



Implementation Lean Warehousing Using Waste Assessment Model (WAM) Method at Warehouse ABC Company

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Abstract

Warehouses play an important role in maintaining product quality until the product is delivered to consumers. The many important activities in the warehouse require companies to improve their performance to be effective and efficient in order to maintain trust. ABC Company is a private company engaged in civil construction, landfilling, cut and fill, heavy equipment rental, and spare part distributor. In warehousing activities, there are various activities that don't have value added or waste. This study aims for identify waste and provide recommendations for improving warehousing activities. The implementation of Lean Warehousing is carried to identifying the warehousing flow process with Value Stream Mapping (VSM), then identifying 7 wastes that occur in the warehousing process using the Waste Assessment Model (WAM) method. The results of the study showed that the waste with the highest percentage level was waste inventory (I) waste overpurchase (O) waste defect (D). From the proposed improvements and Future stream mapping, it was found that the lead time was reduced to 544 minutes, which eliminated 200 minutes of non- value added activity. So that activity increased by 27% from the initial condition.

Introduction

Currently, global competition has increased the role of logistics at production warehouse, especially in terms of design, planning and control of warehousing systems. To improve customer satisfaction, warehouse operations must be optimized by eliminating activities and making the activity reliable of minimizing total logistics costs (Ramadhanti et al., 2023; Gwynne, 2014; Richards, 2017). The application of lean warehouse to minimize waste that exist in the warehouse so that activity operational of the warehouse are more expeditious. This concept focuses on to eliminating from identifying waste or operation that do not have added value (Dhika et al., 2023; Al-Baik & Miller, 2014; Thürer et al., 2017; Shou et al., 2020; Barabadi & Nouri, 2023).

ABC Company is a private company engaged in civil construction, landfilling, cut and fill, heavy equipment rental, and distributor of heavy equipment spare parts. When observing the company, there were various activities that did not have added value, namely activities that were not useful in the warehousing process, namely Non-Value Added (NVA) of 32%. If efforts to resolve and improve are not made immediately, it will disrupt the smooth flow of warehousing and hinder service.

The proposed method to solve the problem is to use the Lean. Lean methods are used to eliminate waste in the operation to reduce costs and increase productivity (Mahmood & Shevtshenko, 2015; Kulkarni et al., 2014; George, 2010). The benefits that can be felt after

using the lean method are reducing raw material waste, reducing processes, improving performance, better use of infrastructure or utilization and reducing lead time (Basiru et al., 2023; Rasanjali et al., 2024). Lean warehousing is interpreted as the concept of minimizing waste in the supply chain management, depending on the types of the warehouse in the supply chain of the company, to serve customers at the right time and place (Prasetyo, et al., 2021; Adeodu et al., 2023; Mwizerwa & Akumuntu, 2024). Value stream mapping (VSM) is a tool of lean that used to find out the flow of company data to complete existing problems (Masuti & Dabade, 2019; Ahmad et al., 2022; Marques et al., 2021). Process activity mapping (PAM) one of a tool in lean that can be used to find out the steps of a process to find and minimize waste, reduce inconsistency and reduce irrationality in order to provide the best goods or services easily, quickly and cheaply (Pogowonto & Amrina, 2020). Waste means as any activity of using resources that does not provide added value to the product. Basically, all waste that occurs is closely related to the time dimension (Fhadillah et al., 2020). Waste Assessment Model (WAM) is a model to simplify the search for waste problems and recognize them to minimize waste (Naziihah et al., 2022; Nguyen et al., 2019; Gómez-Delgado & Tarantola, 2006). Fishbone diagrams are made with the aim of identifying and controlling possible causes. Therefore, a cause and effect diagram is a method to identifying the causes of a problem systematically, so that it will make it easier to overcome the causes of a problem (Armyanto et al., 2020; Abbasi et al., 2020; Van der Lei et al., 2011).

This research is expected to help companies by providing suggestions for improvements to eliminated the waste and reduce time efficiency in the warehousing process so that they can reduce activities that don't increase added value to the warehousing flow process at ABC Company.

