A Social Lifecycle Assessment Model for Sachet Water Production in Nigeria

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***Abstract*— In the last two decades sachet water production and consumption has become an integral part of our consumption culture in Nigerian cities and towns. Its emergence and growth has some significant environmental and socio-economic implications. The aim of this study was to assess social impacts of sachet water production in Nigeria. This paper reports a Social Lifecycle Assessment Methodology developed to evaluate social effects of sachet water production on workers and on the local community where its production is taking place. The methodology is demonstrated with a case study on a Sachet Water brand production by a company in Sango-Ota. The social performance score of the sachet water production facility is 35.7% on workers and 50% on local community. The overall social performance is 42.3%. Results of the analysis revealed social benefits and community engagement as significant issues. The facility therefore needs to make significant improvement on a number of social aspects of its operations with regard to workers. These results provide valuable insight for those who seek to produce or purchase responsibly. The contributions made by this study include articulation of social indicators that are relevant to Nigeria, especially to sachet water production. This being the first reported sLCA study in our country, the developed sLCA model and the case study would provide a platform for future comprehensive sLCA study of a number of Nigerian products and economic activities.**

***Keywords*—** *social sustainability, lifecycle assessment, sachet water, sustainable development, impact assessment*

I. INTRODUCTION (*Heading 1*)

Water packaging in polythene sachet has become one of the most common ways of making water available for people on a journey, at various ceremonies and work sites in Nigeria. It is often used on occasions such wedding ceremony, birthday celebration, burial ceremony, and many other situations when large number of people are gathered for entertainment. It is popularly called "pure water". Like we all know that whatever we do has consequences. There are several positive and negative consequences of sachet water as a product and there are consequences of the facilities that are producing them. According to [1], "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 chosen 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 [2], "social impacts are caused by changes."For instance, setting up a production facility where it has never been in existence is a change. Among the possible effects of such changes include increased employment opportunities and more traffic. These effects in turn have consequences such as improved standard of living from employment and death or injuries in 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 could be enhanced. One of the tools for evaluating social impacts is social lifecycle assessment (sLCA). It is one of the complimentary members of lifecycle assessment family. 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 and business activities affects human well-being. According to [3], "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 [4, 5]. 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 (Figures 1 and 2).

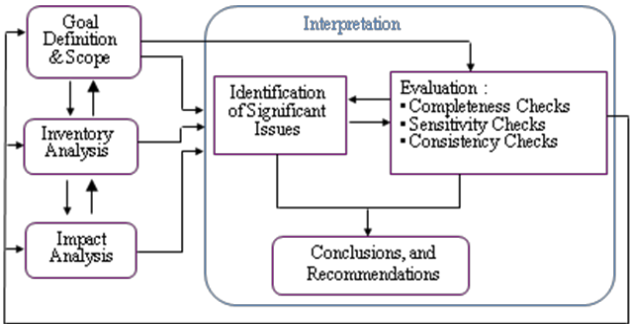

Fig. 1. An illustration of conventional lifecycle assessment process steps
[Source: Dunmade, 2015]

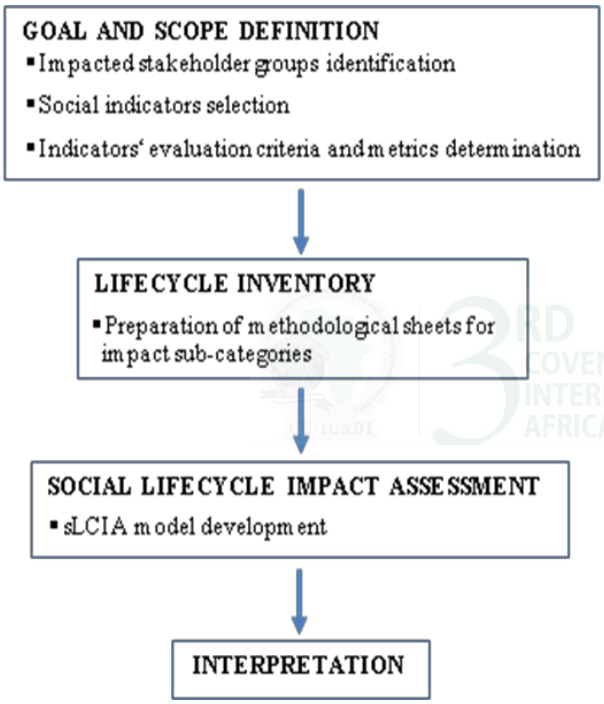

Fig. 2. Additional activities undertaken for sLCA at each LCA stage

II. GOAL AND SCOPE DEFINITION

A. *The goal of the study*

According to [5], 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 sachet water production so that manufacturers and policy makers can make informed decisions at that stage of the sachet water product lifecycle. The work is also aimed at identifying hotspots in social sustainability aspect which will be useful in developing design strategies to support the development of sustainable water sachet production facility. 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 sachet water production?
- How should stakeholders assess the attainment of those criteria based on their experience in a specific case?

