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COST REDUCTION STRATEGY IN PAPAYA PRODUCTION: IMPLEMENTING DMAIC AND LEAN FARM

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Abstract

Great Giant Pineapple (GGP) faced significant losses in papaya production in 2022, with actual costs reaching IDR 25,000/Kg against a budget of IDR 5,900/Kg, resulting in a IDR 4.2 billion loss. Plant care and maintenance, particularly fertilization and manual pesticide application, were the primary cost drivers. Utilizing the DMAIC methodology and SAP data, the research focused on cost reduction. Fertilization costs were dominated by materials, which were deemed unchangeable due to research-backed recommendations. Therefore, the study targeted labor efficiency in manual pesticide application. Cost-benefit analysis identified "Improvement Scenario 1" (layout: double-row, 1,8 meter, 3,25 meter operational road) as the most effective/best alternative for cost reduction. This scenario was selected for implementation to achieve cost efficiency in pesticide application, aiming to reverse the substantial losses incurred in papaya production. The project aimed to bring the cost closer to the budgeted amount, thus making the papaya business profitable.

Keywords: ***DMAIC, ERP, Cost-benefit analysis, Papaya production***

1. Introduction

The demand for fresh fruits in Indonesia is increasing. Revenue in the fresh fruits market is projected to reach US$ 22.57 billion in 2024, with an annual growth rate of 7.28% from 2024 to 2028. The market volume is expected to hit 11.10 billion kg by 2028. This growth is driven by a rising middle class, increased health awareness, and a preference for high-quality imported fruits (Levi et al, 2020; Tambalis et al., 2024). Papayas are among the favorite fruits in Indonesia, as shown by data from the Central Bureau of Statistics, which lists papayas among the top three most consumed fruits. Bananas are the most consumed fruit, with an average daily consumption of 24.71 grams per capita, followed by oranges at 12.57 grams, papayas at 11.71 grams, and watermelons at 8.57 grams per capita per day (BPS, 2024). The demand for papayas in Indonesia is fueled by their year-round availability and popularity among the local population. Papayas can produce fruit throughout the year, providing a consistent source of fresh fruit for consumers. They are considered one of the most important fruits due to their rich content of antioxidant nutrients, B vitamins, minerals, and fiber (Simmonds and Preedy, 2016).

Papaya holds significant importance in Indonesia, both in terms of consumption and production. The country's papaya production has been steadily increasing, with a large portion serving the domestic market (BPS, 2024). Indonesia ranks among the top papaya-producing countries globally, contributing 6.89% to the world's total papaya production. According to the Central Bureau of Statistics, Indonesia's papaya production reached 1,238,692 metric tons in 2023, equivalent to 11.9 grams per capita (Yeh et al., 2014; Hewajulige and Dhekney, 2016; BPS, 2024). However, field visits in 2023 revealed that most papayas in Indonesia are produced by farmers for the general trade or traditional market segment. Consequently, the supply of papayas suitable for the modern trade market is estimated to be significantly below per capita demand. Assuming a market price of IDR 2000/Kg, the market value of papayas in Indonesia could reach IDR 2.4 trillion.

Great Giant Pineapple (GGP), a subsidiary of Gunung Sewu Group, is a prominent fresh fruit producer in Indonesia with a strategy to develop the papaya commodity. The priority for fresh fruit development at GGP is as follows: Cavendish bananas, which have been cultivated for over 25 years, are the largest production, followed by fresh pineapples, crystal guava, and then papaya. GGP has been developing papaya since 2014 with the help of a consultant from Taiwan. The company targets the fresh fruit segment for modern trade, which still has a considerable demand gap. However, the main challenge in GGP's papaya production is the high production costs. Identifying the root causes and implementing cost-efficient strategies is essential to improve profit margins and strengthen Great

Giant Pineapple's competitive edge in the papaya market. At the end of 2022, when operations were still using the old or conventional process (before improvements), the actual cost of producing papayas reached IDR 25,000/Kg, while the budget was only around IDR 5,900/Kg. According to the financial report shown in Figure I.1, the largest cost contributor was the Plant Care and Maintenance activity group, accounting for 40% of the production costs. With an average selling price of IDR 6,300/Kg, papayas in 2022 recorded a loss of IDR 18,700/Kg. With production reaching 225 tons that year, GPP's loss in the papaya business amounted to IDR 4.2 billion.

