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The Social Life Cycle Assessment in Traditional Brick Production to Formulate Recommendation and Improve Environmental Working Condition

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ABSTRACT

Achieving sustainable manufacturing has been recognized as a critical need due to the decrease in non-renewable natural resources, strict regulations related to the environment, and occupational health and safety. The brick industry is favored because it has a wide market and requires simple equipment and manufacturing processes. However, there are complaints from residents regarding the smoke from the production process which is considered disturbing to residents. Therefore, the study is aimed to assess the life cycle of bricks from the social aspect of the stakeholders involved. Data is collected with the questionnaire and scored from three different stakeholders Workers, the Local Community, and Society. The method used in this study is Social Life Cycle Assessment (S-LCA) using UNEP-SETAC 2009 guidelines. From the seven social impact categories used in the study, it is found that the average score of seven subcategories is 3,53 which means that the brick factory has a positive social impact on the stakeholders. The category with the lowest score is Socio-Economic followed by Health and Safety. Both lied in the neutral area indicating the brick factory can improve its production process especially in managing the carbon emission that could affect workers and the local community.

Keywords: Social Life Cycle Assessment, Brick Production Evaluation, Sustainability, Social Impacts

ABSTRAK

Ketercapaian manufaktur berkelanjutan dianggap sebagai kebutuhan penting suatu perusahaan manufaktur karena adanya penurunan sumber daya alam tak terbarukan, peraturan lingkungan yang ketat, serta pentingnya kesehatan dan keselamatan kerja. Industri batu bata merupakan industri unggulan karena memiliki pasar yang luas dan hanya membutuhkan peralatan dan proses pembuatan yang sederhana. Namun, asap dari proses produksinya mengganggu dan menjadi keluhan warga. Oleh karen itu, penelitian ini bertujuan untuk menilai daur hidup batu bata dari aspek sosial *stakeholder* yang terlibat. Pengumplan data dilakukan melalui pembagian kuesioner yang dinilai oleh tiga *stakeholder* berbeda, yaitu *Workers*, *Local Community*, dan *Society*. Metode yang digunakan adalah *Social Life Cycle Assessment* (S-LCA) berdasarkan pedoman UNEP-SETAC 2009. Tujuh kategori dampak sosial yang digunakan memberikan nilai rata-rata sebesar 3,53 yang berarti bahwa pabrik batu bata memiliki dampak sosial yang positif bagi stakeholder. Nilai terendah didapatkan pada kategori *Socio-Economic*, kemudian diikuti oleh kategori *Health and Safety*. Kedua kategori tersebut berada di area netral yang menandakan bahwa pabrik batu bata dapat meningkatkan proses produksinya menjadi lebih baik terutama dalam mengelola emisi karbon yang dapat berdampak pada pekerja dan masyarakat sekitar.

Kata Kunci: Social Life Cycle Assessment, Evaluasi Produksi Batu Bata, Sustainabilitas, Dampak Sosial

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1. Introduction

The manufacturing industry has a significant impact on global growth and development due to the increasing population and increasing demand for products to improve the quality of life. Therefore, manufacturing plays a very important role both in the economic and social systems because it will contribute to job creation and increase the standard of living (Haapala et al., 2013). However, the manufacturing industry is often blamed as a major source of environmental degradation and other social problems (Azapagic & Perdan, 2000).

Currently, sustainable manufacturing is a very important issue among industries around the world. Achieving sustainable manufacturing has been recognized as a critical need due to the decrease in non-renewable natural resources, strict regulations related to the environment, occupational health, and safety, as well as increasing consumer choices for more environmentally friendly products (Amrina & Vilsi, 2015). The concept of sustainability has been the subject of debate since 1987 with the Brundtland report on the environment and development "Our Common Future" by Keeble (1988) which produced the first well-known definition of sustainable development, namely development to meet the needs of the present without compromising the ability of future generations to meet their own needs. It is built on triple bottom lines which are people, profit, and the planet. Sustainable manufacturing is one part of the concept of sustainable development. The United States Department of Commerce defines sustainable manufacturing as the process of making products, which in its application can reduce negative environmental impacts, save energy and natural resources, that are safe for employees, communities, and consumers, and are economical.

