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Integrated Mitigation Strategy Model for Carbon Accounting and Sustainability Index to Encounter Palm Oil Mill Weaknesses Holistically

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Abstract. Palm oil industry has received criticism from various parties on the issue of sustainability and greenhouse gases. Effective mitigation plan is needed to improve the process performance and to counter criticism towards palm oil mill. However, the current framework has limitation to consider sustainability as a whole and may resulting inaccurate selection of further mitigation. This study aims to develop mitigation strategy model based on palm oil mill carbon accounting (POMCFA) and sustainability (POMSI) performances. A result from integrated palm oil mill carbon footprint accounting (POMCFA) and palm oil mill sustainability index (POMSI) framework has been used for the model development in this study. This model is able to predict the best selection to improve the weak performance, forecast new score of palm oil mill carbon accounting (POMCFA) and sustainability (POMSI). A series of mitigation options are selected which impacted any changes to the indicators (in terms of environment and economy aspect). The model is developed and computed using the General Algebraic Modelling System (GAMS). The analysis from integrated assessment shows that highest carbon dioxide equivalent emission was contributed by palm oil mill effluent followed by diesel consumption and water consumption. In terms of sustainability scoring, the results show that the environmental aspect achieved the lowest scores compared to other aspects (social and economy). Weaknesses identified include dust concentration, palm oil mill effluent and boiler emission. The mitigation model been developed shows the optimal mitigation for the weaknesses is to implement high technology boiler. The assessment analysed in terms of carbon dioxide equivalent and sustainability scoring demonstrates its potential to provide comprehensive mitigation selection purposes.

1. Introduction

Malaysian Palm Oil Council CEO, Dr. Kalyana Sundram stated that palm oil industry in Malaysia is estimated produce more than 19 million tons of palm oil each year [1]. Vast development of the industry raises sustainability and carbon emission issues among consumer and NGO. This industry is linked to sustainability issues such as water usage, fuel consumption, safety requirement and etc. Palm oil production is, moreover, criticised for its high greenhouse gasses (GHG) impact such as fossil fuel consumption and methane emission from POME in open anaerobic lagoons at the mill level [2]. The responsibility on this issue seems pointed more towards palm oil producing country, Malaysia and



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Indonesia as a largest palm oil producer. It became more vital to the industry when major palm oil consumer stated they will only use certified palm oil in their production such as Starbucks and Ferrero Corporation. Make it worst European Parliament planned to ban the use of palm oil in their biofuels by 2020 [3]. A ban on palm oil, one of Malaysia's major export, will affect the country's productive resources, economic and production. Malaysia as second largest producer needs to keep track on their sustainability practices from miller, transporter, and refiner to end user not only to encounter the stigma towards palm oil practice but also to remain competitive in the market.

In current practices, applying certification schemes is a way to demonstrate the performance of their sustainability practices and carbon reporting. Among the related international certification schemes are RSPO, ISPO, ISCC and etc. Recently, Malaysia also paving their way through our own national certification standard, Malaysian Sustainable Palm Oil (MSPO) scheme. However, the schemes still have limitations as they practice a qualitative assessment and non-measurable valuation making difficult to the industries to conduct analysis and identifying weaknesses on their performance [4,5]. This resulted in one of the largest palm oil producer in Malaysia, Felda pull out their application from the RSPO due to difficulty to comply the procedure of the certification schemes in 2016 (Ching, 2016).

[6] has addressed the previous limitations in her current works. This new quantitative tools are subjected to all aspect of carbon emission and sustainability which help industries to gather and analyzing data for reporting comprehensively. This will ease industries to submit various report to different kind of bodies such as RSPO for sustainability certification and MYCARBON for carbon emission report. This tool would also help industry to identified weaknesses of the operation. However, this new tool can be only present the performance of palm oil mill but it did not offered any mitigation strategies to improve the weaknesses.