Methods

Based on the problems faced by the company, the proposed method to solve the problem is to use Lean Warehousing, the lean warehousing method here is used by identifying 7 wastes in the company, including: overpurchase, inventory, reject, transportation, overprocessing, waiting, and motion. From the 7 wastes, the 3 largest wastes are identified to be studied using the Waste Assessment Model (WAM) method, the WAM method allows waste research in the warehouse using 3 steps, namely Seven Waste Relationship (SWR) whose data collection is by giving a questionnaire to the warehouse operator containing 31 waste relationship tables with 6 questions in each table with the code (O_I) is the relationship between waste overpurchase and inventory. The results of the SWR questionnaire answers then convert their weights according to the weights in the study (Rawabdeh, 2005) which the results of the addition of these weights will later be converted to fill the matrix contained in the Waste Relationship Matrix (WRM), WRM is made to find out how waste affects other waste which will later be used as a weighting number at the Waste Assessment Questionnaire (WAQ) stage. To obtain WAQ data, namely by providing a second questionnaire containing 68 questions of the type "From" which is for questions explaining that waste comes from the waste, and "To" for questions explaining that other waste results in the waste, with 4 categories namely (Man, Method, Material, and Machine) which weight the results of the explanation on a scale of 0, 0.5, and 1. Then the results of the WRM are used to determine the weighting in the WAQ. The results of the WAQ obtained a ranking of 7 wastes which will later be made into 3 largest wastes to be continued in the fishbone diagram and the 5W + 1H stage.

Then this study also uses the Value Stream Mapping (VSM) method which is used to find waste activities in the warehousing process. data on the VSM contains warehouse activities from the beginning of the process, namely the process of incoming goods being sent by the supplier, then the goods are processed in the warehouse, until the goods are sent to consumers. The data needed is the activity time and how many operators work on each activity. And VSM

mapping is carried out for 1 warehouse cycle, namely with a weekly time or 5 working days. Then the results are identified with the help of Process Activity Mapping (PAM) to categorize activities based on Value Added Activity (VA), Non Value Added Activity (NVA), and Necessary Non Value Added Activity (NNVA). This categorization is useful for knowing which activities are wasteful activities so that they can be eliminated later. This is in line with the principle of lean warehousing which aims to eliminate all forms of waste that occur in the warehousing process.

Results and Discussion

The flow of warehousing activities at ABC Company is grouped into 7 types which are adjusted based on the activities contained in each type of activity which will be shown in the warehouse activity flow diagram below.

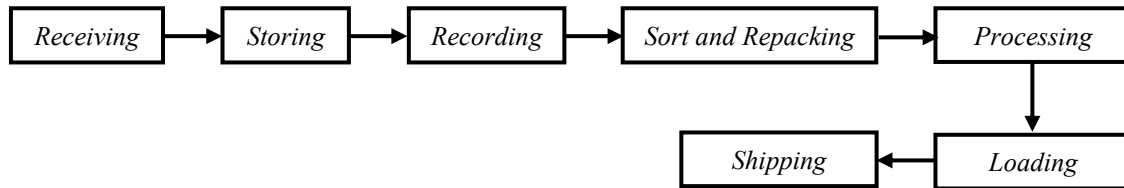


Figure 1. Warehouse Process Flow

Based on the information that has been collected and obtained from the company, it can be seen the details of the activities and time of the warehousing process starting from the process of receiving, recording, sorting and repacking, processing, loading, and shipping. The data is described in Table 1.1 below:

Table 1. Total Warehouse Activity Time

No	Activity	Time (Minutes)
1	Receiving	241
2	Storage	109
3	Record	56
4	Sort and Repacking	108
5	Processing	136
6	Loading	70
7	Shipping	24
		744

From the data above, the warehousing flow process is poured into value stream (VSM). An explanation is given regarding the conditions that occur in the warehousing flow for storing spare parts starting from ordering to spare parts to customers. The total time of the warehousing flow process is 744 minutes. All activities are then defined into 3 categories, namely value added activity, non value added, and necessary non value added.

