Design Key Performance Indicator for Sustainable Warehouse: A Case Study in a Leather Manufacturer

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Abstract. This research discussed the design of Key Performance Indicators (KPIs) for sustainable warehouse for leather manufacturing industry. A thirty-four indicators are found from literature study and validated by experts using likert scale. A number of 30 KPIs are declared valid then suggested to be KPIs for sustainable warehouse for leather manufacturing industry. The KPIs consisted of 12 economical indicators, 10 social indicators and 8 environmental indicators. To find out the priority of each KPIs, then their importance weight are identified using analytical hierarchy process (AHP) by sending AHP questionnaire to experts. The result shows that Economical factor is the most dominant factor (0.4796) followed by social factor (0.4055) and environmental factor (0.1150). The KPIs and its weight can be used as guidance for leather manufactures to increase their sustainable performance.

1. Introduction

Warehousing is one of the toughest thing in supply chain for its contribution which up to 24% from logistic cost [1]. Copra et al., define warehousing as the space for material storing (packing, finished goods, and raw materials) and also referred to as logistics service centre. Warehouse has a bigger role based on value added operations, customization services and appropriate customer order fulfilment [2]. The interest in performance analysis and measurement in warehousing is growing because it support the development of decision support systems for corporate design, planning and management. Performance measurement system can be defined as a set of metrics that can be used to measure both efficiency and effectiveness of actions [3]. Efficiency and effectiveness are most widely used as performance measurement in warehousing [4], [5].

Sustainability is ability to manage economic, social and environmental performance, and at the same time become more important in warehousing management. Since sustainability aspect in warehousing got less attention, therefore this become a challenge. Measuring sustainability is very important in modern supply chain management and now days it is integrated in Performance Measurement and Management Systems (PMMS) for Supply Chain Management [6].

Warehousing management becomes very important in logistics system [7]. Good warehouse management contributes to costs and quality both in terms of customer service and output products [8]. Sustainability raises new opportunity to seeing and examining the value in each process [9]. It is very necessary to look at the environment, social and economic factors in warehousing to get sustainable results [10]. Therefore this research focus on sustainability performance measurement in warehousing. This performance measurement can be used to increase warehouses effectiveness and efficiency.
Performance measurement is useful for managers to take some corrective actions based on periodic reviews [11]. Based on literature reviews in warehouse performance measurement, there are a lot of models and indicators to measure existing warehousing performance, which differ in terms of time, cost, quality, and productivity dimensions [12]. Warehouse measurement which consider social, economic and environment aspect is still limited and becomes something new in sustainable warehousing performance [13]. Sustainability can help companies to maintain their environment and also protect human rights and also providing social responsibility [14]. Sustainability performance measurement can influence decision making and drive achievement of company goals [15].

There are six important process in warehouse need to be considered in warehouse performance measurement, i.e. picking, print label, packing, tracking, delivery time, and return process [16]. This study adopted indicators that has been carried out by [14], [18]-[23]. These indicators are then selected according to the principles and criteria of sustainability in leather warehouse in Yogyakarta, one of province in Indonesia. In order to determine the importance weight of the KPIs, the Analytical Hierarchy Process (AHP) method is employed.

2. Methodology
There are three stages in identifying KPIs. The first step is to identify the sustainability of KPIs based on literature. The second step is to validate the KPIs according to condition in the leather warehouse through expert’s surveys. The third step is to determine the importance weight of KPIs by using Analytical Hierarchy Process (AHP) based on experts preferences. The results of this study are a set of KPIs that can be used to measure the sustainability index of a leather warehouse.

3. Result and Discussion
3.1. Identifying KPIs from literatures and experts
This research began by identifying KPI from literatures and the result is evaluated by expert. There are five experts (expert is someone who has comprehensive knowledge or skills in warehousing for more than 7 years) to give opinions on the importance level of KPIs. The experts are from several positions including Procurement/Supply Chain Manager, Logistic Supervisor, Warehouse Staff (Receipt / Expenditure), Inventory Staff, Warehouse Administration Staff. They are asked to weigh the importance of KPI using Likert scale with a range of 1 to 5 (from very unimportant to very important). From 34 KPIs, there are 30 KPIs which are declared valid with an average value of 3. KPIs i with an average value of less than 3 will be omitted because it is considered insignificant as shown in Table 1.

