Application of The Green Model for Measurement of Green Supply Chain Performances

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Abstract— In this era of globalization, business companies have created and implemented better strategies in line with the best interests of protecting the environment. The purpose of this study was to measure the performance of supply chain management for broiler feed products of SSI company with the Green SCOR and AHP Models. Based on the result of data analysis from eighteen KPIs measured, ten KPIs are in the satisfactory category, five KPIs are in the marginal category, and three KPIs are in the unsatisfactory category. The three KPIs unsatisfactory are Water use, source cycle time and make cycle time. For these three KPIs, special attention needs to be paid to make improvements, and for the marginal ones, attention should also be given so that they can increase to become satisfactory, and those that are satisfactory should be monitored so that they do not fall.

Keywords— Supply Chain Management, Green Supply Chain Management, Supply Chain Operation Reference, Analytical Hierarchy Process, Key Performance Indicator.

I. INTRODUCTION

In this era of globalization, businesses have created and implemented better strategies in line with their best interests in protecting the environment. This is because every link in the traditional supply chain can cause pollution, waste, and other hazards to the environment.

To overcome the occurrence of pollution, waste, and other hazards to the environment due to the impact on supply chain activities as well as the demands of industrial development, it has begun to implement supply chain performance with an environmentally friendly approach known as Green Supply Chain Management (GSCM).

This model is an effort to protect the environment from the impacts generated in the production process of an industry, starting from suppliers of raw materials and manufacturing to distributors of finished products.

One of the benefits of GSCM is increasing efficiency, product quality, and minimising waste in the hope that it will protect the natural environment in a sustainable manner.

In essence, the practise of traditional supply chains that ignore the environment is an inefficiency in logistics costs. According to Srivastava (2007), GSCM is a method or a concept that integrates environmental thinking into supply chain management with the aim of minimising waste.

Kusrini and Primadasa (2017) state that nowadays people tend to spend money on products that have a good impact on the environment and that people also tend to show interest in products that come from companies that have a good reputation for the environment. Environmental aspects in practise tend not to be integrated with the supply chain or supply chain of the company, so that it runs less effectively.

One way to integrate this environmental aspect into the supply chain is green supply chain management (GSCM) (Primadasa and Sokhibi, 2020).

SSI Companies is a company engaged in the business of animal feed production since 1985, which includes broiler feeds, layer chicken feeds, seed chicken feeds, feed to concentrate, quail feed, and several other types of feed, day-old chicks, ready-to-cut live chicken, cut chicken, and processed food products.

PT SSI has implemented GSCM, including Green Warehouse, Green Manufacturing, Green Packaging, and Green Design.

SSI companies have not yet measured the performance of GSCM.

Therefore, this study was conducted to determine the green supply chain performance indicators at SSI companies and provide suggestions for improvements to improve the achievement of GSCM performance indicators, which are still lacking.

II. LITERATURE REVIEW

Supply Chain Management

Supply chain management is a unit of activity that manages the flow of information, materials, and finance, starting from raw materials from suppliers; the production process (the existence of a process of adding material value) that converts raw materials into finished products; the planning and controlling process of inventory (inventory) to the process of supply chain management. distribution (delivery) of the finished product to retailers or consumers. So, from the SCM point of view, competition is no longer a company with other companies, but the competition that occurs is competition between the company's supply chain and the supply chains of other companies. Each supply chain has its own market demand characteristics and operational challenges to meet consumer demands (Yuniarti, 2018).

Green Supply Chain Management (GSCM)

The theory of green supply chain management is a concept contained in operation management. The definition of operations management according to Heizer & Render (2011) is a series of activities that create value for goods and services through changes of inputs to outputs.

In operation management, the term is known as Ten Critical Operation Management Decisions, namely ten operations management decisions that support the mission in implementing strategies in the operations management area.

Of the ten operational management decisions, there is the concept of supply chain management (SCM), which later developed into the concept of green supply chain management (GSCM).

Green supply chain management is the management of companies in the supply chain (supply, manufacturing, and distribution of products to consumers) that integrates with environmental issues, or implicitly includes an ecosystem philosophy that reduces externalities (waste and pollution) in an effort to improve company performance in the long term (Suganda, 2018)

Green Supply Chain Management is a strategy of a company that focuses on sustainability with the ultimate goal of providing a significant ecological impact by developing a strategy for order processing, procurement (green purchasing), green packaging (green packaging), warehouse (green inventory), and transportation (green transportation) (Sutawidjaya 2017).

