

# Model of Warehouse Performance Measurement Based on Sustainable Warehouse Design

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**Abstract—** In sustainable supply chain management (SSCM), sustainability aspects, i.e. economic, social and environmental are integrated in managing supply chain. This concept has elicited government regulations that requiring every company to prevent the occurrence of environmental pollution. However, the concept of sustainability has not been implemented in operational processes of most industries in Indonesia particularly warehouse. This study aims to develop a model of warehouse performance measurement, to measure the warehouse performance, and to identify the indicators needed to be improved. The Balanced Scorecard (BSC) method with Sustainable Supply Chain Management (SSCM) approach is applied in developing the model. Balanced scorecard is a performance measurement method based on four perspectives: financial, customer satisfaction, internal process, and learning growth. BSC is appropriate for overcoming the problems related to performance assessment in SCs according to several researches. There are 12 indicators used in warehouse performance measurement, i.e. warehousing costs, labor cost, perfect quality items, on time delivery, inventory accuracy, environmental friendly tools, waste management, turn over, 5s implementation, worker competency improvement and environmental awareness. The warehouse performance measurement model based on sustainable warehouse design has been successfully demonstrated in medium scale textile industry.

**Keywords—** sustainable supply chain management, balance score card, warehouse performance measurement

## I. INTRODUCTION

The balance of raw material supplies with increased demand for products has led to the concept of sustainability. This concept is widely adopted in various management companies including in Supply Chain Management (SCM). Sustainable Supply Chain Management (SSCM) uses sustainability aspects: economic, social, and environmental in managing supply chain. The emphasis of the economic aspect is extended to integrate considerations of the social and environmental impacts of activity along the supply chain [1]. In SSCM, the management of financial flows, information and goods is conducted with two main focuses that are social and environmental aspects [2].

A framework of SSCM implementation comprises four categories to be developed, i.e., strategic considerations, functional decisions, government regulations and policies, and integration models and decision support tools [3]. There are

three types of SSCM configurations namely efficient, innovative, and reputable [4]. SSCM is efficiently managed based on pollution prevention strategies by minimizing waste and production emissions. Innovative SSCM is done by applying clean technology in SC operations. While the reputable SSCM use a good product management strategy by integrating all stakeholders. SSCM performance measurement consists of three important aspects: all stakeholders must have a commitment in green design, corporate sustainability, and strategic planning in managing the environment [5].

The Government of Indonesia have implement the regulation UU no. 3 Year 2014 for the industry's operation should consider the environmental aspect [6]. In essence, every company in the industrial field has an obligation in preventing the occurrence of environmental damage and pollution. Immediate implementation of SSCM conducted by the government makes the company is required to integrate the environmental aspect in the business process.

Warehouse system is an important part in SSCM that serves to balance the flow of goods between suppliers and consumers [7]. However, the warehouse operational process is still traditionally managed which raises the risk of high operational costs and the risk of loss of goods and investment [8]. The average cost incurred in warehousing is relatively high that is 17% of total logistics activities [9]. Another stated that warehouse is one of the most critical functions in a supply chain as it accounts for 24% of logistical costs [10].

Most researches on SSCM discussed green warehousing system. Implementation of green warehousing in the public and private logistics sector in Sri Lanka shows several areas such as distribution, reverse logistics, purchasing, packing and waste processing [11]. Also, it has been applied in furniture companies in Finland with qualitative research and interview approach using two indicators, i.e., energy efficiency and waste management [12].

Firms are now under pressure of the mandate of sustainability from Governments, general public, social workers, environmentalists, employees, and customers and consumers [10]. In order to remain competitive in an increasingly socially responsible world, companies are directing to introduce the sustainability concept in their supply chains. Textile industry is one of the Indonesian government's priority industries in 2015-2035 [6]. In fact, a sustainable

warehousing (SWH) has not been considered in this industry. Yet, warehousing has received less attention from researchers and practitioners while it holds tremendous potential to achieve the goals of sustainable development [10]. According to a brief literature review, there are various areas affected by warehouse operations. The outputs of operations not only affect the company but also the local environment and society in the form of atmospheric emissions, waste, congestion, noise pollution, accidents, water, burden on public transport, etc. [10]. Therefore, in order to improve its warehouse sustainability performance, especially medium-scale textile industry, this study is conducted. It is to develop a model of warehouse performance measurement. Then, the model is employed in a medium-scale textile industry to measure the performance of its warehouse as well as to identify the indicators to be improved.