Table 2. Percentage of Frequency and Time of Each Type of Warehouse Activity

No	Activity	Frequency	Percentage	Time	Percentage
1	Value Added (VA)	13	38%	400	54%
2	Non Value Added (NVA)	11	32%	200	26%
3	Necessary Non Value Added (NNVA)	10	30%	144	20%
	Total	34	100%	744	100%

Based on the calculations above, it is known that the time for each type of activity, including value added activities, is 400 minutes with a percentage of 54%, Non-Value Added activities

are 162 minutes with a percentage of 20% and Necessary Non-Value Added are 182 minutes with a percentage of 26%.

Waste Relationship Matrix is used for standard to measure the relationship between waste produced. Waste Relationship Matrix is a matrix of columns and rows to analyze measurement standards. This row containing the relation of each waste on the other waste. This column containing the waste have effect by the other wastes. The diagonal matrix shows the biggest of the value. The relationship levels of the seven wastes obtained from the calculations are then converted into WRM form as in the following table:

Table 3. Waste Relationship Matrix

F/T	O	I	D	M	T	P	W
O	A	E	I	I	I	X	E
I	I	A	I	E	E	X	X
D	I	I	A	I	I	X	I
M	X	I	I	A	X	E	A
T	I	E	I	E	A	X	E
P	E	E	A	E	X	A	E
W	E	I	I	X	X	X	A

The initial letter abbreviations of seven wastes are used as assessments, namely O is for overpurchase, I is inventory, D for defects, M is motion, P for processing, T is transportation and W is for waiting. For example, P_O shows the direct effect of over-processing on over-purchase. The correlation score between wastes can be converted with each letter representing a range of scores. (A = 17 until 20 needs improvement; E = 13-16 is very important to improve; I = 9-12 is important to improve; O = 5-8 is not important to improve; U = 1-4 is not very important to improve).

After the waste relationship matrix is obtained, each type of relationship obtained is converted into a number that is in accordance with the rules in the waste matrix value that has been written previously. From this calculation, the percentage of each waste is then calculated to be used for further calculations.

Table 4. Waste Matrix Values

F/T	O	I	D	M	T	P	W	Score	%
O	10	8	6	6	6	0	8	44	15%
I	6	10	6	8	8	0	0	38	13%
D	6	6	10	6	6	0	6	40	14%
M	0	6	6	10	0	8	10	40	14%
T	6	8	6	8	10	0	8	46	16%
P	8	8	10	8	0	10	8	52	18%
W	8	6	6	0	0	0	10	30	10%
Score	44	52	50	46	30	18	50	290	
%	15%	18%	17%	16%	10%	6%	17%		

Waste Assessment Questionnaire stage, the questionnaire results obtained came from 68 questions with 3 weights Yes, Medium, No 1, 0.5, 0. The 68 questions are classified into 4 groups, namely humans, methods, machines, and materials. The first step that must be taken is to group and count the number of questionnaire questions based on "from" and "to".

Table 5. grouping of question types

No	Question Types	Total (Ni)
1	From Overpurchase	3

2	From Inventory	6
3	From Defects	8
4	From Transportation	4
5	From Motion	11
6	From Processing	7
7	From Waiting	8
8	To Defects	4
9	To Motions	9
10	To Transportation	3
11	To Waiting	5
Total		68

From the questions above, data processing is continued using WAQ method to find out and rank which waste has the greatest level of influence on the inefficiency of the warehousing activity process. The results of the calculation are as follows:

Table 6. Waste Assessment Questionnaire

Name	O	I	D	M	T	P	W
Y _j	1,54386	1,51780352	1,480769	1,420565	1,401306	1,965863	1,392045
P _j Factor	0,02302	0,02349584	0,023781	0,021879	0,016409	0,01113	0,017836
Y _j Final	0,03554	0,03566	0,03521	0,03108	0,02299	0,02187	0,02482
Final Result (%)	17,15%	17,21%	16,96%	15,00%	11,09%	10,56%	11,98%
Ranking	2	1	3	4	6	7	5

Based on Table 1, the three types of waste that are identification as biggest in order from the seven of waste are Inventory (17.21%), Overpurchase (17,15%), and Defect (16.96%). This biggest waste give the huge influence on the production process are inefficiency which results in delays in warehouse process and shipping of products. Furthermore, the causes of each waste will be discussed in more depth in the fishbone diagram.

