Green warehouse performance monitoring system design using analytical hierarchy process and supply chain operation reference

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ABSTRACT

The use of logistics service providers in Indonesia progressively increasing from year to year, especially XYZ company as warehouse service providers with main activity are product distribution and storage of finished good. Currently, the XYZ company uses a web-based system to record products in warehouse activities, but this system has not been able to measure and evaluate warehouse performance. In addition, the company has large operating cost caused by product handling costs and warehouse operating costs. In this study, a monitoring system was designed that can measure and evaluate warehouse performance to be a sustainable warehouse. Therefore, this study integrates Supply Chain Operation Reference (SCOR) and Analytical Hierarchy Process (AHP) by considering green warehousing criteria. The weighting of importance level of each criteria using AHP method results in make criteria getting a weighted score (0.421), plan (0.213), deliver (0.152), source (0.119), return (0.064), and environment (0.032). The results of the scoring system using OMAX show that 7 KPIs are included in the green category, yellow category (11 KPIs), and red category (10 KPIs). Total value the company's green warehouse performance index is 11.15 which indicates that overall warehouse performance has not reached expected performance based on Traffic Light System Method.

1. Introduction

Third party logistics (3PL) warehouses play a role in various logistics activities, including goods delivery, storage, assembly, loading, labeling, repackaging, and distribution [1]. 3PL warehouse has an important role for manufacturing companies, therefore each company competes to have their respective advantages [1] with strategic steps, namely monitoring the achievement of company performance in order to compete with other companies in the industry [2]. XYZ company is a Third Party Logistics (3PL) which is main activity product distribution and storage of finished goods that used a web-based system to record products in inbound and outbound activities, but this system has not been able to measure and evaluate warehouse performance. In addition, the company has large operating costs, these costs apart from product handling costs and large warehouse operating costs.

Based on the description above, in this study a green warehouse performance monitoring system was designed by using research data from [3]. The monitoring system will function as a web-based system that supports companies in measuring and evaluating warehouse performance by consider green factor which is expected to reduce company operating costs and can support government

policies in realizing green industry regulated in Law No. 3 of 2014 concerning the industrial sector [4].

To measure and evaluate company performance, SCOR model approach is used which serves to identify KPIs for each warehouse activity, the KPIs will be weighted using AHP and OMAX methods to determine level of importance of KPIs to level of company productivity. Afterward, it will be evaluated using traffic light system method to show KPIs that need to be improved. After measuring and evaluating, a monitoring system wills be designed according to the company's needs to support corporate decision making.

2. Method

In this study, a conceptual model illustrates a brief outline of which will be to conduct research on design of measurement and evaluation of warehouse performance considering green factors based information systems. In the following figure shows steps in completing research that can be seen in Figure 1. below.

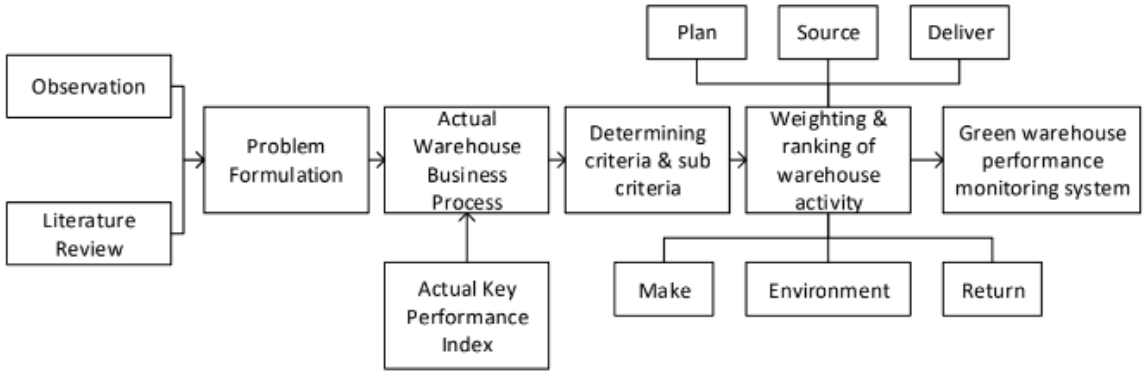

Fig. 1. Research Methodology

In the preliminary stage, problems are described to make it easier to understand the background of problem and topics raised through various references to journals and books. To better understand the problems in the company, field observations were made by conducting interviews and discussions with the warehouse division in the logistics service outsourcing industry. The literature review is a method used to obtain data by studying literature in the library and by reading other information data sources related to discussion. Based on elaboration of the problem in previous chapter, a problem-solving methodology was prepared with first step of determining actual warehouse business process and also criteria and sub-criteria for green warehouse KPI based on warehouse business process.