2. Literature Review

2.1 Pareto Analysis

Pareto analysis, also known as the "80/20 rule," is based on the observation that operational results and economic wealth are not evenly distributed, with some inputs contributing more significantly than others. This concept, introduced by the 19th-century Italian economist Vilfredo Pareto, highlights a "predictable imbalance" where, for example, 80% of Italy's wealth was held by 20% of the population (Powell & Sammut-Bonnici, 2015).

Researchers have observed similar patterns in various systems with inputs and outputs, such as production and financial management. For instance, in quality control of microchip production, most defects often stem from a small set of issues, like specific machines or raw materials. Similarly, an international corporation might find that a majority of its revenues come from a few regional business units, or that a handful of products generate most of its profits. A small subset of customers may also account for the majority of revenues. It's important to note that the 80/20 ratio is not exact but indicative, suggesting that the majority of results often come from a minority of inputs (Powell & Sammut-Bonnici, 2015).

Pareto analysis, as applied in strategy, finance, manufacturing, and also in quality management, differs somewhat from Vilfredo Pareto's original concept. Pareto's idea was that for maximum welfare, the utility of some should not increase at the expense of others. Pareto efficiency is achieved if those who gain can, in theory, fully compensate those who lose, even if compensation does not occur in practice. Pareto was an early advocate of strategic thinking that emphasized social responsibility and competitive regulation. In its modern application, Pareto analysis focuses on the efforts (products, customers, business units) that generate most of an organization's results (revenues, profits, ROI). The 80/20 rule implies that most efforts are inefficient and should be minimized, while efforts that produce the majority of results should be maximized (Powell & Sammut-Bonnici, 2015).

In strategic management, Pareto analysis is linked to evaluating an organization's internal environment. It helps identify internal strengths and weaknesses by assessing resources and capabilities, which form the basis of core competencies and competitive advantage. A Pareto analysis can begin by reviewing organizational inputs from a functional perspective, similar to a SWOT analysis. This includes analyzing finance, management, infrastructure, supply chains, manufacturing, distribution channels, marketing, and innovation resources. The Pareto effect also applies to customers, sales force, and reputational equity. Many businesses tend to add new products and customers without eliminating obsolete or unprofitable ones. Sales functions often resist rationalizing non-viable products or customers, even though a small percentage may account for the majority of costs in areas like inventory, production, IT, and administration (Powell & Sammut-Bonnici, 2015).

2.2 Lean Six Sigma

All sectors exposed to global competition have equal opportunities from various organizations worldwide. To respond to the pressures of global competition, companies must adopt competitive and innovative methods, often emphasizing quality and customer focus. These approaches not only aim to improve quality, products, services, and processes but also prioritize customer satisfaction. The use of quality methods is on the rise (Tampubolon & Purba, 2021). Lean manufacturing is a concept designed to eliminate waste and processes that do not add value to customer satisfaction, thereby increasing the company's efficiency and effectiveness. On the other hand, the Six Sigma method aims to reduce process variability. Motorola successfully adopted Six Sigma in the 1980s to enhance quality by consistently reducing variability in manufacturing operations (Olanrewaju et al., 2019).

Six Sigma focuses on delivering what customers want from a high-quality product, while lean manufacturing specifically targets waste reduction and non-value-adding activities to enhance customer satisfaction (Tampubolon & Purba, 2021). Lean Six Sigma (LSS) has now become a leading business improvement methodology, successfully implemented across various types of businesses. The goal of LSS is to drive business improvement by integrating the key features of Lean and Six Sigma into a cohesive approach to enhance business performance. Six Sigma addresses Critical to Quality (CTQ) issues affecting organizations, while Lean focuses on systematically creating value and reducing waste (Thomas et al., 2016).

