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Assessing Green Supply Chain Operation Reference with Life Cycle Inventory: The Case of Gamboeng Green Tea, Indonesia

ABSTRACT

This study aims to assess the performance of the Gamboeng green tea production system using the Green Supply Chain Operation Reference (GreenSCOR). Fifteen environmental performance indicators were incorporated in the five main processes in the supply chain: planning, sourcing, production, delivery and return. The data were collected from field observations of the supply chain structure and flow process inventory, then validated through in-depth interview with key informants. Data inventory of processes was utilized for measuring several indicators especially in the planning process and the realization of the plan in the production process. Gamboeng tea has an advantage score in indicator of realization (15%) for use of clean energy source (i.e., wood pellet) to substitute liquified petroleum gas as well as for using environmentally friendly packaging, zero waste disposal and total recyclable waste. Further improvements are recommended for the five performance indicators, particularly in the planning process, such as providing training and education for personnel about environmental awareness and management, planning for minimizing water usage, planning in minimizing inorganic fertilizer usage, screening suppliers, and using larger portions of wood pellets.

Keywords: *green supply chain, Gamboeng green tea, Green Supply Chain Operation Reference, DeBoer normalization scoring system, Fuzzy Analytical Hierarchy Process*

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INTRODUCTION

Increase of public awareness about environmentally friendly manufacturing concepts has pushed the industrial world to adopt the green industry concept in each step of their business. To apply continuous improvement towards the green industry, environmental assessment and scoring were required (*Natalia et al. 2015; Fortuna et al. 2014*), in particular by considering the full life cycle of a product (*Harjanto et al. 2012*). Several academicians and researchers had delivered ideas in integrating environmental aspects into business processes to be applied in daily operation in a concept called Green Supply Chain Management (GSCM) (*Gobhakhloo et al. 2013*).

The Green Supply Chain Operation References (GreenSCOR) is a generic model for environmental assessment and scoring of a product and/or a production process to define its suitability to the GSCM concept. This model is an improvement of the results of the previous model called Supply Chain Operation References (SCOR) by incorporating environmental aspects to the model (*LMI 2003*). Among the challenging issues, integrating the model with the available life cycle inventory can provide a critical way to support effective green supply chain management (*Gnoni and Lanzilotto 2013*). A GSCM study has been conducted for environmental assessment and scoring to industry related

to black tea (*Mukharromah et al. 2017*).

This study therefore aims to evaluate the supply chain of Gamboeng Tea using the GreenSCOR model. Evaluation was conducted from tea plantation to the tea factory process to provide potential recommendation. The results will be very valuable for producers in conducting continuous improvement and sustainability (*Vanchon and Klassen 2008*).

MATERIALS AND METHODS

Data collection

Data were collected from the field observation on the supply chain structure of Gamboeng tea, including the flow production process and inventory. The data were then validated by an in-depth interview to determine the performance score. The respondents were plantation manager, tea factory manager, procurement manager, and marketing manager. These four positions were chosen due to their comprehensive knowledge about tea processing and production, and deep understanding about the company's current performance.

Performance Indicator Identification

Performance indicator was designed based on the GreenSCOR model with the first level matrix identification as the basic supply chain management (SCM) processes consist of five processing steps: planning, sourcing, production, delivery and return. The second level matrix was the GSCM dimension of performance assessment that consist of reliability, responsiveness, flexibility and asset. The third level was the technical environmental performance indicator derived from several research references and the data from life cycle inventory. These indicators were then validated with the selected stakeholders by in-depth interviews. The validations were mainly to confirm the suitability of indicators with existing resources and conditions and the goal of Gamboeng green tea assessment.

Weighting Performance Indicator

Weighting validated performance indicators was conducted via interviews using a questionnaire. The questionnaire was designed as pairwise comparison, which pairing compared of all indicators to define relative scale of importance from each identified performance indicator. Weighting was calculated by using the Fuzzy Analytical Hierarchy Process (Fuzzy AHP) method. Calculation step of the Fuzzy AHP method used in this study was adopted from the analysis conducted by *Chang et al.* as presented by *Shega et al.* (*2012*).

The priority of Fuzzy synthesis value (*Si*) was determined using the following equation.

$$Si = \sum_{j=1}^{m} M_{g_i}^{j} x \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} \quad (1)$$

where:

Si: Fuzzy synthesis value

$\sum_{j=1}^{m} M_{g_i}^{j}$: Summing cell values in the column starting from column 1 for each line of the matrix

j: column

i: row

M: triangular fuzzy number

m: amount of criterion

g: observed parameters (l,m,u)

Calculating Environmental Performance Value

Best performance assessment was based on data that actually was collected from daily process. In this part, the life cycle inventory of Gamboeng green tea played its role as one of reference (*Waluyo et al. 2019*). Using the De Boer normalization to synchronize their unit with other performance indicators, the score of each indicator was calculated with the data obtained from the life cycle inventory. Normalization was calculated using the snorm normalization of Equations 2 and 3 (*Nasrudin and Rivana 2019*).

