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Application of objective matrix to improve performance green supply chain management

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Key performance indicators
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ABSTRACT

The eucalyptus oil factory (PMKP) Sukun Ponorogo is an industry with complex supply chain activities, starting from the raw material's procurement, production processes, distribution, and reverse logistics. Some of these activities may result in environmental problems. Therefore, measurement of its supply chain management (SCM) performance related to environmental conditions is critical. The green supply chain management (GSCM) concept can help the company to assess the supply chain's performance conditions that could harm the environment. This study aimed to assess the current SCM and measure its performance, as well as to evaluate the potential implementation on GSCM in the PMKP Sukun Ponorogo. The analytical network process (ANP) was used in this study, consisting of 36 key performance indicators (KPI) from five categories of plan, source, deliver, make, and return. The study results show that all KPIs from the *responsiveness* dimension in the *deliver* category have the lowest weight, thus require priority for improvement. The results of the scoring system using the objective matrix (OMAX) method indicated two KPIs were in the red category (or need improvement), including on-time delivery of raw materials to production site and the rejection rate of raw materials. This study suggested to improve the estimated delivery time for avoiding any delays during the production process. This improvement may support the company to continuously offer on-time production process and product's distribution.

Introduction

Globally, a high competition faced by industries affects their performance. Therefore, industries need to adapt with the expansion of science and technology, and apply it in practice for facing the competition (Dey et al., 2013). Individual competition is no longer faced by any agroindustry, in fact, the competition may occur in each production activities starting from raw material's procurement to product's delivery. In details, activities in any agroindustry consisted of on-farm activities, material handling, processing, packaging, distribution, and product marketing. These activities may provide positive impact on economic sectors, but could trigger negative impacts to the environment (Lin et al., 2011).

Green supply chain management (GSCM) concept must resolve negative and positive impacts (Chin et al., 2015). GSCM is a concept that integrates environmental consideration into supply chain management, starting from purchasing activities, material procurement, manufacturing processes, distribution of finished products to consumers, marketing, and environmentally friendly reverse logistics (Mathiyazhagan et al., 2015). Besides increasing company profits and creating effective and efficient products, GSCM also aimed to reduce the negative environmental impact from the supply chain activities. GSCM can reduce costs, increase customer's satisfaction, and evaluate the company's performance (Sarkis et al., 2011).

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The eucalyptus oil factory (PMKP) Sukun Ponorogo is an industry with complex supply chain activities, including raw material's procurement, production processes, distribution, and reverse logistics (Tippayawong et al., 2016). However, some of these activities could potentially cause problems. For example, damaged raw materials are considered as waste. This waste still contains high damaged high cellulose, making it difficult to naturally. Also, wastewater from production process still have high organic compounds, if directly disposed may cause detrimental effect on the environment. Therefore, the implementation of GSCM may enable the PMKP Sukun Ponorogo to assess its supply chain performance and identify which chain that have potential negative impacts on the environment (Green et al., 2012). Measuring the performance of GSCM in all existing stages is necessary to evaluate the current achievement and condition of the GSCM performance (Mathiyazhagan et al., 2014).

It is essential to determine the performance of GSCM. The measurement can be carried out using the green supply chain operation reference (GSCOR) approach (Yuniarti et al., 2018). This approach becomes a reference in measuring GSCM. Another study also used weighting Analytic Network Process (ANP) method to measure GSCM performance (Natalia and Tobertus, 2015). The ANP method can be combined with the scoring system using objective matrix (OMAX) method. These approaches and measurements could identify which activities that require improvement for reducing the negative environmental impacts (Abdallah and Al-Ghwayeen, 2020). Therefore, this study aimed to assess the current SCM and measure its performance, as well as to evaluate the potential implementation on GSCM in the PMKP Sukun Ponorogo. This study may offer alternative strategies to improve the performance of GSCM in the PMKP Sukun Ponorogo and minimize negative impacts on the environment.

