CHEMICAL ENGINEERING TRANSACTIONS
VOL. 83, 2021
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.cetjournal.it
Guest Editors: Jeng Shiun Lim, Nor Alafiza Yunus, Jiří Jaromír Klemeš

ISBN 978-88-95608-81-5; **ISSN** 2283-9216
DOI: 10.3303/CET2183029

Integration of Roundtable on Sustainable Palm Oil - Environmental Sustainability Index for the Development of Quantitative Environmental Sustainability Index

Siti Mariah Abdul Murad, Haslenda Hashim, Mazura Jusoh, Zaki Yamani Zakaria*

School of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
zakiyamani@utm.my

The Roundtable on Sustainable Palm Oil (RSPO) was founded in 2004 to promote the expansion and use of sustainable oil palm products through credible global standards and multistakeholder governance. Though RSPO was widely accepted as a reliable standard, it still lacks into certain extent quantification element to enable proper and smoother standardized measurement. To eliminate this problem, a new indexing method called Environmental Sustainability Index (ESI) was designed and proposed. The paper presents a case study to demonstrate the real-life application of the ESI-RSPO Integrated Environmental Sustainability Index Framework. The framework designed by the fusion of the key features of the ESI of measuring the overall progress towards environmental sustainability and RSPO of encouraging the growth and use of sustainable oil palm products, exhibits an organized, procedural and scientific pathway of measuring the environmental performance of palm oil manufacturing entities. Quantitative approach from ESI coupled with qualitative valuation from RSPO brings about tremendous advantages in the environmental sustainability context in particular by clearly showing where an entity is positioned in relation to the desired target. The results of this case study clearly pinpoint the environmental parameter outlier and prove that integration of ESI and RSPO will not only promote objectivity but also consistency of results across different production units. Both qualitative and quantitative measurement, operating in conjunction, is very much needed in a system as critical and dynamic with complex inter-relationship and linkages between various subsystems such as environmental sustainability.

1. Introduction

In response to the vital and demanding worldwide call for sustainably manufactured palm oil, the Roundtable on Sustainable Palm Oil (RSPO) was established with the main mission of encouraging the growth and use of sustainable oil palm products. This is implemented via credible global principles and engagement of related stakeholders. The RSPO has designed a set of sustainability criteria covering the environmental, economic and social aspects in which companies must adhere to in order to be granted the Certified Sustainable Palm Oil (CSPO) title (Abdul Murad et al., 2019a). These principles and criteria are predominantly qualitative based and are often seen as abstract and subjective (Brandi et al., 2015).

Being qualitative in nature, it is difficult to eliminate elements of subjectivity, vagueness and biasness in the current RSPO scheme assessment. The cognitive mind-set, emotion and experience vary within the assessors although an RSPO guideline is available. Often consistent and accurate result is tough and challenging to reach (Ruysschaert et al., 2019). To avoid this problem, a more proper quantitative approach to measure the environmental aspect in RSPO is suggested and could solve the problems, which is named Environmental Sustainability Indexed (ESI).

ESI is a tool used to measure the overall progress of a nation towards environmental sustainability in specific introduced recently by Abdul Murad et al. (2019a). The ESI is strictly a quantitative index founded on a compilation of indicators derived from underlying datasets which is very objective. Indicators-based measurement mechanism is currently central to sustainability initiatives (Gary and Terence, 2000). Environmental quality such as ESI is a dynamic property which is a ‘hybrid’ concept because it is both

Paper Received: 05/07/2020; Revised: 19/09/2020; Accepted: 01/10/2020
Please cite this article as: Abdul Murad S.M., Hashim H., Jusoh M., Zakaria Z.Y., 2021, Integration of Roundtable on Sustainable Palm Oil - Environmental Sustainability Index for the Development of Quantitative Environmental Sustainability Index, Chemical Engineering Transactions, 83, 169-174 DOI:10.3303/CET2183029

objective and subjective and these traits cannot be separated or reduced from each other (Angelakoglou and Gaidajis, 2015). This is the reason why a unique measurement tool is necessary to enable to perceive variances, improvements or progress relating to the desired situation in the environmental context (Abdul Murad et al., 2019b). A mix of qualitative and quantitative indicators not only reveals nuances but also provides greater insight into what is actually happening situations (Ahlroth et al., 2011). The ESI is presently at its final development stage and could potentially be introduced to be part of the RSPO scheme. The objective of this paper is to demonstrate the step by step process in the development of the RSPO-ESI Environmental Sustainability Index.

