Triple Bottom Line Analysis and Assessment Towards Sustainable Palm Oil Plantation

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Abstract. Palm oil agroindustry face challenge in business process sustainability. Most of the research consider all stage of business in sustainability analysis moreover less of consideration in upstream parts. This research aims to analyzes the palm oil plantation sustainability performance to provide recommendation in achieving sustainability goals for upstream business parts. This research was conducted in two most productive location in producing palm oil in the world: Sumatera and Kalimantan, Indonesia. A multi-dimensional scaling with leverage analysis were applied to assess the palm oil plantation sustainability performance and provide potential improvement recommendation. The result show that the model had successfully to analyze the sustainability performance on triple bottom line dimensions: economic, social and environment. Twenty-one indicators were assessed and found location sustainability performance on palm oil plantation. Leverage analysis provide recommendation to improve the performance, including CPO quantity loss, CPO quality loss, workers personal rights condition, corporate social responsibility, soil condition and water management.

1 Introduction

Sustainability concept is negotiated as the world approach to provide a better future through sustainable development goals (SDG). United nations agreed with the 17 SDG as the all nations agenda, including zero hunger, poverty, protect the planet by 2030. Briefly, SDG encompasses the integration of economic, social and environmental dimensions which also called as triple-bottom-line (TBL) [1]. One important point to address SDGs is its practices in achieving sustainable agriculture, renewable energy, and sustainable urban development to all sectors.

Before united nations formulated the SDGs, [2] has provided a complete definition of sustainability as the ability to meet the needs of the present without compromising the ability of the future to meets their needs. As the big goal of sustainability involving many sectors, practitioners and scholars proposed practical and theoretical approach to gain the sustainability goals. Related to 17 SDGs goals some related research has proposed as below: to solve poverty issue, [3] proposed the sustainability certification on smallholder palm oil in Indonesian village, [4] proposed a data driven methodology to achieve sustainable industrial and operations and find current trend and challenges, [5, 6] suggest gender equality in many sectors to achieve sustainable goals, [7, 8] discussed sustainable supply chain to achieve industrial operational excellence and many others. Seek the impact of the industry to human being life in fulfilling consumption and its activities in processing natural resources, this research proposed to discussed sustainability assessment in industry.

Palm oil as the most productive industrial plantation has provide world main products in cooking oils and its derivatives. Indonesia acts as the main actor to export palm oil to all over the world that received US$ 26.68 billion in 2022 [9]. In-fact, Indonesian palm oil face challenges to achieve sustainability goals, some problem have been reveals including environmental issue, deforestation, land-use and air pollution [10], industrial coordination, governance and strategic decision [11], structural barriers and policy [12] and supply chain performance [13]. As mentioned, most of the research focus on the whole chain of the palm oil and its impact to the community. Moreover, most of the research limits focus on upstream part of palm oil industry. Palm oil plantation in Indonesia is increase every year, up to 15 million Ha in 2021 [9]. This condition provides an opportunity to analyze current situation and provide the further improvement to achieve sustainability goals from the upstream approach.

This research aims to analyze palm oil plantation sustainability status to provide further improvement. The data is collected from the regions which has the most palm oil plantation area in Indonesia, including Sumatera and Kalimantan Island. The analysis is focus on dimensions and indicators that were formulated by the experts. This analysis is necessary to identify current condition and provide further agenda to achieve sustainable development goals in palm oil industry.

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2 METHODS

2.1 Research stage

The research stage is depicted at Figure 1. This research is comprised six stages to achieve sustainability performance and further improvement initiatives. In the first stage, problem definition and research motivation is conducted. Literature review and field observation provide a whole picture of the current condition to deliver research idea, problems and goals.

In the second stage, the sustainability dimensions and indicators are defined. According to [14] dimensions is sustainability perspective which is defined as triple bottom line while indicator is describe the sustainability dimensions performance of organization in qualitative or quantitative manners. Our previous research on palm oil sustainability is set to be dimensions and indicators in this opportunity [15, 16].

In the third stage, the data collection is conducted. Seven area is set as the research location and data collection area, including central, east and west of Kalimantan, Bangka Belitung, Riau, Jambi and South Sumatera province. These location is selected as the data collection place since it provide the highest number of palm oil plantation area [9].