**Supply Chain Operations Reference (SCOR)*

SCOR is a supply chain reference model based on processes. This model integrates three main elements of management, namely business process reengineering, benchmarking, and process measurement, into a cross-functional framework in the supply chain.

(Sutawidjaya & Marlapa, 2016) In a study entitled "Supply Chain Management: Analysis and Application Using Reference (SCOR) at PT. Indoturbine", he got the results of his research based on the evaluation of the performance of eight supply chains using the SCOR model. Several errors were found at level 1, namely the QC, warehouse, delivery, and end-user sections.

The measurement metrics used by PT. Indoturbine are below the Advantage Data Benchmark, especially in the POF and OCFT sections, causing the supply chain to be less efficient. The part that has an error at level 1 must be corrected in terms of its measurement metrics in order to increase the company's revenue.

SCOR divides the supply chain into five processes, namely plan, source, make, deliver, and return. The five processes function as follows:

1) Plan

A plan is a process that balances supply and demand to make the best decisions to meet procurement, production, and demand needs.

The plan includes the process of estimating distribution needs, planning and controlling inventory, production planning, material planning, capacity planning, and making adjustments (alignment) to the supply chain with the financial plan.

2) Source

Sourcing is the process of procuring goods and services to meet demand. This process includes scheduling deliveries from suppliers; receiving, checking, and authorising payments for goods sent by suppliers; and so on.

Some types of processes can differ depending on whether the items purchased are stocked, make-to-order, or engineer-to-order products.

3) Make

Make is the process of transforming components or raw materials into products that customers expect.

This activity can be done on the basis of forecasts to meet the target stock (make-to-stock), on the basis of orders (make-to-order), or engineer-to-order.

Activities that occur include production scheduling, carrying out production activities, conducting quality testing, managing semifinished goods, and so on.

4) Deliver

Deliver is a process to fulfil the demand for goods or services. Deliver activities include order management, transportation, and distribution. Activities carried out include customer orders; choosing a delivery service company; handling finished product warehouse activities; and sending invoices to customers.

5) Return

A product return is the process of taking or returning a product for several reasons. Activities involved include identifying product conditions, requesting authorization of damaged products, scheduling returns, and making returns. Post-delivery customer support is also part of the return.

Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is a decision support model developed by Thomas L. Saaty. This decision support model will describe a complex multifactor or multi-criteria problem in a hierarchy.

A Hierarchy is defined as a representation of a complex problem with a multi-level structure where the first level is the goal, followed by the level of factors, criteria, sub-criteria, and so on down to the last level of alternatives.

AHP carried out the following steps:

1. Determine the problem and the desired solution.
2. create a hierarchical structure that begins with the main goal. After compiling the main objective as the top level, then the hierarchy level below it is compiled, namely suitable criteria for considering or assessing the alternatives given and determining these alternatives. Each criterion has a different intensity. The hierarchy is continued by sub-criteria (if necessary).
3. Create a pairwise comparison matrix that describes the relative contribution or influence of each element on the goals or criteria at the level above it. The matrix used is simple, has a strong position in the consistency framework, obtains other information that may be needed with all possible comparisons, and is able to analyse the sensitivity of overall priorities for change in considerations. The matrix approach reflects the dual aspects of priorities, namely dominating and being dominated. Comparisons are made based on the judgement of decision makers by assessing the level of importance of an element compared to other elements. To start the pairwise comparison process, a criterion is selected from the topmost level of the hierarchy, for example, K, and then from the lower level the elements to be compared, for example, E1, E2, E3, E4, E5, and so on.
4. Define pairwise comparisons so that the total number of assessments is n [(n-1)/2], where n is the number of elements to be compared.
5. Calculate the eigenvalues and test their consistency

$$CI = \frac{(\lambda max - n)}{(n-1)}$$

CI = Consistency Index

λMax = The Largest Value Eugen in matrix n

n = Number of criteria

$$CR = \frac{CI}{IR}$$

CR = Consistency Ratio

CI = Consistency Index

IR = Index Ratio

What is measured in the AHP is the consistency ratio by looking at the consistency index.

The expected consistency is near perfect in order to produce a decision that is close to valid. Although it is difficult to achieve perfect, the expected consistency ratio is less than or equal to 10% (CR < 0.1).

Key Performance Indicator

KPI is a tool that can be used to measure and evaluate the performance of employees in the company.

With the KPI, business owners can more easily find out how well each employee's individual ability are.