Furthermore, criteria and sub-criteria are weighted based on stakeholder assessment using the AHP method, and level of productivity is calculated using the OMAX and TLS models that have been done in research [12]. After calculating level of importance of criteria and sub-criteria, a green warehouse performance monitoring system is designed to make it easier for users to monitor the company's performance in real time using UML diagram.. To design a monitoring system, there are several diagrams was developed, namely use case diagrams, activity diagrams, and sequence diagrams.

2.1. Green Warehouse

Green warehouse is used to demonstrate a managerial concept that integrates and implements environmentally friendly operations with aim of reducing harmful emissions, reducing resource consumption, and increasing the ecological value of facilities [5]. Green warehousing is one of concepts of branch of green logistics which functions to minimize the ecological impact of logistics [6] [7].

2.2. Supply Chain Operations Reference

Supply Chain Operations Reference (SCOR) is a reference model for supply chain operations. According to [8] SCOR is basically a process based model. Meanwhile, to identify warehouse performance from the perspective of the environment, the SCOR model has its own metric measurement framework, which is described as follows.

2.3. Analytic Hierarchy Process

Analytical Hierarchy Process (AHP) is a decision support model developed by Thomas L. Saaty. The AHP model is a decision support model by describing a complex multi-factor or multi-criteria problem into a hierarchy [9]. To make a decision using the AHP model, several stages of activity are needed, as follows (1) Identification of the adjusted criteria in decision making, (2) Distributing questionnaires to determine the weight of each criterion and sub-criteria, (3) Calculating weights for each criterion and sub-criteria using pairwise comparisons, and (4) Determine the criteria based on value of largest pairwise comparison.

2.4. Objective Matrix (OMAX)

According to [10] OMAX is a partial productivity measurement system developed to monitor productivity in each part of the company with productivity criteria in accordance with the existence of the section (objective). OMAX has several advantages including relatively simple, easy to understand and implement, easy to obtain data and flexible. In addition, OMAX can be applied in the manufacturing industry, services, and large and small government organization sectors [11].

2.5. Traffic Light System (TLS)

Traffic Light System (TLS) is associated with OMAX. TLS functions as a signal whether the KPI needs improvement or not. The indicators of the Traffic Light System are presented in three colours and interval such as red category (0-3) that explains performance below its target, yellow category (4-7) indicates performance has not been achieved even though the value has approached the target, and green category (8-10) that indicates achievement of a performance indicator has been achieved.

2.6. Unified Modelling Language

Unified Modelling Language is a general purpose modelling language that is used to visualize a software system. This visualization help developer in specifying the system of a software in detail, constructing the software and documenting the developer activity and changes in the software. UML is used to capture the static structure of the software system and its dynamic behavior. A collection of objects that interact was modelled to perform tasks or work that benefiting users is called a system.

3. Results and Discussion

In this section, focuses more on developing applications using unified modelling language diagrams, this because in [3] research a warehouse performance evaluation model has been developed by considering the green factor.

3.1. Use Case

Use case diagrams can be used to obtain system requirements and understand how the system should work. This diagram shows the functionality of a system or class and how this system interacts with the outside world. Through use case, it can be identified that the system starts with the login process to input data and then manages dashboard KPIs, after that the user can see the actual data from warehouse activity. This process also be done by warehouse manager and head of warehouse. Use case diagram of this research is shown in Figure 2. below.

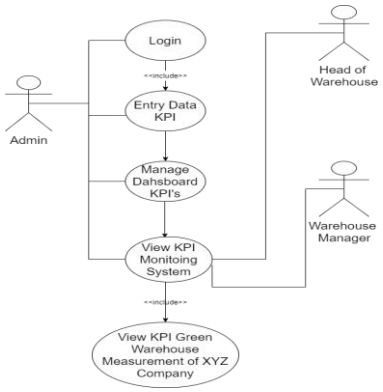

Fig. 2. Use Case Diagram

3.2. Activity Diagram

Activity diagrams describe the various activity flows in the system being designed, how each flow starts, decisions that may occur, and how an activity ends. Activity diagrams can also describe parallel processes that may occur in several activities. An activity can be realized by one or more use cases. Activities describe running processes, while use cases describe how actors use the system to perform activities. Activity diagram of this research is shown in Figure 3. below.