One of the manufacturing industries that is often found in Indonesia is the brick industry. In its manufacture, the brick industry is favored because it has a wide market and requires fairly simple equipment and manufacturing processes. However, there are various complaints from residents regarding the process of making bricks which are considered disturbing to residents. Therefore, the purpose of this research is to assess the life cycle of bricks from the social aspect of the stakeholders involved.

This study uses the Social Life Cycle Assessment method which is used to assess the positive or negative impact and the potential impact of the social aspects of the product on related stakeholders during the procurement of raw materials, production processes, and product distribution to provide information to decision-makers to improve social conditions throughout the life cycle of brick. This study is conducted in Trangkil, Pati Regency, Central Java. The stakeholders involved are the workers, the local community, and the society around the brick factory. There are 217 brick factories in Trangkil, Pati, Central Java. The social indicators used to assess social impacts are based on the UNEP-SETAC 2009 guidelines. The last stage is to provide recommendations for the industry to improve industrial performance. Thus, this study aims to assess the life cycle of bricks from the social aspect of the stakeholders involved. The result of the assessment will be used to formulate improvements to increase the Social Life Cycle Assessment Level.

2. Literature Review

The concept of sustainability has been the subject of discussion since 1987 with the Brundtland report called "Our Common Future" which delivered the primary well-known definition of sustainable development, namely development that meets the desires of the present without compromising the capacity of future eras to meet their claim needs, it is built on triple bottom lines which are people, profit, and planet (Keeble, 1988). To do sustainability assessment, there are seven instruments commonly utilized such as multi-criteria decision analysis (MCDA), material flow analysis, life cycle assessment (LCA), input-output models, sustainability indicators and indices, and cost-benefit analysis (CBA), and optimization methods. MCDA, LCA, CBA, and optimization methods were found to be successful concerning many of the criteria used in the evaluation (Myllyviita et al., 2017).

Sustainability is a process to combines environmental, social, and economic aspects. The sustainability implementation in the industry includes the production process, as we know that the social impacts become one of them. Therefore, it is necessary to assess the social impact using the social life cycle assessment (S-LCA) method. As a sustainability tool, S-LCA is a systematic approach to evaluating positive and negative social impacts throughout the life cycle (SETAC, 2009). S-LCA is also a social impact comparison for companies or institutions (Lucchetti et al., 2018). In this ponder, we conduct a sustainability assessment utilizing social life cycle assessment (S-LCA) which is a part of life cycle assessment (LCA).

2.1 Social Life Cycle Assessment (S-LCA)

S-LCA is a strategy for assessing social effect which that aims to quantify a product's social and socio-economic aspects (Wah et al., 2019). The measurement is conducted on both positive and negative sides of the product throughout its life cycle, which includes raw material processing, manufacturing, distribution, product consumption, reusing the product, recycling, and final disposal. S-LCA adds social and socio-economic aspects to LCA. This concept can be adopted together with LCA or as a stand-alone S-LCA. The S-LCA measures social impact observed throughout the product life cycle with specific generic data. It differs from other social impact assessment techniques that consider the social impact of services, not a product. In addition, the scope of the S-LCA also covers the entire life cycle of a product.

S-LCA attempts to assess both positive and negative social impacts throughout supply chain so that companies cannot ignore principles of social impact. There are two fundamental issues regarding the S-LCA. The first is the function or usefulness of impact measurement and the relationship with other impact interventions, and the second is the effort to address complementary relationship between social and environmental in the LCA development (Paragahawewa et al., 2009). The importance of S-LCA evaluation is to increase consumers' ability to select a product based on its social effect whereas S-LCA supports company's social responsibility by providing information about social impact on both positive and negative aspects of the manufacturing process (Du et al., 2019).