To address the limitations, vast number of sustainability index assessments have been performed by [7], [8]; [9] and [10]. Nevertheless, the literature shows lack of integrated tool developed between sustainability and carbon footprint assessment referring to the standard regulation valuation. A study that included standard regulation in the assessment quantification was performed by [4] but this framework still lack of carbon footprint validation. In 2019, an extensive studies which integrating the sustainability and carbon footprint assessment has been performed [6]. Nevertheless, a comprehensive technology selection which considering possible mitigation plan to improve the weaknesses based on the assessment yet to be established. Therefore, this study aims to develop a holistic mitigation selection tool of integrated sustainability performance and carbon footprint to assist the industries on improvement planning.

2. Main results

2.1. Superstructure

Figure 1 shows superstructure which represent the case study. A line connected Mitigation Strategy, i to the indicator, j if it impacted any changes to it. The data in Table 1 were input to MILP model and optimised with GAMS software with following criteria:

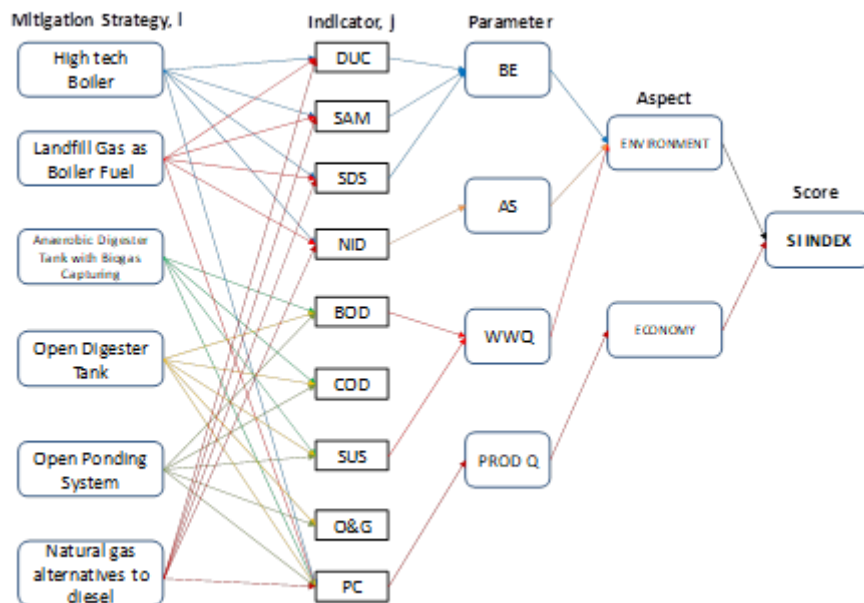


Figure 1 Superstructure of mitigation strategy to the indicator.

2.2. Model Formulation

The objective and model constraints incorporated several aspects of economy and environmental including carbon footprint accounting. The optimisation model will provide an optimal mitigation selection for the improvement plan based on POMCFA and POMSI score. The model is developed and computed using General Algebraic Modelling System (GAMS).

2.2.1. Objective Function

The optimisation model is formulated with an objective function and several constraints. The objective aims to select the minimal total cost (TotCost) of the mitigations selection as described by Equation (1). This function consists C_i , the cost of mitigation options selected to upgrade the palm oil mill process. The values of the options are determined by reviewing various literature of palm oil mill mitigation planning and converted into factor changes as shown in Table. In other hand, x_i is a binary variable and also decision variable for this model.

$$\text{TotCost} = \sum [i, C(i) * x(i)] \quad (1)$$

2.2.2. Constraints

Several constraints were applied for the model developed in this study:

- **Target indicator improvement:** In this case study, target indicator improvement for DUC, SAM, SDS, NID, BOD, SUS, O&G is assume to be improve by 10% thus by applying Equation (2). Some parameters may be considered more responsive to changes in the interest aspect, thus deserve greater weightage (W_j). However, for this case study it was assumed that all the parameters bear the same weightage. Target indicator factor (Y_j) are determined as below:

$$Y_j = \frac{\text{target increment (\%)} \times W_j}{100} \quad (2)$$

$$Y_j = \frac{110\% \times 0.125}{100}$$

$$Y_j = 0.138$$

However, if more significant improvement is required such as 50% target increment for COD, thus,

$$Y_j = \frac{150\% \times 0.125}{100}$$

$$Y_j = 0.1875$$

2.3. Input Data

2.3.1. Factor Changes

Based on Figure 1, option 1 promoted high tech boiler as the mitigation strategy. Based on the review by [11] by implementing this option, DUC and SAM will reduce by 15%, NID will reduce by 13% and SDS will reduce by 13%. High tech boiler giving no changes to the indicator BOD, COD, SUS and O&G will denoted as 1. The full list factor of indicator can be referred in Table 1.

