Sustainable Value Stream Mapping: A Case Study on Office Furniture Production Line

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Abstract

This paper discusses the implementation of Sustainable Value Stream Mapping in office furniture production lines. By using Sustainable Value Stream Mapping, problems in economic, environmental, and social aspects (Triple Bottom Line) can be visualized and presented properly. The efficiency of work in process, recycling of waste, safety rate of employees, and training rate of employees are included in the critical category. The proposed improvement plan is to transfer products in smaller batches, produce new products, use cut-resistant gloves, and regularly send employees for training every month. This improvement would increase the efficiency of work in process by 12.65%, the recycling of waste by 40.32%, the safety rate of employees by 42.86%, and the training rate of employees by 78.18%.

Keywords
Efficiency, Sustainable Value Stream Mapping, Environmental Sustainability, Social Sustainability, Waste

1. Introduction

Approximately 42% of business people emphasize that sustainability is important because this method can increase efficiency and reduce costs, which will certainly be beneficial for their business. 62% of midsize companies believe that sustainability is as important as or even more important than financial success (Prambadi 2021). In the manufacturing industry, the ability of a company to carry out the production process efficiently and effectively can show the productivity of the company itself (Kosasih et al. 2020). One of the tools that can be used to see whether the production process carried out by a company is efficient or not is Value Stream Mapping.

Value Stream Mapping is a method introduced by Toyota Motor Company, which later became one of the fundamental methods of lean management. Value Stream Mapping is a graphical presentation of the flow from receiving buyer requests to shipping products to buyers. This method divides all processes into two, namely value-adding and non-value-adding. Value Stream Mapping can help to make decisions, identify waste, determine improvements, and also visualize the future state (Venkataraman et al. 2014) (Rohac and Januska 2015) (Kosasih et al. 2019).

The existing Value Stream Mapping was then developed by combining conventional metrics with sustainability metrics into Sustainable Value Stream Mapping (Prasetyo and Adi 2019). After being developed, Sustainable Value Stream Mapping includes 3 aspects, namely economic aspects, environmental aspects, and social aspects. These three aspects are important in measuring the value of a company. These three aspects are called the Triple Bottom Line (TBL). This Triple Bottom Line approach can make companies run on economic prosperity, environmental quality, and social justice simultaneously (Hourneaux Jr et al. 2018). With economic, environmental, and social aspects that are handled simultaneously and holistically in a development process, the development can be said to be sustainable development (Rosen and Kishawy 2012).

Therefore, Sustainable Value Stream Mapping can be regarded as a technique to visualize and present a process that has economic, environmental, and social potential (Triple Bottom Line) (Faulkner and Badurdeen 2014). Once visualized, it will be easier to see processes that require immediate improvement, need improvement as soon as possible, and do not require significant improvements to achieve sustainable manufacturing. According to United States Environmental Protection Agency (2020), companies that implement sustainable manufacturing have an

efficient production process, are superior when competing with competitors, have the trust of the public, and most importantly, the company can survive and be successful in the long term.

An office furniture manufacturing company located in Tangerang, Banten, has a domestic (Indonesian) market reach. The production of office furniture carried out by the company uses the main raw material of processed wood. After conducting interviews with the company, it was found that this office furniture manufacturing company has a problem with waste that has not been managed properly. The waste produced has 3 sizes, namely the size of 1,220 mm x 300 mm x 25 mm, the size of 2,100 mm x 80 mm x 25 mm, and the size of 1,220 mm x 200 mm x 18 mm. Waste measuring 1,220 mm x 300 mm x 25 mm generated will be reused for production. Meanwhile, waste with a size of 2,100 mm x 80 mm x 25 mm and waste with a size of 1,220 mm x 200 mm x 18 mm cannot be reused for production. Waste that cannot be reused will be collected first and then disposed of. For the disposal process, the company needs to hire people to do it. This results in waste in costs, activities, and storage (economic aspects and environmental aspects).
This study aims to identify the causes of problems that occur in office furniture production lines, find solutions to reduce waste in office furniture production lines, find solutions to increase efficiency in office furniture production lines, and implement Sustainable Value Stream Mapping in office furniture manufacturing companies.

