

# **Green Lean Six Sigma Implementation Framework: A Case Study of Indonesia Tapioca Flour Industry**

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## **Abstract**

The GLSS approach that has been designed by previous researchers is used to overcome problems that are integrated within a company. The current study uses the GLSS framework with the aim of building a framework for improving product quality and reducing environmental impact on a manufacturing industry. the method used in this research is the GLSS approach with the DMAIC research stage where the GLSS approach in the manufacturing industry is real. Green manufacturing approach will be used to analyze problems in the wastewater treatment plant department. lean manufacturing approach is used to analyze problems in the production department. six sigma approach is used to analyze problems in the quality control department. The results of this study are used to build a framework as a work reference in controlling the company.

## **Keywords**

GLSS, Manufacturing, Product Quality, Environmental Impact

## **1. Introduction**

Covid-19 pandemic entered Indonesia on March 2, 2020. This situation has an impact on the entire life structure of the Indonesian people, one of which is the manufacturing industry sector. Many manufacturing companies experienced a decline in demand and production. Not a few companies have laid off their employees during this pandemic (Ropidin, 2020).

As the pandemic period begins to subside, the order of life, business, and including in the manufacturing industry is no longer the same as it was before the pandemic. All sectors have new challenges in the context of the new normal (Blessings et al., 2020). According to the Ministry of Industry of the Republic of Indonesia, the manufacturing industry in Indonesia also needs to make efforts to recover and face challenges in the new normal era. The recovery of the manufacturing industry sector needs to be balanced with better production processes to welcome the new competitive market era. Every company needs to prepare for market competition in the new normal era, where global

competitors are also indicated to carry out the production process to produce high quality products and services to win market competition.(Sneader, Kevin; Singhal, 2021).

The new normal era has become the starting point for the improvement of Indonesia's manufacturing industry. Moreover, in the last decade, market orientation and consumer satisfaction with service quality and manufactured products are not only related to products that meet specifications and are free of defects but also environmentally friendly products.(Shokri, A.; Li, 2020). Even environmental legislation around the world has forced organizations to synchronize corporate environmental objectives with operational performance requirements(Garza-Reyes, JA; Yu, M.; Kumar, V.; Upadhyay, 2017;Parmar, PS; Desai, 2019). Thus, the post-covid-19 pandemic has prompted the company to restructure its production strategy to help the government's economy and organizations with environmental protection and conservation of natural resources.(Samuel et al., 2021). This challenge also needs to be synchronized with efficient production processes, by minimizing and even eliminating production waste because a system is needed to improve environmental performance in an organization without compromising operational goals.(Mangla et al., 2018).

So far, there are several approaches to overcome the production activities of an industry, including Green Manufacturing, Lean Manufacturing and Six Sigma. In overcoming the waste problem, the Green Manufacturing concept is used, where this approach has the opportunity to increase the dynamics of profitability through reducing emissions, waste and product failure(Kumar, S., Luthra, S., Govindan, K., Kumar, N., Haleem, 2016). Lean Manufacturing is used to systematically eliminate waste in all activities in the production process(Zhu et al., 2018;Panwar et al., 2018). Then, in overcoming product defects, the Six Sigma approach is used, where Six Sigma is used to reduce variations in the process that leads to the reduction of product failures (defects).(Kumaravadivel & Natarajan, 2013).

There is also a Lean Six Sigma approach, where this approach is able to reduce defects, waste and help to remain competitive in the global market. However, in line with market standards, it is necessary to increase production activities that focus on reducing the impact on the environment that is synchronized with the company's operational activities(Kaswan et al., 2021). Although the implementation of each method of Green Manufacturing, Lean Manufacturing and Six Sigma has had a positive impact, the combined implementation of the three is expected to be more significant than the implementation of each method individually.(Green, KW; Inman, RA; Sower, VE; Zelbst, 2018)

This GLSS integrates the three approaches, namely Green Manufacturing, Lean Manufacturing, and Six Sigma. The appropriate GLSS approach was applied to accommodate the problems at PT SM II which still had problems with aspects of industrial waste, production effectiveness and product quality.

