

# Lifecycle Impact Assessment of an Engineering Project Management Process – a SLCA Approach

Israel Dunmade<sup>1</sup>, Mfon Udo<sup>2</sup>, Tunde Akintayo<sup>3</sup>, Sunday Oyedepo<sup>2</sup>, Imhade P. Okokpujie<sup>2</sup>

<sup>1</sup>Faculty of Science & Technology Mount Royal University, Calgary, AB T3K 0C3  
[idunmade@mtroyal.ca](mailto:idunmade@mtroyal.ca)

<sup>2</sup>Mechanical Engineering Department Covenant University, Ota, Nigeria

<sup>3</sup>Mechanical Engineering Department Federal University of Technology, Akure, Nigeria

**Abstract-** Engineering projects are generally designed to solve societal problems, develop a community and/or to improve the quality of life of the beneficiaries. But sometimes there are hidden unintended consequences of projects on human life and the ecosystems. The society also affects implementation of projects. These impacts could be positive or negative. Similarly, the approach to managing engineering projects affects the extent to which project development process impact the workers, the community, the society and the ecosystems. This paper presents a framework for evaluating the potential lifecycle impacts of engineering project management process on workers, clients/consumers, the community and the society at large. The model is based on UNEP/SETAC guidelines on social lifecycle impact assessments. The analytical model is expected to be found helpful by project managers in identifying potential impacts of their projects on various categories of people, communities and the society. The findings will enable them to reinforce positive impacts and to eliminate or minimize negative impacts. Incorporation of a social lifecycle impact assessment in project management is expected to improve the overall value of the project, especially from the social sustainability point of view.

**Keywords—** social sustainability, lifecycle assessment, community impact assessment, Social impacts assessment, engineering project management, sustainable development, impact assessment

## 1. Introduction

There are various approaches to product development. One of them is project management approach. Project Management Institute defines project management as “the application of knowledge, skills, tools and techniques to a broad range of activities in order to meet the requirements of a particular project.” A project lifecycle, according to [1], refers to “a series of phases and activities that a project passes through from its initiation to its closure and can differ from project to project depending on its area of application. It provides the basic framework for managing the project, regardless of the specific work involved, by defining how the project team envisages to start, plan, organize, carry out and close the project.” Project management approach is often used for large size products such as aircraft, bridges, buildings, spacecraft, ship building, and road construction. The product realization process under product management approach consists of five groups of processes. The five process groups are initiating, planning, executing, monitoring & controlling, and closing. Figure 1 is an illustration of a typical project management process.



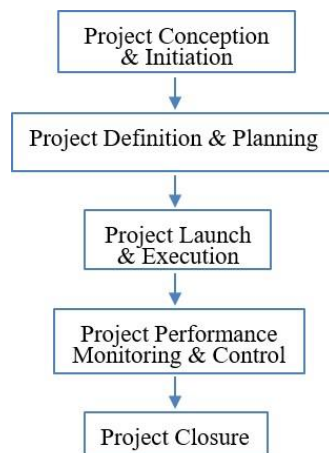


Fig. 1 An illustration of a typical project management process  
Source: [2 - 4]

Project management process, just like any process, activity or product, has both positive and negative impacts on various stakeholders. The kind and severity of impact vary from one category of stakeholder to another. The focus of this study is on social impacts of project management process. According to [5], “society is taking increasing interest in assessing social impacts of various human activities”. However, there are varieties of methods and approaches that are used in evaluating social impacts of our activities. The choice of social impact assessment approach depends on the object of interest. For example, one can utilize social impact assessment or health impact assessment if the focus is on a product, project or facility. According to [6], “social impacts are caused by changes.” For instance, constructing a production facility, a flyover bridge or an airport where it has never been in existence is a change. Among the possible effects of such changes include increased employment opportunities, increased trade, increased noise level, and more traffic. These effects in turn have consequences such as improved standard of living from employment and death or injuries resulting from increased traffic. There is therefore a need to evaluate the overarching social impacts of a product and/or facility with the aim of providing information and shedding lights on areas where negative impacts needs to be addressed and where positive impacts should be reinforced. One of the tools for evaluating social impacts is social lifecycle assessment (SLCA). As the name implies, it is concerned with the social and socio-economic impacts of products, process, activities and facilities. It is a tool used to analyze the way products, projects and other business activities affects human well-being. According to [7], “Social Life Cycle Assessment (SLCA) is emerging as a powerful and necessary tool in sustainability science.” However, the methodological aspects and applications of SLCA are not yet completely developed. They are currently at the evolutionary stage [8, 9]. SLCA is implemented in four steps, just like the counterpart lifecycle assessment tools. The four steps are: goal and scope definition, lifecycle inventory, lifecycle impact assessment, and lifecycle interpretation in Figures 2 and 3.

