

# Designing Performance Measurement Model for Green Supply Chain Pulp

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**Keywords:** Firm Performance, Performance Measurement Model, Supply Chain Performance.

**Abstract:** Measuring performance is necessary to do in order to know the effectiveness and efficiency of the supply chain in the aspect of reducing costs and environmental impacts. The objective of this research is to integrate the concept of lean and green supply chain to design performance measurement model for pulp supply chain. This research was carried out only to the stage of designing system structure of supply chain performance measurement conceptually. Integrating the green concept was designed using a Balanced Scorecard (BSC) perspective covering financial, customer, internal process business and learning and growth. Key Performance Indicators (KPI) was grouped according to the BSC perspective. Next, a paired comparison process was carried out to get the weight of each KPI. The paired comparison assessment of each KPI was based on the opinion of the selected experts referring to the experiences and knowledge relevant to this research. Paired comparison was intended to get the weight of each KPI using the Analytical Hierarchy Process (AHP) method. The weight generated from each KPI will be ordered in descending for priority determination. The performance measurement model will be validated using face validity method. The designed structure of the model showed that the customer perspective is a priority aspect in the pulp supply chain at PT TPL. The implementation of this model requires coordination for easy access to information among departments and the involvement of all company employees.

## 1 INTRODUCTION

Pulp or commonly called as paper pulp is paper making material. Paper is a thin and flat material produced by compression of fibers derived from pulp containing cellulose and hemicellulose. Pulp is the basic material of various paper-based products ranging from boards used in factories to daily necessities such as paper, tissue, tea bags, and magazines. Pressures and movements influenced by globalization drive companies to improve environmental performance (Zhu & Sarkis, 2006). The importance of relationships among organizations encourages companies to integrate networks with suppliers and consumers to create the concept of Supply Chain Management (SCM).

Sustainable development relates to environmental aspects. The concept of sustainable development appears along with human awareness to the environment. Sustainable development is developed due to the anxiety of low earth ability to support life. It happens as the effect of explosion

of high population, the increasing of human activity, the intensity of natural resources exploitation which are accompanied by an increase in the waste released by nature.

The capacity support of the environment is decreasing day after day because pollution tends to increase (Setiawan et al, 2011). Therefore, the environmental aspect should be considered in the pulp industry. Pollution produced from the pulp industry is contamination from liquid, solid and air waste. In addition to environmental conditions, natural resources and the role of government in supporting the sustainability of the pulp industry, the supply chain management should also be improved so that all business processes can run well. In improving the quality and quantity of pulp, effective strategies and performance of the industry supply chain flow are needed.

The concept of supply chain management is needed by companies for the selection of activities in order to increase the added value, meet customer needs and deliver products to the end users. The

supply chain covers all stages involved both directly or indirectly in meeting customer demand including producers, suppliers, transporters, warehouses, retailers and customers (Chopra & Peter, 2007). Supply Chain Management (SCM) is a method, tool or approach to supply chain management (Pujawan, 2005). In this series of supply chain activities, there is an integrated and transparent flow of information from suppliers to end customers making it easier to control their implementation.

The issues of supply chain are currently starting to develop and should be implemented by companies, namely Green Supply Chain Management (GSCM). All stages in GSCM affect the environmental burden from resource extraction, manufacturing, distribution, product use, waste disposal and other activities. Risks associated with the environment include: excessive use of water and energy without conservation, use of hazardous chemicals, pollution and so forth. Various ideas are emerged from researchers and academics to integrate environmental aspects into the management of business processes so that the GSCM concept was created (Shang et al., 2010).

According to (Mudgal et al., 2009), he explains the benefits and importance of implementing green supply chain in companies in reducing supply chain costs and the environmental impact produced by the company. The concept of GSCM itself is based on an environmental perspective, namely how to reduce waste and environmental impacts caused by industrial company supply chain activities.

PT. Toba Pulp Lestari (TPL), a company owned by Asia Pacific Resources International Limited (APRIL) was established in 1992 producing pulp located in Porsea, Toba Samosir Regency. The production level produced by PT. TPL uses raw material for eucalyptus trees. In producing pulp and in marketing its products overseas, it is necessary to apply the supply chain concept to help to select activities to increase added value in meeting customer needs and delivering products to end users. Also, it is necessary to measure the performance of the supply chain to see the level of effectiveness and efficiency.

The principle of sustainability is emphasized in vision of company, namely : be one of the largest, well-managed, most productive, sustainable pulp companies and loved by consumers and the public. The vision and mission can be realized with concrete strategies and objectives. A performance measurement system for GSCM for pulp products is needed to see the effectiveness and productivity of

the supply chain and realize the company's sustainable principles.