Research Methods

Data Collection

There were several data used in this study (Mathiyazhagan et al., 2014), including:

1. Primary data was taken directly by conducting surveys and field observations. The primary data used was the data that relevant with the indicators of each research variable.
2. Secondary data was taken through literature studies to obtain relevant information about the theoretical basis and materials that support the course of the research. Secondary data sources include journals, books, scientific writings, and previous research related to the research's topic.

Several methods for data collection were applied, including (Sharma et al., 2017):

1. Interviews was carried to collect information related with the current state of SCM in the company, the procedures of SCM, the suppliers of raw materials, the manufacturing methods, the transportation used, the marketing, and etc. The interviewed participants were the employees of the PMKP Sukun Ponorogo, suppliers, distributors, retailers, and consumers.
2. Documentation was done via records, archives, and any related documents to measure indicators of GSCM.

Analysis Technique

The collected data were then processed and analyzed quantitatively and qualitatively, based on procedures described in Cazeri et al. (2017), as follows:

1. Validating an indicator weight. Weighting was done for each attribute using the ANP method. The respondents were asked to fill out a questionnaire to help determine the priority of the GSCM indicator.
2. Scoring System with OMAX method. The OMAX method was used to equalize the value scale of each indicator of the key performance indicator (KPI). By using this method, the current KPI of GSCM in PMKP Sukun Ponorogo could be determined.
3. Performance evaluation. The evaluation was carried out on whether the results have reached the company's target. The findings were used to identify which KPIs need to be improved or not.
4. Improvement recommendations. Recommendations for improvement were made on the KPIs that require improvement, following the evaluation results. These recommendations were given based on the priority of improvement to be implemented in the company.

Results and Discussion

KPI's Weighting Results

KPI's weighting was done for each KPI, and the results can be seen in Table 1. The highest weight was found *Make* category, especially in KPI 24 indicating this indicator is more important than other indicators. The lowest weight in KPI indicates that the company has not yet implemented a good performance. The difference in weight is influenced by the level of company needs from each different KPI (Kafa et al., 2013).

Table 1. KPI's Weighting Results

Category	Dimension	No. KPI	KPI	Weight
Plan	*Reliability*	1	Estimated requirement of raw materials	0.081
		2	Inventory of raw material	0.037
		3	Internal labour relations	0.011
		4	Employee expertise	0.022
	Responsiveness	5	Customer's demand responsiveness	0.041
		6	Customer's demand flexibility	0.007
	Flexibility	7	Promptness of sudden demand	0.012
Source	*Reliability*	8	Delivery performance of environmental responsibility supplier	0.048
		9	Delivery expertise of environmental responsibility supplier	0.048
	Responsiveness	10	On-time delivery of suppliers	0.038
	Flexibility	11	Flexibility of the amount of raw materials	0.012
Deliver	*Reliability*	12	Skillfulness of service for finished products	0.017
		13	Use of eco-friendly fuel	0.011
		14	Speed of raw materials delivery	0.003
		15	Speed of finished products delivery	0.012
	Flexibility	16	Flexibility of raw materials delivery	0.005
		17	Flexibility of finished products delivery	0.005
	Responsiveness	18	On-time delivery of raw materials to the production site	0.001
		19	On-time delivery of finished products to customers	0.001
		20	Response to cost changes	0.001
		21	Response to quality of raw materials and products	0.001
		22	Ease of obtaining product information	0.001
Make	*Reliability*	23	Use of eco-friendly materials	0.054
		24	Employee expertise in eco-friendly production process	0.180
		25	Efficiency of equipment and machines in manufacturing	0.025
		26	Unused waste	0.079
		27	Eco-friendly packaging material	0.052
	Flexibility	28	Flexibility of raw materials in cooperatives	0.090
	Responsiveness	29	Responsiveness to various demands	0.020
		30	Flexibility in product's manufacturing	0.024
Return	*Reliability*	31	Rejection rate of raw material	0.007
		32	Complaints from the production party regarding the environmental impacts	0.006
		33	Response to replace unsuitable products	0.039
	Flexibility	34	Flexibility to replace defective products	0.006
	Responsiveness	35	Substitution of raw materials by suppliers	0.010
		36	Product change by PMKP	0.013