The aspects measured in S-LCA are those that have a direct influence on the interests of stakeholders both positively and negatively. Depending on scope of research conducted, social effect examined on S-LCA might include company behaviours, manufacturing process, or the influence of social capital. Depending on research scope, indirect social impact received by stakeholders can also be considered. S-LCA is not a method for determining whether a product should be produced; rather, S-LCA documented product utility and cannot decide the production of a product. The results of S-LCA, such as the social conditions of the product and how the product is used and disposed of, are seldom a sufficient basis for deciding whether or not to produce a product.

The S-LCA can be implemented in several fields, from the big construction industry to micro, small, and medium enterprises (MSME). There are a lot of studies that implement S-LCA on MSME such as in waste management, brick production, and the textile industry. The MSME industry has played an important role in economic development by providing new jobs for people around the area and improving regional development (Bagale, 2014).

S-LCA is a technique that helps in providing improved information for sustainable consumption and living (Ruben et al., 2018). S-LCA give information on social and economic aspect that triggers a discussion about socio-economic aspects of production and consumption to enhance organizational performance and, ultimately, the welfare of stakeholders.

S-LCA is a part of life cycle assessment (LCA). The main difference between LCA and S-LCA lies in the research focus. LCA focuses on evaluating environmental impact while S-LCA aims to assess social and socio-economic impacts. LCA focuses more on gathering physical quantity information related to a product and its production, use, or waste. Meanwhile, S-LCA collects information about organizational aspects along its product chain (SETAC, 2009).

2.2. The Indicators of S-LCA

The UNEP/SETAC guidelines define five stakeholder categories, including workers, local communities, value chain actors, consumers, and society (SETAC, 2009). Those stakeholder categories were used to do a literature review by Wu et al. (2014) and can be seen in Table 1.

Research on the brick industry has been studied by previous researchers, who also used the Social Life Cycle Assessment (S-LCA) as a research method. Lopez et al. (2013) discuss a preliminary selection of indicators of the life cycle of the handmade brick industry. Research focused on determining socio-economic indicators for brick production using Social Life Cycle Assessment (S-LCA). The selected indicators include working conditions, socio-economic impacts, human rights, health, and safety, which are used as references for our research in determining indicators. Another research was done by Nubi et al. (2021) which examines the social impacts of potential waste-to-energy (WtE), and conducted an assessment using the Social Life Cycle Assessment (S-LCA).

Based on a literature review that has been done, workers, local community, and society were the most widely used as stakeholder categories in the previous study. Thus, the stakeholders involved in this research are the workers, the local community, and the society around the brick factory. It was confirmed by interviewing 5 people from each stakeholder and supplemented by secondary information.

3. Methods

The application of social life cycle assessment (S-LCA) has the same phases as the life cycle assessment (LCA) method for assessing the social impact throughout the life cycle. The S-LCA approach refers to the ISO 14040 series standards for the environment, including ISO 14040 to ISO 14043 issued by the International Organization for Standardization (ISO). According to the ISO 14040 series standards, S-LCA implementation has four phases.

This research adopted guidelines from UNEP-SETAC 2009 which guided S-LCA implementation including concepts, elements, stages, and areas that need further research.

1. The first stage is defining the goal and scope of the study. In this stage, the benefits of an organization as a processing unit are explained and the organization's social profile is assessed, including system objectives, functions, functional units, selection criteria, and system boundaries. The focus of this phase is to determine the goals and scope of relevant processes along the product lifecycle and select relevant subcategories.
2. The second stage is inventory analysis. This phase focuses on collecting relevant data from the primary data (direct data from the sites and experts) and or secondary data (indirect data from historical data or calculation results). The results of the phases include the S-LCA model and Life Cycle Inventory (LCI). The analysis started with defining relevant stakeholders, categories, subcategories, and indicators adopted from previous studies. Table 2 shows the social impact subcategories and indicators used in this study.
3. The third stage is impact assessment. The selection of impact categories and subcategories is performed, as well as stakeholders, indicators, and stages of the life cycle which are usually shown in the hierarchy. The characterization then includes a comparison and the weights for each impact category are calculated. Inconsistency analysis (to show that the comparisons are consistent) and sensitivity analysis (ranked relative weights of the various factors) were performed during this phase.
4. The last stage is interpretation. The assessment results then concluded in three steps including issues identification, evaluation, and areas of improvement.