The GSCM concept is urgently required in designing a performance measurement system with the perspective of the Balanced Scorecard (BSC) to achieve an effective and efficient supply chain. Measuring performance using BSC includes financial perspectives, customers, internal business processes, growth and learning. Therefore, the BSC can accommodate important aspects in performance measurement and is often used as a method of measuring the performance of a company's supply chain (Kaplan & Norton, 1996).

In the design of a system for measuring the performance of pulp concepts based on the concept of green, it is used to analyze the procurement of raw materials, production to marketing the pulp. Also, it is used to know whether it has applied the concept of green in the sense of friendly-environment or does not cause environmental impacts and waste minimization caused by pulp supply chain activities. The Implementation of this green concept will produce important indicators that indicate the level of their respective interests in company performance so that companies can determine the right company policies to improve the effectiveness and efficiency of the supply chain (Duarte et al., 2011).

## 2 RESEARCH METHODOLOGY

### 2.1 Study Site

This research was conducted at PT. Toba Pulp Lestari located in Porsea District, Toba Samosir Regency. The research took place from May 2019 - August 2019. The research focused throughout the supply chain from suppliers to pulp distributors.

### 2.2 Data Collection

Data collected in this study are data on pulp supply chain business processes, production processes, raw materials used and the area of raw material suppliers, transportation, distribution areas and marketing data regarding the parties involved (stakeholders), company profile data, vision and mission of the company, organizational structure and line of business, various literatures related to research, such as the concept of green to formulate key performance indicators (KPI). The required data are collected using the methods of observation,

literature study, interviews, KPI weighting questionnaires and experts' opinion.

### 2.3 Research Implementation

The steps to carry out this research are as follows:

1. Understanding and analyzing PT. Toba Pulp Lestari.
2. Formulating KPI from GSCM.
3. Grouping of GSCM KPIs in a BSC perspective.
4. Weighting and Determination of KPI priorities.
5. Designing a GSCM performance measurement model in a BSC perspective.
6. Verifying and validating the performance measurement model created.

### 2.4 Data Processing

The techniques used in analyzing data in this study are as follows:

1. Analytical Hierarchy Process (AHP), AHP is used to weigh each KPI to get the biggest weight of KPI. The KPI which has the highest weight will be as the priority of other KPIs.
2. Verification, Verification is carried out on the KPI with the interview method, which is a direct discussion to ensure that the results of the design of the supply chain performance measurement system can be correctly implemented. Then, it is analyzed to know whether the KPI that is formulated has covered all aspects needed in accordance with the objectives and can be operated.
3. Validation, Validation is carried out to prove that the results of the design of the supply chain performance measurement system are feasible to be applied in the company. The validation technique used in this study is the face validity technique asking for opinions from people who have knowledge about the problem and can assess whether the theory underlying the conceptual model of the supply chain performance measurement system design is correct and acceptable.

## 3 RESULTS AND DISCUSSION

### 3.1 Key Performance Indicator Formulation (KPI)

The obtained KPI at the data collection stage is verified to the company in order to determine the suitability of these indicators with the supply chain system in PT.TPL. Verification results show that there are 10 KPIs with performance which can be measured and in accordance with the existing supply

chain system. KPI is an important indicator that can answer the needs of all stakeholders involved in PT. TPL. Verification of green KPI as many as 10 KPI can be seen in Table 1.

The definitions and descriptive formulations of every KPI are as follows:

1. Energy-efficient operation, i.e. reduction in energy use for all supply chain operations. The amount of energy used when operating can be seen from the ratio index value between the total energy used in production with the total amount of cement produced.
2. Waste disposition, i.e. the amount of waste discharged into the environment produced in the activities of the cement industry plant. Waste disposition is a ratio index value between the weight of waste discharged into the environment and the total waste produced.
3. The use of material that can be recycled, that is the amount of material that can be recycled. The use of recyclable material is a comparison of the amount of material that can be recycled with the total amount of material used.
4. Collaborating with certified suppliers, i.e. establishing cooperation with ISO certified standard environment suppliers. The percentage of suppliers who have an environmental certificate is a comparison between the number of suppliers who have an environmental certificate with the total number of suppliers registered with the company.
5. Environmental costs, namely costs incurred to preserve the environment. Total environmental costs represent the total costs incurred to preserve the environment such as waste management costs, greening costs and environmental costs to preserve the environment.
6. Air and water emissions, namely air and water pollution caused by industrial activities in the form of combustion substances in the production of cement. The number of substances as a result of combustion in production.
7. The use of substances that are not dangerous, namely using materials that are friendly environment and not harmful. The use of hazardous substances can be determined from the number of uses of non-hazardous substances used.
8. Decreasing frequency for environmental accidents, ie reducing accidents environmental accidents that occur. This frequency can be determined by the number of accidentswork that happened.
9. The level of customer interest in environmentally friendly products, i.e. how concerned are they with the environmental impact caused by the products they consume. This can be determined from the value of the comparison between customer interest