2. Methods

This research was conducted using the Sustainable Value Stream Mapping method. The steps of this research are:

1. Conducting field studies: At this stage, interviews with the company will be conducted and field observations will be conducted.
2. Literature study: At this stage, relevant references will be searched and collected to be used as references in the research conducted. References used must be credible, official, and published in the last 10 years.
3. Identifying problems and developing problem-solving strategies: At this stage, the problems to be discussed in this study will be determined.
4. Determining the objectives and benefits of the research: At this stage, the objectives and benefits of the research will be determined in accordance with the formulation of the problem that has been prepared in the previous stage.
5. Determining research boundaries: At this stage, research boundaries will be determined according to the problem formulation, objectives, and benefits of research that have been prepared in the previous stage. This stage is useful so that the research carried out becomes more focused.
6. Identify the data needed: At this stage, the indicators to be measured are: time, work in process, cost, and product defects for the economic dimension; energy consumption, material waste consumption, and waste recycling for the environmental dimension; helath rate of employee, safety rate of employee, satisfaction rate of employee, and training rate of employee for the social dimension (Hartini et al. 2018). The measurement will be carried out by calculating the efficiency. Furthermore, these indicators will require data to be processed at a later stage. The primary data points that will be used are the cycle time of the production process, work stations in the production process, the cost of the production process, energy consumption, waste generated, employee data (attendance data, sick complaint data, new employee data, and employee quitting data), the results of interviews with the company, and field observations. Secondary data that will be used is the company's vision and mission, as well as an overview of the company.
7. Processing data using the Sustainable Value Stream Mapping Method: After the indicators are determined and all the required data has been obtained, the next step is to process the data using the Sustainable Value Stream Mapping Method.
8. Conducting analysis: At this stage, an analysis will be made of the results of the calculations in the previous stage.
9. Determine the proposed improvement: After conducting the analysis, the proposed improvement will be determined for the existing problems.
10. Simulation of improvements: At this stage, the proposed improvements that have been determined will be tested to see if they achieve the objectives of this study.
11. Making conclusions and suggestions for further research: At this last stage, conclusions from the research that has been carried out will be made and also suggestions for further research will be made so that future research will be even better.

3. Results and Discussion

This study includes 11 indicators: time, work in process, cost, product defect, energy consumption, material waste & consumption, recycling of waste, health rate of employee, safety rate of employee, satisfaction rate of employee, and training of employee (Hartini et al. 2018) . The eleven indicators will be calculated using the efficiency formula,

namely the ratio between value added and total. Value-added activities are operations that affect the form, fit, and function of the final product as required by the buyer. A non-value-added activity is an operation that has no effect on the value of the final product required by the buyer (Shou et al. 2019). Therefore, this research requires data on value added time, non-value added time, number of products waiting for process, time for each process, value added cost, non-value added cost, number of product defects, number of products produced, value added energy, non-value added energy, value-added material, non-value-added material, amount of waste, amount of waste that cannot be recycled, number of absent employees (sick), number of activities with risk, number of activities, number of employees, number of employee turnover, and number of employee training (Hartini et al. 2020).

3.1 Sustainable Value Stream Mapping Before the Improvement Plan

After calculating the efficiency of each indicator, the efficiency value will be written into the Sustainable Value Stream Mapping chart. According to the company, if the efficiency value of an indicator is below 65%, it can be said that the indicator is critical and is marked in red. If the efficiency value of an indicator is between 65% and 90% (Figure 1), then the indicator can be said to be moderate and be marked with a yellow color. If the efficiency value of an indicator is above 90%, then the indicator's performance is very good and is marked with a green color (Hartini et al. 2020).