## 2. Goal and Scope Definition

### A. The goal of the study

According to [10], the goal of a lifecycle assessment should specify the intended application, objectives of the study, and intended audience. The goal of this study therefore is to provide awareness of the potential social consequences of project management process so that policy makers, project managers and other stakeholders can make informed decisions regarding various stages of a project lifecycle. The work is also aimed at identifying hotspots in social sustainability aspect which will be useful in developing project plans and strategies to support the development of sustainable project management process.

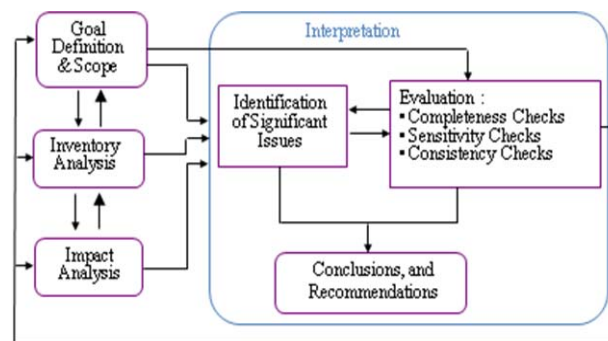


Fig. 2. An illustration of conventional lifecycle assessment process steps

Source: [7]

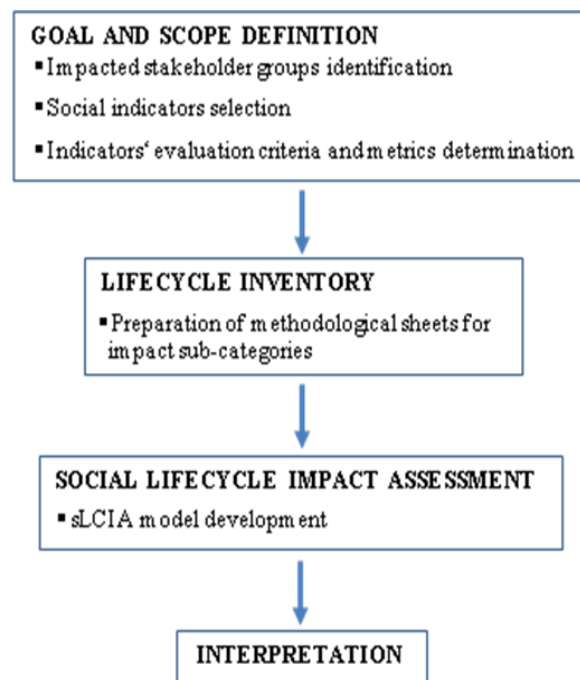


Fig. 3. Additional activities undertaken for sLCA at each LCA stage

To meet the goal of this research, the following questions will be answered:

- What are the appropriate social criteria that should be used to assess the social sustainability of a project management process?
- How should stakeholders assess the attainment of those criteria based on their experience in a specific case?
- What are the generic social sustainability hotspots within project management process lifecycle?
- How can project stakeholders identify/foresee possible social sustainability hotspots at the conceptual/planning stages of a particular project?

## B. Scope of the study

This sLCA study involves the development of a generic sLCA model for project management process and demonstrating it with a case study on an infant food production plant development project. At this stage of the study, we determined the function of the system, its functional unit, the system boundaries, data averaging, limitations and exclusions [11, 12]. We also identified affected stakeholder groups, impact categories, subcategories and indicator to be included in the analysis based on the goal of the study. Furthermore, we articulate the criteria for scoring the performance of the project on each indicator and determine the indicator scoring metrics in preparation for the lifecycle inventory.

#### B.1 A typical project management process

Figure 4 below is an illustration of the project management process of the pilot infant food production plant development project used as a case study. The project started with the recognition of the need by top management for locally produced nutritious baby food made from local ingredients. An infant food project development team/committee was then set up by the top management of the organization. Membership of the committee consists of relevant experts in the area of food science, microbiology, biochemistry, chemical engineering, techno-marketing, agricultural engineering, mechanical engineering, and planning. Project team are then assigned various responsibilities for the realization of the project objectives. The committee develop detailed plan for the project development. Quotations were invited from components, equipment and materials suppliers. After the funding release, selected materials and component suppliers were asked to supply their products. Scientists in the project team developed various formula and eventually came up with agreeable formula. Engineers designed and fabricated machinery for the demonstration infant food production pilot plant. Several experimental trials and modifications were carried out. At a point when the quality of infant food product and the pilot plant operations were considered adequate, the technology and the infant food product were taken to local and international trade fairs. The infant food product was also sold to the public. In addition, seminars were also organized for possible transfer of the technology to potential entrepreneurs while further improvements were still progressively being carried out.

#### B.2 Function and functional unit

The function of a project management process is defined in this study as realization of the project purpose or providing the intended utility (deliverables) at the scheduled time and specified location(s). The functional unit proposed for measuring social impact of any project management process is the “net change in human wellness per person” (NCIHWPP) resulting from such project. This metric was chosen because according to [13], “everyone around the world, regardless of geography, age, culture, religion or political environment, aspires to live well.” It is believed that every project is aimed at improving the human wellbeing. Thus, there is a need to measure how a project affect human wellbeing.