The high weight of the KPI indicates that the company considers the process less critical. While, a low KPI's weight indicates that the process requires more attention to balance each process with the surrounding environmental conditions. Processes is considered necessary due to their significant role for the company to carry out the supply chain (Shabbir et al., 2019). In the reliability dimension of *source* category, KPI of employee expertise and environmentally responsibility process has a low weight, indicating their low performance. Thus, it is necessary to be further improved to meet the company's goals. The interview results suggested that PMKP Sukun Ponorogo has not yet conducted training for all employees related to the application of GSCM. Therefore, the training is needed to enhance the knowledge and skills in implementing GSCM.

Other KPIs with low values were on-time delivery of raw materials to the production site, on-time delivery of finished products to customers, response to cost changes, response to quality ofraw materials and products, and ease of obtaining product information. These results show these indicators were important to be improved. For example, on-time delivery of finished product to customers should be achieved to avoid any delays and to maintain customer's satisfaction.

GSCM Performance Measurement

The first step was to determine the weight of each GSCM's KPIs using the ANP method. Next step, the calculation of the scoring system was done using OMAX and traffic light system (TLS). The OMAX method is a method applied to determine critical criteria in each KPI to improve the performance of GSCM (Cazeri et al., 2017). OMAX calculations were carried out in an interconnected form. The TLS method, used as a scoring system, is a measurement model with three colors parameters of green (accept), yellow (accept with caution for improvement), and red (unaccepted and need immediate improvement).

The TLS results indicated the score of each KPI of GSCM as a result of the OMAX method. The calculation results show how the company's targets were achieved. The findings confirmed that there were several indicators have not yet been implemented optimally and have poor performance, affecting the KPI's weight. The results also showed whether the company's target is achieved, or need improvement. The results of the OMAX and TLS calculation are shown in Table 2 - 6.

Based on Table 2, the lowest score was observed in KPI 1 of estimated requirement of raw materials, giving the level value of 7. This KPI is categorized as yellow because currently the company still not using an appropriate method to estimate the requirement of raw materials. Therefore, excess of raw materials was often occurred at the company, which may contribute to profit loss and high operation cost. Therefore, further improvement in the performance of SCM within the company is essential. Not only to reduce any excess of raw materials, but also to avoid any negative environmental impacts due to unused raw materials (or waste). It is suggested that the company can use calculation method to correct and accurately estimate the stock of raw materials (Cazeri et al., 2017).

In Table 3, the lowest value in *source* category was KPI 9 (i.e. delivery expertise of environmental responsibility supplier), with level value of 6. This KPI has a yellow category, thus further improvement is critical to achieve the company's target. The interview results found that the PMKP Sukun Ponorogo has not yet paid attention to the criteria of suppliers. Several suggestions for improvements were the company to set standard criteria for suppliers and establish good communication with the suppliers to pay attention to environmental conditions in providing the raw materials. If the KPI level is still below the target, the improvement of the company's performance is required (Shrisvastava et al., 2017).

Table 2. Results of Scoring System on *Plan* Category

No. KPI	1	2	3	4	5	6	7
Performance	93.75	5.83	3.61	1	3	3	1
10	98.25	4.58	3.31	1	1	1	1
9	96.75	5.19	3.45	-	2	2	-
8	95.25	5.83	3.61	2	3	3	2
7	93.75	6.47	3.77	-	-	-	-
6	92.25	7.11	3.89	-	-	-	-
5	90.75	7.75	4.09	-	-	-	-
4	89.25	8.39	4.25	3	5	6	3
3	87.75	9.03	4.41	-	-	-	-
2	86.5	9.36	4.6	-	-	-	-
1	85.25	9.68	6.8	-	-	-	-
0	84	10.00	5.00	-	-	-	-
Level	7	8	8	10	8	8	10
Weight	0.081	0.037	0.011	0.022	0.041	0.007	0.012
Value	0.567	0.296	0.088	0.220	0.328	0.056	0.120

