Sustainability Framework for Palm Oil Mill

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Palm oil mill has been regarded as a profit making industry for the past decades. Besides revenue from the palm oil production itself, the abundance of biomass could generate high economic return to the palm oils mill by converting it to value added products. However, the palm oil industry currently suffered various criticisms and negative reports from the international non-government organisations on the sustainability issue. This paper presents the development and the applicability of sustainability index (SI) for palm oil mill in order to enhance the competitiveness of the industry. The methodology will include the index development and identify area of weaknesses (hotspot). The index will be able to identify performance of the mills in sustainable aspect against benchmarks and differentiate every mills performance. By this, the mills can easily identify its hotspot and take necessary steps to improve. The system will also benefit the marketing team to market its products (CPO, PKO etc.) to niche markets that seek uptake from mills with lowest footprints (Carbon, water, energy etc.). The results can be used not only to evaluate the performance of an operating process against standard benchmarking but also to establish the best sustainable practices among palm oil industry. It is anticipated that the development of sustainable index will be an important instrument for supporting sustainable operation for palm oil mill.

1. Introduction

Some of the research done regarding sustainable issues on palm oil area are waste utilization through thermochemical conversion liquefaction (Awalludin et al., 2015) and innovation on effective utilization of waste to become renewable energy (Yusoff, 2006). Other than that, eco-labelling for carbon footprint modelling which can help to measure the value taken of product and services thus reducing impact to the environment (Choong and McKay, 2013). Most of sustainability trend research from 2004 to 2013 in Malaysia dominate to technology and residue use area which include to the palm oil mill effluent (POME) treatment and value added product from the POME. There are several index research has been practiced. One of them is ENERGY STAR industry program but it focuses to corporate energy management level on encouraging and enabling sustainable electrical appliances (Gale et al., 2008). Meanwhile, Environmental performance index (EPI), is a global metric of environmental performance between the countries to protect ecosystems and human health from environmental harm (Ahmad et al., 2014). Tan et al. (2015) proposed a development of the Low Carbon Indicator (LCCI) for the research that focused on evaluation, implementation and standardisation of low carbon cities (LCC) by measure on waste management, environment control, economic factor and municipal solid waste (MSW) of the country. Meanwhile Zhang et al. (2016) evaluate sustainability of city in China based on economic, social and environment factor. Hashim et al. (2014) invented a tool to identify environmental level in palm oil mill industry but it were only focus on environmental aspect and no weightage being considered in their method. Thus, it can be said research on sustainability index is still lack in palm oil plantation and palm oil mill area.

2. Methodology

The summary of methodology flowchart of sustainability index for palm oil mill as shown in Figure 1.
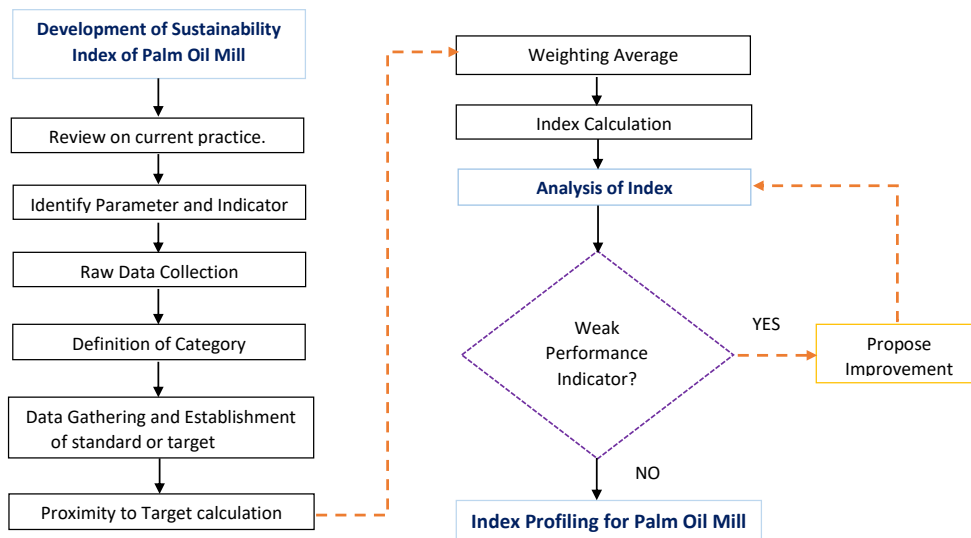
Figure 1: Methodology flowchart of Sustainability Index for Palm Oil Mill

