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Analysis of green supply chain management performance with green supply chain operation reference at the batik enterprise

Abstract
Nowadays, the Hayuningrum Batik Industry keeps trying to optimize the production of batik cloth until the batik cloth can be accepted by consumers, but the Hayuningrum Batik Industry lacks awareness about environmental issues. One effort that can be taken is by measuring the performance of Green Supply Chain Management (GSCM). This study aims to calculate and analyze GSCM performance in the Hayuningrum Batik Industry in the year 2020 and provide proposed improvement to improve GSCM performance in the Hayuningrum Batik Industry located in Laweyan, Surakarta. The method used are the Green Supply Chain Operation Reference (Green SCOR) model approach, weighting with the Analytical Hierachy Process (AHP) method, and normalization using the Snorm de Boer formula. Based on research conducted, 26 Key Performance Indicators (KPI) have been verified. The KPI is weighted using the AHP method. Then, the normalization score has been calculated for each indicator. The results of these measurements show the value of GSCM performance in the Hayuningrum Batik Industry of 57.42, which means that the performance is classified as Average. Therefore, the Hayuningrum Batik Industry need to improve their performance. The proposed improvement is given to each indicator in the Hayuningrum Batik Industry that need to be prioritized for improvement.

Keywords: Analytical Hierarchy Process; Green Supply Chain Management; Green Supply Chain Operation Reference; Performance
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Аналіз ефективності управління зеленим ланцюжком поставок у галузі батику

Анотація. Нині батик-індустрія в Суракарті, зокрема підприємство «Хайюнінгрум» (Hayuningrum Batik Industry) намагається оптимізувати виробництво тканини для батика, проте підприємство й галузь у цілому недостатньо обізнані про екологічні проблеми. Мета нашого дослідження – вимірювання ефективності управління екологічним (зеленим) ланцюжком поставок (GSCM). Це дослідження спрямоване на розрахунок й аналіз ефективності GSCM «Хайюнінгрум» в 2020 році й надання пропозицій щодо поліпшень для підвищення продуктивності GSCM. На підставі проведених досліджень було перевірено 26 ключових показників ефективності (KPI). Кожний показник KPI зважувався з використанням методу аналітичної ієрархії. Потім для кожного показника був розрахований бал нормалізації. Результати цих вимірювань показують значення продуктивності GSCM в батиковій промисловості «Хайюнінгрума», рівне 57,42, що означає, що продуктивність класифікується як середня. Таким чином, виробники батика «Хайюнінгрум» потребують поліпшення своїх показників. Авторами запропоновано шляхи покращення кожного з них.
Ключові слова: екологічний менеджмент; екологічне управління ланцюжком поставок; продуктивність; батик.

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Анализ эффективности управления зеленой цепочкой поставок в отрасли батика

Аннотация. В настоящее время батик-индустрия в Суракарте, в частности предприятие «Хайюнингрум» (Hayuningrum Batik Industry) пытается оптимизировать производство ткани для батика, однако предприятие и отрасль в целом недостаточно осведомлены об экологических проблемах. Цель нашего исследования – измерение эффективности управления экологической (зеленой) цепочкой поставок (GSCM). Это исследование направлено на расчет и анализ эффективности GSCM «Хайюнингрум» в 2020 году и предоставление предлагаемых улучшений для повышения производительности GSCM. На основании проведенных исследований было проверено 26 ключевых показателей эффективности (KPI). KPI взвешивался с использованием метода аналитической иерархии. Затем для каждого показателя был рассчитан балл нормализации. Результаты этих измерений показывают значение производительности GSCM в батиковой промышленности «Хайюнингрума», равное 57,42, что означает, что производительность классифицируется как средняя. Таким образом, производители батика «Хайюнингрум» нуждаются в улучшении своих показателей. Авторами предложены пути улучшения каждого из показателей.
Ключевые слова: экологический менеджмент; экологическое управление цепочкой поставок; производительность; батик.

1. Introduction

The Green Theory or issues regarding environmental problems emerged around the 1960s as a response to the deteriorating quality of the environment and also began to feel the impact of

global warming, most of which were caused by industrialization. Based on these conditions, then appeared government regulations such as ISO 14000 which is an environmental standard as a guideline for companies (Hasan and Chan, 2014; Riaz and Saeed, 2020; Wang et al., 2021) and many people are starting to be interested in buying environmentally friendly products as a form of concern for the environment (Puspitasari et al., 2020).

GSCM is a combination of environmentally friendly with the activities of procurement of raw materials, production and processing of raw materials, the distribution system and marketing, and reverse logistics (Sarkar, 2012). The aim is to consider the environmental impact of all products and processes to protect the environment. This GSCM concept must be continuously evaluated in order to be developed. This evaluation process can be realized by measuring the performance of an environmentally friendly supply chain.