Table 3. Results of Scoring System on *Source* Category

No. KPI	8	9	10	11
Performance	99.16	95.13	1	3
10	100	98	1	3
9	99.16	97.26	-	-
8	98.3	96.55	2	3
7	97.44	95.84	-	-
6	96.58	95.13	-	-
5	95.72	94.42	-	-
4	94.86	93.71	4	-
3	94	93	-	7
2	93.34	92.34	-	-
1	92.67	91.67	-	-
0	92	91	-	-
Level	9	6	10	8
Weight	0.048	0.048	0.038	0.012
Value	0.432	0.288	0.38	0.096

Table 4. Results of Scoring System on *Deliver* Category

No. KPI	12	13	14	15	16	17	18	19	20	21	22
Performance	97.66	96.99	97.7	91.82	4	94.54	77.32	31.79	92.91	61.45	2
10	99.2	99.4	97.7	96.63	5	97.3	99.02	22.4	96.6	72.5	1
9	98.68	98.56	95.4	94.22	-	96.58	96.3	81.5	95.7	13.29	-
8	98.17	97.75	93.15	91.82	4	95.9	93.6	14.04	94.77	25.33	2
7	97.66	96.44	90.9	89.42	-	95.22	90.9	19.97	93.84	37.37	-
6	97.15	96.13	88.65	87.02	3	94.54	88.2	25.88	92.91	49.41	-
5	96.64	95.32	88.4	84.62	-	95.86	88.5	31.79	91.98	61.45	-
4	96.13	94.51	84.15	82.21	2	93.18	82.8	37.67	91.05	73.50	1
3	95.62	93.7	81.9	79.16	-	92.5	80.1	39,50	90,12	73.58	-
2	94.08	92.8	80.1	76.11	1	88.34	77.31	41.33	88.4	74.25	-
1	92.54	91.9	77.8	73.06	-	84.17	73.66	43.16	86.7	74.63	-
0	91	91	75	70	0	80	70	45	85	75	-
Level	7	7	10	8	8	6	3	5	6	4	8
Weight	0.017	0.011	0.003	0.012	0.005	0.005	0.001	0.001	0.001	0.001	0.001
Value	0.119	0.077	0.03	0.096	0.04	0.03	0.003	0.005	0.005	0.004	0.008

Table 4 shows that in *delivery* category, KPI 18 of on-time delivery of raw materials to the production site has a low level value of 3. This KPI has a red category that requires immediate improvement to meet the company's targets. Currently, the PMKP Sukun Ponorogo still facing problem of delays in raw materials delively. Such condition had negative impact on further delaying the production process. Delays in production can also affect the delivery of finished products to the customers and customer satisfaction. Therefore, immediate repairs were needed as the red category also indicates a performance condition of far below the target (i.e. categorized as high priority for improvement). The recommended improvement is that the PMKP Sukun Ponorogo to provide direction to suppliers regarding delivery estimation, thus allowing on-time delivery of raw materials (Seman et al., 2012).

Table 5 shows the results of scoring system on *make* category, giving the lowest level value of 7 from KPI 23 (i.e. use of eco-friendly materials). To date, the PMKP Sukun Ponorogo still cannot fully utilized all raw materials, thus returned raw materials to the supplier were occurred. These returned raw materials were then directly disposed to the surrounding environment, thus leading to a buildup of waste from unused raw material. The recommended improvement includes to optimize the use of raw materials for minimizing unused or wasted raw materials.

Table 5. Results of Scoring System on *Make* Category

No. KPI	23	24	25	26	27	28	29	30
Performance	93.3	99.81	96.45	93.13	1	5.04	18.65	1
10	98.85	99.81	99.6	99.87	3	0	5.32	1
9	96.96	98.44	98	97.81	0	1.26	7.33	-
8	95.13	97.09	96.45	96.25	1	2.52	9.34	2
7	93.3	95.74	94.9	94.69	3	3.78	11.35	-
6	91.47	94.39	93.35	93.13	5	5.04	13.36	-
5	89.64	93.04	91.8	91.57	7	6.30	15.37	-
4	87.81	91.69	90.25	90	9	7.54	17.40	3
3	85.98	90.34	88.71	88.75	10	11.91	19.30	-
2	82.32	96.98	87.5	87.5	14	16.28	21.20	-
1	78.66	87.34	86.24	86.25	18	20.65	23.10	-
0	75	78	85	85	21	25	25	-
Level	7	10	8	6	8	5	8	10
Weight	0.054	0.18	0.025	0.079	0.052	0.09	0.02	0.024
Value	0.378	1.8	0.2	0.474	0.416	0.45	0.16	0.24