3.2. Determining KPIs important weight using Analytical Hierarchy Process (AHP)
Each KPI has different contribution to warehouse performance, therefore to find out the priority contribution of each KPIs, then their importance weight are identified using analytical hierarchy process (AHP) by sending AHP questionnaire to five experts. The result of AHP is summarized on Figure 1. This result is considered valid because the value of consistency ratio are less than 0.1.

Analytic Hierarchy Process (AHP) was first introduced by Thomas L. Saaty in 1971 and became a method of decision making in complex problem solving. The AHP method is designed to find solutions for complex problems with many criteria into multiple domains. AHP is a very important tool for practitioners and academics to conduct and measure management theory [24].

Cheng et al., said that AHP has several benefits. First, it helps to solve an unstructured problem into a rational decision-making hierarchy. Second, it shows a lot of information from experts and decision-making with paired comparisons of various individual groups. Third, to measure the level of importance of each element needs to have calculation producer, standard of consistency to validate the consistent ranking from experts and decision makers.
| Factor                              | Metric                             | Reference                           | Description                                                                                                                                                                                                 | Mean |
|------------------------------------|------------------------------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| Economic                           | Layout Configuration (LC)          | Yayyab Wakas Amjed & Norma J Harrison[14] | Design made to produce minimum travel distance for warehouse operations, such as equipment selection, operational strategy, aisle’s width, etc.                                                                 | 4.5  |
| Storage Sistem (SS)                |                                    | Yayyab Wakas Amjed & Norma J Harrison[14] | Part of the warehouse layout design that is used to keep goods or materials in various types, shapes and sizes, which related to the physical design of the system and performance attributes such as storage capacity, ease of access, space utilization, and storage policies. | 4.0  |
| Order process on time              |                                    | Yayyab Wakas Amjed & Norma J Harrison[14] | The process or workflow associated with taking up, packing, and shipping of goods that are packaged and delivered on time.                                                                                         | 4.5  |
| Inventory Optimization             |                                    | Yayyab Wakas Amjed & Norma J Harrison[14] | Inventory items optimization is very important for achieving sustainability goals because it is related with lead times filling, forecasting, visibility, inventory prices in the future, available warehouse spaces, customer returns, obsolete inventory, recorded costs, supply quality. | 3.5  |
| MHE Maintenance and Servicing (MMS)|                                    | Yayyab Wakas Amjed & Norma J Harrison[14] | MHE maintenance and service is carried out so that forklift truck can work with optimum efficiency. Maintenance is done to avoid fuel or battery leakage, damaged over pressure tires, misalignment, loose screws, unnecessary friction. | 4.0  |
| Inbound Processes (IP)             |                                    | Yayyab Wakas Amjed & Norma J Harrison[14] | The inbound processes consists of unpacking, receiving, reworking and sending the goods after inspecting the compatibility with quality standards.                                                                   | 4.5  |
| Factor                          | Metric                      | Reference                                    | Description                                                                                                                                                                                                 | Mean |
|--------------------------------|-----------------------------|---------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| Storage Processes (SP)         | Yayyab Wakas Amjed & Norma J Harrison[14] | Storing process consists of activities which started with arranging the pallet in storing space and ended when they are taken to be stored. The activities are pallet orientation, stacking, utilizing efficient storing slots, pallet relocation, and inventory calculation. | 3.5  |
| Outbound Processes (OP)        | Yayyab Wakas Amjed & Norma J Harrison[14] | Outbound processes related to stock movements aimed at fulfilling customer orders including adjusting or packaging products into a new form (standard), to meet specific customer / business / market needs. | 4.5  |
| Work In Process               | Faulkner et.al[18]          | Inventory of in-process goods, in this case can be in form of fresh cluster of fruit, loose fruit or CPO. | 4.5  |
| Cost Associated with EHS       | Veleva et.al[19], Bai & Darkis[20] | Incurred cost related to environment, health and safety. | 4.0  |
| Shipping Cost Per Customer     | Frazelle[17]                | Shipping cost to customers. | 3.5  |
| Order Picking                 | Frazelle[17]                | Product drawing from storage. | 4.5  |
| Environment                    | Physical Load Index         | Faulkner et.al[18]                          | Sport load index carried out by employees | 2.5  |
| Daylight Usage (DU)            | Yayyab Wakas Amjed & Norma J Harrison[14] | Fas Warehouse facilities allow maximum daytime use. Entry points for sunlight are usually windows, entrances and roof space | 3.5  |
| Temperatur Control (TC)        | Yayyab Wakas Amjed & Norma J Harrison[14] | Warehouse temperature needs to be controlled to keep the product in prime condition. Temperature reduction will help to save energy and keep the environment safe | 4.5  |
| Water Consumption (WC)         | Yayyab Wakas Amjed & Norma J Harrison[14] | Water consumption in warehousing for toilet, landscaping, kitchen, cooling system. Water can be conserved through sophisticated roof designs to collect rainwater. Water reserved by using brown and | 4.0  |
| Factor                          | Metric                                    | Reference                                      | Description                                                                                                                                                                                                 | Mean |
|--------------------------------|-------------------------------------------|-----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| Noise Pollution (NP)           |                                            | Yayyab Wakas Amjed & Norma J Harrison[14]     | green roofs, roof drainage techniques, water irrigation technology and modern sanitation equipment. Noises related to transportation, fleet management, and noise pollution. The choice of the location and situation of the building, the use of green roofs that absorb sound transmission and the use of photovoltaics (PV) to convert sunlight into electricity also can reduce noise. | 4.0  |