When implemented correctly, lean principles can significantly impact a business by improving efficiency, reducing cycle times, lowering costs, and enhancing competitiveness. The primary goal of lean is to eliminate waste—

non-value-added components in any process. Lean principles are not limited to manufacturing; they can also improve inventory management and client interactions, enhancing team collaboration (Tampubolon & Purba, 2021). According to researchers (Sibalija & Vidosav, 2014), the basic principles of lean include:

1. Value Flow: Identify the value flow for each product, which includes both value-added and non-value-added activities. This sequence of events, from concept to delivery, should add value to customer expectations. Lean aims to eliminate activities that do not create value. There are seven known wastes in manufacturing, with less than 1% of activities typically being value-added.
2. Value: Determine the value of a product precisely from the customer's perspective.
3. Pull: The customer pulls value from the producer. In the production chain, when the customer demands the product, each production process is triggered to produce it simultaneously.
4. Flow: Create a continuous flow of products based on customer requirements, ensuring that the process is uninterrupted. This involves a strict order of steps to ensure smooth product flow towards the customer.
5. Perfection: Continuously strive for perfection by eliminating wasted steps and introducing flow and pull. The goal is to achieve a state where no waste exists, resulting in perfect value.

The Japanese term “Muda” refers to the elimination of wasteful activities, a fundamental lean principle known as “Toyota's seven wastes,” identified by Ohno (1988) in the Toyota Production System (TPS). These wastes include over-processing, overproduction, transport, unnecessary/excessive movements, waiting, defects, and unnecessary inventory.

2.3 8 Waste of Lean

Lean manufacturing identifies eight types of waste that do not add value to the customer (Tampubolon & Purba, 2021). These wastes are:

1. Overproduction: Producing more products than needed, leading to excess inventory and increased storage costs.
2. Waiting: Idle time when people or equipment are not in use, causing delays and inefficiencies.
3. Overprocessing: Spending more time or resources on a product than necessary, such as using high-tech machinery for simple tasks or adding features that customers do not need.
4. Excess Inventory: Holding more inventory than required, which ties up capital and increases storage and handling costs.
5. Unnecessary Transportation: Moving products or materials more than necessary, which can lead to damage and increased costs.
6. Unnecessary Motion: Excessive movement of people, equipment, or machinery, which can cause wear and tear and reduce productivity.
7. Unused Talent: Not fully utilizing employees' skills and creativity, leading to missed opportunities for improvement and innovation.
8. Defects: Producing defective products that require rework or replacement, resulting in additional costs and wasted resources.

By addressing these wastes, lean manufacturing aims to streamline processes, reduce costs, and deliver greater value to customers. This approach not only improves efficiency but also enhances the overall quality and competitiveness of the manufacturing process (Tampubolon & Purba, 2021).

2.4 DMAIC Six Sigma Methodology

Six Sigma is a statistical methodology aimed at reducing variability and standard deviation in data relative to the mean. Operating at a Six Sigma level means achieving an efficiency rate of 99.9997%, with only 3.4 to 4 errors per million components produced. The DMAIC process—Define, Measure, Analyze, Improve, and Control—is fundamental to Six Sigma, enabling the completion of projects by systematically addressing quality issues (Tijerina et al., 2023).

Each phase of DMAIC employs various quality and identification tools to determine which variables need control. After identifying the root causes of failures, improvements can be implemented to enhance performance or reduce issues. Tools such as the voice of the customer, process mapping diagrams, design of experiments, and root cause analysis are categorized within each DMAIC phase for better understanding and effective application (Tijerina et al., 2023). Stage of DMAIC Cycle:

Define (D). The goal of the Define stage is to identify and document any potential issues or factors that could impact the process or outcome. Tools such as the SIPOC diagram, voice of the customer, process mapping, and chain mapping are utilized for this purpose. After selecting the variables, objectives for the DMAIC method and Six Sigma approach are established. These goals are typically set based on the anticipated savings from addressing major challenges and reducing variability (Tijerina et al., 2023).