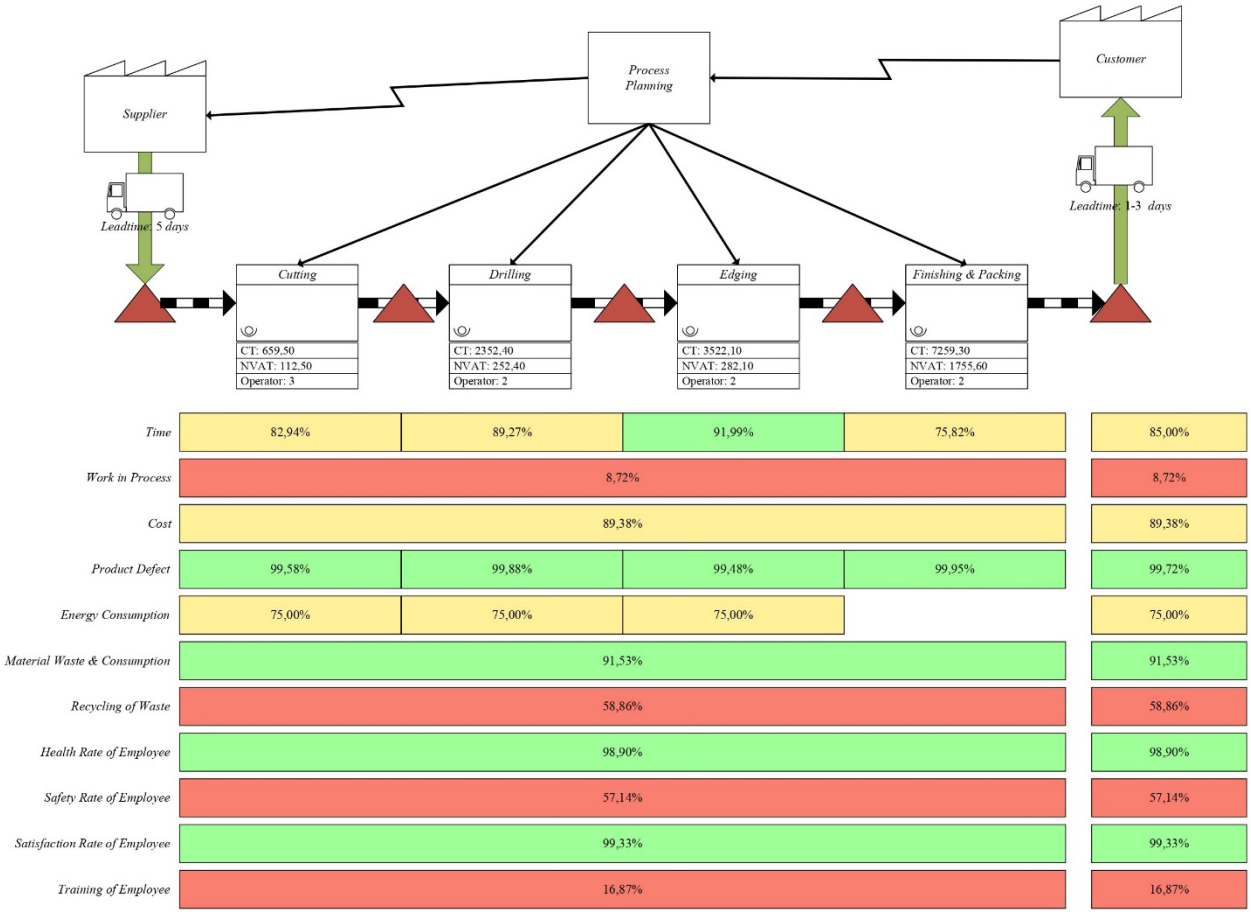


Figure 1. Sustainable Value Stream Mapping Before the Improvement Plan

After conducting field observations and interviews with the company, the work in the process indicator is in the critical category because in the cutting process, cutting can be done simultaneously (one process can immediately produce 12 pcs). But for the next processes, namely the drilling process, the edging process, and the finishing and packing process, one process can only produce one piece. Therefore, the efficiency of work in the process is low. The recycling of waste indicator is in the critical category because the rest of the material used cannot be reused and is immediately disposed of by the company. For disposal, the company also needs to pay or hire workers to do it. The fee that needs to be paid is Rp. 50,000 per m^3. This results in waste of cost. The place used to put waste before it is disposed also

causes waste storage, which can actually be used to store raw materials or finished goods. The safety rate of employee indicator is included in the critical category because there are still many processes that are carried out manually and are carried out with sharp tools such as cutters and drill bits. In addition, workers have been advised to use personal protective equipment (PPE), but many employees do not want to use it for various reasons. The training of employees is in the critical category because, in this pandemic situation, the budget is limited and it is difficult to find workshops or training that can be done. In addition, the company has not been too focused on the employee training, so the efficiency value is low.

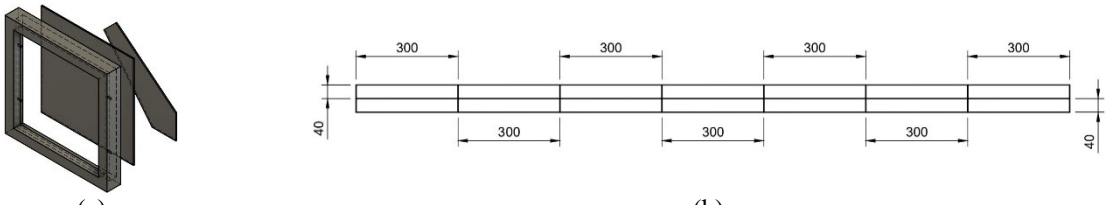
3.2 Improvement Plan

To increase the efficiency of the work in process indicator, products can be moved one by one so that the waiting time is not too long. For products from the cutting process to the drilling process, it cannot be changed anymore because one cutting process immediately produces 12 pieces. Products from the drilling process to the edging process can be moved after 6 pcs are finished and start the edging process so that only 5 pcs are waiting for the edging process. Products from the edging process to the finishing & packing process can be moved every 1 piece of product is finished because the distance between the edging work station and the finishing & packing work station is close. So therefore, the product waiting for the finishing and packing process is only 1 piece. This will certainly reduce waiting times and increase the efficiency of the work in process indicator.

