced by the workers in the workshop or factory; there are upstream suppliers for raw materials and downstream customers for product use of for the company. Considering of the characteristics of manufacturing company, a quantitative social sustainability assessment model for manufacturing company based on S-LCA is set up in this study, which is improved on the basis of the method put forward by Dreyer [12–13].

2 COMPANY SOCIAL SUSTAINABILITY ASSESSMENT MODEL BASED ON S-LCA

2.1 Social sustainability assessment model

Based on the UNEP/SETAC guidelines for S-LCA [10], there are four groups of main stakeholders of workers, society, local community, and value chain actors in company production activities. Social impact inventory data is about the stakeholders involved in the social life. Based on the characteristics of manufacturing company, social impact categories are divided into four groups: labor rights, social economy, community engagement and value chain responsible practice. The basic idea of the company social sustainability is expressed through the company social risk and product social risk score [12–13]. The social sustainability assessment model based on S-LCA is shown in Fig. 1.

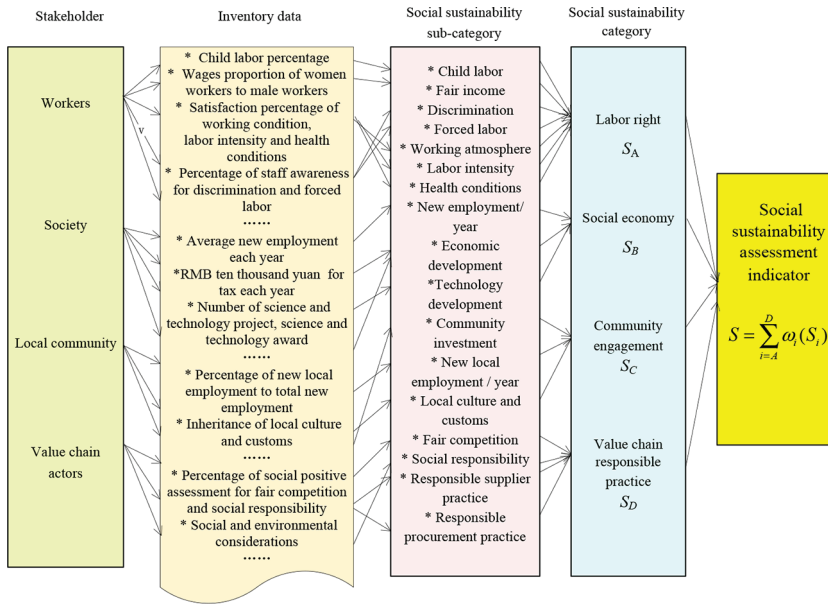

Figure 1: The social sustainability assessment model based on S-LCA.

2.2 Social sustainability assessment indicators

Based on the social impact categories, the calculation steps of social impact indicators of S_A, S_B, S_C, and S_D are as follows:

Step 1, company social performance are divided into three dimensions (*I*, *II*, *III*) from low to high (the score is from 0 to 4), according to Dreyer *et al.* [12–13] about the classification rules for social impact factor of labor rights, the three-dimensional scoring value descriptions are shown in Table 1, the company social performance score *CSPS* is the product of three dimensions multiplication, namely:

$$CSPS = f(I, II, III) = I \times II \times III \tag{1}$$

where, social performance *I* is the actual social performances of company, which is divided into four grades: I_1, I_2, I_3 and I_4, and also referred to Dreyer *et al.* [12–13], the scoring criteria is shown in Table 2, the meanings of social performance *II* and *III* and the scoring criteria are shown in Table 3.

Table 1: Three-dimensional social impact score value of company social performance.

	Company social performance											
	I				*II*				*III*			
Dimensions of social performance	**Company performance**				**Company responsibility system formulation**				**Companies continue to implement the responsibility system**			
Classification	I_1	I_2	I_3	I_4	II_1	II_2	II_3	II_4	III_1	III_2	III_3	III_4
Score	0	0.7	2	4	0	1	1.2	2	0	1	1.2	2

Table 2: Social impact scoring criteria of company social performance *I*.