Measure (M). In the Measure phase, the quality critiques identified in the Define stage are applied to significant factors contributing to process issues. Since every process has inherent variance, the goal is to identify this variation. It's crucial to understand what needs to be measured and how to measure it at this stage. Various methodologies are used to select and evaluate the critical variables to comprehend their variation and significance (Tijerina et al., 2023).

Analyze (A). The aim of the Analyze stage is to pinpoint the root cause of the problem, influenced by the key variables identified during the Measure phase. The tools used in this stage may vary depending on the project type, but they must adhere to the scientific method, involving meticulous data collection and interpretation. This approach ensures accurate analysis and identification of the root cause. (Tijerina et al., 2023).

Improve (I). In the Improve stage, since the root causes of the problem have already been identified, the changes implemented should be straightforward and sustainable within the organization. If continuous variables are used or factors were identified at this stage, a design of experiments can be employed to determine the best way to organize these variables to minimize the issues identified in the Define stage.

Control (C). The Control stage focuses on maintaining the improvements made. This can be achieved using tools that provide visibility and ensure ongoing control over the enhancements. To confirm that the changes effectively addressed the issues identified in earlier stages, the critical variables are reassessed at this stage (Tijerina et al., 2023).

3. Research Methods

3.1 Research Design

This research utilized the DMAIC methodology (Define, Measure, Analyze, Improve, Control) to achieve strategic cost reduction in papaya production, Great Giant Pineapple. Data was collected through interviews or brainstorming with farm staff or management, and historical records from the Enterprise Resource Planning (ERP) software used by Great Giant Pineapple, specifically SAP, ensuring data reliability.

3.2 Data Collection Method

DMAIC Stage	Purpose	Data Used	Data Collection Methods
Define	Clearly defining the problem or improvement opportunity.	Quantitative Data: Historical process performance data, key performance indicators (KPIs), and costs.	**Interviews,** **Document analysis,** **Brainstorming sessions,** **Process flow diagrams,** **Historical records:** from ERP software used by GGP: SAP.
Measure	Measuring the current process performance	Quantitative data: Process performance data	**Historical data analysis.**
Analyze	Identifying the root cause of the problem or improvement opportunity.	Quantitative data collected in the Measure phase.	**Cause-and-effect,** **Histograms,** **5 Whys,** **Brainstorming sessions.**
Improve	Developing and implementing solutions	Data from the Analyze phase. Data from experiments/trials.	**Simulation.**
Control	Ensuring that the implemented improvements are sustained.	Process performance data after the improvement.	**Periodic monitoring** of process performance.

The interview participants consisted of a combination of the internal team from the Other Fruit Dept-Papaya Sub Dept., followed by two customers, namely the Packing House Dept. team and the Sales and Marketing team at

PT. Sewu Segar Nusantara, as well as the operational support team, which includes the Accounting team. Here is the list of questions used in the interview session. The questions asked in the interview session vary for each respondent.

The brainstorming session was attended by the internal team from the Other Fruit Dept-Papaya Sub Dept. The issue discussed was finding the root cause of the high operational production costs of papaya in the field. The internal team members participating in the brainstorming session were personnel who are accustomed to operational activities, with the hope that they could help identify more accurate root causes.

Simulations were conducted by trying several solution options to the existing problems. For example, if the problem was found to be related to the capacity of facilities and infrastructure, a simulation of increasing the capacity of facilities and infrastructure was carried out to immediately determine its impact on the production process and the production costs of papaya. In operations, the simulation began with calibration activities. The calibration results were then used as a reference for calculations in the simulation. The option with the greatest impact on reducing operational production costs was chosen as the solution/improvement.