2. Advantage of quantitative approach for environmental sustainability measurement

Technological advancements within the palm oil industry not only mean innovation in the manufacturing aspect but also that research methodologies are continuously evolving to be better and more effective. Having said this, before undertaking any study, it is vital to have a good understanding of the research approaches available. For a system as dynamic and complex as environmental sustainability, quantitative approach brings about many advantages as opposed to qualitative method as qualitative method is more superior to define problems or to develop and approach the issue rather than to resolve or find a solution to an issue (Thomé and Scavarda, 2015). Table 1 outline some of the many benefits of opting for quantitative approach for the measurement of environmental sustainability (Waas et al., 2014).

Table 1: Pros of quantitative measurement for environmental sustainability

Pros of Quantitative Measurement for Environmental Sustainability	Elaboration of the Pros
More scientific	A wide range of data is consolidated and studied statistically which eliminates bias.
Objective and focused	Promotes objectivity without bias and subjectivity. No room for self-interpretation
Repeatable	The framework can be easily replicated or repeated for validation and comparison.
Organized in simple analytical methods	Data collections are direct and in the form of numbers and statistics. Generally presented in tables, charts, figures or other non-textual methods.
Data consistency	With quantitative study, data obtained is precise, reliable and consistent.
More acceptable	Very likely to have higher credibility among influential people especially decision makers given its simplicity in relating to the figures.
Useful for decision making	Data from quantitative study provides important information for important decisions
Easier monitoring	Data presented can be easily tracked and monitored for improvement and trend analysis.

3. Construction of the ESI-RSPO Environmental Sustainability Index

3.1 Outlining the concept for enhancement of RSPO to reflect environmental sustainability

It is imperative to outline the concept for enhancement of RSPO to reflect environmental sustainability in this field of study. The baselines of the framework are:
RSPO: The indicators selected for the framework were based on the globally recognised Palm Oil assessment scheme, RSPO. The main reason for this is primarily fulfilling the objective of the development of this framework to address the gaps of the current RSPO scheme rather than replacing the scheme all together.
Upstream: The framework is design to assess the activities in the upstream portion of palm oil production namely the crude palm oil manufacturing process which covers activities in estates and mills. The rationale being these are the stages where the major conversion activities take place and subsequently resulting in the greatest environmental impact.
Environment Pillar: The framework that follows focuses only the environmental aspect of the sustainability concept. Being an environmental dominant industry, the palm oil sector has very high reliance on the natural biosphere relative to the other two pillars-social and economy. The social advancements and economic benefits brought about by the palm oil industry is a takeaway from the management of the natural resources contained within the environment.

3.2 Review of existing data and raw data collection

The pre-existing RSPO principles and criteria were reviewed and categorised into the 3 pillars of sustainability (environment, social and economy) as well as administrative, legal, health and safety; training and Development as demonstrated in Table 2. The indicators which fall under the environment pillar are then reviewed for its relevance and measurability. Details of pre-existing RSPO principles can be referred to the RSPO Principles and Criteria Guide (RSPO, 2018).

Table 2: Categorisation of RSPO indicator by sustainability pillar

Principle	Criteria	Category
1	1	Administrative
	2	Administrative
	3	Administrative
2	1	Legal
	2	Legal
	3	Legal
3	1	Economy
4	1	Environment
	2	Environment
	3	Environment
	4	Environment
	5	Environment
	6	Environment
	7	Health and Safety
	8	Training and Development
5	1	Environment
	2	Environment
	3	Environment
	4	Environment
	5	Environment
	6	Environment
6	1	Social
	2	Social
	3	Social
	4	Social
	5	Social
	6	Social
	7	Social
	8	Social
	9	Social
	10	Social
	11	Social
	12	Social
	13	Social

3.3 Selection and fine tuning of principles, criteria and indicator

The indicator narrowed from the previous step are then further refined ensuring the indicators are specific, observable and measurable characteristic that can be used to show changes or progress of the palm oil manufacturing process is making toward achieving a specific outcome. It is crucial to ensure the indicators are focused, clear and specific. Focus is put on ensuring the indicators are defined in precise, unambiguous terms that describe clearly and exactly what is being measured. The indicators developed are not meant to specify a particular level of achievement, the words “improved”, “increased”, or “decreased” are voided as they do not belong in a quantitative indicator.