## II. BASIC THEORY

### A. Sustainable Warehouse

Sustainable warehouse is an important part of SSCM which includes the process of receiving, storing, retrieving and shipping of raw materials, work in process or final products. In sustainable warehouses, companies not only consider financial factors such as ordering costs and holding costs, but also maintain a balance of the warehouse's operational impact on the surrounding social and environment [13]. A balance between economic, social and environmental factors must be maintained because one factor with another can impact each other. For example, there are three types of activities to reduce the environmental impact of warehouse operations, i.e. tree planting, carbon credits and modification of material handling devices. All these activities will increase the warehouse operating costs, so that the allocation of funds for employee training and some other investments will be reduced.

### B. Balanced Score Card (BSC)

Sustainable warehouse is an important part of SSCM which includes the process of receiving, storing, retrieving and shipping of raw materials, work in process or final products. In sustainable warehouses, companies not only consider financial factors such as ordering costs and holding costs, but also maintain a balance of the warehouse's operational impact on the surrounding social and environment [13]. A balance between economic, social and environmental factors must be maintained because one factor with another can impact each other. For example, there are three types of activities to reduce the environmental impact of warehouse operations, i.e. tree planting, carbon credits and modification of material handling devices. All these activities will increase the warehouse operating costs, so that the allocation of funds for employee training and some other investments will be reduced.

The Balanced Scorecard (BSC) is an assessment method that balances four measurement perspectives, i.e. financial perspective, customer perspective, internal business process perspective and learning and growth perspective [14]. Kaplan and Norton have developed nine steps to create and implement the Balanced Scorecard in an organization, i.e. [15]:

- Conduct an overall organization estimation.

- Identify strategic themes.
- Define strategic perspectives and targets.
- Develop a strategy map.
- Create a performance matrix.
- Prioritize initiative strategies.
- Communicating strategy.
- Implement Balanced Scorecard.
- Collect data, evaluate and make improvements

## III. RESEARCH METHOD

Research on the model development of warehouse management system performance measurement of based on sustainable warehouse design is done on medium scale textile industry in Central Java, Indonesia. The sample in this study are some warehousing experts and practitioners in medium textile industry sector in Central Java. So it can be assumed that the respondent is able to evaluate warehouse performance. There are four main stages in this research, i.e.:

- Preliminary Research

The literature study and observation are done to get an idea about the problems of warehousing and SSCM implementation in textile industry.

- Model Development

The company's vision, mission, strategy and strategic objectives are identified. Then warehouse performance indicators based on SSCM are developed using four perspective of balanced scorecard, i.e. financial, customer, internal business process, learning and growth perspective. This process is done with two stages of focus group discussion with practitioners and related field experts.

- Warehouse Performance Measurements

The measurement stage includes the measurement and assessment of warehouse performance using the measurement model matrix that already developed. For this research, the warehouse performance measurement is done for period 2017.

- Analysis

The analysis includes performance measurement system analysis and interpretation of the achievement result of warehouse performance based on sustainable warehouse design.

## IV. RESULT AND DISCUSSION

The performance measurement model of warehouse management system based on sustainable warehouse design using BSC method is developed based on the vision and mission of the industry. The textile industry that studied in this research have a vision of becoming a global company in textile industry that always make continuous improvement in quality, safety and security aspects as well as legality with orientation on mutual internal and external long term relationship. While the company's mission is to increase productivity, employee competency development, machine maintenance and repair and management systems are controlled, scalable and directed to meet consumer requirement. There are 12 indicators for the

warehouse performance model based on sustainable warehouse design using BSC method that successfully developed as shown in Table I.

#### A. Financial Perspective

In a financial perspective, the things to consider are what factors affect the cost for each time the process is done.

- Warehousing Cost

All cost involved in a warehouse should be controlled using this indicator. The cost consist of operation, labor, facility and administrative cost.

- Labor Cost

Labor cost consist of any cost related to labor activities to support warehouse operation, i.e. receiving, storing and loading the goods for delivery.