To improve the efficiency of the recycling of waste indicator, company can make new products with material sizes that match the size of the waste. Material with dimensions of 1,220 mm x 200 mm x 18 mm can be made into a storage box. Material with dimensions of 2,100 mm x 80 mm x 25 mm can be made into a photo frame or phone stand. The storage box has an outer size of 200 mm x 156 mm x 80 mm and an internal size of 164 mm x 120 mm x 62 mm. The storage box can be seen in Figure 2(a). The photo frame has an outer size of 300 mm x 300 mm x 40 mm and an inner size of 250 mm x 250 mm x 20 mm. The photo frame can be seen in Figure 3(a). The phone stand has a size of 140 mm x 80 mm x 25 mm. The phone stand can be seen in Figure 4(a). The cut pattern of the storage box can be seen in Figure 2(b). The cut pattern of the photo frame can be seen in Figure 3(b). The cut pattern of the phone stand can be seen in Figure 4(b).

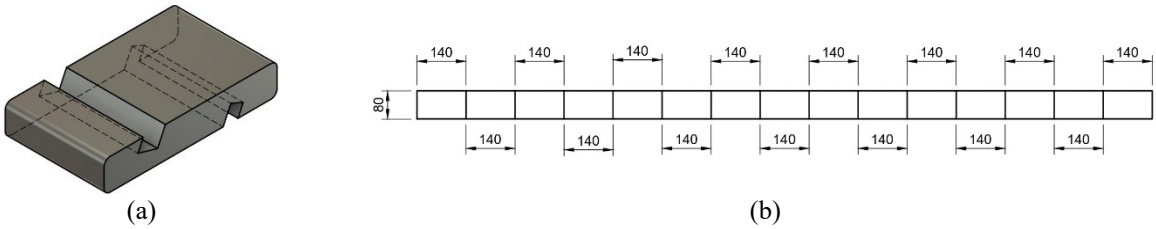
(a) (b)

Figure 2. (a) Storage Box , (b) Cut Pattern of Storage Box



(a) (b)

Figure 3. (a) Photo Frame , (b) Cut Pattern of Photo Frame



(a) (b)

Figure 4. (a) Phone Stand , (b) Cut Pattern of Phone Stand

In one process that produces 12 products, there is a waste of 0.025584 m^3 that cannot be recycled. The company needs to pay a disposal fee of RP 1,279,20. By making products from this waste, the amount of waste that cannot be recycled in one process (12 pcs) is 0.00050688 m^3 and the company only needs to pay Rp. 25.34 for the disposal process. This makes the company save on disposal costs by 98.02%.

To improve the efficiency of the safety rate of employee indicator, the company can impose sanctions on operators who do not comply with the use of PPE. In addition, the company must provide occupational health and safety training so that workers understand the importance of using PPE at work. The company can also carry out impromptu inspections on a regular basis and also conduct socialization regarding the sanctions given if workers do not use PPE in accordance with the specified standards. It is also recommended to use INGCO Cut Resistant Gloves HGCG01, which are safe from sharp objects, so that workers will avoid injuries and can work more productively.

To improve the efficiency of the training rate of employee indicator, it is recommended to regularly schedule sending around 8% to 10% of the number of employees per month for training. With regular scheduling, the number of employees receiving training will increase, which, of course, will make employees have added value for the company. For the budget, it is advisable to collaborate with an agency that focuses on employee training to get a more affordable price. In addition, the company can also use the profits from the sale of new products (storage boxes, photo frames, and phone stands) or the savings in waste disposal costs to create an employee training budget.

3.3 Sustainable Value Stream Mapping After the Improvement Plan

After determining the improvement plan, the efficiency calculation is carried out again for the four indicators that were previously included in the critical category (Table 1). After calculating the efficiency after the improvement plan for each indicator, a Sustainable Value Stream Mapping chart is made, which can be seen in Figure 5. The proposed improvement plan brings changes to the efficiency values of the four indicators that were previously in the critical category.