Stakeholder	Impact category	Sub-category	Social performance inventory description	Value	Scoring criteria
Workers	Labor right *A*	Child labor A_1	Child labor percentage	31–100	0
				21–30	0.7
				11–20	2
				0–10	4
		Fair income A_2	Wages proportion of women workers to male workers	0–30	0
				31–50	0.7
				51–80	2
				81–100	4
		Discrimination A_3	Percentage of staff awareness	0–30	0
				31–50	0.7
				51–80	2
				81–100	4
		Forced labor A_4	Percentage of staff awareness	0–30	0
				31–50	0.7
				51–80	2
				81–100	4
		Working atmosphere A_5	Satisfaction percentage	0–30	0
				31–50	0.7
				51–80	2
				81–100	4
		Labor intensity A_6	Satisfaction percentage	0–30	0
				31–50	0.7
				51–80	2
				81–100	4
		Health conditions A_7	Satisfaction percentage	0–30	0
				31–50	0.7
				51–80	2
				81–100	4
Society	Social economy *B*	New employment each year B_1	Average number	1–50	0
				51–100	0.7
				101–200	2
				>200	4
		Economic development B_2	RMB ten thousand yuan for tax each year	0–500	0
				501–1000	0.7
				1001–2000	2
				>20000	4
		Technology development B_3	Number of undertaking the science and technology project, science and technology award	0-3	0
				4-6	0.7
				6-10	2
				>10	4

Local community	Community engagement C	Community investment C_1	RMB ten thousand yuan each year	0-0.5	0
				0.6–2	0.7
				2.1–4	2
				>4	4
		New local employment each year C_2	Percentage of new local employment to total new employment	0–30	0
				31–50	0.7
				51–80	2
				80–100	4
		Local culture and customs C_3	inheritance of local culture and customs (percentage of positive assessment)	0–30	0
				31–50	0.7
				51–80	2
				81–100	4
Value chain actors	Value chain responsible practice D	Fair competition D_1	Percentage of social positive assessment	0–30	0
				30–60	0.7
				60–80	2
				80–100	4
		Social responsibility D_2	Percentage of social positive assessment	0–30	0
				30–60	0.7
				60–80	2
				80–100	4
		Responsible supplier practice D_3	Average percentage of customer satisfaction	0–30	0
				30–60	0.7
				60–80	2
				80–100	4
		Responsible procurement practice D_4	Social and environmental considerations (percentage of social positive assessment)	0–30	0
				30–60	0.7
				60–80	2
				80–100	4

Note: RMB is the abbreviation of RenMinBi, which is the expression of Chinese currency.

Table 3: Scoring criteria of company social performance *II* and *III*.

Company performance II	**Score**	**Company performance III**	**Score**
No responsibility system	0	Not carried out	0
Responsibility system not detailed	1	Continue to execute, without supervision measures	1
Responsibility system is detailed	1.2	Continue to execute, has supervised measures	1.2
Responsibility system is very detailed	2	Continue execution, has supervision measures, employee feedback	2

Table 4: *CAF* value meaning.

Contextual risk class CRC	Contextual adjustment factor CAF	Probability
1	1.0	Very highly probability
2	0.9	High probability
3	0.7	Medium possibility
4	0.5	Small probability
5	0.4	Without probability

Step 2, employ *CFR* (Company free rein) to express the difference between actual company social performance score *CSPS*, the greater the difference, the bigger space the company to be improved, assuming $CSPS_{\max}$ is the ideal performance score, and C*FR* is expressed as:

$$CFR = (CSPS_{\max} - CSPS) / CSPS_{\max} \tag{2}$$

Step 3, calculation of *CSR* (company social risk), which is expressed as:

$$CSR = CFR \times CAF \tag{3}$$

where, *CAF* is contextual adjustment factor, the value scope is for [0.4, 1.0], the larger the value, the greater the risk of company, the relationship of *CRC* (contextual risk class) and *CAF* (contextual adjustment factor) is shown in Table 4.

Step 4, calculation of product social risk score *PSRS*, in which *CSR* is converted into *PSRS*, then the company social sustainability indicator would be available, *PSRS* is expressed as:

$$PSRS = PSRF \times CSR \tag{4}$$

Where, *PSRF* is product social relation factor, the value scope is for [0, 1], the larger of the value, the greater risk of the product.