3.4 Data gathering and establishment of standard or target value

Indicators can then be used for determining progress toward results in monitoring as well as in monitoring the context of the conflict (Carvalho et al., 2014). The indicators need to be benchmarked against the best, expected or targeted condition to fulfil this objective. This is done by obtaining values from regulation and industry best practices. However, in case of the indicator does not have any target or standard, trend line data from the industry is used to determine the best condition to be set as auditors' or checkers' target.

3.5 Data standardization and normalization

Due to the inconsistency in measurement units the data are homogenized by applying the proximity-to-target (PTT) method using the PTT formula (Sala et al., 2018). The formula for PTT calculation of type A data (high values equate to good performance) and type B (high values equate to bad performance) are shown in Eq(1) and Eq(2). Description of the equation has been elaborated previously (Abdul Murad et al., 2019a).

$$\text{PTT Type A} = \frac{[(\text{target}-\text{min})-(\text{target}-\text{raw data})] \times 100}{(\text{target}-\text{min})} \quad (1)$$

$$\text{PTT Type B} = \frac{[(\text{max}-\text{min})-(\text{raw data}-\text{target})] \times 100}{(\text{max}-\text{target})} \quad (2)$$

3.6 Weightage average, index scoring computation and profiling

Given the impact of every indicator measured are equally harmful to the environment, each indicator weightage is set to be equal. The final outcome of the computation performed is tabulated in Table 3.

Table 3: Outcome of Index Computation

Parameter	Unit	PTT Type	Threshold Value	Actual Value	Normalized value	Percentage Contribution (%)
			Gaseous Emission			
GHG from fossil fuel for transport & machinery	CO_2-eq/ t CPO	B	45	85	50.00	11.47
GHG from fertilizer use	CO_2-eq/ t CPO	B	250	360	50.00	11.47
GHG from POME	CO_2-eq/ t CPO	B	625	1046	50.00	11.47
Flue gas from stack SO_x	kg/t palm kernel	B	0.0005	0.0006	96.00	22.03
Flue gas from stack NO_x	kg/t palm kernel	B	0.07	0.07	100.00	22.95
Flue gas from stack CO	kg/t palm kernel	B	0.07	0.12	89.796	20.61
			Liquid Effluent			
pH	NA	A	7	4.2	22.22	5.44
Oil and grease	mg/L	B	50	6,000	66.41	16.24
BOD	mg/L	B	100	25,000	19.70	4.82
COD	mg/L	B	1,000	51,000	35.35	8.65
Total solids	mg/L	B	1,500	40,000	37.42	9.15
Suspended solids	mg/L	B	400	18,000	58.58	14.33
Volatile solids	mg/L	B	9,000	34,000	60.32	14.76
Ammoniacal Nitrogen	mg/L	B	4	35	59.21	14.48
Total nitrogen	mg/L	B	150	750	49.60	12.13
			Solid Waste			
Waste Disposal (Raw)	kg/t FFB	B	0	510	49.00	3.45
Biomass Recovery Ratio (Recycle : Generate)	%	A	100	50	50.00	3.52
Pesticide Application Frequency	time/ month	B	0	15	51.61	3.63
Fertilizer Consumption Ratio (Organic : Inorganic)	NA	A	1.0	0.5	50.00	3.52
Soil pH	NA	B	6.25	6.25	1,220.00	85.88

Spider web charts are a useful way to display multivariate observations with an arbitrary number of variables. The radar chart is a chart or plot that consists of a sequence of equi-angular spokes, called radii, with each spoke representing one of the variables. The data length of a spoke is proportional to the magnitude of the variable for the data point relative to the maximum magnitude of the variable across all data points. The radar charts plotted for the data from Table 3 is illustrated in Figure 1.