Table 1. Indicator in Previous Research (Source: Wu et al. (2014))

Stakeholder categories	Subcategories	Schmidt et al. (2004)	Hutchins & Sutherland (2008)	Dreyer et al., (2010a, 2010b)	Franze & Ciroth (2011)	Aparcana & Salhofer (2013a, 2013b)	Foolmaun & Ramjeeawon (2013)	Hsu et al. (2013)	Hosseinijou et al. (2014)	Manik et al. (2013)	Vinyes et al. (2013)	Martínez-Blanco et al. (2014)
Workers	Freedom of association, collective bargaining	X		X	X	X		X	X	X		X
	Child labor	X		X	X	X	X	X	X			X
	Fair salary	X	X		X	X	X	X	X	X		X
	Working hours				X	X		X		X	X	X
	Forced labor	X		X	X		X	X	X	X		X
	Equal opportunities/discrimination	X		X	X	X	X	X	X	X	X	X
	Health and safety	X	X		X	X	X	X	X	X		X
	Social benefits/social security	X	X		X	X	X	X		X		
	Employees' development	X										
	Families' benefits	X	X			X					X	
Consumer	Health and safety	X			X							
	Feedback mechanism				X							
	Consumer privacy											
	Transparency	X			X					X		
	End of life responsibility				X							
Local community	Access to material resources				X				X	X		X
	Access to immaterial resources				X					X		
	Delocalization and migration				X					X		
	Cultural heritage				X				X	X		
	Safe and healthy living conditions				X				X	X		X
	Respect for indigenous rights	X			X					X		
	Community engagement	X			X		X			X		
	Local employment	X			X				X	X	X	
	Secure living conditions				X					X		
Society	Public commitments to sustainability issues	X	X		X					X	X	
	Contribution to economic development	X			X		X		X	X	X	
	Prevention and mitigation of armed conflicts	X			X					X		
	Technology development	X			X				X	X		
	Corruption	X			X					X		X
Value chain	Fair competition	X			X				X	X		
	Promoting social responsibility	X			X							
	Supplier relationships				X				X			
	Respect for intellectual property rights				X							

Table 2. Social Impact Subcategories and Indicators Used

Social Impact Categories	Subcategories	Questions/Indicators
Human Rights	Fair wage	Monthly wage [W]
Working conditions	Job satisfaction	Level of job satisfaction and without coercion from other parties [W]
	Environment	Noise during the production process [W] Smoke from the burning process [W]
Health and Safety	Work Risk	Availability of PPE [W]
	Health and safety	Types of disease that are often experienced [LC],[S] Impact of air pollution on public health [LC],[S] Impact of water pollution on public health [LC],[S] Impact of soil pollution on public health [LC],[S] Impact of noise pollution on public health [LC]
Income	Income	Monthly sales [W] Incentives [W]
Education & training	Education	Waste management education and training [W]
	Training	Waste treatment for brick production [W]
Socio-economic	Location	The impact of taking raw materials and factories on people's convenience [LC] Impact of factory location on the surrounding economy [LC] Impact on the aesthetics of the location [LC] Job offers that are open to the community [LC]
	Contribution to economic development	The impact of the brick factory on the economy of the surrounding society [S] Impact of taking raw materials and factories on people's economic conditions [S]
Acceptance	Public acceptance	Public acceptance of the brick factory [S]

Notes: W = Workers; LC = Local Communities; and S = Society

A preliminary selection of indicators to assess the S-LCA of brick production is referred to Human Rights, Working Conditions, and Health and Safety (Lopez et al, 2013). The other subcategories were adopted from Nubi et al. (2021). Indicators from the second stage are developed into a questionnaire, there are 32 questions. The respondent is six stakeholders suggested in the UNEP guidelines and prior research. The stakeholders are workers (people working in brick production), the local community (people living near the brick production site), and society (individuals that are indirectly affected by the brick production, living not too far from the brick factory).