3.3 Data Analysis Method

DMAIC Stage	Purpose	Data Analysis Methods
Define	Clearly defining the problem or improvement opportunity.	**Process Flow Diagrams, Brainstorming.**
Measure	Measuring the current process performance and identifying relevant metrics.	**Histograms, Pareto Charts.**
Analyze	Identifying the root cause of the problem or improvement opportunity.	**Cause-and-Effect Diagrams (Fishbone Diagrams), 5 Whys, Brainstorming.**
Improve	Developing and implementing solutions to address the problem.	**Simulation, Cost-Benefit Analysis.**
Control	Ensuring that the implemented improvements are sustained.	**Control Charts, Trend Analysis.**

The stakeholders mentioned above are as follows: in the Define phase, they include a combination of the internal team from the Other Fruit Dept-Papaya Sub Dept., followed by customer, namely Sales and Marketing team at PT. Sewu Segar Nusantara, as well as the operational support team, which includes the Accounting team.

In the Analyze phase, the stakeholders referred to are the internal team from the Other Fruit Dept-Papaya Sub Dept., who are personnel accustomed to daily operational activities.

During the Improve Phase, discussions and brainstorming sessions will be planned to confirm the results of previous simulations and cost-benefit analyses. The chosen solution will take into account the outcomes of these discussions.

4. Results

4.1 Define Phase

Based on the 2022 Papaya financial performance report, it was found that the Papaya commodity experienced losses. The realized cost per kilogram (IDR/Kg) in that year was recorded at 14,837 IDR/Kg, which significantly exceeded the previously agreed budget with management. It is known that there are two main factors that can cause the high IDR/Kg: the costs incurred to finance operations or production, and the production that can be achieved in that year, shown in Table 4.1.

With the 2022 performance data, assuming that the expected/budgeted production plan was achieved, the financial performance of the Papaya commodity was still above the set budget. This was because the total realized direct costs during 2022 exceeded the established budget, shown in Table 4.1.

Table 4.1 Papaya Cost of Production Report in YTD 2022

PT Great Giant Pineapple
Papaya Cost Of Production 2022

Description	Year to Date (IDR) Actual		Year to Date (IDR) Budget		Variance
	IDR 'Mio	IDR / Kg	IDR 'Mio	IDR / Kg	
Harvesting Area (Ha)		147		38,42	109
Production Kebun (Kg)		301.517		983.416	(681.899)
Production Volume (Kg)		**225.475**		**848.500**	**(623.025)**
Direct Cost :					
Harvesting	**232**	**1.027**	**289**	**341**	**(686)**
Labor	191	849	183	215	(634)
Material	-	-	-	-	-
Transport	40	178	107	126	(52)
Plant Care + Maintenance	**2.361**	**10.473**	**2.055**	**2.422**	**(8.051)**
Labor	994	4.411	703	829	(3.582)
Material	1.309	5.804	1.283	1.512	(4.292)
Transport	58	258	69	81	(177)
Irrigation	**637**	**2.825**	**257**	**303**	**(2.522)**
Labor	-	-	183	216	216
Material	-	-	-	-	-
Charge	637	2.825	75	88	(2.737)
Quality Control	**1**	**2**	**14**	**16**	**14**
Labor	1	2	14	16	14
Packing House	**115**	**510**	**517**	**609**	**99**
Labor	93	411	498	587	176
Material	-	-	18	22	22
Transport	22	99	-	-	(99)
Genset	-	-	-	-	-
Charge		-		-	-
Total Direct Cost	**3.345**	**14.837**	**3.132**	**3.692**	**(11.145)**

5. Conclusion and Suggestions

4.2 Measure Phase

Based on the information obtained in the Define phase above, during the brainstorming activity, it was agreed that the next step in this phase would be to use the Pareto concept, where one cost group would be sought from all the components in the financial statements that contributes to the most to the realized direct costs. By examining the 2022 financial statements, it was found that the activity group or cost group that contributed the most to direct costs was Plant Care and Maintenance. Out of the total direct costs of 3,345 million IDR, this cost group was recorded at 2,361 million IDR, or contributing 70.5% of the overall total direct costs in 2022, shown in Table 4.1 and Figure 4.1.