The fourth stage is data pre-processing and preparation. In this stage, data from the field observation and interview are analyzed and clean following the requirement of sustainability assessment methodology. The data pre-processing method are applied, including: data transformation, reduction, cleansing, and remove outlier.

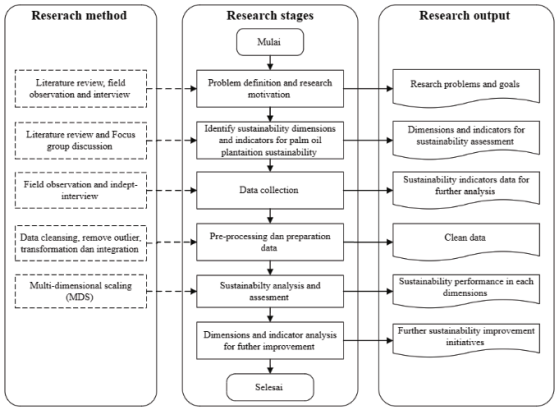

Fig. 1. Research stage

Fifth and sixth stage are the main stage of the research including data analysis and recommendation. Previous research proposed many methods to assess the sustainability, including fuzzy inference system [17], adaptive neuro fuzzy inference system [18], MCDM approach [19] and system dynamics [20]. Consider the collected data and palm oil business process situation, this research applied multidimensional scaling (MDS) approach which proposed by [21] to assess and suggest sustainability improvement in palm oil plantation. The detail of MDS model is describe in the next parts.

2.2 Sustainability dimensions and indicators

In this study, three sustainability dimensions is proposed, economic, social and environment with also called as triple bottom line (TBL). Even some previous research proposed more dimensions, we formulate all indicators in a complete TBL. The proposed indicators are provided at Table 1.

Table 1. Sustainability indicators

No	Dimension	Code	Indicators
1	Economic	E1	CPO quantity loss
2		E2	CPO quality loss
3		E3	Fresh fruit bunch (FFB) productivity
4		E4	Employee average salary
5		E5	Document validation related to palm plantation
6		E6	Document validation related to employee
7		E7	Company's work procedure availability
8	Social	S1	Fatality rate
9		S2	Fatality rate out of working activity
10		S3	Incident rate
11		S4	Workers personal rights condition
12		S5	Employee and community welfare
13		S6	Worker safety
14		S7	Corporate social responsibility
15	Environment	N1	Water management
16		N2	Water consumption
17		N3	Wastewater quality
18		N4	Water contamination level
19		N5	Soil condition
20		N6	Possibility of fire
21		N7	Fire management in the plantation

2.3 Multi-dimensional scaling (MDS)

MDS has been largely applied in sustainability analysis since it was firstly introduce by [21]. [22] applied MDS for bioenergy sustainability, [23] applied MDS for cacao agroindustry, and [24] analyze the sustainability performance on horticulture product. The idea of MDS analysis in sustainability is provided as follow:

1. Data normalization of the indicators into range 0-10 which 10 means the best score compare to benchmark.
2. Calculate the MDS ordination based on Euclidean distance (d) as formulated below:
$$d = \sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2}$$
3. The value of Euclidean distance thatn approximated by regression (d_{ij}) as formulated below:
$$d_{ij} = \alpha + \beta\delta_{ij} + \varepsilon$$
4. The sensitivity analysis is found by leverage and uncertainty using Monte-Carlo method. In leverage analysis aims to identify each indicators effect to provide sustainability

performance as calculated by root mean square error.

3 Result and Discussion

The multidimensional scaling (MDS) is applied to analyze the palm oil plantation sustainability. The 21 indicators are processed in each dimension then determine its sustainability score. RStudio code is applied to process the MDS algorithm with the result is provided at Table 2.

Table 2. Sustainability score for TBL in specific location

No	Economic	Social	Environment
East Kalimantan	81.96	90.88	96.38
Central Kalimantan	87.27	92.48	100
West Kalimantan	77.32	93.37	90.90
Riau	91.07	100	95.02
Bangka Belitung	83.70	100	93.06
South Sumatera	91.02	100	98.04
Jambi	84.96	100	100

3.1 Economic dimension performance

Economic dimension performance for each location in palm oil upstream industry is depicted at Figure 2. The economic dimension sustainability performance shows Riau and South Sumatera as the highest score while the lowest is west Kalimantan. Simultaneously, to improve the economic dimensions for all location, a leverage analysis is provided.