in environmentally friendly products to the overall existing product.  
 10. Recycling efficiency, namely the effectiveness of the recycling process in terms of the length of

time and costs incurred. Recycling efficiency can be determined by comparing the time and costs incurred for actual recycling against the time and costs incurred for planned recycling.

Table 1: KPI Supply Green Green Pespective.

No	KPI	Kode
1	Energy saving operation	G1
2	Waste disposition	G2
3	The use of material which can be recycled	G3
4	Cooperate with certified suppliers	G4
5	Environmental costs	G5
6	Air and water emission	G6
7	The use of substances that are not dangerous	G7
8	Frequency reduction for environmental accidents	G8
9	The level of customer interest in friendly environment products	G9
10	Efficiency of recycle	G10

### 3.2 KPI Grouping in the Balanced Scorecard (BSC) Perspective

The formulated KPIs are then grouped into a BSC perspective consisting of financial, customer, internal process business and learning & growth perspectives. This is done to make it easier to do a pairwise comparison of each indicator where the pairwise comparison is done for each KPI that is in the same group in the perspective of the BSC. Financial perspective is related to how to serve the shareholders who specifically use the measurement of cash flow, return on capital, sales and income growth. Customer perspective is related to the level of customer satisfaction that specifically adds measurements related to the level of damage, on-time delivery, warranty support, product development, and others derived from direct customer input and linked to company-specific activities. The internal perspective of business processes and learning and growth is related to the main competencies and areas of operating

excellence that have effective implementation as measured by productivity, cycle times, quality measurements, unproductive periods, various cost measurements and others that are input to this perspective.

The learning and growth perspective is related to continuous improvement and value creation that emphasizes measurements related to innovation and organizational learning to calculate performance in this dimension, leadership, technology, product development cycle times, improved operating processes, and others. The grouping of KPIs is done by matching the understanding of each KPI to the understanding and scope of each BSC perspective. In addition, the grouping also refers to several references related to the grouping of supply chain KPIs against the BSC perspective. This grouping can be done by structuring an integrated green supply chain performance appraisal model in a BSC perspective. The structure of the integrated green supply chain performance appraisal model can be seen in Figure 1.

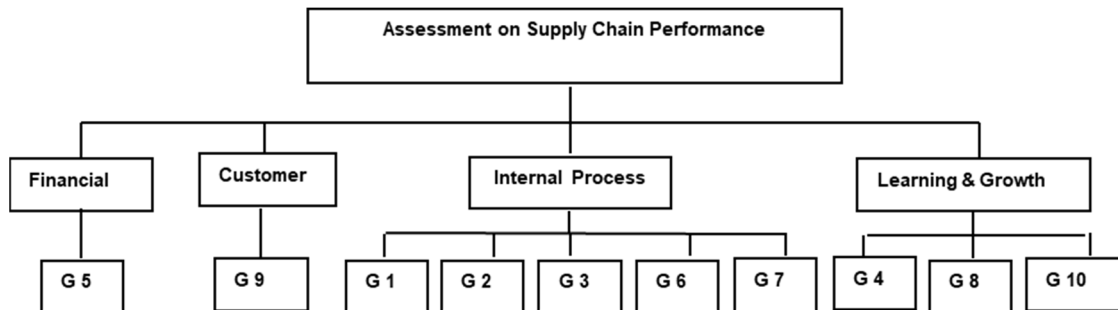


Figure 1: Structure of the integrated Green Supply Chain Performance Assessment Model in the BSC Perspective

### 3.3 Weighting of KPI

Weighting of KPI is done to determine the priority level and interest of each KPI towards other KPIs. This weighting is done by making a pairwise comparison among KPIs using a weighting questionnaire that is assessed by an expert at PT. TPL, academics in the field of green supply chain and pulp practitioners (distributors) of PT. TPL. This pairwise comparison value is processed with the help of expert choice software to determine the weight value of each KPI. The higher the weight value of a KPI, the higher the level of importance compared to other KPIs. The weight of each KPI can be accepted if the inconsistency ratio value is less than 0.1. The inconsistency ratio value shows the level of consistency of the expert in providing value from pairwise comparisons for each KPI.