##### B.2.1 Human Wellness

According to [14], “Human well-being is a broad concept, one that includes many aspects of our everyday lives. It encompasses material well-being, relationships with family and friends, and emotional and physical health. It includes work and recreation, how one feels about one's community, and personal safety.” [13] in sharing similar view stated that “Wellbeing is not necessarily bound by income, rather, it is an individual's thoughts and feelings about how well they are doing in life, contentment with material possessions and having relationships that enable them to achieve their goals.” Quoting [15], [14] stated that “quality of life, welfare, well-living, living standards, utility, life satisfaction, prosperity, needs fulfillment, development, empowerment, capability expansion, human development, poverty, human poverty, land and, more recently, happiness” are other terms that are often used interchangeably with human well-being. [14] defined “human well-being as “the degree to which an individual, family, or larger social grouping (e.g. firm, community) can be characterized as being healthy (sound and functional), happy, and prosperous”. [16] described wellness as “a full integration of physical, mental and spiritual well-being that leads to quality of life.” [16] also described the seven dimensions of wellness, stating that “neglecting anyone dimension for a length of time has adverse effects on overall health.” This study adopted the principles of

the seven dimensions of wellness described by [16] for the evaluation of the social lifecycle impacts of project management process on human wellbeing.

### B.3 System boundaries

The scope of the study covers an evaluation of how every stage in a project management process lifecycle affect human well-being. The focus of this study is on individual wellbeing, although according to [14], “the determinants of an individual's well-being can include characteristics that include characteristics of family, community, nation, and so forth”. This evaluation is limited to impacts of a project on the wellbeing of project team and on the wellbeing of the immediate community where the project is implemented.

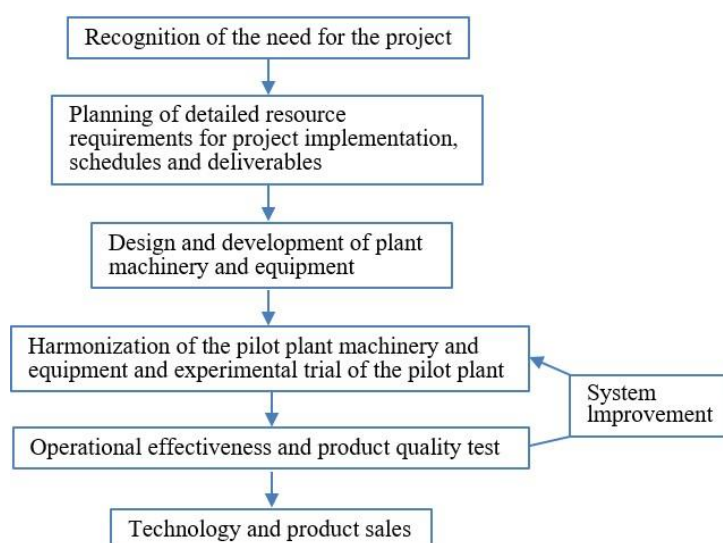


Fig. 4. The case studied Infant food pilot production plant project management process lifecycle

## 3. Lifecycle Inventory (LCI)

According to [17], lifecycle inventory “involves articulation and quantification of data to be used for impact analysis. Two major approaches have emerged in SLCA community regarding lifecycle inventory data to use. The first approach depends on company/site specific data. But they are often difficult to access. The second approach depends on generic data such as those obtainable from national censuses or public surveys which are easier to access [18]. According to [19], the development of social indicators that can be integrated into LCA depends on the sector that is monitored and the national context.” Data used for this analysis is a site specific data relating to a research and development organization in Lagos State, Nigeria.

### 3A. Data Collection

There are three forms of social LCA data: quantitative, semi-quantitative (yes/no or rating scale responses) and qualitative (descriptive text) [20-26]. This is the stage where interview questions to obtain requisite data is prepared. The data collection is based on the UNEP/SETAC methodological sheets and focused on how project management process affect human wellbeing and ignite industries [43-45]. Stakeholder category of interest would have to be interviewed. The lifecycle inventory data reported would have to be an average of the data collected in each stakeholder category. Tables 1 and 2 are illustrative examples of lifecycle inventory analysis results for the case studied infant food production project management process. They show some of the project management process’ social sustainability impact assessment criteria as they affect project team/workers and the local community where the project was implemented.