From the radar charts presented in Figure 1, it can be seen that the number of indicators determine the type of polygon formed as the number of indicators is directly proportional to number of sides of the polygon shaped. A more regular shaped polygon implies equal contribution by each indicator whereby a longer spoke signifies higher contribution and vice versa. The centre point symbolizes the target state to be achieved by the indicators in which a shorter spoke is closer to the goal. On the other hand, the furthest spoke describes the worst performing indicator or the hotspot. This significant feature of the radar chart helps to locate outliers swiftly and easily. Outliers in this case would mean extremely bad performing indicators. The bad performing indicators are the hotspots marked in bright red box that are identified as the peak furthers from the centre. For instance, Figure 1a shows that the flue gas from stack (NOx) is extremely out of range and could be effortlessly detected. Flue gases from stack (CO and SOx) are also on the bad side and can be also marked as not complying with the standard. Other bright red boxes are showing other parameters that are far from acceptable standard as shown in Figure 1b, 1c and 1d. The concept of radar chart profiling does not end here. It can be further improved, modified and implemented with circular economy and digitalization in the palm oil upstream industry. The outlier parameters can also be categorized or lumped together to show more than one stubborn critical parameters, which subsequently allows necessary corrective action to be taken.

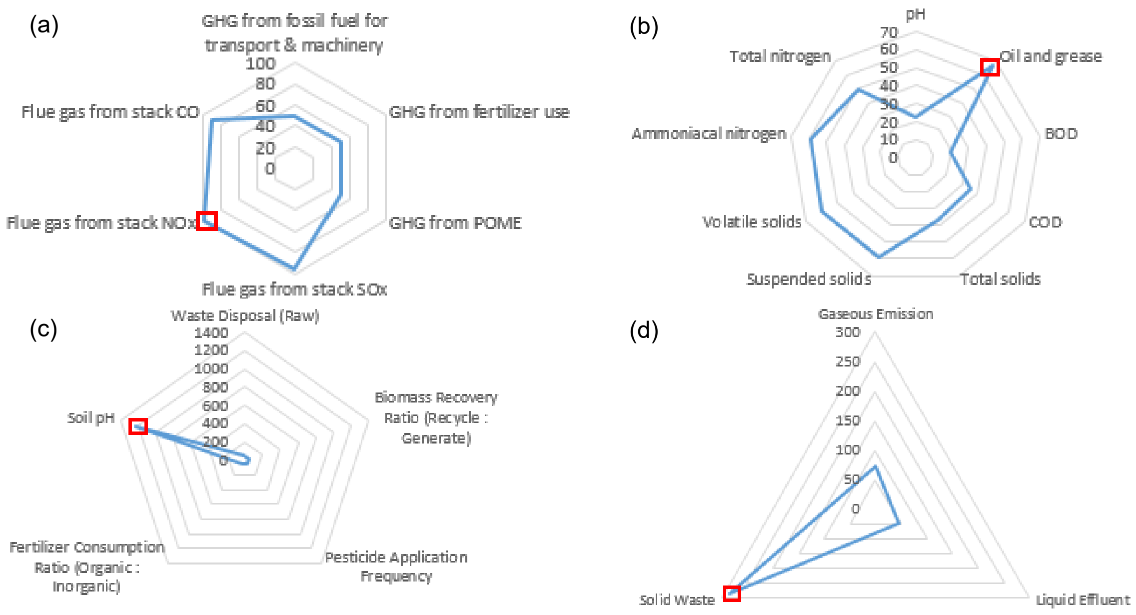

Figure 1: Radar Charts Profiling (a) Gaseous emission (b) Liquid effluent (c) Solid waste (d) Gaseous Emission-liquid effluent and solid waste triangle

3.7 Identification of weak performance indicators and mitigation action recommendation

Based on the spider-web plot using the normalized data, hot spots are identified in terms of performance, measurability, relevance and consistency. These weak performance indicators are further reviewed prior to suggesting the recommendations. Weak performance indicators are identified based on lack of measurable criteria as well as vagueness of the indicators.

For the flue gas from stack NOx as illustrated in Figure 1a, recommended actions are to reduce temperature and residence time, apply chemical reduction of NOx (William et al., 2007), apply oxidation of NOx (Ruben et al., 2019), and to remove nitrogen from combustion. For the liquid effluent concerning oil and grease as depicted in Figure 1b, it is suggested to remove oil and grease content for POME using solvent extraction method (Rydberg, 1992).