What are social sustainability hotspots within the production stage of the sachet water lifecycle that needs further research and policy development?

B. *Scope of the study*

This sLCA study involves the development of a sLCA model for sachet water production and demonstrating it with a case study on a sachet water brand production by a company in Sango-Ota. At this stage of the study, we determined the function of the system, its functional unit, the system boundaries, data averaging, limitations and exclusions [6, 7]. 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 production facility on each indicator and determine the indicator scoring metrics in preparation for the lifecycle inventory.

B.1 Sachet water production system

Figure 3 below is an illustration of the production process of the sachet water brand used as a case study. The source of the water used is a well. When water is pumped from the well it is either stored in a number of storage tanks or pumped through a number of biological and ultraviolet treatment devices before being passed to another set of storage tanks from where it is packaged. The treated water is metered into 500ml sachet packaging and automatically sealed. Twenty sachets of water are then packed together in another polythene for onward distribution to retailers. Consumers purchase individual sachet or packs of twenty sachets from retailers. When a sachet of water is emptied, the sachet waste is disposed off. There are different levels of automation used in the industrial sub-sector depending on the ability of the investor. The process at this case study facility is about 60 – 70% automated.

B.2 Function and functional unit

The function of sachet water in this study is to quench human thirst, thereby preventing dehydration and associated consequences. The functional unit used in this study is a pack of sachet water containing 20 units of 500ml sachet water.

B.3 System boundaries

The scope of the study covers the production stage of sachet water lifecycle as a representation of sachet water production in Lagos/Ogun Area. The distribution and consumption of the sachet water is mainly within Sango-Ota metropolis. Only about 10% of the distribution goes to Lagos. This study did not include consumption and residual management stages of the sachet water lifecycle. Furthermore, transport of sachet water involved in distributing the product to

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the retailers is excluded. These activities also have social impacts, but are not covered within the scope of the study because the focus was on sachet water production.

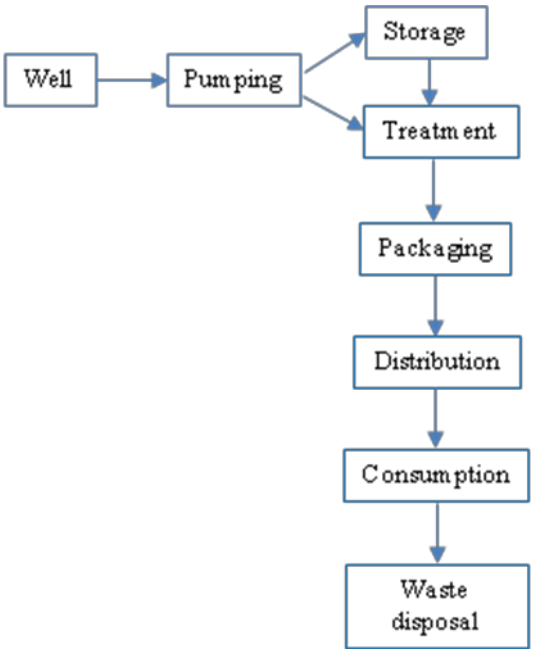

Fig. 3. The case studied Sachet water production process lifecycle

III. LIFECYCLE INVENTORY (LCI)

This 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 [8]. According to [9], 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 from the sachet water production facility in Sango-Ota, Ogun State, Nigeria.