#### 4. Social Lifecycle Impact Assessment (SLCIA)

According to [17], “Social Impact refers to the consequence of positive and negative pressure on social end points, i.e. the well-being of stakeholders. There are six steps in conventional (environmental) lifecycle impact assessment. The six steps are: definition of impact categories, classification, characterization, normalization, grouping and weighting. The same is transposed unto social lifecycle impact assessment.” [17] explained that SLCIA stage of the lifecycle is still a work in progress and that this is in view of the “evolving understanding of possible social consequences of products, products and facilities.” He further explained that there are several factors that bring variations in effects caused by products and facilities as experienced by individuals and groups of people. The author opinion is that the list of such impacts cannot be fixed but examples can be found in social lifecycle assessment literature.

##### A. Selection of impact categories and classification

In 2009 UNEP/SETAC published a set of SLCA guidelines [27]. The guidelines identified five stakeholders, out of which two of the stakeholder’s categories are the focus of this study. The two stakeholder categories under consideration as earlier mentioned are project team/workers and local community where the project is implemented. The SLCA classification step in this study involved mapping impacts of project management process on the wellbeing of the project team/workers and on the local community. The selection of subcategories is based on the principles of UNEP/SETAC methodological sheets, currently relevant human wellbeing indicators project management practices in Nigeria and on the scope of the study. The indicators of the selected subcategories are defined by a set of semi-quantitative data.

##### 4A. Characterization and normalization

The implementation of this step is as described in [17]. It involves converting the social information into interpretable indicators of a list of impacts. Quantitative approach was adopted in this study because it provides a platform for comparison with results. This will enable us to compare the results obtained from this study with future studies thereby enabling us to identify the improvements that had occurred over the period. The quantitative approach used in this study is the SIMSAW model developed by [17] and implemented in Microsoft excel program [7, 28-42].

##### 4B. The SLCIA Calculation

The compilation of the potential social lifecycle impacts of a project management process performance for each stakeholder group was assessed using the SIMSAW model developed by [17]. The multi-layer model compiles normalized indicators scores at sub-category level and then sum up the weighted totals of all relevant sub-categories for each stakeholder group to obtain the facility’s score with regard to the stakeholder group. The overall social impact (score) of a project management process is finally calculated by adding all relevant stakeholders’ scores together. According to [17, “the normalization at subcategories level becomes necessary to avoid certain subcategories dominating the final result.”

Using the SIMSAW model [17], the overall social impact (score) of the project management process under study is obtained from the expression,

$$S = T_1 + T_2 + \dots + T_T \quad \dots\dots\dots (1)$$

where  $T_k$  is the project management process performance score for stakeholder category  $t$  and obtained

$$T_k = \frac{\sum_{j=1}^J w_j J_j}{\sum_{j=1}^J w_j} \quad \dots\dots\dots (2)$$

from

Table 1: Sample LCI \_ Stakeholder category: Project team/workers

Subcategories	Inventory Indicator	Normalized scoring metric	Averaged score	Maximum possible score
Physical Wellbeing	1. Working on this project provide me opportunity to exercise my body	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	2. The level of exposure to injuries, harm and contagious disease while working on this project	High = -1, low = -0.5, Not at all = 0	-0.5	0
	3. Working on this project made me develop healthy habits (i.e. adequate rest, stop smoking, use safety equipment, etc.) .	Yes = 1, No = -1, N/A = 0	-1	1
Emotional wellbeing	1. Working on this project encouraged me to cultivate optimistic attitude	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	2. Working on this project allowed me to freely express my feeling and share my views	Yes = 1, No = -1, N/A or Unverified = 0	0	1
	3. Working on this project enabled me to learn time management skills	Yes = 1, No = -1, N/A or Unverified = 0	1	1
Intellectual Wellbeing	1. Working on this project encouraged creativity and stimulated my mental activities	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	2. Working on this project kept me up-to-date on current events and facilitated my participation in activities that arouse my mind	Yes = 1, No = -1, N/A or Unverified = 0	1	1
Social wellbeing	1. Working on this project helped me learn good communication skills (of my thoughts, feelings and ideas)	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	2. Working on this project propelled me to get involved, share my talents and skills, and contribute to my community	Yes = 1, No = -1, N/A or Unverified = 0	1	1
Spiritual wellbeing	1. Working on this project encouraged me to meditate regularly and foster my commitment to my beliefs	Yes = 1, No = -1, N/A or Unverified = 0	0	0
	2. Working on this project gave me and those around me the freedom to be who we are	Yes = 1, No = -1, N/A or Unverified = 0	1	1

Environmental wellbeing	3. Working on this project made me see opportunities for growth in the challenges that life brings	Yes = 1, No = -1, N/A or Unverified = 0	0	1
	1. Working on this project increased my awareness regarding effects of our daily habits on the physical environment	Yes = 1, No = -1, N/A or Unverified = 0	0	1
	2. Working on this project encouraged me to conserve material, energy and water resources (i.e. reduce, reuse, recycle) thereby minimizing harm to the environment	Yes = 1, No = -1, N/A or Unverified = 0	1	1
Occupational/Vocational wellbeing	1. Working on this project enhanced my vision for the future	Yes = 1, No = -1, N/A or Unverified = 0	0	1
	2. Working on this project facilitated my openness to change and learn new skills	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	3. While working on this project I experienced satisfaction/pleasure in my employment and gave me a positive attitude to work	Yes = 1, No = -1, N/A or Unverified = 0	1	1

and  $J_k$  is the score of the project management process for subcategory  $j$  (under category  $t$  with regard to stakeholder group  $k$ )

Using similar procedure, maximum obtainable score for each stakeholder category is determined. The project management process score is then compared to the maximum obtainable score in assessing the social impact of the project.