TABLE I. WAREHOUSE PERFORMANCE MATRIX BASED ON SUSTAINABLE WAREHOUSE DESIGN

Code	SSCM Indicators	Key Performance Indicators	Calculation
F1	Economic	Warehousing costs	Total warehousing cost per unit in this year-prior year/ prior year x 100
F2	Economic	Labor cost	Labor cost per unit in this year-prior year/ prior year x 100
C1	Economic	Perfect Quality Item	Number perfect quality item/ total item x 100
C2	Economic	Ontime Delivery	Number ontime delivery/ total delivery x 100
IP1	Economic	Inventory Accuracy	Inventory record/ actual x 100
IP2	Environmental	Environmental Friendly Tools	Number of environmental friendly tools/ all tools x 100
IP3	Environmental	Waste Management	Number of reduce, reuse, recycle activities
LG1	Social	% Turn Over	Number of fired worker/ total workers x 100
LG2	Environmental	5S Implementation	Number of 5s activity
LG3	Social	Worker Absent	Number of days of workers absent per period
LG4	Social	Worker Competency Improvement	Number of training per period
LG5	Environmental	Environmental Awareness	Number of environmental training per period

Note: F = Financial Perspective, C = Customer Perspective, IP = Internal Perspective, LG = Learning and Growth Perspective

#### B. Customer Satisfaction Perspective

In the perspective of the customer, things to be considered is the process that is directly related to the customer. Because the object of this research is done on raw material warehouse, then the customer is production department.

- Perfect Quality Item

Perfect quality item is the accuracy of the quality of raw materials in the warehouse. The purpose is to make comparative study of good quality raw materials with total raw materials.

- Ontime Delivery

The purpose of this indicator is to know how much the delivery time of raw materials from the warehouse to the production department.

#### C. Internal Process Perspective

The Balanced Scorecard in this perspective enables managers to measure how well the business is running and whether the products and or services conform to specifications.

- Inventory Accuracy

Calculation of the data accuracy level of goods in the warehouse is needed to minimize the error of inventory data.

- Environmental Friendly Tools

The use of environmental friendly tools is needed to minimize the environmental impact of the warehouse operations process.

- Waste Management

In waste management indicators, a waste management strategy is implemented. In this indicator, calculated based on waste elimination activities that have been done in raw material warehouse.

#### D. Learning and Growth Perspective

This process identifies the infrastructure that the company must build to promote long-term growth and performance. This learning and growth process is derived from human resources factors, systems, and organizational procedures. Included in this perspective is employee training and corporate culture that deals with individual and organizational improvement.

- % Turn Over

Turn over here is the ratio of raw material warehouses that resign from the company. The purpose of this calculation is to lower the turnover rate within the warehouse.

- 5S Implementation

The application of 5S (sort, store, shine, standardize and sustain) is used to improve environmental quality in warehouse. The purpose of this calculation is to know the number of 5S implementation activities that have been implemented in the warehouse.

- Worker Absent

Percentage of worker attendance is used to measure the absenteeism of workers or employees due to sickness, leave, alpha and permits in 1 period.

- Worker Competency Improvement

In improving the skills of warehouse workers, training is needed for warehouse workers. This training aims to improve the quality and expertise of warehouse workers.

### • Environmental Awareness

In improving the skills of warehouse workers, training is needed to raise awareness of warehouse workers about the importance of maintaining the environment.

Based on the sustainable warehouse performance measurement model that already developed, there are 7 indicators that have met the company target in 2017 as shown in Table II. While the other five indicators have not met the target, i.e. warehousing cost, labor cost, inventory accuracy, waste management and 5s implementation.

Total percentage of warehouse performance can be calculated using percentage of number of key performance indicators that reach the target divided by total key performance indicators [16]. The result is 58% indicating that raw material warehouse performance have good enough standard. To improve warehouse performance in the next period, it is necessary to improve the five indicators that are considered more important for improvement. For economic indicators, it is necessary to increase the productivity of warehouse workers so that labor cost per unit can be lowered. For social indicator, all target already achieved for 2017 so it needs to be maintained. For environmental indicators, improvements should be made to the 5S implementation indicators. Improvements that can be made include the addition of SOPs on 5S and 5S poster to standardize. As for the sustain aspect, it is necessary to audit 5S periodically every year.