| Cross-Docking Facility (CFD)   |                                            | Yayyab Wakas Amjed & Norma J Harrison[14]     | Warehouse process where the products are directly transferred from inbound to outbound area, and reconfigured in accordance with customer’s wish (goods transit facility)                                                   | 4.0  |
| Warehousing Strategy and Roadmap (WSR) |                                      | Yayyab Wakas Amjed & Norma J Harrison[14]     | The use of WMS, road maps and strategic planning helps to avoid congestion, performance monitoring, to do comparative analysis, to set future targets, as a benchmark for industry standards, to do simulations.                  | 3.5  |
| Electrical System Hazard       |                                            | Faulkner et.al. [18], Bai & Darkis[20]        | Disturbance caused by electrical system                                                                                                                                                                       | 4.5  |
| Energi Storage system          |                                            | Tan et al[22]                                 | Energy saving system                                                                                                                                                                                          | 4.0  |
| Renewable Energy Sources       |                                            | Yayyab Wakas Amjed & Norma J Harrison[14]     | Energy collected from renewable resources, which naturally recharged in human timescale such as sunlight, wind, rain, ocean wave, and geothermal heat                                                                 | 2.5  |
| Carbon absorption by trees     |                                            | Tan et al[22]                                 | Carbon control by reforestation (planting trees)                                                                                                                                                               | 2.5  |
| Social Shifts Roster (SR)      |                                            | Yayyab Wakas Amjed & Norma J Harrison[14]     | System application to identify fatigueness, tasks planning to avoid fatigueness accumulation, to provide many opportunities for fatigueness recovery                                                                 | 4.0  |
| Factor                          | Metric                                      | Reference                        | Description                                                                                                                                                                                                 | Mean |
|--------------------------------|---------------------------------------------|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|                                | Utilisation which considers the effectiveness and efficiency of space usage | Tan et al[22]                   | Utilization that considers space effectiveness and efficiency                                                                                                                                              | 3.0  |
| General Training (GT)          |                                              | Yayyab Wakas Amjed & Norma J Harrison[14] | Warehouse staff training to ensure safety and efficient warehousing operations, such as safe and efficient use of MHE, manual handling, hazardous substance neutralizer, personal hygiene, stress and fatigue management, emergency escape, warehouse operations, storage equipment audit, MHE maintenance, stock quantity, dealing with spills and ruptures, utilization of firefighting equipment, etc. | 3.5  |
|                                | Occupational Health and Safety (OHS)        | Yayyab Wakas Amjed & Norma J Harrison[14] | Occupational Safety and Health (OSH) related with illness and injury at work, including all forms of work that are not paid or paid for in all environments.                                                   | 4.5  |
|                                | Emergency Room (ER)                         | Yayyab Wakas Amjed & Norma J Harrison[14] | Emergency Room facilities, doctors, nurses, and medicines must be available.                                                                                                                                  | 4.5  |
|                                | Performance Measurement (PM)                | Yayyab Wakas Amjed & Norma J Harrison[14] | Performance Measurement (PM) is done to track every Key Performance Indicator (KPI) to measure the performance and identify the way for more improvement                                                                 | 4.0  |
|                                | Job satisfaction                            | Tan et al[22]                    | Working satisfaction is developed when individual needs have fulfilled, also related to the degree of employee’s likes and dislikes                                                                                        | 4.5  |
|                                | Wage                                        | Tan et al[22]                    | Wages given to employees                                                                                                                                                                               | 3.5  |
|                                | Number of employees                         | Tan et al[22]                    | To make sure that employees are not overworking                                                                                                                                                          | 3.5  |
|                                | Driver/Operator Training                    | Yayyab Wakas Amjed & Norma J Harrison[14] | To make sure operator’s productivity and effectiveness and their advanced capability.                                                                                                                      | 4.5  |
|                                | Average Length of Service of Employees      | Veleva et al[19], Hall et al[21] | Employee’s average length of service                                                                                                                                                                       | 4.0  |
Based on the result, the most importance weight for sustainable warehouse is Economic (0.4796) followed by Social (0.4035) and Environmental (0.11). Indicators of processing order on time is consider to be highest priority in economic, while occupational health and safety is the most important KPIs in Social. Indicator of energy storage system is the highest ranking in environmental aspect. By focusing to each indicators that have higher impact could lead to increasing warehouse sustainability performance.