Table 2 Sample LCI \_Stakeholder category: Local community where the project is implemented

Subcategories	Inventory Indicator	Normalized scoring metric	Averaged score	Maximum possible score
Physical Wellbeing	1. Working on this project provide recreation opportunity for the community	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	2. The level of exposure of the local community to injuries, harm and contagious disease as a result of project	High = -1, low = -0.5, Not at all = 0	-0.5	0
Emotional wellbeing	1. The project encouraged members of the local community to cultivate optimistic attitude towards the municipality	Yes = 1, No = -1, N/A or Unverified = 0	1	1

	2. The project enhanced freedom of expression by community members	Yes = 1, No = -1, N/A or Unverified = 0	0	0
Intellectual Wellbeing	1. The project encouraged creativity and stimulated mental activities of the members of the local community	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	2. The project made the local community to be up-to-date by such facility being in their domain. It also foster the participation of community members in activities that arouse their curiosity	Yes = 1, No = -1, N/A or Unverified = 0	1	1
Social wellbeing	1. The project fostered good communication and rapport among the members and leaders of the local community	Yes = 1, No = -1, N/A or Unverified = 0	0	0
	2. The project propelled community members to get involved, share their talents and skills, and contribute to the local community	Yes = 1, No = -1, N/A or Unverified = 0	0	0
Spiritual wellbeing	1. The project encouraged members of the local community to be committed to their beliefs	Yes = 1, No = -1, N/A or Unverified = 0	0	0
	2. The project provided the local community increased opportunities to grow and to overcome its challenges	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	3. The project enhanced community members' freedom to be who they are, thereby preserving their culture and tradition	Yes = 1, No = -1, N/A or Unverified = 0	1	1
Environmental wellbeing	1. The project increased the local community's awareness regarding effects of its activities on the physical environment	Yes = 1, No = -1, N/A or Unverified = 0	0	0
	2. The project facilitated communal effort to conserve material, energy and water resources (i.e. reduce, reuse, recycle) thereby minimizing harm to the environment	Yes = 1, No = -1, N/A or Unverified = 0	1	1
Sense of community well being	1. The project facilitated community's openness to change and to learning	Yes = 1, No = -1, N/A or Unverified = 0	1	1

3. The project increased the community members' satisfaction /pleasure with the changes taking place in their local community	Yes = 1, No = -1, N/A or Unverified = 0	1	1
---	---	---	---

#### 4C. Sample calculation

Taking the physical wellbeing sub-category under project team/workers stakeholder category as an example to demonstrate the calculation procedure:

The project's normalized score on physical wellbeing (pw) sub-category

$$J_{pw} = \frac{1}{3}[1 + (-5) + (-1)] = -0.17 \dots\dots\dots (3)$$

The maximum obtainable normalized score by the project on physical wellbeing under project team/workers stakeholder category

$$\text{Max } J_{pw} = \frac{1}{3}[1 + 0 + 1] = 0.67 \dots\dots\dots (4)$$

## 5. Results and Discussion

Tables 1 and 2 are the lifecycle inventory data resulting from the data collection and site observation while Figure 5 is an illustration of the lifecycle impact assessment results obtained from the analysis of the data from Tables 1 and 2 based on the SIMSaW model. The lifecycle impact assessment results were calculated by using equations 1 – 4 with the first step exemplified in the section above. The calculation showed that the social impact score for workers (wkr) = 4 while the score for local community = 3.5. The overall social impact score for the infant food production plant development process = 7.5. Similarly, the maximum obtainable overall social impact score by the project management process = 6.3 + 4.5 = 10.8. The overall social impact of the infant food production plant development process in relation to the possible achievable score,  $S_R = 7.5/10.8 = 0.694 = 69.4\%$ .