TABLE II. WAREHOUSE PERFORMANCE RESULT BASED ON SUSTAINABLE WAREHOUSE DESIGN

Code	SSCM Indicators	Key Performance Indicators	Target	Actual Performance
F1	Economic	Warehousing costs	15%	23%
F2	Economic	Labor cost	15%	25%
C1	Economic	Perfect Quality Item	95%	97%
C2	Economic	Ontime Delivery	95%	95%
IP1	Economic	Inventory Accuracy	99%	97%
IP2	Environmental	Environmental Friendly Tools	20%	20%
IP3	Environmental	Waste Management	12 activities	4 activities
LG1	Social	% Turn Over	5%	4%
LG2	Environmental	5S Implementation	5S	3S
LG3	Social	Worker Absent	24 days	20 days
LG4	Social	Worker Competency Improvement	2 per year	2 per year
LG5	Environmental	Environmental Awareness	1 per year	1 per year

### V. CONCLUSION

Development of performance measurement model of warehouse management system based on sustainable

warehouse design have been successfully done and implemented in medium scale textile industry. There are 12 indicators used in the warehouse performance measurement, i.e. warehousing costs, labor cost, perfect quality items, ontime delivery, inventory accuracy, environmental friendly tools, waste management, turnover, 5s implementation, worker absent, worker competency improvement and environmental awareness. Based on the model implementation, it is found that the total percentage of warehouse performance based on sustainable warehouse design is 58% indicating that raw material warehouse performance have good enough standard. There are five indicators that need to be improved, i.e. warehousing cost, labor cost, inventory accuracy, waste management and 5s implementation.

### ACKNOWLEDGMENT

Researchers thank to the support of Industrial Engineering Department, Faculty of Industrial Technology, Universitas Islam Indonesia.

### REFERENCES

- [1] M. Tseng, "Modeling the sustainable production indicators in linguistic preferences", *J. of Cleaner Production*, Vol. 40, 2013, pp. 46.
- [2] F. Teuteberg and D. Wittstruck, "A systematic review of sustainable supply chain management research", *MKWI*, 2010, pp. 1001.
- [3] V. Gupta, N. Abidi, A. Bandhopadhyay, "Supply chain management-a three dimensional framework", *J. of Management Research*, Vol. 5, no. 201376, <https://doi.org/10.5296/jmr.v5i4.3986>
- [4] SM. Masoumik, SH. Abdul Rashid, EU. Olugu, RAR. Ghazilla, "Sustainable supply chain design: a configurational approach", *The Scientific World J.*, 2014, <http://dx.doi.org/10.1155/2014/897121>
- [5] M. Tseng, M. Lim, WP. Wong, "Sustainable supply chain management: a closed-loop network hierarchical approach", *Industrial Management & Data Systems*, Vol. 115, 2015, <https://doi.org/10.1108/IMDS-10-2014-0319>
- [6] Kementrian Perindustrian Republik Indonesia, "Penyusunan rencana pembangunan industri di daerah", *FGD RPIP*, Sumatera Utara, Medan, 2017.
- [7] A. Ramaa, KN. Subramanya, TM. Rangaswamy, "Impact of warehouse management system in a supply chain", *International J. of Computer Applications*, Vol. 54, 2012, pp. 14.
- [8] N. Younis, RAK. Naseeb, U. Kausar, "Warehouse management system as locomotive of supply chain management: some evidences from united kingdom manufacturing sector", *International J. of Management Sciences and Business Research*, Vol. 2, 2013, pp. 85.
- [9] JH. Havenga, ZP. Simpson, A. De Bod, NM. Viljoen, "South Africa's rising logistics costs: an uncertain future", *J. of Transport and Supply Chain Management*, Vol. 8, 2014, pp. 55. <http://dx.doi.org/10.4102/jtscm.v8i1.155>
- [10] Amjed, TW., and Harrison, NJ., "A model for sustainable warehousing: from theory to best practices", *Asia Pacific DSI Conference Proceedings*, Decision Sciences Institute, 2013.
- [11] RDCP. Indrasari and WL. Rathnayake, "Analysis of green warehouse practices in Sri Lanka", *Proceedings of 8th International Research Conference*, 2015.
- [12] M. Luu, "Developing the implementation of green warehousing at IKEA Finland", *Bachelor's Thesis Degree Programme*, International Business, Haaga-Helia, 2016.
- [13] KS. Tan, MD. Ahmed, D. Sundaram, "Sustainable warehouse management", *Proceeding of The International Workshop on Enterprises & Organizational Modeling and Simulation*, Vol. 8, 2009, doi>10.1145/1750405.1750415

- [14] R. Kaplan and D. Norton, "The balanced scorecard: translating strategy into action", Harvard Business School Press, Boston, 1996.
- [15] M. Isoraite, "The balanced scorecard method: from theory to practise", Intellectual Economics, 2008.
- [16] Anggraini, I., Nurkholis, "Analisis Pengukuran Kinerja Perusahaan Dengan Pendekatan Balanced Scorecard (Studi Kasus PT Rajawali I Unit PG Kreet baru)", Universitas Brawijaya, 2014.