For larger is better

$$snorm = \frac{(Si\text{-}Smin)}{Smax\text{-}Smin} \times 100 \quad (2)$$

For lower is better

$$snorm = \frac{(Smax\text{-}Si)}{Smax\text{-}Smin} \times 100 \quad (3)$$

The scoring system for each weighting indicator was then converted into several distinctive intervals from 0 as the worst performance to 100 as the best performance. By this scoring system, all indicators had the same parameter. The results can be analyzed by using the monitoring system (**Table 1**) (*HVolby 2000*).

Table 1. Monitoring system for performance indicators.

Monitoring System	**<40**	**40-50**	**50-70**	**70-90**	**>90**
Performance Indicator	Poor	Marginal	Average	Good	Excellent

RESULTS AND DISCUSSIONS

Gamboeng Green Tea Supply Chain Overview Based on Stakeholder Identification

Based on the supply chain, the direct or indirect role of each interviewed stakeholders, can be identified in their relation to supply chain and environmental performance (**Figure 1**). The supply chain of Gamboeng green tea starts from the tea plantation. The farm labour had a crucial role in maintaining quality of fresh tea leaf. The harvesting, collection and weighing is done by the plantation division of Gamboeng to be delivered to the tea factory. Some samples of collected fresh tea leaves are sent to an analytical laboratory for fresh leaf quality testing, harvesting quality check, and pest and plague check. The dried Gamboeng green tea in the factory will then be packed in gunny sacks. PT. Kabepe Cakra coordinated the distribution the Gamboeng green tea products.

Furthermore, suppliers of raw materials like fuel and packaging are also part of the Gamboeng green tea supply chain. For example, Liquified Petroleum Gas and wood pellets used as fuel for heat generation are supplied by two different companies. Electricity for machinery is supplied by the National Power Company (PLN).

Performance Indicator for Environmental Performance of Gamboeng Green Tea

Specific approaches suitable for Gamboeng green tea and related tea and references were defined in the third level of performance indicator. It defined 15 environmental performance indicators used in this study (**Table 2**).

The process consists of planning for minimizing resource utilization and environmental impact. In this process, the observed data were discussed in the managerial level for improving overall company performance. Thus, training and education for company personnel were closely related here.

In the sourcing process, performance indicators were designed to assess selection process of suppliers, whether the environmental aspect had already been considered. The practical example was by selecting a certified Environmental Management System or ISO 14001 supplier as partner. In the production process, the conversion of fresh tea leaves into dried green tea product and how it impacted the environment was assessed. In the delivery process, the environmental aspect of sending the product to the end-user was assessed. In the return process, the response of the company when the product needs to be withdrawn from the market or rejected by the end-user was assessed.

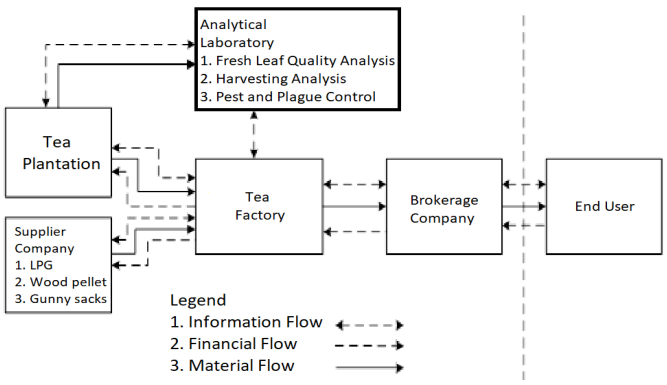

Figure 1. Supply chain of Gamboeng Green Tea.

Weighting Performance Indicator for Gamboeng Green Tea

All performance indicators were validated with stakeholders and experts (**Table 2**). Thus, the assessment continued to weigh the indicators. The goal of this weighting process was to capture the scale of importance for each indicator. In the larger scale, the most important indicator will be the overall performance of the company. At the end of assessment, the weighting indicators will be the multiplication factors for defining environmental performance value.

All of the stakeholders placed the highest weight (0.362) in the production process for the first dimension. This perception is deeply related to the managerial point of view that the production process is considered as the most important stage in producing high quality products. This perception is aligned to the environmental point of view since the production process has the greatest contribution to environmental impact (**Figure 2**).

Green Supply Chain Environmental Performance Value of Gamboeng tea

Data gathered from questionnaire and Life Cycle Inventory were used for calculating the Environmental Performance Indicators using De Boer Normalization Scoring System. Environmental Performance Indicators as the third level of indicators were then classified according to the performance indicator monitoring system (**Table 1**).

Gamboeng tea production system obtained full score of 15% as an LPG substitute and clean energy

Table 2. Performance indicators for GreenSCOR*.