KPIs that have been verified according to the needs of each stakeholder are as follows:

Key Performance Indicator	Definisi	Karakteristik	Formula
Water usage	Total air yang digunakan untuk memproduksi satu unit produk	*Smaller better*	Total water usage Jumlah Unti yang diproduksi
Energy usage	Total Energi Listrik yang digunakan untuk memproduksi satu unit produk	*Smaller better*	Total Energy usage Jumlah Unit yang diproduksi
Cangkang Sawit usage	Total Cangkang sawit yang digunakan untuk memproduksi satu unit produk	*Smaller better*	Total Cangkang sawit usage Jumlah Unit yang diproduksi
% hazardouz material in inventory	Persentase dari berat material berbahaya pada persediaan dari total berat material pada persediaan	*Smaller better*	Jumlah raw material berbahaya Jumlah total material
% of Supplier with an ISO 14000 Certification	Total Supplier yang memiliki sertifikat ISO 14000	*Higher better*	Total Supplier yang memiliki sertifikat ISO 14000 Total Supplier
% Order Received Damage Free	Prosesntase bahan baku yang tidak mengalami kecacatan	*Higher better*	Total Unit Bahan Baku yang Cacat Total Bahan baku yang masuk
Source Cycletime	Waktu yang dibutuhkan oleh supplier mulai pemesanan hingga bahan baku di terima di gudang	*Smaller better*	Waktu produk di terima di gudang Total waktu pemesanan
% of not feasible package	Persentase jumlah produk rusak pada saat proses pengemasan, penyimpanan dan pendistribusian produk	*Smaller better*	Jumlah Produk yang gagal Total Produk
Yield	Efisiensi Material yang berguna untuk mengukur tingkat efisiensi yang digunakan dalam proses produksi	*Higher better*	Efisiensi Penggunaan Material Total Material yang di gunakan
Make Emission Liquid	Jumlah zat yang dikeluarkan ke air untuk memproduksi satu unit produk	*Smaller better*	Jumlah limbah cair Total limbah
% of recycleable materials	Persentase material yang dapat di daur ulang atau digunakan kembali untuk proses produksi dari total material yang ada	*Higher better*	Berat material yang dapat digunakan kembali Total material
Make Cycletime	Waktu yang dibutuhkan oleh karyawan untuk membuat produk	*Smaller better*	Waktu untuk membuat satu unit produk Total Waktu produksi
Pengaruh Limbah Produksi	Total berat limbah (air,liquid dan solid) dibagi dengan berat produk jadi yang di produksi	*Smaller better*	Berat total limbah Berat produk jadi
Deliver Quantity Accuracy	Prosentase jumlah permintaan konsumen yang dapat dipenuhi oleh perusahaan	*Higher better*	Jumlah Unit terkirim tepat waktu Jumlah pesanan Konsumen
Shipping document accuracy	Persentase dari dokumen pengiriman yang lengkap, bocor, dan tersedia pada waktu dan kondisi yang diinginkan konsumen,pemerintah dan pihak pihak yang berkaitan dengan pengaturan dalam supply chain	*Higher better*	Total deliveries - non complaint deliveries Total deliveries
Deliver Cycletime	Waktu yang dibutuhkan dari mulai produk dikemas hingga dikirimkan ke konsumen	*Smaller better*	Jumlah Unit terkirim tepat waktu Jumlah pesanan Konsumen
% off Error - Free Return Ship	Prosentase produk jadi yang dikirimkan ke konsumen dan dikembalikan oleh konsumen	*Smaller better*	Jumlah unit di kembalikan Jumlah Produk dikirim
% of complains regarding missing environmental requerement from product	Persentase banyak keluhan dari customer terkait spesifikasi dan persyaratan lingkungan dari produk	*Smaller better*	Jumlah keluhan customer terkait lingkungan Jumlah keluhan dari customer

Table 1: *KPI*

III. RESEARCH METHODOLOGY

This study uses a quantitative descriptive research design. Descriptive research is conducted with the aim of describing or describing facts about the population systematically and accurately.

Quantitative descriptive research is one type of research that aims to systematically, factually, and accurately describe the facts and characteristics of a particular population, or try to describe phenomena in detail by Lehmann in Bungin's book (2017).