The leverage analysis is depicted in Figure 3. To improve the economic dimensions, stakeholders must pay attention into the two most sensitive effect to the performance, including CPO quantity loss (E1) and CPO quality loss (E2). Quantity and quality loss is the main issue in Indonesian palm oil business that must be managed with the precision farming.

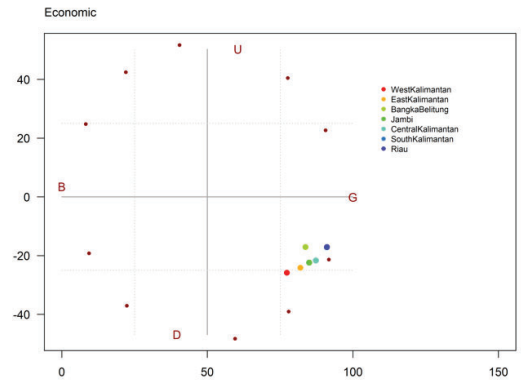

Fig. 2. Economic dimension score

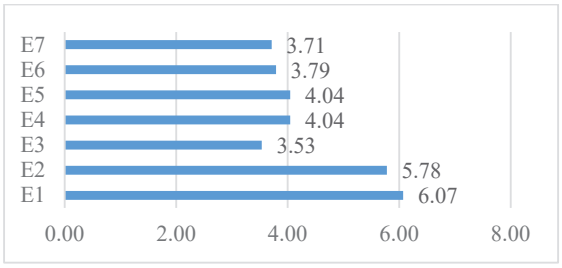

Fig. 3. Leverage analysis for economic dimension

3.2 Social dimension performance

Social dimensions performance analysis show that four location has maximum value: Riau, Bangka Belitung, South Sumatera and Jambi. All locations are in Sumatera Island while others at Kalimantan which are not fulfilled maximum score. The possibility to improve the social dimensions is possible with focus on highest score on leverage analysis. In this case, two indicators must be considered: Workers personal rights condition and corporate social responsibility. Most of the location achieve score more than 90 which means it has good environmental performance. Moreover, as the leverage analysis revealed that the environmental dimensions should pay attention into workers personal rights condition and corporate social responsibility.

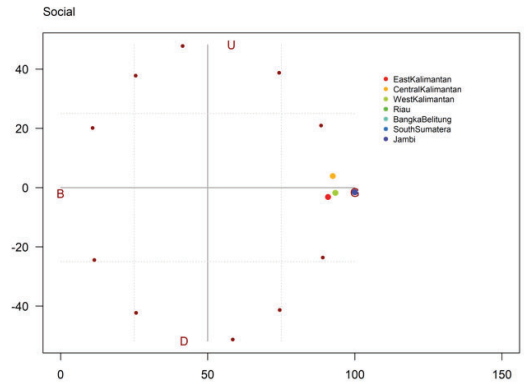

Fig. 4. Social dimensions performance

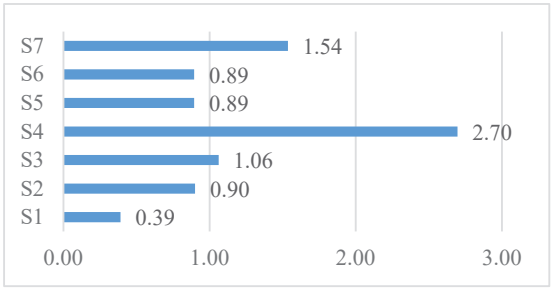

Fig. 5. Social dimensions leverage analysis

3.3 Environmental dimension performance

Environment on palm oil industry face challenges in climate change, deforestation and green house gas. Most of the research consider environmental dimension as the

main effect to achieve sustainability goals. Our analysis finds that two locations provide high score of environmental dimension performance: Central Kalimantan and Jambi. Moreover, two indicators must be considered to improve immediately: soil condition and water management. Most of the location provide score more than 90 while some of that provide score 70-80.