Data collecting was done by interviewing from each stakeholder and supplemented by secondary information. The questionnaire consisted of closed-ended and open-ended questions. In the close-ended questions, respondents were asked to provide value on the indicators provided with a five-point Likert scale that goes from the less extreme to another i.e., 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree. The same scale scoring system was suggested by Nubi et al. (2021) to analyze the S-LCA of municipal solid waste. This scale type was used to ease the respondents to answer the questions as this is the most familiar scale type. The responses were multiplied and divided by the number of respondents to generate the impact scores. The results were then converted by color coding to characterize the social impact of each indicator and category as suggested by Azimi et al. (2020) shown in Table 3. Meanwhile, open-ended questions were used to validate the responses.

The results then were processed and evaluated by scoring and color coding to characterize the social impact. Questionnaires were distributed to the owners of brick factories, mostly small and medium enterprises. The workers, the local community, and the society around the brick factory also fill out a questionnaire related to workers and the impact of the industry on the surrounding environment. The local community is the community around the industry that still contributes to the industry while the society around the brick factory is the surrounding community that has no involvement whatsoever in the industry and is only affected positively or negatively.

Table 3. Social Impact Category Impact Characterization

Color Code for Social Impact Category	Scores
Very Negative	1.0-1.5
Negative	1.5-2.5
Neutral	2.5-3.5
Positive	3.5-4.5
Very Positive	4.5-5.0

Observational study has been carried out and it was found that the level of homogeneity of the brick factory is quite high so that. The assessment was then carried out by interviewing five people of each business owners, workers, and the surrounding community. Some of the questions were answered by business owners, some by employees and some by the local community. The total number of respondents is 15 people. Data was collected by conducting deep interviews with each respondent.

4. Results and Discussion

4.1. Brick Production Process

In Indonesia, the brick industry is usually conducted as an informal industry where the owner does not register their business to the government. Being an informal industry, there are a lot of brick factories owned by individuals with small capacities. This caused the probability of having some brick factories in one area to rise. Because of the increasing demand, these factories seemed to have no plans to stop multiplying. The brick industry in Indonesia is quite developed because the government is concerned with building infrastructures. Also, the simple production process with materials that are easy to find makes this industry became one of the entrepreneurs' favorites.

The production process begins with gathering all materials needed (clay, water, and ash from the sugar factory). The ingredients are mixed with a certain ratio to form a dough. After the dough is ready, it finally can start being molded using a mold made from wood or glass. The next step is to aerate the bricks until half dry and then dried in the sun. The duration of the process is dependent on how the weather is. The next step is to burn the bricks in the kiln to ripen the bricks for 14 days. After the burning process, the bricks are cooled by leaving them in a kiln where the fire has been extinguished. When the bricks have cooled down, the bricks are ready to be distributed. The production process of bricks certainly has various impacts especially is on environmental aspects. There is still high pollution caused by the process of burning the bricks.

4.2. Results of Social Life Cycle Assessments

Data obtained from observational study shows that the largest proportion of respondents is within the age ranges of 50 and above, followed by those 31-40 years old. Most respondents had completed secondary school, and there was a roughly equal number of male and female participants. Based on the calculations of obtained data, the Social Impact Sub-Categories scores based on the stakeholder category are shown in Table 4. The scoring was done to discover the differences between each sub-category based on the stakeholder category. Table 5 shows the combined indicator scores and color codes for each Social Impact subcategory. The scoring was performed to determine significant differences between the subcategories.