Table 6. Results of Scoring System on *Return* Category

No. KPI	31	32	33	34	35	36
Performance	903	9738	1	100	2	1
10	9775	992	1	100	3	1
9	9636	9829	-	95	-	-
8	953	9738	2	90	2	2
7	9424	9649	-	85	-	-
6	9318	9556	-	80	-	-
5	9212	9465	-	75	-	-
4	9106	9374	3	70	1	3
3	903	9283	-	65	-	-
2	8854	8988	-	60	-	-
1	8677	8694	-	55	-	-
0	85	84	-	50	0	-
Level	3	8	10	10	8	10
Weight	0.007	0.006	0.039	0.006	0.010	0.013
Value	0.021	0.048	0.390	0.060	0.080	0.130

Also, KPI 26 of unused waste has the lowest level value of 6. The production process in PMKP Sukun Ponorogo generated wastewater. Currently, the company still has no proper wastewater treatment and monitoring of the wastewater's quality. Hence, the wastewater is directly disposed to the nearby environment. The recommended improvement is that the wastewater should be regularly monitored for the quality, followed appropriate treatment and on-site effluent recycling (i.e. for irrigation, plant watering, and etc.). Furthermore, KPI 28 (i.e. flexibility of raw materials in cooperatives) has the lowest level value of 5 and fitted with yellow category. Therefore, the company should be flexible in facilitating and fulfilling the requests from the cooperatives. Ability of the company to meet the cooperative demands could support the fulfillment of customer's demand. Therefore, further performance improvements are required in these KPIs as the level were still below the target (Luthra et al., 2013).

Table 6 shows that in *return* category KPI 31 (i.e. rejection rate of raw materials) has the lowest level value of 3, compared with other KPIs. KPI 31 was also categorized in red zone, indicating requirement for immediate improvement to meet the company's targets. Returning raw materials from suppliers causes wasted raw materials. This may cause the accumulation of rejected and wasted raw materials, hence leading to negative impact to environment.

Managerial Implications

Improvement activities could provide direct systematic steps to measure the performance implementation of GSCM in the PMKP Sukun

Ponorogo (Pratama and Henry, 2018). Based on the GSCM evaluation, the improvement needed should be focused on 5 KPIs of estimated requirement of raw material, environmentally responsibility suppliers, on-time delivery of raw material to the production site, use of eco-friendly raw materials, and unused waste. Providing an estimation of raw materials required in manufacturing process could enable the company to avoid any excess and wasted raw materials. Similarly, providing on-time delivery service within the company's operation may improve the efficacy of production process and on-time delivery of finished products. While, having an environmentally responsibility suppliers could further contribute in reducing negative environmental impacts. These proposed improvement framework for the PMKP Sukun Ponorogo should be discussed by company members. While, the managers can plan and maintain the performance of GSCM activities within the company.

Conclusion

The overall GSCM performance of the PMKP Sukun Ponorogo still need further improvement. The evaluation from the KPI's level indicated several indicators such as on-time delivery of raw material to the production site and rejection rate of raw materials. The recommended recommendation is that the PMKP Sukun Ponorogo to calculate an estimation of raw materials required in each production to avoid any delays. With this, the company could provide timeline and information of time and the amount of the required raw materials to be delivered by the suppliers. Furthermore, the careful handling of raw materials should also be carried out by the company and suppliers to reduce the potential damage or rejection of raw materials. Finally, the company should also improve the waste management and to reuse waste for reducing any detrimental impacts on the environments.

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Declarations

Conflict of interests The authors declare no competing interests.

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