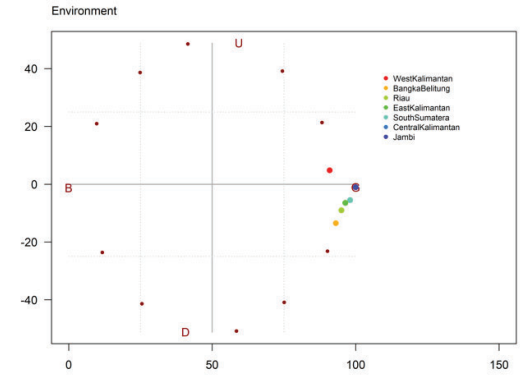

Fig. 6. Environmental dimensions performance

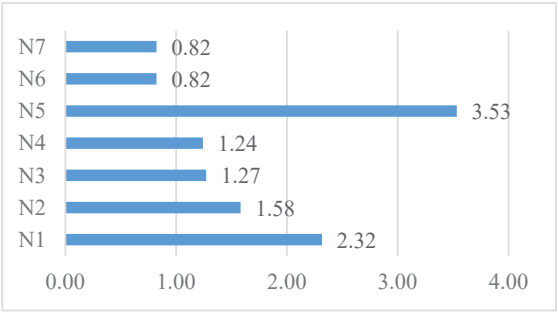

Fig. 7. Environmental dimensions leverage analysis

4 Conclusion

Sustainability is the main issue to solve in industry which exploit natural resources. Palm oil plantation has largely discussed on its effect to environment, climate change, greenhouse gas and deforestation. Moreover, this research provide a complete analysis on palm oil plantation which consider three dimensions of sustainability, economic, social and environment. Further the proposed dimensions are known as triple bottom line to achieve sustainable development goals. The result show that seven locations in Sumatera and Kalimantan have been analyzed and the dimensions performance have been found. Economic dimensions is found as the lowest sustainability dimensions performance in 3 location west Kalimantan, east Kalimantan, Bangka Belitung and central Kalimantan. This research also provide recommendation to improve the sustainability performance for each dimensions based on leverage analysis. Six indicators to consider in sustainability performance are improve the performance, including CPO quantity loss, CPO quality loss, workers personal rights condition, corporate social responsibility, soil condition and water management.

For further research it needs to provide overall sustainability performance which combine all dimensions in triple bottom line.

References

[1] S. A. R. Khan, Z. Yu, and K. Farooq, “Green capabilities, green purchasing, and triple bottom line performance: Leading toward environmental sustainability,” *Bus. Strateg. Environ.*, 2022.

[2] World Commission on Environment and Development, *Our common future: report of the world commission on environment and development*, vol. 4, no. 1. 1987.

[3] T. Santika *et al.*, “Impact of palm oil sustainability certification on village well-being and poverty in Indonesia,” *Nat. Sustain. 2020 42*, vol. 4, no. 2, pp. 109–119, Nov. 2020.

[4] M. L. Tseng, T. P. T. Tran, H. M. Ha, T. D. Bui, and M. K. Lim, “Sustainable industrial and operation engineering trends and challenges Toward Industry 4.0: a data driven analysis,” *https://doi.org/10.1080/21681015.2021.1950227*, vol. 38, no. 8, pp. 581–598, 2021.

[5] G. Miotto, M. P. López, and J. R. Rodríguez, “Gender Equality and UN Sustainable Development Goals: Priorities and Correlations in the Top Business Schools’ Communication and Legitimation Strategies,” *Sustain. 2019, Vol. 11, Page 302*, vol. 11, no. 2, p. 302, Jan. 2019.

[6] R. Provasi and M. Harasheh, “Gender diversity and corporate performance: Emphasis on sustainability performance,” *Corp. Soc. Responsib. Environ. Manag.*, vol. 28, no. 1, pp. 127–137, Jan. 2021.

[7] H. M. Alzoubi, G. Ahmed, A. Al-Gasaymeh, and B. Al Kurdi, “Empirical study on sustainable supply chain strategies and its impact on competitive priorities: The mediating role of supply chain collaboration,” *Manag. Sci. Lett.*, vol. 10, no. 3, pp. 703–708, 2020.