Step 5, calculation of company social sustainability indicator of the *ath* impact category S_a, the value scope is for [0, 1], and the greater of the value, the higher of the social sustainability, S_a is given as:

$$S_a = 1 - PSRS_a \ (a = A, B, C, D) \tag{5}$$

Company risk, product risk, and company social sustainability criteria are shown in Table 5.

Table 5: Company risk, product risk and social sustainability decision criteria.

Company social risk	Company risk	Product risk score	Product risk	Sustainable Indicator	Social sustainability
$0.9 < CSR \leq 1.0$	Very high risk	$0.9 < PSRS \leq 1.0$	Very high risk	$0.8 < S \leq 1.0$	Very high
$0.6 < CSR \leq 0.9$	High risk	$0.6 < PSRS \leq 0.9$	High risk	$0.6 < S \leq 0.8$	High
$0.4 < CSR \leq 0.6$	Higher risk	$0.4 < PSRS \leq 0.6$	Higher risk	$0.4 < S \leq 0.6$	Medium
$0.2 < CSR \leq 0.4$	Medium risk	$0.2 < PSRS \leq 0.4$	Medium risk	$0.2 < S \leq 0.4$	Low
$0.0 < CSR \leq 0.2$	Low risk	$0.0 < PSRS \leq 0.2$	Low risk	$0.0 < S \leq 0.2$	Very low

3 CASE STUDY

Sinotruk Jinan Fuqiang Power Co., Ltd. (hereinafter referred to as 'Fuqiang Power') would be taken as the case study for the model verification in this study. Fuqiang Power is the first company in China engaged in the automobile engine remanufacturing; there are more than 1,500 employees in the company, the products and staff are stable at present. Compared with traditional manufacturing, the working conditions of remanufacturing are more adverse, and the working intensity is much greater, which brings more harm to workers' physical and mental health. In addition, as the automobile engine remanufacturing belongs to the emerging industry, people still have doubts about the company society serving ability. Therefore, compared with other mature companies, Fuqiang Power is more appropriate for social sustainability research. Through the interviews and questionnaire survey, including 80% of workers, 10% office managers, and 10% of engineers and designers, the original inventory data of social performance is obtained; social sustainability assessment by the proposed method is applied as follows.

3.1 Company social performance inventory and social sustainability indicators

According to the company investigation, the basic inventory data of social performance *I*, *II* and *III* are shown in Table 6. By expert investigation (including a company manager, a worker, a professor, and a local government officer) and data inquiry, we can determined the values of four contextual adjustment factors *CAF*, company risk class *CRC*, product social relation factor *PSRF*, and the weight ω of each social impact category. According to section 2.2, the social sustainability indicators of Fuqiang Power can be calculated, shown as Table 6.

3.2 Company social sustainability result analysis

The result of social sustainability indicator *S* shows that Fuqiang Power is with high social sustainability and has a high contribution to the social stakeholders.

From Table 6, it also shown that Fuqiang Power is with the better social performance in '*A* labor rights', and '*D* value chain responsible practice', and relative lower performance in '*B* social economy' and '*C* community engagement', and there is also great space to improve for the two impact categories for this company. The reasons for above situation can be figured out from Fig. 2, the best social performance happened in A_7, D_1 and D_2, on the contrary, the worst social performance happened in B_1, B_2 and C_1, C_2, and the performance of A_4, A_5, A_6 and B_3 are relatively higher than others, that is to say that, Fuqiang Power did very well with the workers working conditions and paid enough attention to the value chain responsible practice, therefore, the social sustainability indicators of S_A and S_D are higher than that of S_B and S_C, although the comparatively good performance in B_3.

The detailed reasons for the lower social performance of B_1, B_2 and C_1, C_2 can be observed from Table 6; there is a lower score of social performance *I* for 'B_1 New employment/year', only 0.7 point; and the scores of social performance *II* and *III* for 'B_2 Economic development' and 'C_3 Local culture and customs' are relative low; also there are lower scores of social performance *I*, *II* and *III* for 'C_1 Community investment', and 'C_2 New local employment/year', which lowered the social performance for the social impact categories of '*B* social economy' and '*C* community engagement', and the stakeholders of 'society' and 'local community' are not getting more social rewards compared with 'workers' and 'value chain actors'. Consequently, the company should be pay attention to the social performance improvement for the public warfare, and formulate strict and detailed company responsibility system, and implement the responsibility system continuously.