## **1.1 Objectives**

This study will focus on analyzing and trying to improve product quality by taking into account the environmental impacts caused and investigated on real manufacturing study objects by implementing GLSS in three departments, namely WWTP, production and Quality Control (QC). The method used in this study uses the DMAIC method with research results that provide a framework as a work reference and company control.

## **2. Literature Review**

### **2.1. GLSS concept**

The Green Lean Six Sigma approach is a complementary method to the three stand-alone approaches, namely Green Manufacturing, Lean Manufacturing and Six Sigma because each approach has the potential to minimize the weaknesses of the other.(Sony, M., Up, 2020). Previously there were several strategies that had been developed by(Garza-Reyes, JA; Yu, M.; Kumar, V.; Upadhyay, 2017;Bhat, S., Gijo, EV, Jnanesh, 2014)which aims to manufacture products with high specifications. However, it turns out that the strategy is not able to communicate all the points collectively related to sustainability(Pandey, H., Garg, D., Luthra, 2018). The Green Manufacturing approach if it stands alone can only overcome environmental problems, it has not been able to overcome the problems related to waste production and product defects. Likewise with the Lean Manufacturing approach and the Six Sigma approach which have not been able to solve complex problems and integrate within a company so that assistance from other approaches is needed. Therefore, the GLSS approach emerged that was able to address each other's problems in

an integrated manner. Therefore, (Kaswan & Rathi, 2020) conducted research that resulted in the GLSS approach. Then followed by research (Yadav et al., 2021) which produces the GLSS framework.

## **2.2. Green Manufacturing**

Green Manufacturing is an approach to reduce the negative environmental impact of a product by making the product environmentally friendly (Garza-reyes & Garza-reyes, 2015). The Green Manufacturing method is used as a company operations management that is aware of the environmental impacts of the operations and production processes (Deif, 2011). Green Manufacturing is a manufacturing practice that is safe for the environment in every production process (Prabowo, 2017). With the development of the industrial world, the concept of Green Manufacturing does not only focus on manufacturing, but also extends to a process of the system with the aim of minimizing environmental impacts or even eliminating negative impacts on the environment. (Prabowo, 2017).

## **2.3. Lean Manufacturing**

Lean Manufacturing is an approach that advocates the systematic elimination of waste through improvement at all levels of the organization (Panwar et al., 2018; Zhu et al., 2018). According to research conducted by (Kaswan & Rathi, 2020) Waste can be identified based on seven points of wastage, which are as follows:

1. Overproduction, waste at this point is caused by excessive production quantities such as producing earlier than a predetermined schedule, producing with more capacity than the daily target.
2. Waiting, the waste at this point is caused by the waiting time for the next process. Waiting is an interval when the operator does not use the time to do value adding activity. This happens because the operator is waiting for the product flow from the previous process.
3. Transportation, waste at this point is caused by the activity of requesting material or work in process (WIP) from one workstation to another.
4. Excess processing, the waste at this point is caused by the work method or work order used so far that is not flexible and good. In addition, this waste also occurs because there is no standard operating process so that it causes variations in the work method of the operator and causes quite high damage.
5. Inventories, the waste at this point is caused by the presence of supplies that are not too important. With the supply of unnecessary materials will require a lot of space to store it.
6. Motion, waste at this point is caused by unnecessary activities or movements carried out by the operator and does not add value and slows down the process so that lead time increases.
7. Defect, the waste at this point is caused by the damage of a product or a product that does not meet the specifications. So it is necessary to carry out a less effective rework process. In addition, there will be complaints from consumers and a high-level inspection is possible.