This study aims to calculate and analyze GSCM performance and provide propose improvement to improve GSCM performance in the Hayuningrum Batik Industry. The methods used are Green Supply Chain Operation Reference (Green SCOR), Analytical Hierarchy Process (AHP) method, and Snorm de Boer normalization.

Supply Chain Operation Reference (SCOR) is used to measure supply chain performance and to identify supply chain performance indicators by showing supply chain processes so that it can be an evaluation in improving the performance in the Hayuningrum Batik Industry. SCOR is a framework to describe business processes between supply chain components to fulfil consumer demand while Green SCOR is a modified SCOR, which includes environmental management system elements in each process in the SCOR model, namely plan, source, make, deliver, return, and enable (Putra and Putra, 2018; Rinaldi et al., 2021).

Analytical Hierarchy Process (AHP) is used to determine the priority weights of each criterion. AHP is a method of measuring pairwise comparisons for complex and unstructured situations into a hierarchical arrangement and depends on subjective judgments from experts on how important these criteria are to get priority weighting (Abdel-Basset et al., 2017).

2. Methods and Methodology

The study was conducted at the Hayuningrum Batik Industry located in Laweyan, Surakarta in the year 2020. The selection of the object of this research because the Hayuningrum Batik Industry has no awareness of environmental issues. Therefore, the focus of this research is the measurement of GSCM performance using the Green SCOR model, the AHP method, and the Snorm de Boer normalization. The research steps carried out are divided into three stages, as follows:

The preliminary stage includes the identification of problems, the formulation of the problems encountered, the determination of research objectives, and the study of literature regarding the research conducted.

This research has several stages of processing that will complete the raw data obtained previously; the steps taken are as follows.

2.1. Identifying Metrics for Each Level

Design performance measurements based on the Green SCOR model approach by identifying Level 1 metrics, namely the GSCM process in the Hayuningrum Batik Industry. Level 2 metrics are green objective dimensions. Level 3 metrics are indicators of each process.

2.2. Verification of Key Performance Indicator (KPI)

This KPI presents indicators that focus on the environment. The purpose of KPI verification is to find out whether the GSCM performance indicators that have been designed are in accordance with the conditions in the Hayuningrum Batik Industry so that they can be used to measure performance GSCM in the Hayuningrum Batik Industry. This verification phase is carried out by giving a performance indicators selection questionnaire to the Hayuningrum Batik Industry owners.

2.3. Weighting with Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) is a method for assessing actions by comparing several alternative choices. The purpose of weighting with the AHP is to determine the level of importance of each level and the existing indicators. The weighting stage with AHP is carried out by giving AHP questionnaires to the owner and all workers in the Hayuningrum Batik Industry.

2.4. Normalization Score Calculation Using Snorm De Boer

Snorm de boer normalization is used to equalize the weight and scale of values for each indicator (Rinaldi et al., 2021). The indicators used to consist of two categories those are indicators which if the lower is carried out, the results will be better (1) and the indicators which if the larger is carried out, the results will be better (2). The results of calculations using these formulas produce a score between 0 (worst) to 100 (best). Performance indicator monitoring system (Nazim et al., 2017) is shown in Table 1.

Table 1:
Performance indicator monitoring system

Monitoring system	Performance indicator
<40	Poor
40 – 50	Marginal
50 – 70	Average
70 – 90	Good
>90	Excellent

Source: Compiled by the authors

3. Results and Discussion

3.1. Identification of KPIs

In determining GSCM performance indicators, the researcher reviewed the indicators compiled by (Putra and Putra, 2018), (Saputra and Fithri, 2012), (VenkatesaNarayanan and Thirunavukkarasu, 2021) and (Susanty et al., 2017) which were then adjusted to the conditions in the Hayuningrum Batik Industry. An indicator selection questionnaire containing 34 KPIs was then given to the Hayuningrum Batik Industry owners to verify KPIs. After KPI verification, 26 KPIs were obtained in accordance with the conditions in the Hayuningrum Batik Industry. The selected KPIs are shown in Table 2.

The selected KPIs (in Table 2) are then calculated using AHP weighting and Snorm de Boer normalization to determine the score of performance indicators which will later the results of those calculations be used to measure GSCM performance in the Hayuningrum Batik Industry.