4. Conclusion

This study found 30 KPIs valid for sustainable warehouse performance. The KPIs consist of 12 Economic indicator, 10 Social indicators and 8 Environmental indicators. To find out the importance weight of each KPIs, then Analytic Hierarchy Process (AHP) is conducted by sending questionnaire to five expert. The result of AHP analysis shows that Economic factor is the most dominant (0.4796) follow by Social factor (0.4055) and Environmental (0.11). This result could be employed as a guidance for improving sustainable warehouse performance.

References

[1] Speh T W 2009 Ackherman. Warehouse Forum. 4.
[2] Baker P and Canessa M 2009 Eur. J. Oper. Res. 193 425–36.
[3] Neely A, Gregory M and Platts K 2005 Int. J. Oper. Prod. Man. 25 1228–63.
[4] Ammons D N 1995 Public. Admin. Rev. 55 37–47.
[5] Kusrini E, Subagyo and Masruroh N A 2014 Int. J. of Eng. Buss. Man. 6.
[6] Hassini E, Surti C and Searcy C A 2012 Int. J. Prod. Econ. 140 69–82.
[7] Jokisalo J, Kurnitski J, Korpi M, Kalamees T and Vinha J 2009 Build. Environ. 44 377–87.
[8] Ackah M R and Erick E G 2016 Dama Int. J. of Res. 1 17–27.
[9] Seuring S, Sarkis J, Müller M and Rao P 2008 J. Clean. Prod. 16 1545–51.
[10] Seuring S 2013 Decis. Support. Syst. 54 1513–20.
[11] De Koster M B M and Warffemius P M J 2005 Int. J. Prod. Man. 25 762–80.
[12] Staudt F H, Alpan G, Mascolo M and Rodriguez C M T 2015 Int. J. Prod. Res. 53 5524–44
[13] Miller G, Pawloski J and Standridge C R A 2010 J. of Industrial Eng. and Man. 3 11–32.
[14] Tayyab W A and Harrison N J 2013 Int. DSI and Asia Pacific DSI Conf. proceedings. 28 1892–919.
[15] Ingrida B and Griedre V 2014 Procd. Soc. Behv. 156 605–11.
[16] Keebler J S and Plank R E 2009 Benchmarking: An Int. Journal. 16 785–98.
[17] Frazelle E H 2002 McGraw-Hill New York Journal of business and management 5 1
[18] Faulkner W, Badurdeen F, Templeton W and Gullet D 2016 Proc. of the 2012 Int. Conf. on
Industrial Engineering and Operation Management 2 6
[19] Bai C and Sarkis J 2014 Determining and applying sustainable supplier key performance
indicators Supply Chain Management: An Int. J. 19 275–91.
[20] Hall J, Matos S and Silvestre B 2012 Int. J. Prod. Res. 50 5
[22] Tan K, Ahmed D and Sundaram D 2010 Buss. Proc. Man. J. 16 871–86.
[23] Magdalena F, Marta B, Jacek N, Marek T and Justyna P 2018 Microchem. J. 142 126–34.
[24] Chopra S and Meidl P 2007 Supply chain management: Strategy, planning & operation 3rd ed
(Pearson Prentice Hall, NJ) 42.