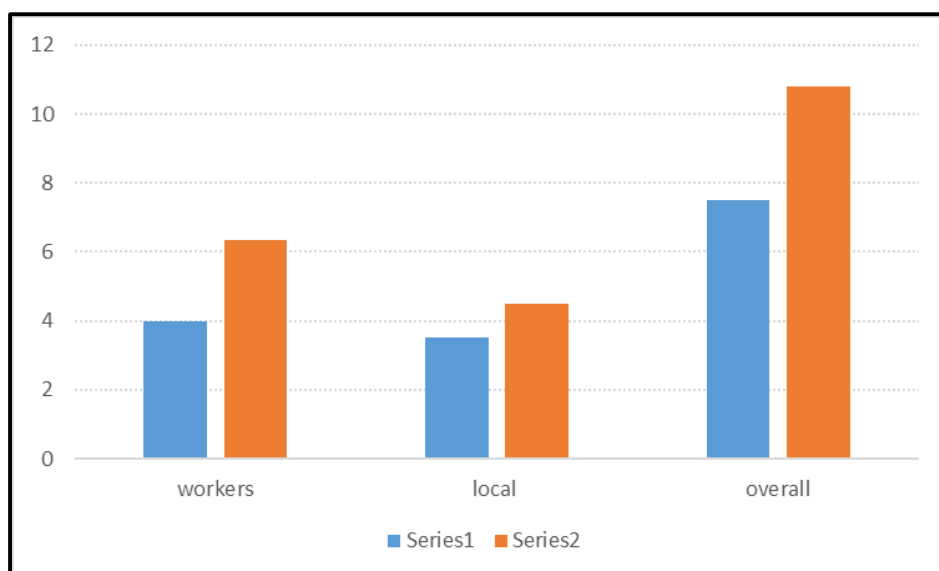


Fig. 5. Infant food production plant development process' social performance score in comparison with achievable score.

### *The SLCA Interpretation*

According to ISO 1440/44, we are to examine the results obtained from lifecycle inventory and lifecycle impact assessment for interpretation of the results. An examination of the lifecycle inventory results in Tables 1 – 2 and lifecycle impact assessment results revealed that increase in workers' and local community's exposure to injuries, harm and disease is the significant issue. Further evaluation of the results shows the social performance of the facility under worker's stakeholder category and local community stakeholder category (in comparison with possible performance score) to be 63.16% and 77.78% respectively. The infant food production plant project management process' overall social impact score = 69.44%. Using the interpretation criteria table (Table 3), the social lifecycle impact assessment of the project management process showed that its social performance is very good both for the project team/workers and the local community. It however showed better performance towards the local community than to the project team.

Table 3 Interpretation criteria

Percentage score	Remark
$\geq 80$	Excellent
61 - 79	Very good
50 - 60	Good
21 - 49	Poor
0 - 20	Very poor

### *Social impact on workers*

The impact of infant food production plant development on the project team was evaluated to promote the understanding of potential impacts of project management process on the project team/workers. The results showed that increased exposure to injuries, harm and diseases is the only outstanding issue that would need to be addressed.

### *Impact on the local community*

Evaluation of the infant food production plant development impacts on the local community also showed increased exposure of the local community to harm, injuries and diseases.

### *Evaluation*

According to [17], "the process of implementing the SLCA study needs to be evaluated to ensure conformity with the ISO 14040/44, UNEP/SETAC guidelines on SLCA and methodology sheets provided UNEP/SETAC on SLCA." "In addition, the scope of the study, data collected, and impact analysis steps undertaken were also examined in terms of their adequacy in meeting the goals of the study. Best practices were adopted where no definite guide was available."

## **6. Conclusion**

A procedure for evaluating potential social lifecycle impacts of project management process on human wellbeing was developed. The requisite criteria for the evaluation was also articulated. The procedure was implemented with a case study on an infant food production plant process. On the overall, the analysis showed that the project management process has a fairly good social performance. The only area requiring attention is the need to take adequate steps to reduce the exposure of the project team and the local community to harm. The case study analyzed showed how stakeholders can assess the attainment of those criteria based on their experience in a specific case. Furthermore, it helped to pinpoint social sustainability hotspots within the project lifecycle that needs further improvement.

Moreover, the study is a good contribution to the progress in social sustainability studies that is at an infant stage in this country. The case study would also serve as an example and a good reference for further sustainability studies