The framework of thinking in this research is as follows:

1. Found a problem
2. The data used for problem-solving
3. Data related to the environment (Energy use, related to packaging, and also data related to waste) as well as data related to Operations (Product, Plan, and also return)
4. From this data, it will be calculated using the green Supply Chain Operation Reference
5. Follow by calculations using the Analytical Hierarchy Process
6. From the results of the AHP it will produce several selection criteria, namely satisfactory, marginal and unsatisfactory
7. From the process, the final result are managerial implications, conclusions and suggestions

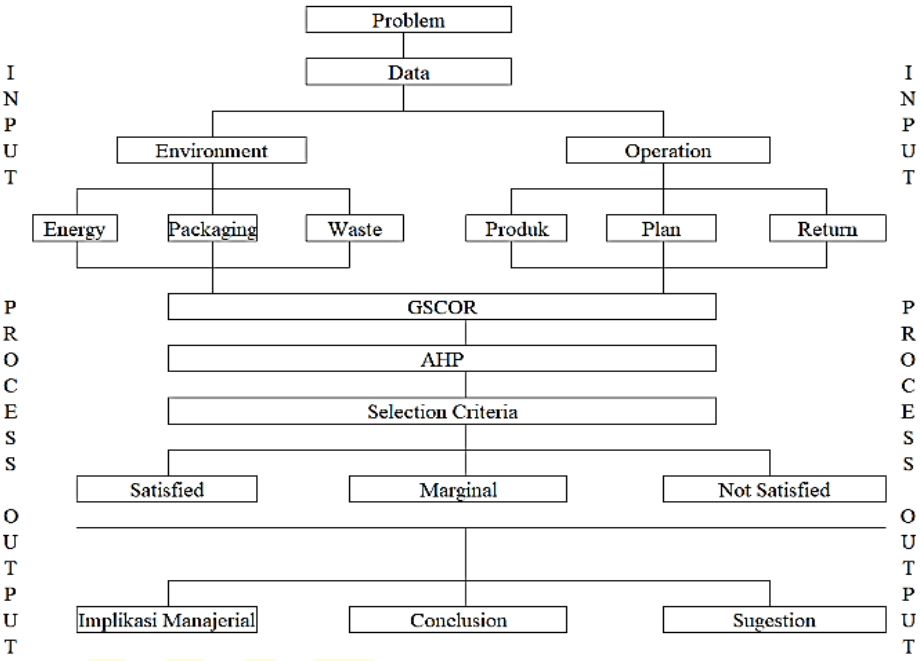

Figure 1: *Framework of think*

IV. RESULT AND DISCUSSION

Based on the KPI calculations that have been determined and also carried out calculations using the analytical hierarchy process as follows:

Proses	Plan	Source	Make	Deliver	Return	Enable
Plan	1	3	5	7	7	4
Source	0.33	1	3	3	5	5
Make	0.2	0.33	1	3	5	3
Deliver	0.14	0.33	0.33	1	3	3
Return	0.14	0.2	0.2	0.33	1	0.33
Enable	0.25	0.2	0.33	0.33	3	1
Total	2.06	5.06	9.86	14.66	24	16.33

Table 2: *Weighting Between the Processes*

Proses	Plan	Source	Make	Deliver	Return	Enable
Plan	0.48	0.59	0.51	0.48	0.29	0.24
Source	0.16	0.2	0.3	0.2	0.21	0.31
Make	0.1	0.07	0.1	0.2	0.21	0.18
Deliver	0.07	0.07	0.03	0.07	0.13	0.18
Return	0,07	0.04	0.02	0.02	0.04	0.02
Enable	0.12	0.04	0.03	0.02	0.13	0.06
Total	1	1	1	1	1	1

Table 3: *Normalization Between the Process*

Proses	Total Weight Matrik	Eugen Vector	Perkalian Matrik	Eugen Value	Max	CI	CR
Plan	2.6	0.43	2.99	6.92			
Source	1.38	0.23	1.59	6.91			
Make	0.86	0.14	0.96	6.69	5.55	-0.09	-0.07
Deliver	0.55	0.09	0.59	6.44			
Return	0.21	0.04	0.22	6.32			
Enable	0.4	0.7	0.41	6.05			