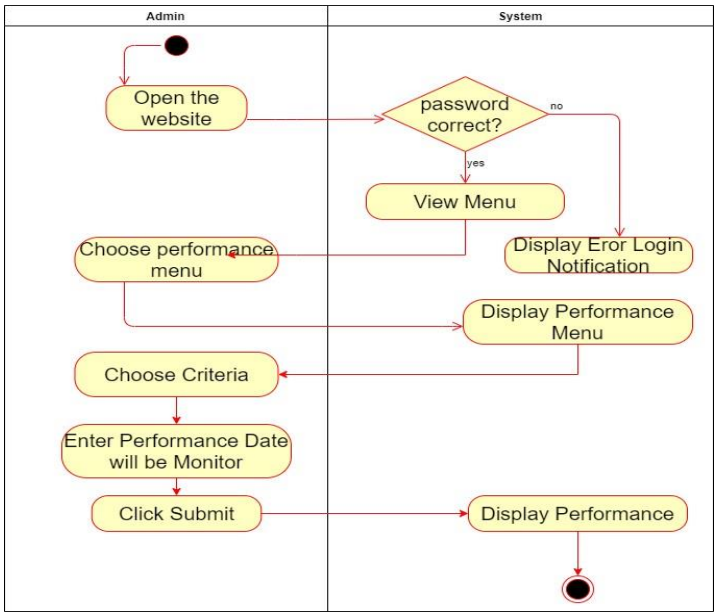

Fig. 3. Activity Diagram

3.3. Sequence Diagram

Sequence diagrams describe interactions between objects in the form of messages that are depicted against time. Sequence diagrams consist of vertical dimensions (time) and horizontal dimensions (related objects). Message is described as an arrow line from one object to another. In the next design phase, messages will be mapped to the operations / methods of the class. Sequence diagram in login process of this research is shown in Figure 4. below.

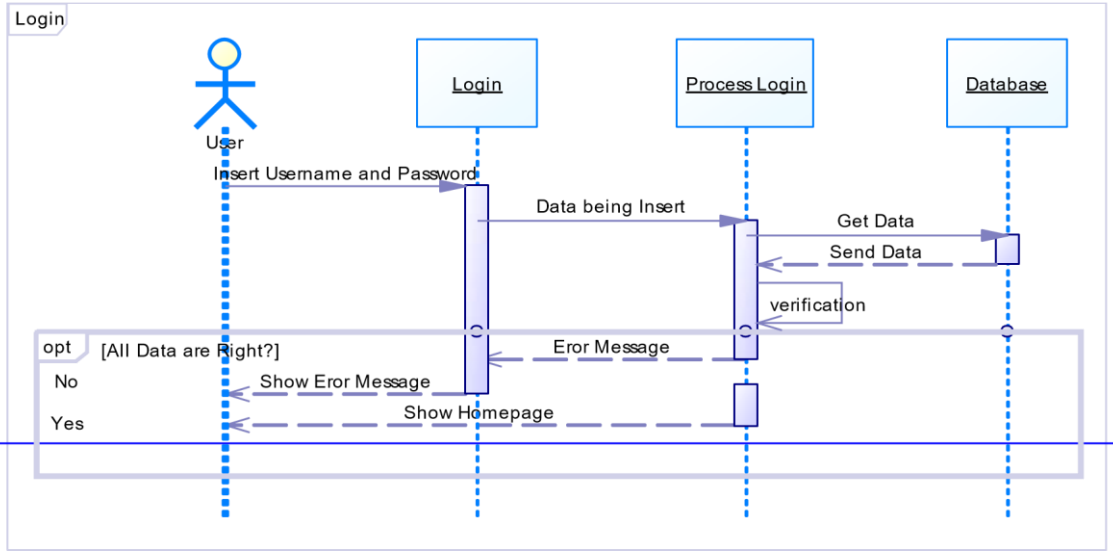

Fig. 4. Sequence Diagram (Login Process)

Based on Figure 4. it can be seen that there is a user login process to the monitoring system. From the sequence diagram, it can be seen that the monitoring system login process has actors, login

activities that will display the monitoring system home page, the login process which functions as a connector or provides information on the login process with the databases.

3.4. Interface Monitoring System

This monitoring system is designed so that not all users can access it. This is intended as a safety against irresponsible users by making changes to the data that has been recorded in the system. So, this monitoring system is equipped with user authentication with security in the form of registered. Username and Password. The display of the monitoring system login page is as shown in Figure 5.