If mitigation option lead to positive changes to the indicator as DUC and SAM Equation (3) will be applied,

$$\text{Positive factor of indicator} = 1 + \frac{\% \text{ of changes}}{100} \quad (3)$$

Thus,

$$\text{Positive factor of indicator} = 1 + \frac{15}{100}$$

$$\text{Positive factor of indicator} = 1.15$$

For option Natural Gas alternatives to diesel it will increase the SDS by 3% which indicate negative changes to the indicator equation Equation (4) are applied

$$\text{Negative factor of indicator} = 1 - \frac{\% \text{ of changes}}{100} \quad (4)$$

Thus,

$$\text{Negative factor of indicator} = 1 - \frac{3}{100}$$

$$\text{Negative factor of indicator} = 0.97$$

The full list of data based on calculation above can be referred to Table 1.

Table 1: Factor changes of mitigation option to indicator.

Mitigation Option, i Mitigation Cost C_i	Indicator, j								
	DUC	SAM	SDS	NID	BOD	COD	SUS	O&G	
Weightage	<i>0.125</i>	<i>0.125</i>	<i>0.125</i>	<i>0.125</i>	<i>0.125</i>	<i>0.125</i>	<i>0.125</i>	<i>0.125</i>	<i>0.125</i>
High Tech Boiler	1	1.15	1.15	1.13	1.08	1	1	1	1
AD Tank with Biogas	1	1	1	1	1.12	1.14	1.15	1.13	
Open Digester Tank	1	1	1	1	1.08	1.09	1.11	1.10	
Open Ponding System	1	1	1	1	1.05	1.03	1.06	1.07	
Natural Gas alternatives to diesel	1	1.02	1.01	0.97	0.99	1	1	1	1
Target indicator Factor* (Y_j)		<i>0.138</i>	<i>0.138</i>	<i>0.138</i>	<i>0.138</i>	<i>0.138</i>	<i>0.1875</i>	<i>0.138</i>	<i>0.138</i>

*Assumption: All target indicator having 10% target increment except COD 50 % increment

3. Results and discussion

The modelling and optimisation results in Table 2 shows the optimal mitigation strategy with minimal cost which is high technology boiler. Next, the information of selected mitigation will be used to recalculate the POMSI and POMCF score.

Table 2: Output of the mitigation selection model.

Mitigation Option, i	GAMS output
High Technology Boiler	√
AD Tank with Biogas	
Open Digester Tank	
Open Ponding System	
Natural Gas alternatives to diesel	
Optimal cost (\$/ton of ffb)	1

3.1. Recalculation of POMCF and POMSI score

Based on finding as shown in Table 2, score comparison are calculated as shown in Figure 2 for the PTT score of each indicator and Figure 3 for the emission index of the carbon footprint. Table 3 show overall total score of the POMSI increased from 92% to 95.55%, indicate a positive changes.