#### 3.3.1 Indicator Weight in BSC Scope

The results of this weighting are obtained from pairwise comparisons between the four perspectives, namely financial perspective, customer, internal business processes and learning and growth using expert choice software. Weighting results can be seen in Table 2.

Table 2: Indicator Weight in BSC Scope.

No	KPI code	Definition	Score
1	F	Financial	0,162
2	C	Customer	0,487
3	IP	Internal Process	0,223
4	LG	Learning & Growth	0,127

#### 3.3.2 Weight Indicators on the Financial Perspective

The result of weighting in this financial perspective is obtained from pairwise comparisons between KPIs in a financial perspective using expert choice software. Weighting results in can be seen in Table 3.

Table 3: Indicator Score in Financial Perspective.

No	KPI code	Definition	Score
1	G 5	Environment Cost	0,1

#### 3.3.3 Indicator Weight on the Customer Perspective

The result of weighting on the customer's perspective is obtained from pairwise comparisons

between KPIs in the customer's perspective using expert choice software. Weighting results can be seen in Table 4.

Table 4: Indicator Score in Customer Perspective.

No	KPI code	Definition	Score
1	G 9	The level of customer interest to the product of friendly environment	0,1

#### 3.3.4 Indicator Weight on the Internal Process Business Perspective

The result of weighting in the internal business process perspective is obtained from a pairwise comparison between KPIs in the internal process business perspective using expert choice software. The results of this weighting can be seen in Table 5.

Table 5: Indicator Score in Internal Process Business Perspective.

No	KPI code	Definition	Score
1	G1	Energy saving operation	0,078
2	G2	Waste disposition	0,088
3	G3	The use of materials that can be recycled	0,099
4	G6	Water and air emission	0,106
5	G7	The use of substances that are not dangerous	0,094

#### 3.3.5 Indicator Weight in the Learning and Growth Perspective

The result of weighting in the learning and growth perspective is obtained from pairwise comparisons between KPIs in the learning and growth perspective using expert choice software. The results of this weighting can be seen in Table 6.

Table 6: Indikator Weight in Learning and Growth Perspectives.

No	KPI code	Definition	Score
1	G 4	Cooperate with certified suppliers	0,082
2	G 8	Frequency reduction for environment accident	0,262
3	G10	Recycle efficiency	0,154

**3.3.6 KPI Priorities based on Overall Weighting Results**

The weighting of the KPI as a whole is done by multiplying the weight of each KPI with the weight of the perspective where the KPIs are grouped. The overall KPI weighting results can be seen in Table 7, while the perspective of each KPI is determined which can be seen in Table 8. Based on the overall weight of each KPI, the KPI priority determination is then carried out starting from the KPI that has the highest weight to the KPI that has the lowest weight. KPI priorities can be seen in Table 9.

Table 7: Score on overall KPI.

No	KPI code	KPI score	Perspective	Overall Score
1	G 1	0,078	Internal Process & Business	0,017
2	G 2	0,088	Internal Process & Business	0,020
3	G 3	0,099	Internal Process & Business	0,022
4	G 4	0,082	Learning & Growth	0,010
5	G 5	0,333	Financial	0,054
6	G 6	0,106	Internal Process & Business	0,024
7	G 7	0,094	Internal Process & Business	0,021
8	G 8	0,262	Learning & Growth	0,033
9	G 9	0,257	Customer	0,125
10	G 10	0,154	Learning & Growth	0,020

Table 8: Perspective of each KPI.

No	KPI code	KPI score	Perspective	Score of KPI perspective	Overall Score
1	G 1	0,078	Internal Process & Business	0,104	0,017
2	G 2	0,088	Internal Process & Business		0,020
3	G 3	0,099	Internal Process & Business		0,022
4	G 6	0,106	Internal Process & Business		0,024
5	G 7	0,094	Internal Process & Business		0,021
6	G 4	0,082	Learning & Growth	0,063	0,010
7	G 8	0,262	Learning & Growth		0,033
8	G 10	0,154	Learning & Growth		0,020
9	G 9	0,257	Customer	0,125	0,125
10	G 5	0,333	Financial	0,054	0,054

Table 9: KPI Priorities.

No	KPI code	Definition	Score
1	G9	The level of customer interest in friendly environment products	0,125
2	G5	Environment cost	0,054
3	G8	Frequency reduction for environment accident	0,033
4	G6	Water and air emission	0,024
5	G3	The use of material that can be recycled	0,022
6	G7	The use of substances that are not dangerous	0,021
7	G2	Waste disposition	0,020
8	G10	Recycle efficiency	0,020
9	G1	Energy Saving Operation	0,017
10	G4	Cooperate with certified suppliers	0,010

Table 10: Structure of the supply chain performance measurement model.