3.2. Calculation of AHP Weighting

AHP weighting is carried out at each level in Green SCOR with pairwise comparisons on all aspects that exist at each level. Level 1 is the process level consisting of the plan, source, make,

Table 2:
KPIs in the Hayuningrum Batik industry

Code	Key performance indicator (KPI)
P11	% of Recyclable / Reusable Materials
P21	Energy Used
P22	Water Used
P23	Fuel Used
S11	% Purchasing of Eco-friendly Materials
S12	% Hazardous Material in Inventory
S21	% of Not Feasible Package
S22	% Products Damage During Storage
S23	% Order Received Damage Free
S31	% Upside Source Flexibility
M11	% Waste (Malam) Generated from Products
M21	% Yield
M22	% Use of Natural Ingredients
M23	% of Synthetic Chemical Used
M31	% Upside Make Flexibility
D11	% of Eco-friendly Vehicle Use
D21	Delivery Scheduling to Maximize Transportation Capacity
D22	Selecting the Shortest Route to Minimize Fuel
D31	% Shipping Document Accuracy
D32	% Deliver Quantity Accuracy
D41	Delivery Cycle Time
D51	Fuel Cost
R11	% of Complaint Regarding the Environment
R12	% of Products Returned
R21	Scheduling Defective Product Replacement
E11	% of Employees who Care about the Environment

Source: Compiled by the authors

deliver, return, and enable, Level 2 is the green objective dimension, and Level 3 is the GSCM performance indicators in the Hayuningrum Batik Industry. Hierarchy of GSCM performance measurement weight is shown in Figure 1.

Based on Figure 1, it is known that the highest level of weight is found in the sourcing process with a weight of 0.31. The highest weight of Level 2 is in the enable process, which is knowledge of green operation with a weight of 1 and the highest weight of Level 3 is in each process with a weight of 1 because it consists of only one objective.

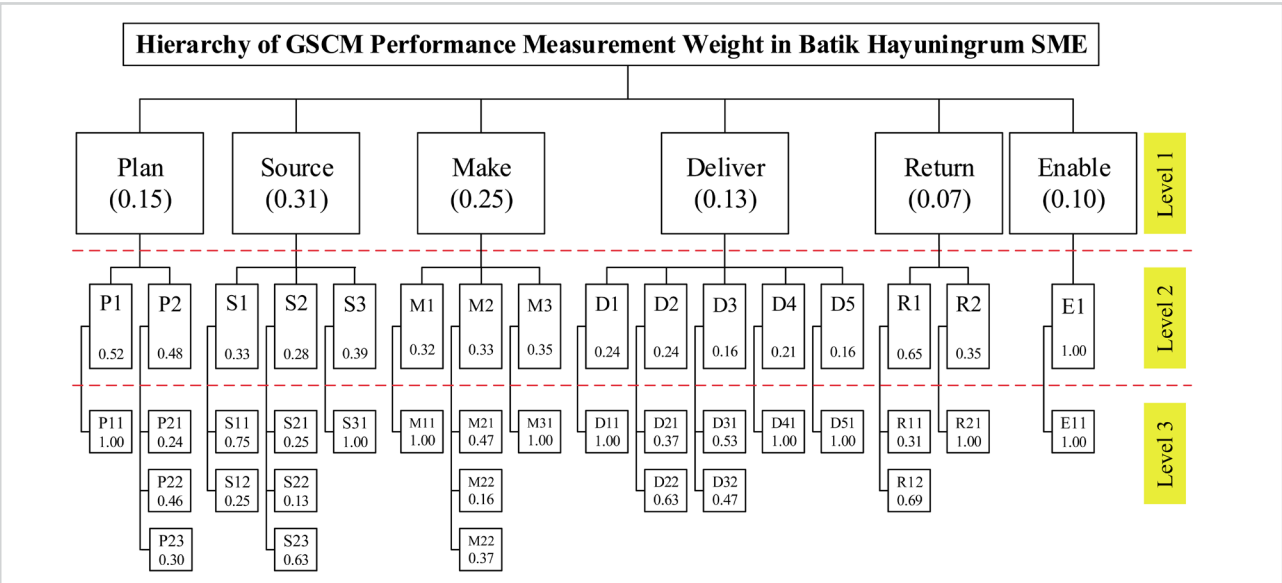

Figure 1:
Hierarchy of GSCM performance measurement weight
Source: Compiled by the authors

3.3. Calculation of Snorm de Boer Normalization

Snorm de Boer normalization calculation is needed because performance GSCM indicators in the Hayuningrum Batik Industry have different weights and size scales.

3.4. Calculation of GSCM Performance Final Value

Calculation of the GSCM performance final value is obtained by multiplying each score and weighting from each level. Calculation of the GSCM performance final value is shown in Table 3.

Based on Table 3, it is known that there are three indicators of the Poor and Marginal categories, 11 indicators of the Average category, nine indicators of the Good category, and the GSCM performance in the Hayuningrum Batik Industry of 57.42, where the numbers are included in the Average category. The greatest performance is obtained in the sourcing process with a performance of 18.58.