Table 4. Data Collection

No	Stakeholder Categories	Impact Categories	Subcategories	Questions/Indicators	1	2	3	4	5	Score
1	Workers	Human Rights	Fair Wages	Wages per month	0	2	0	3	0	3.2
		Working conditions	Job satisfaction	Level of job satisfaction and without coercion from other parties	0	0	0	4	1	4.2
				Working hours per week	1	1	0	1	2	3.4
		Health and safety	Environment	Noise during the production process	0	0	1	1	3	4.4
				Smoke from the burning process	1	4	0	0	0	1.8
			Work risk	Availability of PPE	0	2	2	1	0	2.8
				Near miss rate	0	1	0	4	0	3.6
		Income	Income	Monthly sales	0	0	4	0	1	3.4
				Incentives	0	1	0	4	0	3.6
		Education & training	Education Training	Waste management education and training	0	0	0	5	0	4.0
				Waste treatment for brick production	0	0	0	5	0	4.0
2	Local communities	Socio-economic	Location	The impact of taking raw materials and factories on people's convenience	2	2	1	0	0	1.8
				Impact of factory location on the surrounding economy	0	0	1	4	0	3.8
				Impact on the aesthetics of the location	0	4	1	0	0	2.2
				Job offers that are open to the community	1	2	2	0	0	2.2
		Health and safety	Health and safety	Types of diseases that are often experienced	0	3	2	0	0	2.4
				Impact of air pollution on public health	0	2	3	0	0	2.6
				Impact of water pollution on public health	0	2	3	0	0	2.6
				Impact of soil pollution on public health	0	1	4	0	0	2.8
				Impact of noise pollution on public health	0	4	1	0	0	2.2
3	Society	Acceptance	Public acceptance	Public acceptance of the brick factory	0	0	0	5	0	4.0
		Socio-economic	Contribution to economic development	The impact of the brick factory on the economy of the surrounding society	0	0	0	4	1	4.2
				Impact of taking raw materials and factories on people's economic conditions	0	0	0	5	0	4.0
		Health and safety	Health and safety	Types of diseases that are often experienced	0	0	2	3	0	3.6
				Impact of air pollution on public health	0	0	1	4	0	3.8
				Impact of water pollution on public health	0	0	0	3	2	4.4
				Impact of soil pollution on public health	0	0	0	3	2	4.4

Table 5. Social Impact Category Scores

Social Impact Categories	Score
Human rights	3.20
Working conditions	3.80
Health and safety	3.18
Income	3.50
Education & training	4.00
Socio-economic	3.03
Public acceptance	4.00
Average Score	3.53

The category with the lowest score is Socio-Economic at 3.03. It accommodates Location sub-category of Local Community stakeholders and Contribution to Economic Development sub-category of Society stakeholders. The lowest score of Socio-Economic happened because the material extraction process disturbed people's convenience (score=1.8) and also affected the aesthetic of the location (score=2.2). The factory used to take the raw materials not far from the residential area. The process caused huge damage to the resident's soil environment that eventually had to be stopped by the residents. Meanwhile, the distribution process causes a really loud noise and an overweight soil truckload that could damage the road. Haack and Khatiwada (2007) also stated that the damage structures of the roads also happened due to the extraction of topsoil for bricks. Not only that, to the extraction of topsoil may also induces landslides and occurs hydrologic problems where the water level will be decreased. Those will be impacted to Local Community and Society stakeholders. The lowest score of Socio-Economic also happened because the Local Community believes that there is lack job offers that are open to them (score=2.2). The Socio-Economic score then gets better because both the Local Community and Society feel a positive impact on factory surrounding economy, with value of 3.8 and 4.2 respectively.

The second lowest score is Health and Safety at 3.18. It happened because local communities stated that there is noise pollution (score=2.2) and there are types of diseases that are often experienced (score=2.4). That score indicates that those indicators have negative social impact. Saha et al., (2019) confirmed that most brick kiln areas had noise levels exceeded the acceptable level of 75 dB. Noise exposure for a long period of time will causes discomfort and adverse health effects such as noise-induced hearing loss (NIHL; Jamatia et al. 2014). Health is also impacted by burning bricks process that burns coal or biomass without pollution controls. Emissions of particulate matter and gaseous pollutants can reduce air quality thereby affecting the respiratory health of workers (Guttikunda et al., 2014; Kaushik et al., 2012; Weyant et al., 2014). A mitigation strategy should be implemented to reduce the noise and air pollution especially in managing the carbon emission in the Trangkil brick industry cluster.