2.1 Review and raw data collection on current practice in palm oil industry

First step, comprehensive review on palm oil mill and management are conducted to understand the current practices in palm oil industry. The raw data are gathered from selected palm oil mill and previous studies to develop framework of the index. Besides, sources of data are from palm oil mill manual, discussion with plant manager or staff and data extraction from palm oil mill current data system. Later the data are classified to different category such as big scale mill, small scale mill, and technology used.

2.2 Indicators and parameter selection

In depth, parameter is a benchmarks of the aspect and obtained from previous study, palm oil policies and discussion with the industry. Therefore, parameters obtained are assigned to one of the suitable aspect either economy, environment or social. Indicator is a tool to measure the parameter and monitor the sustainability level. Generally, indicators are selected based on the relevance, performance orientation, transparency, data quality, data sustainability and data custodian (Ahmad et al., 2015). Table 1 profiled the indicator with their representing unit for performance calculation. Indicators are given a symbol and mapped into the palm oil process flowchart as in Figure 2. The aim of this step is to have a clear visual of where the indicator located.

2.3 Data gathering and establishment of standard or target value

Standard values are obtained from related authorities such as FELDA, DOE and etc. In some cases, industry targets and historical data used as a standard value. For example, FELDA target to increase Oil Extraction Rate (OER) production annually more than 21.94 %. Thus, 21.94 % used as a benchmark to be achieved by the indicator. By having the standard value, it can be determined the performance of each indicator as opposed to the target or specify standard. However, in case of the indicator does not have any target or standard, trend line data from the industry are used to determine the best condition to be set as our target.

2.4 Proximity to Target (PTT)

The indicator collected are different in unit and dimension. Each indicator either positive (type A) or negative indicator (type B), where the positive indicates the high value equates good performance and vice versa (Tan et al., 2015) the concept of Proximity to Target (PTT) is illustrated in Figure 3. PTT is a simple approach of measure on how close mill performance compared to the standard. PTT using Eq(1) for type A indicator and Eq(2) for type B indicator to normalise the indicators.

2.5 Weightage Average

In this step, it required expert view to give weight to the parameter using questionnaire and interview because not every parameter have same value of importance. Might be this parameter will be more important than another parameter so we will take expert view and opinion to give rating to the parameter.

Table 1: List of Parameter and Indicator

Aspect	Parameter	Symbol	Indicator	Symbol
Environment	Water Consumption	E1	Use of water	UOW
	Boiler Emission (Air Quality)	E2	NO_X	NOX
			CO_2	CO
	Waste Water Quality after treatment	E3	BOD_5	BOD5
			COD	COD
			Oil and grease	O&G
			Suspended Solid	SS
			pH	PH
			Temperature	TEM
Economy	Kernel Extraction Rate	P1	Production of Crude Kernel Oil	CPKO
	Oil Extraction Rate	P2	Production of Crude Palm Oil	CPO
Social	Customer Satisfaction	S1	No of Complaint	NOC
	Occupational Injuries	S2	No of Accident	NOA