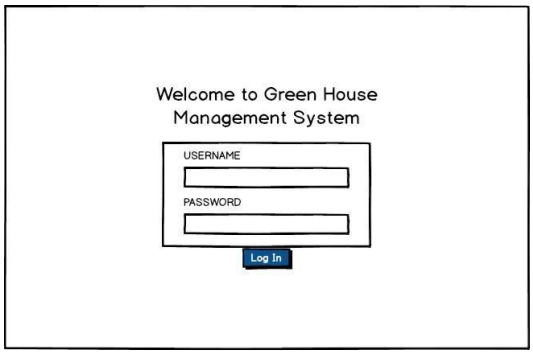

Fig. 5. Login Page

The logout page is a page that appears when a user exits the monitoring system web. When a user logs out, the user cannot return to the monitoring system dashboard page, but the user re-logs in. On the logout page the user can log back in by selecting the login button. The display of the monitoring system logout page is as shown in Figure 6.

Fig. 6. Logout Page

The KPI data input page is the page that serves as the entry page for metric / KPI performance data for each measurement period. On this page, there is a list of KPIs that are already available. Every month, the KPI performance achievement data needs to be recorded into the monitoring system. The display of the monitoring system data input page is as shown in Figure 7.

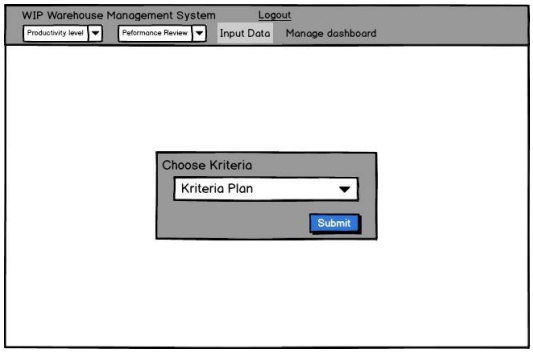

Fig. 7. Data Input Page

On Manage Dashboard page, there are three main functions that can be performed. The three functions are Replace Metrics, Delete Metrics, and Add Metrics. The display of the monitoring system manage dashboard page is as shown in Figure 8.

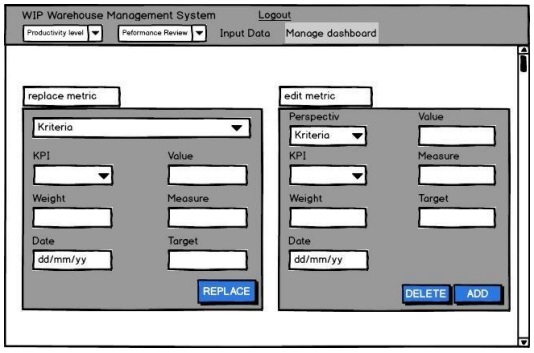

Fig. 8. Manage Dashboard Page

The Criteria Performance page is a page on the monitoring system that displays the performance of the criteria or design for the company. The display of the monitoring system criteria performance page is as shown in Figure 9.

Fig. 9. Criteria Performance Page

The Productivity Level page is a page that will display input of data to show the productivity level of the company's performance. On this page the user will upload a file in Ms Excel format (.xls). For files to be uploaded to the productivity level data input page, you can download them first on the same page. This file upload process aims to enter the data needed to measure the productivity level of the warehouse performance criteria which will be displayed on the productivity level page based on each of the criteria. The display of the monitoring system productivity level page is as shown in Figure 10.

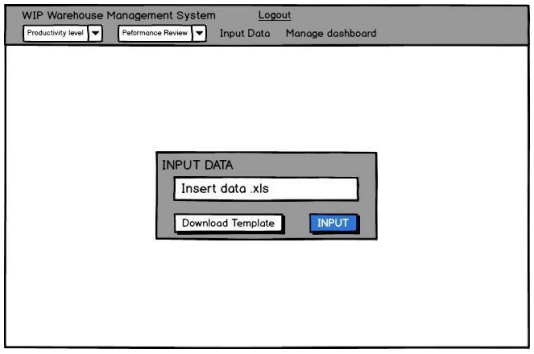

Fig. 10. Productivity Level Page

This page is designed on the design of a green warehouse performance monitoring system aimed at helping company decision-making. In this view, user can select what criteria are displayed for example plan, source, make, deliver, return, and environment productivity. The example display of the monitoring system in plan criteria productivity page is as shown in Figure 11.