Fishbone diagram is used to show the causes and effects of waste in the warehousing flow process, so that recommendations for improvements can be determined. Figure 1.2 until 1.4 is an identification of the causes and effects of waste that occurs in the warehousing flow process in the fishbone diagram below:

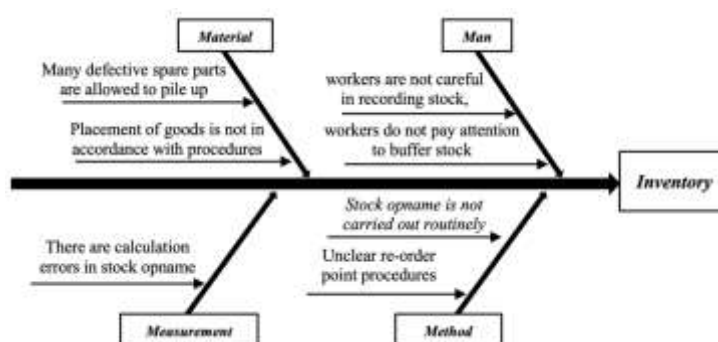


Figure 2. Fishbone Diagram Waste Inventory

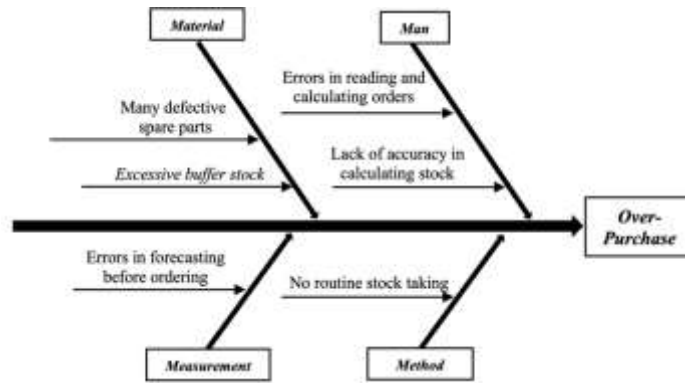


Figure 3. Fishbone Diagram Waste Overpurchase

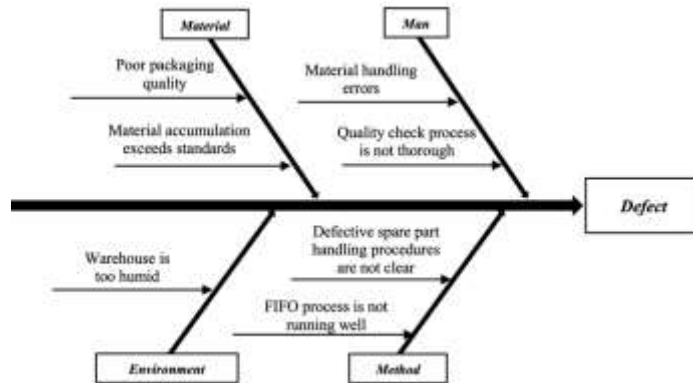


Figure 4. Fishbone Diagram Waste Defect

Recommendations for improvement using the 5W+1H method were made after the factors causing waste were obtained based on the fishbone diagram result of the identifying using the fishbone diagram. Then the results of the fishbone diagram were used as a basis for compiling recommendations to reduce waste in the warehouse at ABC Company.