Figure 3: Proximity to Target Concept

$$\frac{raw\ data - min}{target - min}\ x\ 100 \tag{1}$$

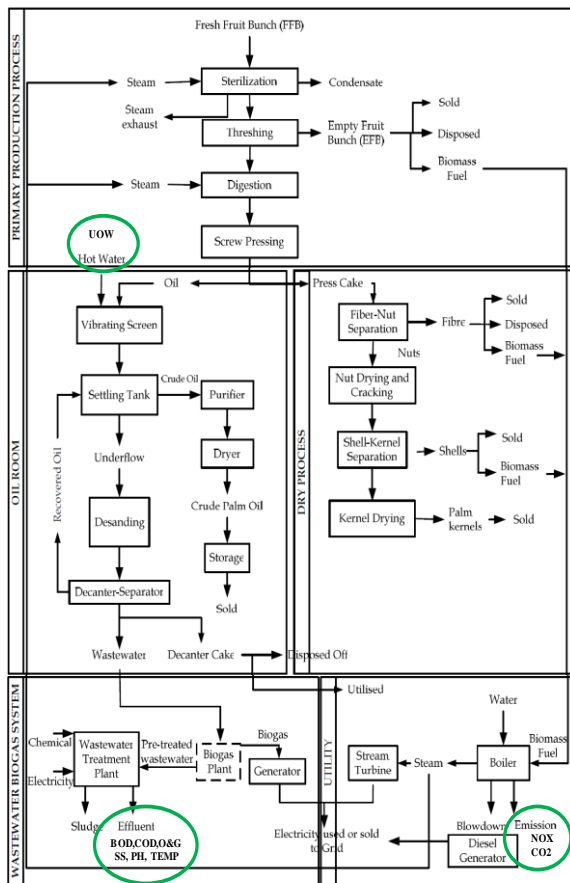$$\frac{max - raw\ data}{max - target}\ x\ 100 \tag{2}$$

Figure 2: Indicator Location

2.6 Index Calculation

Figure 4 shows calculation flow steps to obtain the index value. It starts from normalise data using PTT, averaged it according their parameter, sum up to the aspect score and lastly obtain the index.

2.7 Sustainability Index Profiling and Analysis of Index

Sustainability Index Profiling is a method to collect and clustered the result according to their own mill. Therefore, easier to compile and make comparison between the mill. The analysis of Sustainability Index is presented
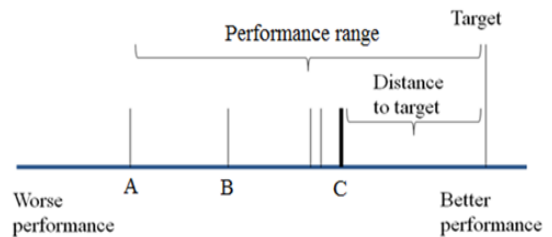
using radar chart. Radar chart are selected because it gives explicit results analysis by clearly shows areas for improvements. The outer ring of the web which mean 100% score, so towards the outer ring it shows a better result. Radar chart allows the industries to quickly recognise area which they perform well or to identify area for improvement.
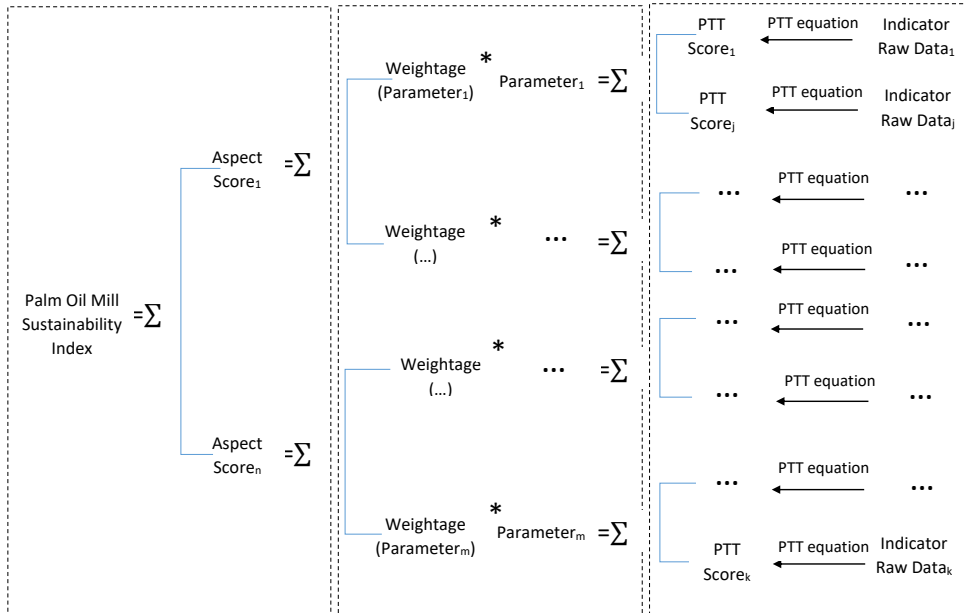