The next lowest score sequentially is Human Rights at 3.20 and Income at 3.5. Two of them lay in the neutral area indicating no social impact of brick industry production to stakeholders. Researchers suggest that the factory should also work on increasing income for workers and Human Rights category since these two are related to each other. The workers were paid IDR 100,000 for every 1,000 units brick and the monthly average sales were only 10,000 pieces. It means that every worker only gets paid IDR 1,000,000 per month which is still very less than the welfare standard (World bank poverty line 2019 is $2.15 per person per day). Mancini et al. (2023) also found that the cashew and rice production in India show the lowest S-LCA value in wage salary. Researchers suggest that they either need to fix the wage system or increase the monthly sale to meet the regional minimum wage and give more impact on the local community. It is also important to note that most of the workers are freelancers and don't have another permanent job outside the factory.

The top three come from Working Conditions at 3.8, Education and Training at 4.00, and Public Acceptance also at 4.00. The workers were satisfied working at the factory but were quite disturbed by the smoke from the burning process (score=1.8). This is in line with the Health and Safety category score for workers. Brick kilns operate at high temperatures and release large quantities of black smoke containing harmful gases that contribute to environmental pollution (David et al., 2020; Khan et al., 2019). Rajarathnam et al. (2014) measure the emission in South Asia that are about 0.94 million tons of PM; 3.9 million tons of CO and 127 million tons of CO2 per year. It have negative impacts on human health (Khan et al., 2019). Another research from Kalvani et al. (2022) found that around 62% of local Iranian people reported air pollution from rice residue burning in agroindustries. The factory should provide Personal Protective Equipment (PPE) so the workers can work comfortably. Therefore, they should also work on the smoke management system. Despite the air pollution emitted by the burning process, the factory has implemented waste treatment and education. The burning process also produced ashes and the workers were quite educated to recycle them into dishwashing ash.

Overall, the average score of the seven categories is 3.53 which means that the brick factory has a positive social impact on the stakeholders. Regardless of the negative impacts, society was quite accepting of the brick factory since it helps boost the local economy and offers cheap bricks for the society. Local communities agreed that the factory escalate the surrounding economy and workers were satisfied without any coercion from other parties.

5. Conclusion

From the study, we can see that the average score from the seven categories used is 3.53. This indicates that the brick production had a positive social impact on the workers, local community, and society around them. The S-LCA category Education & Training and Public Acceptance ranked the highest with a score of 4.00, while the category Socio-Economic had the least positive impact with a score of 3.03. Even though the overall score indicates a positive impact from the brick factory, the brick factory still needs some improvement with sustainable manufacturing and business. As explained earlier, the socio-economic has a negative impact, where the material extraction process and distribution harm the surrounding environment. Therefore, the factory needs to revitalize the extracted material place, such as by planting green plants along with the location. and so on. The raw material transportation must be carried out according to or less than the load of the transport vehicle. The impact of the study only up to giving some recommendations for the factory to improve their sustainability.

As with all research, this study has several limitations. First, the S-LCA indicator used is generic based on ISO. Special characteristics related to traditional industry have not been explained properly. Second, the scope of this research is for small and medium enterprise of brick production, then the result is only applicable for that types of area. It is may different from large industries that have used more advanced technology. Third, this research only focuses on stakeholder's perspective whereas the supply chain of the brick production has not been included. For future research, Social Organizational Life Cycle Assessment (SO-LCA) method, which used The Life Cycle Thinking (LCT) methodologies allow the entire supply chain of brick to be analyzed via a systematic approach, can be used. A future study might also need to involve more stakeholders to get a different and wider perspective.

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