## References

- [1] PMTA (Project Management Training Africa) (2014). The 47 PMBOK project management processes made simple. Accessed online at <http://www.pmta.co.za/free-resources/the-47-pmbokr-project-management-processes-made-simple>
- [2] Duncan, W. R. (1993). The process of project management. *Project Management Journal*, 24(3), 5–10
- [3] Metafuse and Core Performance concept (2018). Project Insight. Accessed online at <https://www.projectinsight.net/projectmanagement-basics/basic-project-management-phases>
- [4] Bisk Education (2018). Five Phases of the Project Management Lifecycle. Accessed online at <https://www.villanovau.com/resources/project-management/5-phases-project-management-lifecycle/#.WxZNZ0iFOM8>
- [5] C. Macombe, P. Leskinen, P. Feschet and R. Antikainen, “Social life cycle assessment of biodiesel production at three levels: a literature review and development needs,” *Journal of Cleaner Production*, Vol. xxx, pp. 1-12, 2013. <http://dx.doi.org/10.1016/j.jclepro.2013.03.026>.
- [6] F. Vancley, “International principles for social impact assessment,” *Impact Assessment and Project Appraisal*, Vol. 21, No. 1, pp. 5–11, 2003.
- [7] Y. Fan, R. Wu, J. Chen and D. Apul, “A review of social life cycle assessment methodologies,” In Muthu, S.S. (Ed) *Social Life Cycle Assessment: An Insight*. Springer Science+Business Media Singapore 2015. ISBN 978-981-287-296-8: Chapter 1.
- [8] Y.H. Dong, and S.T. Ng, “A social lifecycle assessment model for building construction in Hong Kong,” *Int. J. Life Cycle Assess.*, Vol. 20, pp.1166–1180, 2015, DOI 10.1007/s11367-015-0908-5.
- [9] J. Fava, R. Denison, B. Jones , Curran M, Vigon B, Selke S, Barnum J, editors. “A Technical Framework for Life-Cycle Assessment,” Pensacola (FL): SETAC Press, 1991.
- [10] I.S. Dunmade, “Environmental Profile Assessment of a Plastic Framed Tambourine Musical Instrument – A Lifecycle Approach,” *Resources and Environment*, Vol. 3, No. 5, pp. 129-134, 2013. doi: 10.5923/j.re.20130305.03.
- [11] I.S. Dunmade, “Lifecycle Assessment of a Stapling Machine,” *International Journal of Engineering & Technology*, Vol. 4, No.1, pp. 12-19, 2015.
- [12] L.C. Dreyer, “Inclusion of social aspects in life cycle assessment of products: development of a methodology for social life cycle assessment,” PhD Thesis, DTU Management Engineering, Denmark, 2009.
- [13] Ashton, K. and Jones, C. (2013). Geographies of human wellbeing. Accessed online at [http://www.globaleducation.edu.au/verve/\\_resources/Global\\_Wellbeing\\_booklet.pdf](http://www.globaleducation.edu.au/verve/_resources/Global_Wellbeing_booklet.pdf)
- [14] PSI (Puget Sound Institute) (2018). The Nature of Human Well-being. Accessed online at <https://www.eopugetsound.org/science-review/section-3-nature-human-well-being>
- [15] McGillivray, M., and M. Clarke. 2008. *Understanding Human Well-being*. Bookwell Publications, New Delhi, India.
- [16] GRCC (2018). Seven dimensions of wellness. Accessed online at <https://www.grcc.edu/humanresources/wellness/sevendimensionsofwellness>
- [17] Dunmade, I.S.; Onawumi, S; Loto, C. and Oyawale, F (2016). Social Lifecycle Assessment of Sachet Water: A Case Study on a Nigerian Facility’s Impacts on Workers and the Local Community. *European International Journal of Science and Technology*, Vol. 5 No 6 p. 31-45
- [18] A. Jørgensen, “Developing the social life cycle assessment: addressing issues of validity and usability,” PhD Thesis, DTU Management Engineering, Denmark, 2008.
- [19] S.A. Husseinijou, S. Mansour and M.A. Shirazi, “Social life cycle assessment for material selection: a case study of building materials,” *Int. J. Life Cycle Assess.*, Vol. 19, pp. 620–645, 2015, DOI 10.1007/s11367-013-0658-1.