Figure 4: Index Performance Calculation Block Diagram

3. Preliminary Result

Analysis results and interpretation of the Environmental Index of Palm Oil Mill. It can be analyses in various way, such as index profiling, bar and radar chart. Up to this, 13 indicators were identified and classified into 7 parameters

3.1 Database

Database should contain category, parameter, list of indicator, indicator unit, parameter limit of indicator, type of indicator, parameter and indicator symbol as shown in Table 2.

3.2 PTT Score result

From the raw data, PTT score are calculated using Eq (1) and (2) depends on type of indicator to get percentage value as in Table 3

3.3 Parameter Score

PTT score from Table 3 are averaged to get parameter score in Table 4, parameter score then calculated to parameter aggregation score as in Table 5.

3.4 Category and Index Score

The summation of parameter aggregation for every parameter for each mill will get aspect score and lastly the summation of aspect score will get Sustainability Index Score for each mill as shown in Table 6.

3.5 Sustainability Index Analysis

The results are analyse using bar chart and radar chart. Bar chart used to show sustainability index performance of every mill. Industry can compare their performance against other mill industry, thus they aware their performance rating compared to others. If identified their mill have the lowest rating the industry can zoom in the problem factor using radar chart. Both methods will help industries identify their weaknesses and area of improvement effectively. As an example, from Figure 5 it shows that Mill D have a highest index performance (47.01%) but low performance in environment aspect (6.48%). Thus, radar chart is used to detect the factors. It shows most of the weaknesses of mill D are in environment aspect such as usage of water (UOW), CO_2 emission (CO2), etc. as shown in Figure 6.

Table 2: Palm Oil Mill SIPOM Database

	Aspect	Parameter	Parameter Symbol	Indicator (from literature)	Indicator Symbol	Unit	Standard	Type
Sustainability Index of Palm Oil Mill	Environment	Water Consumption	E1	Use of water	UOW	t	1.3	B
		Air Quality (Boiler)	E2	NO_X	NOX	Kg	-	B
				CO_2	CO	Kg	-	B
		Waste Water Quality after treatment	E3	BOD_5	BOD5	Mg/L	100	B
				COD	COD	Mg/L	1000	B
				Oil and grease	O&G	Mg/L	50	B
				Suspended Solid	SS	Mg/L	400	B
				pH	PH	-	7	B
				Temperature	TEM	˚c	45	B
	Economy	Kernel Extraction Rate	P1	Production of Crude Kernel Oil	CPKO	%	52	A
		Oil Extraction Rate	P2	Production of Crude Palm Oil	CPO	%	21.94	A
	Social	Customer Satisfaction	S1	No of Complaint	NOC	%	1	B
		Occupational Injuries	S2	No of Accident	NOA	%	1	B

Table 3: Mill Raw Data and Indicators PTT Score

Indicator	Mill (Raw Data)					PTT Score (%)				
	A	B	C	D	E	A	B	C	D	E
UOW	3.42	2.95	3.67	4.01	3.51	21.77	39.11	12.55	0.00	18.45
NOX	0.04	0.08	0.12	0.10	0.20	100.00	75.00	50.00	62.50	0.00
CO	13.74	43.47	60.70	161.20	142.18	100.00	79.84	68.15	0.00	12.90
BOD5	11,000	25,000	22,700	23,888	25,545	57.16	2.14	11.18	6.51	0.00
COD	50,000	50,000	44,300	70,900	55,775	29.90	29.90	38.05	0.00	21.64
O&G	8,000	4,000	3,000	4,850	8,020	0.25	50.44	62.99	39.77	0.00
SS	19,000	18,000	19,780	25,800	18,479	26.77	30.71	23.70	0.00	28.82
PH	4.50	4.70	4.05	4.52	3.40	30.56	36.11	18.06	31.11	0.00
TEM	83.00	84.00	88.00	85.00	70.00	11.63	9.30	0.00	6.98	41.86
CPKO	46.35	45.52	46.39	50.07	48.14	12.81	0.00	13.43	70.22	40.43
CPO	19.84	18.85	20.57	19.32	17.88	48.28	23.89	66.26	35.47	0.00
NOC	10.00	8.00	6.00	3.00	1.00	0.00	22.22	44.44	77.78	100.00
NOA	9.00	5.00	7.00	1.00	1.00	0.00	50.00	25.00	100.00	100.00