Main Process (level 1)	Dimension (level 2)	Performance Indicator (level 3)
#1 Planning	#11 Responsiveness	#111 Number of in-house training and education for environmental awareness and management
	#12 Asset	#121 Number of employees that join training and education
		#122 planning for minimizing water usage
		#123 planning for clean energy usage
#2 Sourcing	#21 Responsiveness	#211 % supplier with EMS or ISO 14001 certificate
	#22 Asset	#221 Use of environmentally friendly packaging
		#222 Minimizing inorganic fertilizer usage
#3 Production	#31 Reliability	#311 % of recyclable waste
		#312 Waste disposition
	#32 Responsiveness	#321 Electricity usage
		#322 LPG Usage
		#323 Wood pellet usage
#4 Delivery	#41 Reliability	#411 Using environmentally friendly packaging
		#412 Transportation emission
#5 Return	#51 Flexibility	#511 Complaints regarding missing environmental requirements of product

* Each indicator is represented with numerical code started with #

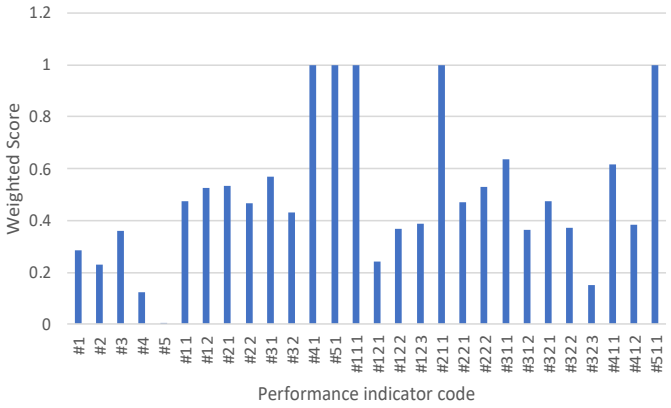

Figure 2. Weighted performance indicator for Gamboeng Green Tea.

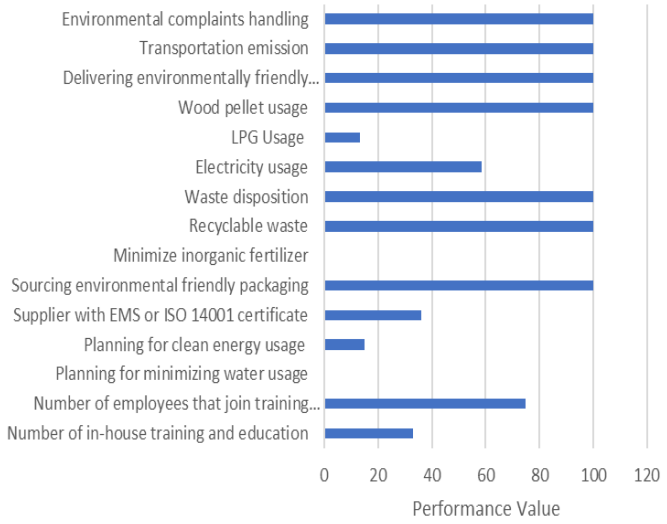

Figure 3. Gamboeng Green Tea Supply Chain Environmental Performance Value.

source from wood pellet. It also obtained a full score for on using environmentally friendly packaging, zero waste disposition and total recyclable waste. However, most of this planning is based on profit and managerial point of view. Based on technical perspective, the study about energy and energy analysis of Gamboeng green tea and its comparison with Turkey Black Sea tea showed that reducing 0.01 kg LPG per kg of product can decrease 42.2 kg of LPG per batch, which results in a savings of Rp 477.000 per batch (*Bardant et al. 2018*).

Incorporating environmental awareness in the planning step needs to be improved. The indicator for the number of in-house training showed a low performance value of only 33 (**Figure 3**). The situation was overcome by sending employees to join training and education to other institutions, as three out of four persons planned to join trainings.

Gamboeng highlands is blessed with abundance of groundwater and surface water sources. This is the main reason why no plan was designed to minimize water usage. Planning for water conservation become more interesting when the economic point of view is considered, in particular, when it leads to an eco-labelling concept (*Setiawan et al. 2018*). For such purpose, customer behaviour and preference in selecting and preparing tea should also be considered to minimize environmental impact (*Prasetia et al. 2020*).

CONCLUSIONS AND RECOMMENDATIONS

The green supply chain performance value of Gamboeng green tea was assessed by using GreenSCOR. Gamboeng tea obtained full score of 15% LPG substitute

and clean energy source, such as wood pellet. It also obtained full score in using environmentally friendly packaging, zero waste disposition and total recyclable waste. Planning was the main process with the lowest performance and had a huge opportunity to be improved.

It is recommended to increase environmental awareness among the managerial board by training and education. It should be implemented in each planning stage as an effective effort for improving overall green supply chain performance value. Performance indicators in selecting suppliers that hold EMS or ISO 14001 certificates has a big opportunity to improve. Consequently, the Gamboeng tea factory managerial board can initiate a multiplier effect on their supplier by creating a better environment.

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