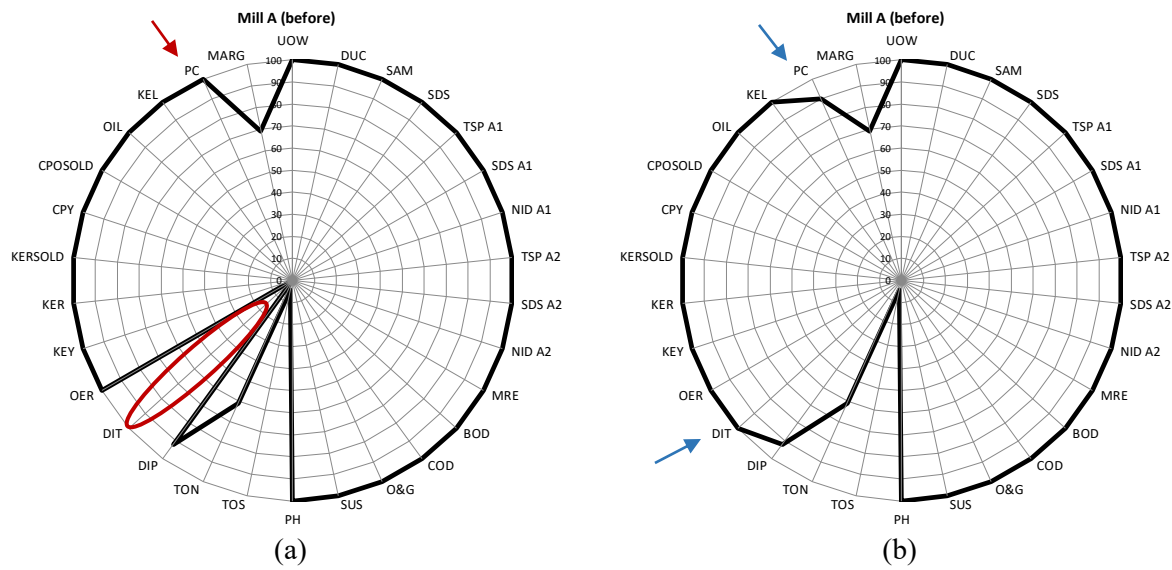


Figure 2 POMSI web chart of before (a) and after (b) mitigation is applied

Table 3: POMSI Score Before and After Improvement Results.

MILL A						
Mill data		PTT score (%)		Index Score		
Before improvement	After improvement	Before improvement	After improvement	Before improvement	After improvement	
0.21 L/mt	0.002 L/mt	0%	100%	92%	95.55%	

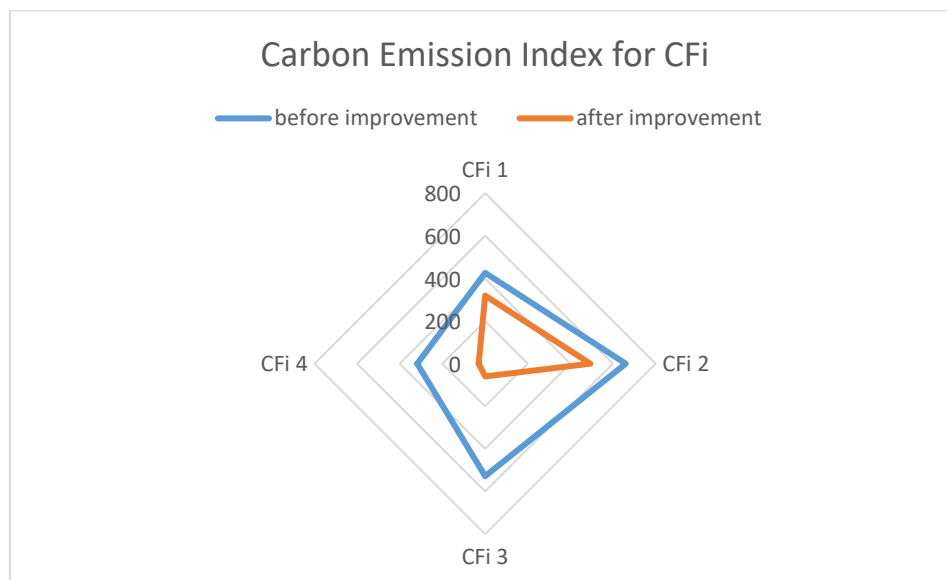


Figure 3 Comparison of Carbon Emission index for CFi before and after mitigation

4. Conclusion

This mitigation planning of integrated assessment would provide comprehensive platform to improve the decision making. This tool will play big role in determining industries decision for optimal mitigation selection. This study may serve as a preliminary study to ease industries obtained a better sight of the mitigation strategy to be applied.

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