- [20] C. Benoît, D. Aulisio and G.A. Norris, "Identifying social impacts in product supply chains: overview and application of the social hotspot database," *Sustainability*, vol. 4, pp.1946–1965, 2012.
- [21] M. Blom and C. Solmar, "How to socially assess bio-fuels: a case study of the UNEP/SETAC Code of Practice for social- economical LCA," Master thesis, division of quality and environmental management. Luleå University of Technology, Stockholm, 2009.
- [22] L.C. Dreyer, M.Z. Hauschild and J. Schierbeck, "A framework for social life cycle impact assessment," *Int. J. Life Cycle Assess.* Vol.11, No. 2, pp. 88–97, 2006.
- [23] L.C. Dreyer, M.Z. Hauschild and J. Schierbeck, "Characterisation of social impacts in LCA, Part 1: development of indicators for labour rights," *Int. J. Life Cycle Assess.*, vol. 15, No. 3, pp. 247–259, 2010.
- [24] L.C. Dreyer, M.Z. Hauschild and J. Schierbeck, "Characterisation of social impacts in LCA, Part 2: implementation in six company case studies," *Int. J. Life Cycle Assess.*, vol. 15, No. 4, pp. 385–402, 2010.
- [25] UNEP/SETAC, "Methodological sheets for 31 sub-Categories of impact for a social LCA of products," 2010. [www.estis.net/sites/lcinit/default.asp?site=lcinit&page\\_id=A8992620-AAAD-4B81-9BACA72AEA281CB9](http://www.estis.net/sites/lcinit/default.asp?site=lcinit&page_id=A8992620-AAAD-4B81-9BACA72AEA281CB9). Accessed March 2016
- [26] E. Ekener-Petersen and G. Finnveden, "Potential hotspots identified by social LCA—part 1: a case study of a laptop computer," *Int. J. Life Cycle Assess.*, Vol. 18, No. 1, pp. 127–143, 2013.
- [27] J. Franze and A. Ciroth, "A comparison of cut roses from Ecuador and the Netherlands," *Int. J. Life Cycle Assess.*, Vol. 16, pp. 366–379, 2011.
- [28] M.Z. Hauschild, C. Dreyer and A. Jørgensen, "Assessing social impacts in a life cycle perspective—lessons learned," *CIRP Ann. Manuf. Technol.*, Vol. 57, pp. 21–24, 2008.
- [29] A. Jørgensen, A. Le Bocq, L. Nazarkina and M.Z. Hauschild, "Methodologies for social life cycle assessment," *Int. J. Life Cycle Assess.*, Vol. 13, No. 2, pp. 96–103, 2008.
- [30] A. Jørgensen, L.C. Lai and M. Hauschild, "Assessing the validity of impact pathways for child labour and well-being in social life cycle assessment," *Int. J. Life Cycle Assess.*, Vol. 15, No. 1, pp. 5–16, 2009.
- [31] A.K. Kruse, A. Flysjo and N. Kasperczyk, "Socioeconomic indicators as a complement to life cycle assessment—an application to salmon production systems," *Int. J. Life Cycle Assess.*, Vol. 14, pp.8–18, 2009.
- [32] A. Manhart, "Key social impacts of electronics production and WEEE-recycling in China," *Öko-Institut e.V, Freiburg*, 2007.
- [33] A. Manhart and R. Griebhammer, "Social impacts of the production of notebook PCs. Contribution to the development of a Product Sustainability Assessment (PROSA)," *Öko-Institut e.V, Freiburg*, 2006.
- [34] Y. Manik, J. Leahy, and A. Halog, "Social life cycle assessment of palm oil biodiesel: a case study in Jambi Province of Indonesia," *Int. J. Life Cycle Assess.*, Vol. 18, pp. 1386–1392, 2013.
- [35] C. Benoît and B. Mazijn, "Guidelines for social life cycle assessment of products," *UNEP/SETAC Life Cycle Initiative, Druk in de weer, Belgium*, 2009.
- [36] C. Benoit, and G.V. Niederman, "Social sustainability assessment literature review," *The Sustainability Consortium, Arizona State University and University of Arkansas*, 2010.
- [37] I.S. Dunmade, "A Multi-Criteria Model for Sustainability Assessment of an Agri-Industrial Technology Meant for a Developing Economy," *International Journal of Engineering Research and Applications*, Vol. 3, No. 1, pp. 445–456, 2013.
- [38] I.S. Dunmade, "The Use of Lifecycle Management Principles in Biosystems Engineering: A Pragmatic Approach to Solving Agri-Industrial Sustainability Problems," *Journal of Agricultural Science and Technology A*, Vol. 2, No. 3, pp. 357–362, 2012.
- [39] I.S. Dunmade, "Development of System Models for Industrial Processes Selection with regard to Product Lifecycle Extension (PLETS Models)," *Logos Verlag Berlin*, 2001, ISBN 978-3-89722-744-6.

- [40] G.A. Norris, “Social impacts in product life cycles: towards life cycle attribute assessment,” *Int. J. Life Cycle Assess.*, Vol. 11, No. 1, pp. 97– 104, 2006.
- [41] M. O’Brien, A. Doig and R. Clift, “Social and environmental life cycle assessment (SELCA): approach and methodological development,” *Int. J. Life Cycle Assess.*, Vol. 11, No. 2, pp. 87–97, 1996.
- [42] C. Reiting, M. Dumke, M. Barosevic and R. Hillerbrand, “A conceptual framework for impact assessment within SLCA,” *Int. J. Life Cycle Assess.*, Vol. 16, No. 4, pp. 380–388, 2011.
- [43] O.N. Nwoke, I.P. Okokpujie, S.C. Ekenyem. Investigation of Creep Responses of Selected Engineering Materials. *Journal of Science, Engineering Development, Environmen and Technology (JOSEDET)*. 2017;7(1):1-5.
- [44] J. Azeta, K.O. Okokpujie, I.P. Okokpujie, O. Osemwegie, A.A. Chibuzor. Plan for Igniting Nigeria’s Industrial Revolution. *International Journal of Scientific & Engineering Research*. 2016;7(11):489.
- [45] E.Y. Salawu, I.P. Okokpujie, O.O. Ajayi, M.C. Agarana. Analytical Technique for the Determination of Hoop Stress and Radial Stress on the Tooth Spur Gear under Vertical Loading in a Food Packaging Machine. *InProceedings of the International MultiConference of Engineers and Computer Scientists 2018 (Vol. 2)*.