[8] S. K. Mangla, S. Kusi-Sarpong, S. Luthra, C. Bai, S. K. Jakhar, and S. A. Khan, “Operational excellence for improving sustainable supply chain performance,” *Resour. Conserv. Recycl.*, vol. 162, p. 105025, Nov. 2020.

[9] BPS-Statistic Indonesia, *Statistik Kelapa Sawit Indonesia 2021*. Badan Pusat Statistik, 2022.

[10] A. I. Suroso, H. Tandra, Y. Syaukat, and M. Najib, “The issue in Indonesian palm oil stock decision making: Sustainable and risk criteria,” *Decis. Sci. Lett.*, vol. 10, pp. 241–246, 2021.

[11] R. Wardhani and Y. Rahadian, “Sustainability strategy of Indonesian and Malaysian palm oil industry: a qualitative analysis,” *Sustain. Accounting, Manag. Policy J.*, vol. 12, no. 5, pp. 1077–1107, 2021.

[12] E. I. K. Putri *et al.*, “The Oil Palm Governance: Challenges of Sustainability Policy in Indonesia,” *Sustain. 2022, Vol. 14, Page 1820*,

vol. 14, no. 3, p. 1820, Feb. 2022.

[13] Marimin *et al.*, "Supply chain performance measurement and improvement of palm oil agroindustry: A case study at Riau and Jambi Province," in *IOP Conference Series: Earth and Environmental Science*, 2020, vol. 443, no. 1.

[14] I. Juwana, N. Muttil, and B. J. C. Perera, "Indicator-based water sustainability assessment - A review," *Science of the Total Environment*, vol. 438. pp. 357–371, 2012.

[15] H. Warid and M. Asrol, "GIS-based Sustainability Assessment for Palm Oil Industry," *TEM J.*, vol. 11, no. 4, pp. 1432–1438, 2022.

[16] M. Asrol, H. Warid, A. A. N. P. Redi, and Y. T. Prasetyo, "A Framework for GIS-Based Sustainability Assessment for Palm Oil Industry: An Overview," in *International Conference on Biospheric Harmony Advanced Research (ICOBAR)*, 2021.

[17] Y. Phillis, V. S. Kouikoglou, and V. Manousiouthakis, "A Review of Sustainability Assessment Models as System of Systems," *IEEE Syst. J.*, vol. 4, no. 1, pp. 15–25, 2010.

[18] M. Yani *et al.*, "An Adaptive Fuzzy Multi-Criteria Model for Sustainability Assessment of Sugarcane Agroindustry Supply Chain," *IEEE Access*, vol. 10, pp. 5497–5517, 2022.

[19] F. Ecer, "Sustainability assessment of existing onshore wind plants in the context of triple bottom line: a best-worst method (BWM) based MCDM framework," *Environ. Sci. Pollut. Res.*, vol. 28, no. 16, pp. 19677–19693, Apr. 2021.

[20] A. Francis and A. Thomas, "System dynamics modelling coupled with multi-criteria decision-making (MCDM) for sustainability-related policy analysis and decision-making in the built environment," *Smart Sustain. Built Environ.*, vol. ahead-of-print, no. ahead-of-print, 2022.

[21] T. J. Pitcher and D. Preikshot, "RAPFISH: A rapid appraisal technique to evaluate the sustainability status of fisheries," *Fish. Res.*, vol. 49, no. 3, pp. 255–270, 2001.

[22] P. Papilo, E. Hambali, I. S. Sitanggang, Marimin, E. Hambali, and I. S. Sitanggang, "Sustainability index assessment of palm oil-based bioenergy in Indonesia," *J. Clean. Prod.*, vol. 196, pp. 808–820, Sep. 2018.

[23] I. K. Sriwana, Y. Arkeman, D. Syah, and M. Marimin, "Sustainability improvement in cacao supply chain agro-industry," *World Rev. Sci. Technol. Sustain. Dev.*, vol. 13, no. 3, pp. 256–275, 2017.

[24] F. S. Wiryawan, Marimin, and T. Djatna, "Value chain and sustainability analysis of fresh-cut vegetable: A case study at SSS Co.," *J. Clean. Prod.*, vol. 260, 2020.