Table 4: Parameter Score

Mill	Parameter Score (%)						
	E1	E2	E3	P1	P2	S1	S2
A	21.8	100.00	26.04	12.81	48.28	0.00	0.00
B	39.11	77.42	26.43	0.00	23.89	22.22	50.00
C	12.55	59.08	25.66	13.43	66.26	44.44	25.00
D	0.00	31.25	14.06	70.22	35.47	77.78	100.00
E	18.45	6.45	15.39	40.43	0.00	100.00	100.00

Table 5: Parameter Aggregation Score

Mill	Parameter Aggregation Score						
	E1	E2	E3	P1	P2	S1	S2
A	3.11	14.30	3.72	1.83	6.90	0.00	0.00
B	5.59	11.07	3.78	0.00	3.42	3.18	7.15
C	1.79	8.45	3.67	1.92	9.47	6.36	3.58
D	0.00	4.47	2.01	10.04	5.07	11.12	14.30
E	2.64	0.92	2.20	5.78	0.00	14.30	14.30

Table 6: Category and Environmental Index Score

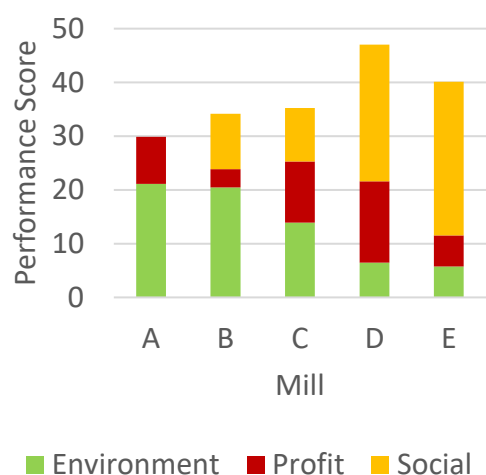|		Aspect Score (%)			Sustainability Index (%)
	Mill	Environment	Profit	Social	
Sustainable Index for Palm Oil Mill	A	21.14	8.74	0.00	29.87
	B	20.44	3.42	10.33	34.19
	C	13.91	11.39	9.93	35.24
	D	6.48	15.11	25.42	47.01
	E	5.76	5.78	28.60	40.14

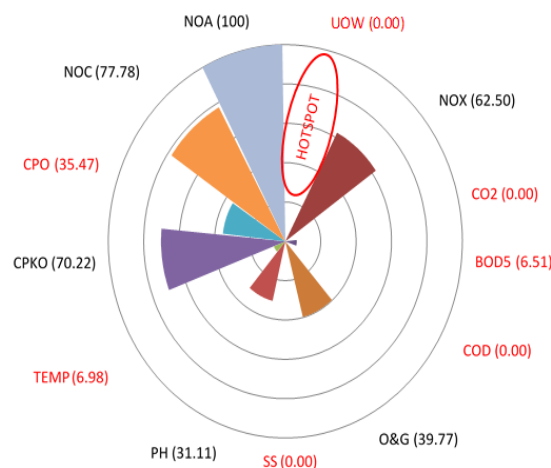*Figure 5: Sustainability Index of every Mill*

Figure 6: Indicator analysis of Mill D (Radar chart)

4. Conclusions

A new systematic approach to analyse palm oil mill sustainability index performance has been developed. Using the database and index calculation, this system is able to determine the SI performance rating between palm oil mill industries. Besides, it can give information to the industry the area of weaknesses (hotspot) that should give an attention. However, in this paper, parameter weightage is considered equally important. The detail on weightage will be discussed in future publication.

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