In identifying the presence of waste, a mapping of production activities is carried out through Value Stream Mapping (VSM). VSM is an adaptation of the Toyota Technique, which is a flow diagram of materials and information used to represent and analyze all processes and activities that add value or do not provide added value and allow quantification of production time and identification of opportunities for improvement. (Rother, M. and Shook, 1999). The stages in the preparation of VSM are to determine the product, create a current VSM map, create a future VSM map and design improvements (Maulana et al., 2019).

## **2.4. Six Sigma**

Six Sigma is a method used to reduce variations in the process that leads to the reduction of product defects (Kumaravadivel & Natarajan, 2013). Six Sigma merupakan pendekatan berbasis statistik yang bekerja pada sebuah proyek dengan menggabungkan alat-alat yang berkualitas untuk dapat melengkapi metodologi dari Green Lean (Sreedharan, V.R., Sandhya, G., Raju, 2018). Dalam menganalisis masalah yang berkaitan dengan defect product, dilakukan dengan tahapan DMAIC. Berdasarkan penelitian yang dilakukan oleh (Caesaron & Simatupang, 2015), tahapan DMAIC adalah sebagai berikut :

1. Define  
Tahap define merupakan tahap awal dalam konsep Six Sigma. Pada tahap ini akan ditentukan tujuan dan sasaran serta mengidentifikasi masalah-masalah yang berkaitan dengan kecacatan produk.
2. Measure  
Tahap ini merupakan tahap pengukuran tingkat kecacatan, seperti menggunakan diagram pareto, menentukan cacat yang dominan, mengukur tingkat sigma dan mengukur DPMO.

3. Analyze

This stage is the stage to analyze and find the root cause of the problem of product defects. At this stage can be used several tools, i.e., diagram fishbone, control of process capability and quality characteristics.

4. Improve

This stage is the stage for providing short-term solutions to product defects. Some studies use the method failure mode and effects (FMEA) at this stage. This is done to determine the improvement plan that will be proposed.

5. Control

This stage is the stage to provide long-term solutions, where control is carried out on the process that has been improved. Tools used at this stage can be taken from tools that ever existed.

## **2.5. Green Lean Manufacturing**

Lean Manufacturing used because it is able to measure waste but cannot measure the environmental impact generated during the production process (Sreedharan, VR, Sandhya, G., Raju, 2018). Meanwhile, Green Manufacturing is able to measure the gap and can estimate the environmental impact of the waste generated. The main purpose of green manufacturing is to reduce waste of resources and pollution, as well as to improve the environmental performance of the organization (Kaswan & Rathi, 2020). Thus, the application of the Green Manufacturing method can overcome the limitations experienced by Lean Manufacturing. Green Manufacturing will help Lean Manufacturing because it can reduce negative environmental impacts and other related waste (Dües, CM, Tan, KH, Lim, 2013). Likewise with the Green Manufacturing method, if it is not combined with the Lean Manufacturing method, even though it can reduce environmental impacts, the Green Manufacturing method cannot reduce waste in production activities. (Siegel, R., Antony, J., Garza-Reyes, JA, Cherrafi, A., Lameijer, nd). Therefore, a Green Lean Manufacturing approach is needed that not only minimizes waste but also reduces the environmental impact generated during the production process (Bergmiller and McCright, 2009).

## **2.6. Lean Six Sigma**

Lean Six Sigma is an approach that reduces defects, waste and helps to remain competitive in the global marketplace. In line with market standards, it is necessary to increase production activities that focus on reducing harmful impacts on the environment that are synchronized with the company's operational activities (Kaswan, 2021). The manufacturing sector has also implemented a Lean Six Sigma strategy in the production process with the aim of minimizing waste and process variation. However, due to increasing concerns about the sustainability of policies demanded by the government, the organization must be able to change the dynamics of its operations towards environmentally friendly methods.