No	KPI Code	Definition	Financial		Customer		Internal PB		Learning & Growth		Weight
			L	G	L	G	L	G	L	G	
1	G9	The level of customer interest in friendly environment products				X					0,125
2	G5	Environment cost		X							0,054
3	G8	Frequency reduction for environment accident								X	0,033
4	G6	Water and air emission						X			0,024
5	G3	The use of material that can be recycled						X			0,022
6	G7	The use of substances that are not dangerous						X			0,021
7	G2	Waste disposition						X			0,020
8	G10	Recycle efficiency								X	0,020
9	G1	Energy Saving Operation						X			0,017
10	G4	Cooperate with certified suppliers								X	0,010

Based on the structure of the model, it can be seen the priority order of all KPIs starting from the highest to the lowest based on the weight in BSC perspective. KPI with the highest priority means that this KPI is a critical KPI, namely KPI which has a major contribution to the overall supply chain performance. Based on this, the company can determine the right policies to achieve the effectiveness and efficiency of its supply chain.

### 3.4 Structure of the Supply Chain Performance Measurement Model

Green supply chain performance measurement model with a BSC perspective is designed in the form of metrics. These performance measurement metrics can be seen in Table 10. Customer perspective is a priority based on this research. This is evident from the three KPIs in the highest order of weight in the supply chain performance appraisal metric designed, namely quality improvement, level of customer satisfaction and level of customer interest in friendly environmental products.

In this case, it can be seen that important aspects which are prioritized by PT. TPL is the fulfillment of customer needs in accordance with the company's mission. When viewed in terms of green, the company also prioritizes cement as an friendly environmental product that is in demand by customers. This is also in accordance with the vision of the company "to be a reliable, superior and friendly environmental pulp industry".

### 3.5 Validation

Validation is a step that needs to be done to explain that the supply chain performance measurement model designed is feasible to be applied to a real system. The aspects considered in the model validation process are as follows:

1. KPI in accordance with the real conditions of PT. TPL and representative.
2. KPI contained in the model can be measured its performance in pulp supply chain activities.
3. The priority order of the KPI contained in the model is a KPI that truly becomes a critical indicator for the supply chain performance of PT. TPL.
4. The supply chain performance measurement model designed can be implemented in PT. TPL to measure the effectiveness and efficiency of pulp supply chains.

The validation results show that the supply chain performance measurement model designed is valid and can be accepted by PT. TPL. This model can be implemented to measure the performance of a company's supply chain. Performance measurement is carried out to see the effectiveness and efficiency of the supply chain. The priority aspect is the consumer aspect to increase value in order to achieve pulp consumer satisfaction. This is consistent with the results of determining priorities carried out on all KPIs. The third highest priority weighting value of all KPIs shows that improving the quality and level of customer satisfaction with environmentally friendly products must be a priority on the company's target. It is also recognized by the company that creating quality pulp with minimal

environmental impact is an important demand from current pulp consumers.

### 3.6 Model Implication

The implementation of the supply chain performance measurement model can be carried out through the following stages:

1. Collecting data related to KPIs according to the designed supply chain performance measurement model.
2. Making Standard Operating Procedure to measure the performance of the cement supply chain and make the forms needed in measuring and documenting the results of performance measurements.
3. Measuring the performance of the cement supply chain at PT. TPL and document the results of these performance measurements.
4. Determining the right policies on the supply chain performance of PT. TPL is based on the results of performance measurements that have been made for each KPI.

## 4 CONCLUSIONS

This research has produced a set of KPIs obtained from the integration of the green concept in the pulp supply chain at PT. TPL. The results of integration are as follows:

1. KPI Formulation of 10 green supply chain of KPIs. This KPI is an important indicator that can answer the needs of all stakeholders involved in the pulp supply chain at PT. TPL in terms of cost reduction and environmental impact.
2. KPI grouping in four BSC perspectives, namely financial perspective, perspective, internal business process and learning and growth perspective. The total of 10 KPI can be grouped, namely 1 KPI for financial perspective, 1 KPI for customer perspective, 5 KPI for internal business process perspective and 3 KPI for learning and growth perspective.
3. Determination of overall KPI priorities is done by sorting KPIs starting from those with the highest weight to the lowest weight. KPI which has the highest priority means that this KPI is a KPI that has a major influence on the performance of the company's supply chain. In this study, the customer perspective is the priority as evidenced from the 1 KPI in the highest order of weight in the valuation model.

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