A. Data Collection

There are three forms of social LCA data: quantitative, semi-quantitative (yes/no or rating scale responses) and qualitative (descriptive text) [10-15]. At this stage we prepared the interview questions and developed the methodological sheets for relevant subcategories in line with the UNEP/SETAC methodological sheets for 31 subcategories of impact [16]. The data was collected in the form of face-to-face interviews and site observation on Wednesday 10 February 2016. The data collected are qualitative, semi-quantitative and quantitative in nature. The proprietor and the production supervisor were independently interviewed. The questions asked ranged from raw material acquisition through water sourcing, treatments, packaging, marketing and distribution, socio-political impacts, employment matters, community relations and many other vital issues bordering on societal impacts of the production facility and that of the sachet water product brand. One of the value chain actors (i.e. plastic bottle producer/polythene supplier) was also interviewed on the same day. The lifecycle inventory data reported is an average of the data collected in each category from the stakeholders. Tables 1 and 2 are samples of lifecycle inventory analysis results of this study. They show some of the appropriate social criteria that should be used to assess the social sustainability of sachet water production regarding workers and local community matters.

Table 1 Sample LCI _ Stakeholder category: Workers

Subcategories	Inventory Indicator	Normalized scoring metric	Averaged score	Maximum possible score
Freedom of Association and Collective Bargaining	1. Employment is not conditioned by any restrictions on the right to collective bargaining	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	7. Workers have access to a neutral, binding, and independent dispute resolution procedure	Yes = 1, No = -1, N/A or Unverified = 0	0	
Child labour	1. Absence of working children under the legal age	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	3. Records on all workers stating names and ages or dates of birth are kept on file	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	2. The lowest paid workers considered their wages meets their needs	Yes = 1, No = -1, N/A or Unverified = 0	-1	1
	4. Regular and documented payment of workers (weekly, bi-weekly)	Yes = 1, No = -1, N/A or Unverified = 0	1	1
Hours of Work	1. Respect of contractual agreements concerning overtime	Yes = 1, No = -1, N/A or Unverified = 0	0	
Forced Labour	1. Workers are free to terminate their employment within the prevailing limits	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	2. Workers are bonded by debts exceeding legal limits to the employer	Yes = -1, No = 1, N/A or Unverified = 0	1	1

I. SOCIAL LIFECYCLE IMPACT ASSESSMENT (sLCIA)

Social Impact refers to 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 [6, 7]. The same is transposed unto social lifecycle impact assessment. However, this stage of the lifecycle is still a work in progress in view of the evolving understanding of possible social consequences of products, products and facilities. There are several factors that bring variations in effects caused by products and facilities as experienced by individuals and groups of people. The list of such impacts cannot be fixed but examples can be found in social lifecycle assessment literature. Furthermore, consensus is yet to be reached on a number of them [17-25].

A. Selection of impact categories and classification

Following the published UNEP/SETAC sLCA guidelines, a top-down method is adopted to select the stakeholder categories and subcategories [26]. The guidelines identified five stakeholders, namely: workers, consumers, local community, society, and value chain actors. For this study, impacts on only two of the five stakeholder groups were considered relevant in view of the scope of the research. The considered stakeholder categories are workers and local community. In sLCA classification for this study, situation relevant social impact subcategories and indicators were mapped into the relevant two of the five stakeholder categories. The social impacts assessed in this study have to do with human rights, working conditions, health and safety, cultural heritage and socio-economic repercussions. The selection of subcategories is based on UNEP/SETAC methodological sheets, currently relevant indicators for that Nigerian industrial sector and the scope of the study. The indicators of the selected subcategories are defined by a set of semi-quantitative data.

B. Characterization and normalization

This is the stage when life cycle inventory data is modeled to evaluate impacts of a product, process or a facility. It is the process of converting the social information into interpretable indicators of a list of impacts. Two methods are often used in analyzing and reporting social impacts in the sLCA, namely: quantitative approach which is based on scoring and the qualitative approach that simply reports the impacts in linguistic terms. A quantitative approach was adopted in this study. This quantitative approach was adopted because the results obtainable from the approach provide a platform for comparison with results that would be obtained from future studies of other similar production facilities. It would also facilitate determination of the extent to which the production system is improved whenever it is done. The quantitative approach used in this study involved the development of a customized simple additive weighting scoring model for analyzing the social impact of sachet water production. The model was implemented in Microsoft excel program [3, 26-34].

C. The sLCIA Calculation

The facility performance for each stakeholder group was assessed by compiling its normalized indicators scores at sub-category level. The weighted totals of all relevant sub-categories for each stakeholder group were then summed up to obtain the facility's score with regard to the stakeholder group. The overall social impact (score) of the facility is finally calculated by adding all relevant stakeholders' scores together. The normalization at subcategories level becomes necessary to avoid certain subcategories dominating the final result.