Table 7. 5W+1H Analysis Waste Inventory

What	Where	Who	When	Why	How
Man	Storage area goods and office	Warehouse Supervisor	In the stock opname process and purchase order (PO) process	Worker not enough thorough in take notes stock	Use system realtime and barcode interface For stocking
				Worker No notice buffer stock	Add system interface like ERP.
Method	Storage area goods and office	Warehouse Supervisor	In the stock opname process and purchase order (PO) process	inventory taking No done in a way routine	Use system realtime and barcode interface For stocking
				Procedure re-order point that does not clear	Make scheduling booking repeat in a way regular
Material	Storage area goods	Warehouse Supervisor	In the storage	The amount spare part	Handling spare-part

			process goods	defects are left	defects for fixed or destroyed
				Placement goods No in accordance procedure	Make name tag board (board) information
Measurement	Storage area warehouse	Warehouse Supervisor	In the stock opname process	Happen error count in stock admission	Use system realtime and barcode interface For stocking

Table 8. 5W+1H Analysis Waste Overpurchase

What	Where	Who	When	Why	How
Man	Office	Marketing Division	In the purchase order (PO) process	Error in reading and counting order	Count repeat and create double receipt delivery order (DO) before do booking .
				No thorough in stock calculation	Enforce barcode system to every goods
Method	Storage area goods	Warehouse Supervisor	In the stock opname process	Stock opname process No done routine	Make timetable inventory taking in a way routine as well as add system interface
Material	Storage area goods	Warehouse manager and warehouse supervisor	In the purchase order (PO) process	The amount spare part defect	Do Handling more carry on on spare part defect
				Buffer stock excessive	Add system real time For all stock in warehouse
Measurement	Office	Marketing division	In the forecasting process	Error forecasting before booking	Pay attention to history, trends , and market conditions when do forecasting

Table 9. 5W+1H Analysis Waste Defect

What	Where	Who	When	Why	How
Man	Loading area goods	Warehouse Supervisor	In the loading and unloading process goods	Error use equipment material handling	Do better planning in Material handling process

				QC process is lacking thorough	Do training as well as give labels to goods that pass QC
Method	Storage area goods	Warehouse Manager	In the storage process goods .	Procedure Handling spare part defect Not yet clear	Make criteria For type spare-part defects that can fixed.
				The FIFO process does not walk with Good	Do arrangement reset on system storage so that the FIFO process runs
Material	Storage area goods	Warehouse Manager	In the storage process goods .	Quality packaging bad	Using plastic pallets stand termite
				Material accumulation exceeds standard	Streamlining warehouse layout
Environment	Storage area goods	Warehouse Manager	All warehouse processes	Warehouse too moist	Add ventilation in the warehouse For guard humidity

The proposed improvement recommendations to reduce waste will affect the results of the future value stream mapping that is made. based on the prediction results after the application or implementation of the proposed improvements given. Improvements can be made through process simplification. non value added (NVA) activities are process that don't have any added value at all, so these activities need to be eliminated or removed. NVA activities are activities that are included in waste. Therefore, improvements are needed to eliminate or minimize this waste. The following is a table of warehousing activities after the proposal is given.

Table 9. Comparison of Warehouse Activity Frequency and Time Based on NA, NVA, and NNVA Before and After Improvement

No	Activity	Frequency Before Improve	Frequency After Improve	Time Before Improve	Time After Improve	Percentage of Improve
1	Value Added (VA)	13	13	400	400	0%
2	Non Value Added (NVA)	11	0	200	0	100%
3	Necessary Non Value Added (NNVA)	10	10	144	144	0%
Total		34	23	744	544	

Table 10. Comparison of Warehouse Flow Process Before and After Improvement

Types of Comparison	Before Improvement	After Improvement	Percentage Improvement (%)
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Total Activity	34	23	32%
Value Added	13	13	0%
Necessary Non Value Added (NNVA)	10	10	0%
Non Value Added (NVA)	0	0	100%
Lead Time	744	544	27%

Based on the comparison table above, it can be seen that there is a simplification of the process where there is a reduction from 34 activities to 23 activities with a percentage of improvement of 32%. In non-value added (NVA) activities, Non-value added activities with the longest time eliminated are operators preparing forklifts and equipment for material handling in receiving activities, searching for types of goods according to orders in delivery orders (DO) for sorting and repacking activities, and goods waiting to be processed for processing activities. Warehousing activities became more efficient and eliminated waste with a percentage of improvement of 100%. There was a change in time where previously all warehousing activities took 744 minutes. After the improvement proposal, the time required was reduced to 544 minutes with a percentage of improvement of 27%.