Finally, to tackle the soil pH issue as per shown in Figure 1c, three recommendations are made which are to alternate the consumption of ammonium nitrate and/or urea if acidification is a potential problem in the soil

(Andersson, 2000), to use of ammonium sulphate rather than ammonium nitrate in order to lower the pH to an optimum for oil palms (Lal, 1991); and finally to use bunds and proper water-table management to prevent seawater inundation or seawater seepage into ground water.

4. Conclusions

The proposed ESI index will eliminate any subjectivity, vagueness and biasness that the current RSPO scheme carries. This in turn would be significantly reduce the time taken to reach to a unanimous decision in relation to environmental sustainability as opposed to the qualitative method in practice. The result shows that by integrating the quantitative aspect of sustainability measurement to the existing RSPO package will not only promote objectivity but also consistency of results across different manufacturing entities. The enhanced RSPO-ESI Framework is aimed to aid as a more practical scheme of modeling, measuring and reporting a wide range of indicators linked to the manufacturing supply chain.

Acknowledgments

The authors would like to acknowledge the financial support from Ministry of Higher Education Malaysia (MyPhD Industry) and Universiti Teknologi Malaysia (Vote No: 07H81 & 02G42).

References

Abdul Murad S.M., Hashim H., Jusoh M., Zakaria Z.Y., 2019a, Enhancement to Roundtable on Sustainable Palm Oil (RSPO): Qualitative to quantitative assessment tool, Chemical Engineering Transactions, 72, 67-72.

Abdul Murad S.M., Hashim H., Jusoh M., Zakaria Z.Y., 2019b, Sustainability assessment framework: A mini review of assessment concept, Chemical Engineering Transactions, 72, 379-384.

Ahlroth S., Nilsson M., Finnveden G., Hjelm O., Hochschorner E., 2011, Weighting and valuation in selected environmental systems analysis tools - Suggestions for further developments, Journal of Cleaner Production 19 (2-3), 145–156.

Andersson S., Nilsson S.I., Saetre P., 2000, Leaching of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) in more humus as affected by temperature and pH, Soil Biology and Biochemistry, 32, 1–10.

Angelakoglou K., Gaidajis G., 2015, A review of methods contributing to the assessment of the environmental sustainability of industrial systems, Journal of Cleaner Production, 108, 725–747.

Brandi C., Cabani T., Hosang C., Schirmbeck S., Westermann L., Wiese H., 2015, Sustainability standards for palm oil: Challenges for smallholder certification under the RSPO, Journal of Environmental Development, 24, 292–314.

Carvalho A., Mimoso A.F., Mendes A.N., Matos H.A., 2014, From a literature review to a framework for environmental process impact assessment index, Journal of Cleaner Production, 64, 36–62.

Gary R.S., Terence H.P., 2000, A generalized environmental sustainability index for agricultural systems, Agriculture, Ecosystems and Environment, 79, 29–41.

Lal R., 1991, Soil structure and sustainability, Journal of Sustainable Agriculture, 1, 67–91.

Santiago R., Mossin S., Bedia J., Fehrmann R., Palomar J., 2019, Methanol promoted oxidation of nitrogen oxide (NOx) by Encapsulated Ionic Liquids (ENILs), Environmental Science and Technology, 53, 11969–11978.

RSPO, 2018, RSPO Principles & Criteria for the Production of Sustainable Palm Oil, <rspo.org/resources> accessed 24.07.2020.

Ruysschaert D., Carter C., Cheyns E., 2019, Territorializing effects of global standards: What is at stake in the case of ‘sustainable’ palm oil?, Geoforum, 104, 1-12.

Rydberg J., 1992, Introduction to Solvent Extraction, Marcel Dekker, New York.

Sala S., Cerutti A.K., Pant R., 2018, Development of a weighting approach for the Environmental Footprint, Publications Office of the European Union, Luxembourg.

Thomé A.M.T., Scavarda A., 2015, A systematic literature review of design-manufacturing integration for sustainable products, Chemical Engineering Transactions, 45, 691-696.

Waas T., Hugé J., Block T., Wright T., Benitez-Capistros F., Verbruggen A., 2014, Sustainability assessment and indicators: Tools in a decision-making strategy for sustainable development, Sustainability, 5512–5534.

William S.E., Yezerets A., Currier N.W., 2007, The effects of regeneration conditions on NO_X and NH_3 release from NO_X storage/reduction catalysts, Applied Catalysis B: Environmental, 74, 117-129.