Table 2 Sample LCI _Stakeholder category: Local community

Subcategories	Inventory Indicator	Normalized scoring metric	Averaged score	Maximum possible score
Community Engagement	1. Availability of written policies on community engagement at organization level	Yes = 1, No = -1, N/A or Unverified = 0	-1	1
Cultural heritage	1. Cultural Heritage in Urgent Need of Safeguarding due to corporate activities	Yes = -1, No = 1, N/A or Unverified = 0	1	1
Local Employment	1. Percentage of workforce hired locally	% > 50 = 1, % between 10 - 49.9 = 0, % < 10 = -1	1	1
	3. Percentage of spending on locally-based suppliers	% > 50 = 1, % between 10 - 49.9 = 0, % < 10 = -1	1	1
Access to Material Resources	1. Has the organization developed project-related infrastructure with mutual community access and benefit	Yes = 1, No = -1, N/A or Unverified = 0	1	1
	2. Tendency for material resource conflict between organization and local community	Yes = -1, No = 1, N/A or Unverified = 0	1	1
Safe and Healthy Living Conditions	3. Management effort to minimize use of hazardous substances	Yes = 1, No = -1, N/A or Unverified = 0	1	1

C.1 The SIMSaW model

C.1.1 Facility's absolute scoring model

Let i be the ith social indicator

In_i is the facility's score on ith indicator in sub-category j under category t with respect to stakeholder group k. The original data of indicators are data provided by the company and national statistical data that represents an average condition in certain national context. For the quantitative indicators, the indicator values are normalized to a scale of −1 to 1, and −1 is considered to be the worst and 1 is the best social performance.

n_{In} is the total number of indicators considered for a sub-category

w_j is the importance weight attached to the jth sub-category

Importance weight is applied at the sub-category level because it is usually the highest level at which the product impact is assessed.

The score of the facility for sub-category j (under category t with regard to stakeholder group k,)

$$J_k = \frac{1}{n_{In}} \sum_{i=1}^{I} In_i \qquad (1)$$

The facility's score for stakeholder category t

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

The overall social impact (score) by the facility in absolute term,

$$S = T_1 + T_2 + \ldots + T_T \qquad (3)$$

However, to make the results obtained meaningful, it needs to be reported and interpreted in relation to obtainable maximum score in that scenario.

C.1.2 Maximum obtainable score determination
The maximum obtainable score for sachet water production can be calculated as follow:

The maximum obtainable normalized score for sub-category j with regard to stakeholder group k

$$J_k^{\max} = \frac{\sum_{i=1}^{I} In_i^{\max}}{n_{In}} \qquad (4)$$

where $In_j^{\max}$ is the maximum obtainable score with regard to social indicator j

The maximum obtainable weighted score for social impact category t with regard to stakeholder group k,

$$T_k^{\max} = \frac{\sum_{j=1}^{J} w_j J_j^{\max}}{\sum_{j=1}^{J} w_j} \qquad (5)$$

The maximum obtainable overall social impact (score),

$$S_{max} = T_1 + T_2 + \ldots + T_T \qquad (6)$$

The overall social impact of the sachet water production facility in relation to the possible achievable score,

$$S_R = S/S_{max} \qquad (7)$$

D. Normalization

Conventionally, this has to do with the rescaling of characterization results into a comparable range. The comparison may be in relation to the benchmark, industry standard, national standard or international standard. The normalization in this study is made in relation to the benchmark as represented by maximum obtainable value in each indicator category. The importance weight is also normalized. The normalization aspects were already built into the model.

E. Weighting

This involves attaching importance values to the normalized subcategories' results. Although the model provided for importance weighting, in this study all indicators are adjudged to be of equal importance. Consequently the weighting is unity and this cancels out the weighting aspect of the model.

For the quantitative indicators we convert the linguistic rating to numerical values in the range of −1 to 1. For example, the semi-quantitative indicators, such as cultural heritage, are evaluated by determining if the product or the process causes damage to cultural heritage or not, values of −1 is assigned if such indicator has negative impact, 1 if it has positive impact and 0 if it is not applicable or unassessed/unverified.