## **2.7. Green Six Sigma**

Six Sigma is a data-driven approach and provides a step-by-step and concrete methodology for reducing waste (Sreedharan, V., R. Sunder M., V. Madhavan, 2020). Although the Six Sigma approach is able to reduce waste through the reduction of defects, it cannot identify the different wastes and their environmental impacts (Hussain, K., He, Z., Ahmad, N., Iqbal, 2019). Therefore, it takes a combination of strategies, namely Green Manufacturing, in order to cover this gap. Based on this, it is necessary to integrate Green Manufacturing and Six Sigma in overcoming the problems that exist in a manufacturing industry.

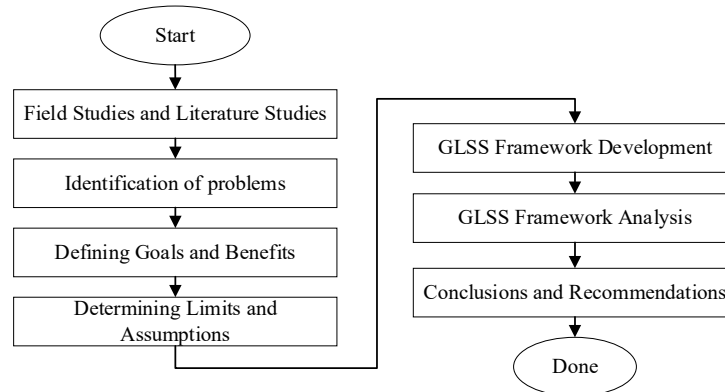
## **2.8. Green Lean Six Sigma (GLSS)**

The three dimensions of sustainability, namely environmental, economic and social are important factors that must be considered by an industry (Ershadi, MJ, OQ Taghizadeh, 2021). GLSS complements the organization's efforts to achieve these three dimensions by reducing waste, wasted production and product defects. The integration between the Green Lean Manufacturing concept that has been formed has been able to recognize waste and measure the ecological impact, but this concept has not been able to provide an actual method to reduce waste and defects related to the production process. (Garza-reyes & Garza-reyes, 2015). Meanwhile, in the last few decades, various individual strategies from Green Manufacturing, Lean Manufacturing and Six Sigma when working alone have not been able to communicate the three problems above collectively and sustainably. (Pandey, H., Garg, D., Luthra, 2018). Therefore, it is very important to integrate these three methodologies in the GLSS umbrella unit. An integrated GLSS approach will help companies to reduce energy use in their production processes (Kaswan, MS, Rathi, 2019). The implementation of a comprehensive GLSS approach must use gradual work steps, which must estimate the strengths and weaknesses of the company and determine priorities, as well as select targets for successful GLSS

implementation.(Gholami, H., N. Jamil, MZM Saman, D. Streimikiene, S. Sharif & Zakuan., nd). With the combination of Green, Lean and Six Sigma, we are able to produce products that are not only of high quality and low cost but also environmentally friendly.(Hussain, K., He, Z., Ahmad, N., Iqbal, 2019). This can be proven by previous research which states that industries that have included GLSS have achieved greater performance than using the previous independent strategy.(Kaswan & Rathi, 2020).

### 3. Methods

The method used in this study, namely the GLSS method with the following research stages.



The following is an explanation of the research stages.

- a. Field Studies and Literature Studies  
Field studies were carried out to observe and identify constraints during the production process, especially in the Department of Waste Water Management Installation (WWTP), Production Process and Quality Control (QC) in the company.
- b. Identification of problems  
After describing the problems studied, the formulation of the problem is carried out. The problem studied in this study is to identify three company departments, namely WWTP, Production and QC..
- c. Determining Goals and Benefits  
The next stage is to determine the objectives and benefits of the research. The purpose of this research is to implement GLSS in a company to analyze the problems that exist in the company.
- d. Determining Problem Limits and Assumptions  
This stage is the stage to determine the boundaries of the problem that may not be discussed in this study. This stage also takes some assumptions that are used to solve the problem to be solved.
- e. Developing the GLSS Framework  
At this stage, the research framework is developed (Yadav et al., 2021) which has been developed in accordance with the problems that exist in PT SM II. This framework explains how the stages of problem solving are integrated and look for ways to solve problems that will exist in the company.
- f. GLSS Framework Analysis Stage  
After identification using DMAIC analysis, the next step is to analyze the results obtained.
- g. Closing Stage  
At this stage, conclusions are obtained as a result of the research that has been done. Conclusions answer the goals that have been set previously.