Table 4: *Weighting and Consistency Between the Process*

No	Proses Bisnis	Bobot Level 1	Arribut	Bobot Level 2	*Key Performance Indicator (KPI)*	Bobot Level 3	Aktual	*Min*	*Max*	Normalisasi	Bobot Akhir	Normalisasi x Bobot	Kinerja akhir
1	*Plan*	0.43	*Reliability*	1	*Energy Used*	0.58	4.33	3.9	5.23	67.66	0.25	16.91	85.65
2					*Water Used*	0.11	90.47	89.95	91.12	55.55	0.05	2.77	
3					*Cangkang sawit Used*	0.31	20	20	100	100	0.13	13	
4	*Source*	0.23	*Reliability*	0.67	*% Order Received Damage Free*	0.78	0.09	0	10	99.1	0.34	33.69	
5					*% Hazardous Material in Inventory*	0.15	0	0	100	100	0.02	2	
6					*% of Supplier with an ISO 14000 Certification*	0.07	100	0	100	100	0.01	0	
7			*Responsiveness*	0.10	*Source Cycletime*	0.83	5	4	6	50	0.03	1.5	
8					*% of not Feasible Package*	0.17	2.62	1.2	100	98.56	0.01	0.98	
9	*Make*	0.14	*Reliability*	0.64	*Yield*	0.48	95.25	93.05	100	68.34	0.04	2.73	
10					*Make Liquid Emission*	0.11	0	0	100	100	0.01	1	
11					*% of Reusable Material*	0.41	41.5	40	44	62.5	0.04	2.5	
12			*Responsiveness*	0.21	*Make Cycletime*	0.83	0.81	0.16	1.5	51.49	0.02	1.02	
13					Pengaruh Limbah Produksi	0.17	30	30	100	100	0	0	
14	*Deliver*	0.09	*Reliability*	0.83	*Deliver Quantity Accuracy*	0.5	92.07	87.59	100	63.9	0.04	2.55	
15					*Shipping Document Accuracy*	0.5	100	0	100	0	0.04	0	
16			*Responsiveness*	0.17	Deliver Cycletime	1	8.25	0.25	24	66.31	0.02	1.32	
17	*Return*	0.01	*Reliability*	0.5	*% of complaint regarding missing environmental requirement from product*	1	0.01	0	100	99.99	0.02	1.99	
18			*Responsiveness*	0.5	*% off Error - Free Return Ship*	1	15.38	0	100	84.62	0.02	1.69	

Table 5: *Normalisation KPI*

Key Performance Indicator (KPI)	Actual	Min	Max	Normalisation	Category
Energy Used	4.33	3.9	5.23	67.66	Marginal
Water Used	90.47	89.95	91.12	55.55	Un Satisfied
Cangkang Sawit *Used*	20	20	100	100	Satisfied
% Order Received Damage Free	0.09	0	10	99.1	Satisfied
% Hazardous Material in Inventory	0	0	100	100	Satisfied
% of Supplier with an ISO 14000 Certification	100	0	100	100	Satisfied
Source Cycletime	5	4	6	50	Un Satisfied
% of not Feasible Package	2.62	1.2	100	98.56	Satisfied
Yield	95.25	93.05	100	68.34	Marginal
Make Liquid Emission	0	0	100	100	Satisfied
% of Reusable Material	41.5	40	44	62.5	Marginal
Make Cycletime	0.81	0.16	1.5	51.49	Un Satisfied
Pengaruh Limbah Produksi	30	30	100	100	Satisfied
Deliver Quantity Accuracy	92.07	87.59	100	63.9	Marginal
Shipping Document Accuracy	100	0	100	100	Satisfied
Deliver Cycletime	8.25	0.25	24	66.31	Marginal
% of complaint regarding missing environmental requirement from product	0.01	0	100	99.99	Satisfied
% off Error - Free Return Ship	15.38	0	100	84.62	Satisfied

Table 6: *Result KPI Base on Category*

The results of the AHP calculation have three criteria, namely satisfied with a value of > 80, marginal with a value of 60 > 80, and unsatisfied with a value of < 60. This calculation is carried out on eighteen KPIs that have been determined previously. Of the eighteen KPIs measured, ten KPIs are in the satisfied category, five KPIs are in the marginal category, and three KPIs are in the unsatisfied category. The three unsatisfactory KPIs are: water used, source cycle time, and make cycle time

V. CONCLUSION

Based on the results of research on measuring the performance of Green Supply Chain Management and data processing using the Green SCOR model related to the structure of the supply chain for broiler feed products at SSI Company, starting from sending raw materials from suppliers, receiving raw materials in warehouses and checking raw materials, Good raw materials will go into the production process, from the production process to those that pass the quality check, they will be sent to distributors and depots, and finally sent to consumers.

Performance measurement of supply chain management of the broiler feeds products of SSI company with green SCOR and AHP models shows that the company is in the satisfactory category with a value of 85.65 from a maximum value of 100.

Alternative solutions to supply chain problems after the measurement of supply chain management performance at the SSI company are known, namely the use of water to minimize it, workers must be more disciplined in the use of water, the KPI Source Cycletime is by routinely checking the availability of raw materials to be used. supplied and placed an order for a predetermined time, in the KPI Make Cycletime, the company must target the production time as efficiently as possible.

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