F. Sample calculation

Taking the health and safety sub-category under worker stakeholder category as an example to demonstrate the calculation procedure:

The facility's normalized score on health and safety (hs) sub-category

$$J_{hs} = \frac{1}{4}\left[1 + (-1) + 1 + 1\right] = 0.5 \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

The maximum obtainable normalized score by the facility on health and safety under worker stakeholder category

$$J_{hs}^{\max} = \frac{1}{4}\left[1 + 1 + 1 + 1\right] = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

II. RESULTS AND DISCUSSION

Tables 1 and 2 are the lifecycle inventory data resulting from the interview and site observation while Figure 4 is an illustration of the lifecycle impact assessment results obtained from the analysis of the data from Tables 1 and 2 based on the scoring model developed. The lifecycle impact assessment results were calculated by using equations 1 – 7 with the first step exemplified in section F above. The calculation showed that the social impact score for workers (wkr) = 2.5 while the score for local community = 3. The overall social impact score for the sachet water production facility = 5.5. Similarly, the maximum obtainable overall social impact score by the

facility = 7 + 6 = 13. The overall social impact of the sachet water production facility in relation to the possible achievable score, S_R = 5.5/13 = 0.423.

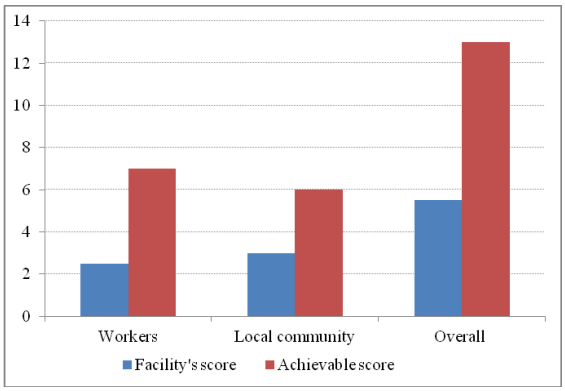

Fig. 4. Sachet water production facility's social performance score in comparison with achievable score.

A. 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 social benefits (under workers stakeholder category) and community engagement (under local community stakeholder category) as significant issues. Further evaluation of the results show the social performance of the facility under workers stakeholder category and local community stakeholder category (in comparison with possible performance score) to be 35.7% and 50% respectively. The facility's overall social impact score = 42.3%. Using the interpretation criteria table (Table 3), the social lifecycle impact assessment of the sachet water facility showed that the facility's social performance is poor to workers while it is okay with regard to the local community matters.

Table 3 Interpretation criteria

Percentage score	**Remark**
≥ 80	Excellent
61 - 79	Very good
50 - 60	Good
21 - 49	Poor
0 - 20	Very poor

A.1 Social impact on workers

The impact of pure water production on the worker was evaluated in terms of fairness of salary as there is no known/observed child labor nor forced labor practice in/by the organization. The salary/wage payment is considered unfair in view of the cost of living in Sango-Ota area. For example, a management staff of the company with MSc. degree receives about N32000 salary per month. One can then imagine what the factory staff is earning. However, this is typical of the general exploitation of staff in the private sector in our country. This is consequent upon high unemployment rate in Nigeria. The effect of such income on the workers' well being can then be interpolated. This accounts for 2.5 points score of the production facility out of a maximum obtainable 7 points score.

A.2 Impact on the local community

Evaluation of the facility's impacts on the local community showed an average score. Interview information revealed that the company provides the neighborhood free potable water from 5:30am to 9:00am twice a week. The production activities of the organization do not have negative impact on cultural heritage of the people as it does not infringe on the local communities cultural practices as at when due. The production of processed and packaged water in sachet instead of women and children having to fetch water from stream for festivities actually make cultural practice easier. These accounts for the company's 3 points score out of the maximum possible score of 6 points. The company's total score for the two stakeholder categories evaluated is 5.5 points out of the 13 points. This is below average of the total score.

B. Evaluation

The process of implementing the sLCA study was 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.

C. Conclusion

A social lifecycle assessment model was developed for sachet water production. The model was implemented with a case study on a sachet water brand production in Sango Ota. On the overall, the analysis showed that the facility has poor social performance. The facility would therefore need to make significant improvement on a number of social aspects of its operations with regard to workers. The model and its demonstration with a case study have shown appropriate social criteria that should be used to assess the social sustainability sachet water production process. It also 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 production stage of the sachet water lifecycle that needs further improvement.

Moreover, the study has opened up an essential area of sustainability studies that is yet to be explored in this country. The developed sLCA model and the case study provided a platform for comprehensive evaluation of our industrial activities in terms of their social sustainability. It would be a good reference for future sLCA study of many Nigerian

manufactured or imported products and on our other economic activities.

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