### 4. Data Collection

This GLSS integrates the three approaches, namely Green Manufacturing, Lean Manufacturing, and Six Sigma. The appropriate GLSS approach was applied to accommodate the problems at PT SM II which still had problems with aspects of industrial waste, production effectiveness and product quality. The implementation of Green Manufacturing in SM II will be used as an effort to support waste water management (WWTP) in order to reduce the smell of waste from production. Lean Manufacturing will be implemented in order to reduce waste in the production process, such as waiting time at PT SM II. Then, Six Sigma is used to reduce product defects at PT SM II. During the first observation, several problems were found in the company as shown in Table 1.

**Table 1** Company Problem

Department Waste Management Problems	Production Department Waste Problems	QC Department Defect Product Problems
Smell of sewage	Waiting time production equipment cleaning	Out of Spec Moisture Content
The factory area is not tidy	Losses starch levels	Dangers of Metals in Flour
	PPE is not complete	No warehouse specification control
	There is no master schedule for daily production	
	There is no master schedule for daily maintenance	

## 5. Results and Discussion

After finding several problems that exist in the company under study, the following is the development of the GLSS framework in overcoming the existing problems.

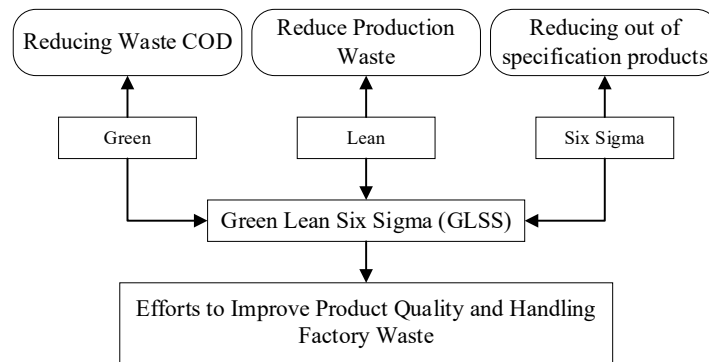


Figure 1 GLSS Framework Development (Yadav et al., 2021)

Based on the results of initial observations and data obtained during the research period, several problems were found which are shown in Table 1. Figure 1 shows the framework for the problem that has been reduced to 3 parts, namely green, lean and six sigma.

At this stage, GLSS addressing green problems is used to identify, measure, analyze and fix problems related to the WWTP department. In this study, the focus is on overcoming the smell of factory waste. At this stage, GLSS overcoming lean problems is used to identify, measure, analyze and fix problems related to the production department. In this research, the problem is focused on reducing waste in the production process. At the problem solving stage, GLSS six sigma is used to identify, measure, analyze and fix problems related to the quality control department. In this study, the problem focused on overcoming product defects in tapioca flour. At the unified stage the GLSS is used to identify, measure, analyze and fix problems related to the integration of the three departments, namely WWTP, production and QC. In this study, the problem is focused on overcoming the emergence of problems that are integrated from the three departments.

The results of the study indicate that there are root causes that were found, and it is possible that they are the root cause of the unity of the three departments. The root of the problem is not yet updated. The company's daily master production schedule causes asynchrony between each department.

## 6. Conclusion

The Green Lean Six Sigma approach is a complementary method to the three stand-alone approaches, namely Green Manufacturing, Lean Manufacturing and Six Sigma because each approach has the potential to minimize the weaknesses of the other. Based on the research results that have been obtained, one solution to overcome the problems

of each department is to update the master production schedule. In addition, the company needs to develop a production and control SOP that integrates the three departments to prevent problems arising from the three departments in the future.

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## **Biography**

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