Table 6: Values of the social sustainable indicators of Fuqiang Power Company.

Impact category	I	II	III	I*II*III	CSPS	$CSPS_{max}$	CFR	CAF	CSR	PSRF	PSRS	S_a	ω	S
A_1	4	1.2	1.2	5.76										
A_2	4	1	1	4										
A_3	2	1.2	1.2	2.88										
A_4	2	2	2	8	54.24	112	0.52	0.5	0.26	0.3	0.08	0.92	0.4	
A_5	2	2	2	8										
A_6	4	2	1.2	9.6										
A_7	4	2	2	16										
B_1	0.7	2	2	2.8										
B_2	2	1.2	1.2	2.88	15.28	48	0.68	0.4	0.27	0.4	0.11	0.89	0.3	0.90
B_3	4	2	1.2	9.6										
C_1	2	1	1	2										
C_2	2	1.2	1	2.4	8.4	48	0.83	0.4	0.33	0.5	0.17	0.83	0.1	
C_3	4	1	1	4										
D_1	4	2	2	16										
D_2	4	2	2	16	40.64	64	0.37	0.5	0.18	0.4	0.07	0.92	0.2	
D_3	4	1.2	1.2	5.76										
D_4	2	1.2	1.2	2.88										

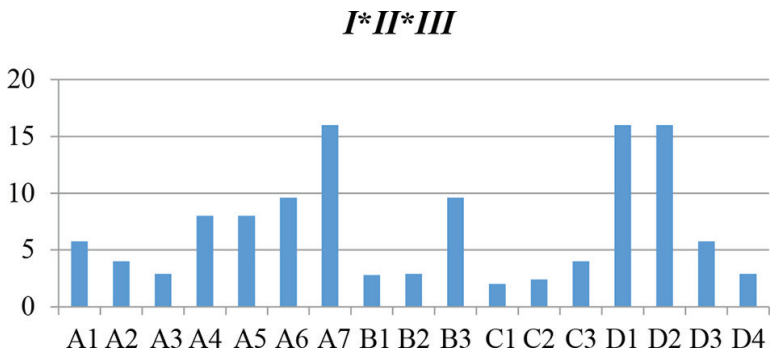

Figure 2: *I*II*III* values comparison of 17 sub-categories.

4 CONCLUSION

In this paper, a social sustainability assessment model for manufacturing company based on the S-LCA is proposed. Referred to UNEP/SETAC Guidelines, workers, society, local community and value chain actors as the main four groups of the stakeholders involved in the production activities; considering of the characteristics, four social impact categories are considered, namely labor rights, social economy, community engagement and value chain responsible practice; by the social performance inventory data, social sustainability indicator can be given. Fuqiang Power as the research case, the four social sustainability assessment indicators are calculated according to the social performance inventory data, and the comprehensive social sustainability indicator is 0.90, which shows the good social sustainability of this company. This social sustainability assessment method based on S-LCA overcomes the disadvantages of the social sustainability not be quantitatively analysis and the social characteristics not be considered in detail, which is relatively simple understood and easy to operate, this method can be used for any type of manufacturing company only if there are enough data for analysis. Company managers and researchers can evaluate the company sustainability through data research.

The purpose of this study is that, through the social sustainability assessment to cause people's attention to manufacturing production behavior, so as to improve the workers working environment and reduce the health and safety hazards, and also to improve the social benefit and interests of stakeholders. In fact, in this model, only four social impact categories and 17 subcategories selected, some categories, such as 'industrial injury compensation' and 'product hazard' are not considered, and also some stakeholders are not included, such as 'consumers' and 'dealers'; hence, some ethical and equity relevant factors are omitted, it is the important task for future model improvement. On the other hand, when using this social sustainability assessment method, it is important to note that the assessment results are dependent on researcher's subjectivity to a large extent, the different research data may lead to different assessment results, and therefore, to ensure the accuracy of the assessment result, it is necessary for the detailed data investigation.

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