Figure 5. Sustainable Value Stream Mapping After the Improvement Plan

Table 1. Comparison of Efficiency Values

Indicator	Efficiency Value Before Improvement Plan	Efficiency Value After Improvement Plan	Efficiency Improvement
Work in Process	8,72%	21,37%	12,65%
Recycling of Waste	58,86%	99,18%	40,32%
Safety Rate of Employee	57,14%	100,00%	42,86%
Training Rate of Employee	16,87%	95,05%	78,18%

4. Conclusion

The research conducted revealed that of the 11 indicators in 3 aspects (economic, environmental, and social), there were 4 indicators that were in the critical category. The first indicator is work in process, which is included in the economic aspect. The second indicator is recycling of waste, which is included in the environmental aspect, and the third and fourth indicators are the safety rate of employees and training rate of employees, which are included in the social aspect. The improvement plan for the work in process indicator is to move products every 6 pcs from the drilling process to the edging process and move products every 1 pc from the edging process to the finishing & packing process. For the recycling of waste indicators, the proposed improvement plan is the manufacture new products, namely storage boxes, photo frames, and phone stands. For the safety rate of employee indicator, suggestions for improvement are: providing training on the dangers of not using PPE, strict sanctions for violators, and using cut-

resistant gloves so that workers could not get injured by sharp objects. The efficiency of the training rate of employee indicator can be improved by regularly scheduling every month to send 8% to 10% of the total number of employees for training. For the training budget, the company can collaborate with relevant agencies to get affordable prices and use the profits from selling new products (storage boxes, photo frames, and phone stands) as well as the budget saved on waste disposal costs.

After the improvement, the 4 indicators that were previously included in the critical indicators experienced an increase in efficiency values. The increase in the efficiency value for the work in process indicator was 12.65%, the recycling of waste indicator increased 40.32%, the safety rate of employee indicator increased 42.86%, and the training rate of employee indicator increased 78.18%. With this increase, 3 indicators are in the excellent category and the work in process indicator is still in the critical category, but the efficiency value has increased considerably. This shows that improvement plans can have a positive impact on efficiency.

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Biographies

Vilia Vianti Halim was a student in the Department of Industrial Engineering at Tarumanagara University who graduated in 2022. She is active in various activities on and off campus, such as community service and other organizational activities. She has also participated in the 2021 International Conference on Mechanical, Industrial and Electrical Engineering (ICMIEE). She is highly motivated to gain more knowledge and experience that will benefit her in the future. She also likes to take on challenges as she is able to complete them as soon as possible, even under stressful conditions, with a positive attitude.

Wilson Kosasih was born in Medan, North Sumatra, Indonesia, is a lecturer in the Department of Industrial Engineering at Faculty of Engineering, Universitas Tarumanagara. Since 2005 conducted teaching, research and has served as Industrial Engineering Undergraduate Chairman since 2018 until now. He completed his Undergraduate Mechanical Engineering Education at Universitas Tarumanagara, obtained a Master Degree in Industrial Engineering at the Universitas Indonesia and is currently taking a Doctoral Program at the Institut Teknologi Sepuluh Nopember with a concentration in Industrial Management. Holders of professional certification in the field of supply chain and logistics, Certified Supply Chain Manager (CSCM) and Certified Professional in Logistics Management (CPLM) from ISCEA, USA, certification for Professional Engineer (IPM) from PII, and ASEAN Engineer certification from AFEO. He worked in a multinational company in the FMCG field before becoming a full-time lecturer since 2009. He has professional experience and consultant in the field of Productivity and Quality Engineering. Since becoming a lecturer, he has been active in research, scientific publications and community service by obtaining grants from within and outside Untar, such as from the Ministry of Research, Technology and Higher Education. His research field are Lean Manufacturing, Quality Engineering, and Supply Chain Management. In addition, he is also active in professional organizations, currently as a member of the Professional Competency Assessment Board for Industrial Engineering Engineers at BKTI PII, as well as an External Assessor for Electronic-Based Government Systems, Ministry of State Apparatus Empowerment and Bureaucratic Reform of the Republic of Indonesia.

Lithrone Laricha Salomon is a lecturer at Industrial Engineering Department of Universitas Tarumanagara since 2006. She graduated from Universitas Tarumanagara with a Bachelor's Degree in Mechanical Engineering. She continued her study and got her Master's Degree from Industrial Engineering Program at Universitas Indonesia. She teaches a subject related to quality management system such as Total quality management, Quality Control, Design of Experiment and Industrial Statistic. Besides teaching she also did some research and carrying out a number of community service activities in many places around Indonesia. She has written more than 40 publication on International and national proceeding and journal since 2007.