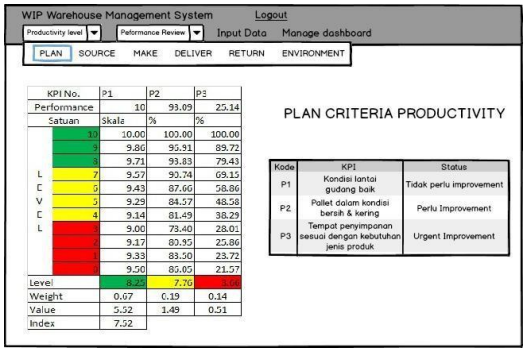

Fig. 11. Plan Criteria Productivity

4. Conclusion

The result of this research for PT XYZ is a design as a means of measuring the performance of the green warehouse at XYZ Company using the integration of the SCOR model and the AHP method that has been done on research [3]. Based on previous research state that weighting of the importance level of each criteria using AHP method results in make criteria getting a weighted score (0.421), plan (0.213), deliver (0.152), source (0.119), return (0.064), and environment (0.032).

The results of the scoring system using OMAX show that 7 KPIs are included in the green category, yellow category (11 KPIs), and red category (10 KPIs). Total value the company's green warehouse performance index is 11.15 which indicates that overall warehouse performance has not reached expected performance based on Traffic Light System Method.

The design of the Green Warehouse performance monitoring system for PT XYZ which has been designed is then given the application of technology so that the resulting performance calculations are more accurate and historical data is recorded systematically. With the use of a web-base application, PT XYZ will more easily access data and obtain a more efficient analysis of performance achievements. In this study, a mockup or design visual display that resembles the original function of the web-base application is presented. The design monitoring system dashboard has functions including, being able to process KPI data input, Manage Dashboard which means that it can replace and delete and add the desired KPIs, see the performance of XYZ's performance which is divided into six categories, namely there is a page that can display performance achievements plan criteria, source criterion performance display, make criterion performance, deliver criterion performance, return criterion performance, and environmental criterion performance. There is also a productivity level menu that will display the productivity level of company performance achievement for each criterion along with a simple evaluation analysis of the achievement of the productivity level of the green warehouse performance indicator, so that it can support company decision making regarding unattainable performance and requires improvement.

Declarations

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References

[1] F. Li and et al., "A 3PL Supplier Selection Model Based on Fuzzy Sets," *Comput. Oper. Res. 3*, pp. 1879–1884, 2013.

[2] N. Batarliene and A. Jarasuniene, "3PL Service Improvement Oppoturnities in Transport Companies," *Procedia Eng.*, vol. 187, pp. 67–76, 2017.

[3] W. Margareta, A. Y. Ridwan, and P. S. Muttaqin, "Green Warehouse Performance Measurement Model for 3PL Warehousing," *Environ. Waste Manag.*, vol. 44, pp. 180–186, 2020, doi: 10.1021/jz4018464.

[4] Undang Undang Republik Indonesia, "Undang Undang No. 3 Tahun 2014 tentang Perindustrian," 2014.

[5] M. Bartolini, E. Bottani, and E. H. Grosse, "Green warehousing: Systematic literature review and bibliometric analysis," *J. Clean. Prod.*, vol. 226, no. Elsevier Ltd, pp. 242–258, 2019.

[6] K. W. Green, P. J. Zelbst, and V. Bhadauria, "Green supply chain management practices: Impact on performance," *Supply Chain Manag. An Int. J.*, vol. 17, no. 3, pp. 290–305, 2012, [Online]. Available: https://www.researchgate.net/publication/235278864_Green_supply_chain_management_practices_Impact_on_performance.

[7] A. McKinnon and E. Al., "Green Logistics: Improving the Environmental Sustainability of Logistics," in *Transport Reviews*, 2011, p. limited, doi: 10.1080/01441647.2010.537101.

[8] I. N. Pujawan, "Supply Chain Management," Kedua., Surabaya: Guna Widya, 2010.

[9] H. K. Chan and X. Wang, "Fuzzy Hierarchical Model for Risk Assessment, Fuzzy Hierarchical Model for Risk Assessment," 2013, doi: 10.1007/978-1-4471-5043-5.

[10] B. Yosan, *Modul Elearning 13 Metode Omax*. Jakarta: Universitas Mercubuana, 2015.

[11] J. L. Riggs, "Production System: Planning, Analysis, and Control," 1986.

[12] D. N. Rachmaniar, Y. Sumantri, and R. Yuniarti, "Evaluasi Kinerja Gudang Consumer Goods Menggunakan Supply Chain Operation Reference Dan Scoring System Evaluation Of Consumer Goods Warehouse ' S Performance With Supply Chain Operation Reference And Scoring System," *REKAYASA DAN Manaj. Sist. Ind.*, vol. 3, no. 11, pp. 1–9, 2016.