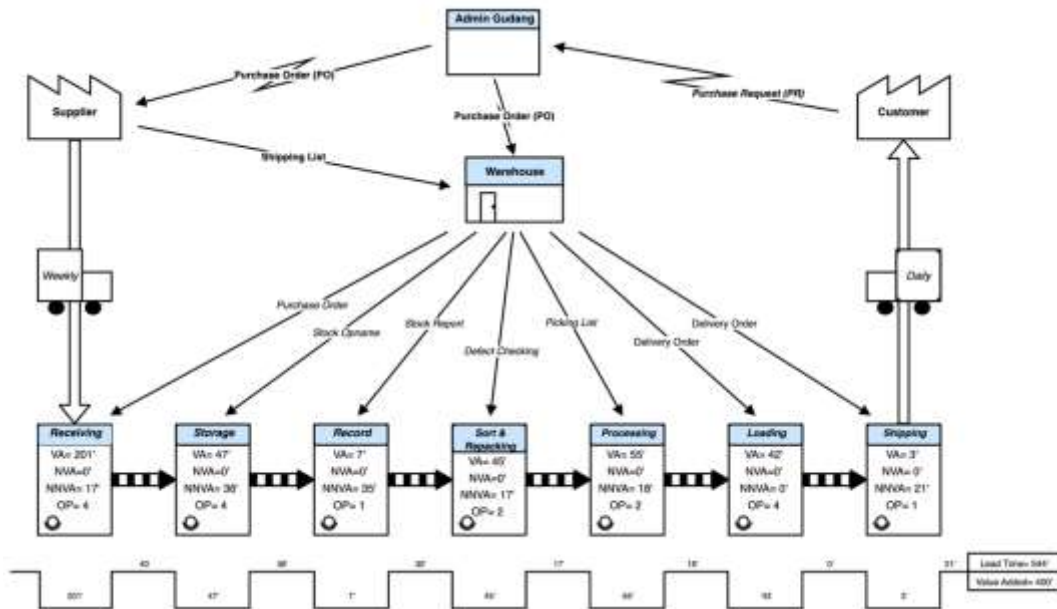


Figure 5. Future Value Stream Mapping

After improvements are made to warehousing activities, the next step is to calculate the efficiency of warehousing activities at ABC Company after recommendations for improvements are made, so that the results are obtained on how much time efficiency increases in warehousing activities. The calculation of time efficiency of warehousing activities can be seen as follows:

$$\begin{aligned}
 \text{Efficiency} &= \frac{\text{Current lead time} - \text{lead time after Improvement}}{\text{Current lead time}} \times 100\% = \\
 &= \frac{744 - 544}{744} \times 100\% \\
 &= 27\%
 \end{aligned}$$

From the calculation above, it can be concluded that after the provision of the proposed improvement, the efficiency of warehousing activities increased by 27%. This means that the better the warehousing activities carried out because process that do not add value are eliminated so that the time for unnecessary activities is reduced.

Conclusion

Based on the analysis using value stream mapping and process activity mapping, it was found that the total lead time of all warehouse activities in the initial condition was 744 minutes with a total value added time of 400 minutes, so it was necessary to eliminate 11 non-value added activities. Furthermore, mapping of the current conditions was carried out using future value stream mapping. It was found that the lead time was reduced to 544 minutes, namely eliminating 200 minutes of non-value added time. So that delay activities do not occur and the warehouse activity process increases by 27% from the initial condition.

Based on the results of the ranking on the waste assessment model, it is known that the 3 wastes that have the greatest level of influence include waste inventory (I) with a percentage of 17.21%, second, waste overpurchase (O) with a percentage of 17.15%, and third, waste defect with a percentage of 16.96%. The priority of the proposed improvements includes utilizing a barcode system for each item so that each item activity can be detected, then utilizing an ERP system to synchronize all activities carried out in the warehouse, and improving the company's SOP to ensure activities run effectively and efficiently and create continuous improvement.

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