3.5. Proposed Improvements

The results of measuring GSCM performance in the Hayuningrum Batik Industry show that the industry is included in the Average category and this cannot be said to be good, so it needs to be improved and re-evaluated against existing performance indicators. The suggestions for improvement given for indicators with the Poor category are as follows:

The first Poor category indicator is Percentage Purchasing of Eco-friendly Materials and Percentage Use of Natural Ingredients. In the Hayuningrum Batik Industry, there is still the use of chemicals such as remasol and porkasol for dyeing fabrics and chemical fixing materials, namely water glass or Sodium Silicate (Na_2SiO_3) for the colour locking process. This is due to customer demand to produce more striking colours and more varied colours, and the price of batik cloth is lower than the price of batik cloth with natural materials.

Cheap raw materials can be obtained by making a water storage tank to collect rainwater so that the water requirement for batik production does not cost money or is free (Abu-Zreig et al., 2019), while for other raw materials it can be done by conducting research on raw material prices at various suppliers to find the lowest price. Then, to save raw materials, it can be done by reusing batik cloth

Table 3:
Calculation of the GSCM performance final value

Process	Green Objective		KPI	Score	Performance
Plan	Maximizing Reuse and Recycle of Resources		P11	68.05	9.13
	Minimization of Resources and Energy	P21	60.04		
		P22	48.74		
		P23	54.74		
Source	Material purchase		S11	39.58	18.58
			S12	48.04	
	Packaging, Storage and Handling of Products		S21	75.00	
			S22	72.92	
			S23	80.00	
	Procurement Flexibility		S31	65.12	
Make	Minimization and Management Waste		M11	47.73	13.53
	Material Use	M21	71.77		
		M22	39.92		
		M23	50.00		
	Production Flexibility	M31	58.08		
Deliver	Eco-friendly Shipping		D11	75.00	9.34
	Delivery System for Fuel Minimization	D21	62.50		
		D22	75.00		
	Shipping Documentation Information Systems	D31	75.00		
		D32	72.92		
	Delivery Time	D41	68.75		
	Shipping Cost	D51	75.00		
Return	Customer Satisfaction of the Company and Products		R11	50.00	4.30
			R12	66.74	
	Defective Product Replacement		R21	66.67	
Enable	Knowledge of Green Operations		E11	25.00	2.53
Final Value of GSCM Performance in the Hayuningrum Batik Industry					57.42
				Average	

Source: Compiled by the authors

washing water for the same colour of batik cloth, and raw material recycling can be done by making a stove cross-section to accommodate the scattered «Malam» so that the «Malam» can be reused for the batik process (Rinaldi et al., 2021).

The second in terms of human, namely by informing customers of the benefits of using natural materials such as waste from the production of batik cloth which is more environmentally friendly and safe for health because substances contained in natural materials are easily biodegradable, produce batik fabrics with more natural, soft and unique colours according to the characteristics of natural colours, and the aroma of batik cloth that does not smell of chemicals. Natural materials that can be used are shown in Table 4.

The last Poor category indicator is Percentage of Employees who Care about the Environment. The suggestions for improvement given by researchers are the first in terms of methods, namely facilitating the batik industry to be environmentally friendly such as by using natural materials, having a liquid waste filtering tool and an environmentally friendly distribution system. The use of natural materials for the production process of batik cloth is shown in Table 4.

Table 4:
Natural materials for Batik production

Natural Dyes	Colour
Indigofera	Blue
Secang	Red
Tingi	Brown
Tegeran	Yellow
Jambal	Brownish Yellow
Jolawe	Yellow/ Orange/ Brown
Mahogany	Brownish Red
Meer Wood	Magenta/ Pink
Noni	Brick Red
Noni Root	Brown
Mangosteen Skin	Red/ Purple
Jackfruit Wood	Light Yellow
Natural Fixation	Colour
Alum	-
Tunjung	-
Chalk	-

Source: Compiled by the authors

4. Conclusion

The measurement of GSCM performance in the Hayuningrum Batik Industry in 2020 is used to monitor the performance of GSCM in this batik industry, such as knowing the position of the Hayuningrum Batik Industry towards the objectives to be achieved and also its competitors as well as to determine improvement strategies in order to create a competitive advantage.

Green SCOR is a framework that can describe business process activities between supply chain components related to environmental concern so that it can be used as a tool to manage the environmental impact of a supply chain network and the AHP method is used to calculate the weighting at each level in Green SCOR so that priority weights can be obtained for each of the existing criteria.

The final score of the GSCM performance in the Hayuningrum Batik Industry is in the average category so it is necessary to make improvements and re-evaluation of each indicator to be able to improve the performance of GSCM in this batik industry so that the Hayuningrum Batik Industry can care more about the environment.

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