Plant Care and Maintenance is an activity group, which means that the realized cost data of 2,361 million IDR in 2022 is a combination of several activities in plantation operations. For this reason, the Pareto concept is used again at this stage. With the help of data sourced from the ERP system used by GGP, the 5 largest activities in the Plant Care and Maintenance activity group are known as follows, as shown in the Figure 4.2. Based on data from the GGP SAP system, it is known that the activity with the highest cost (Plant Care + Maintenance Component) is the Fertilization activity, followed by Manual Pesticide Application, shown in Figure 4.2. The total cost was then analyzed to see the composition between labor costs and material usage. The results of this cost analysis are shown in Table 4.2. The analysis shows that although Fertilization ranks first for the largest total cost, the cost of this activity is dominated by material costs at 92%. The material itself cannot be easily changed because the materials used in operations are based on recommendations from the research team that need to be followed. Therefore, the efficiency in this project will focus on labor usage efficiency. The data from the analysis in Table 4.2 shows that the activity with the largest labor cost component is Manual Pesticide Application, with labor costs accounting for 60%, as shown in Table 4.2. If a Pareto analysis is conducted on the costs in 2022 specifically for labor usage, as shown in Figure 4.3, it can be seen that Manual Pesticide Application is the activity with the largest labor usage in 2022.

The Manual Pesticide activity is an activity of managing plant pests and diseases in the field. The materials applied in this activity are generally insecticides or fungicides. In addition, this activity is also used to apply nutrients or foliar fertilizers and biopesticides. This activity is considered to be carried out very regularly in the field. In a brainstorming session with the internal team of the Sub Department, it was found that under normal conditions, this activity is carried out once every 7 days or 52 times in one operational year. However, there are times when this activity becomes more frequent to adjust to field needs, such as when the humidity is high to avoid attacks by pathogenic fungi, the spraying activity becomes once every 5 days or 72 times in one year. Or the activity can become even more frequent, every 3 days, often due to attacks by Thrips insects. Based on the data above, it can be concluded that this Manual Pesticide activity is often carried out so that if changes can be made to this activity to become more efficient, for example in the use of resources such as labor, it can help in cost efficiency in Papaya commodity operations.

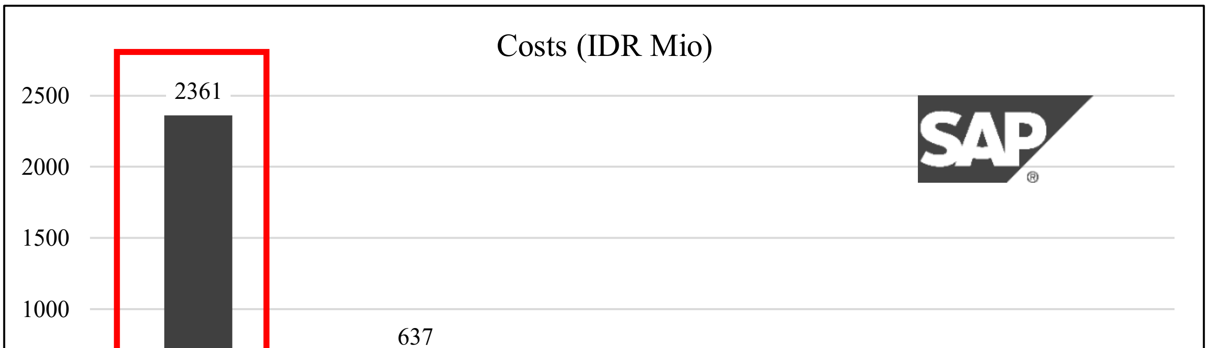

Figure 4.1 Pareto Components of Direct Cost for Papaya in the 2022 Financial Report

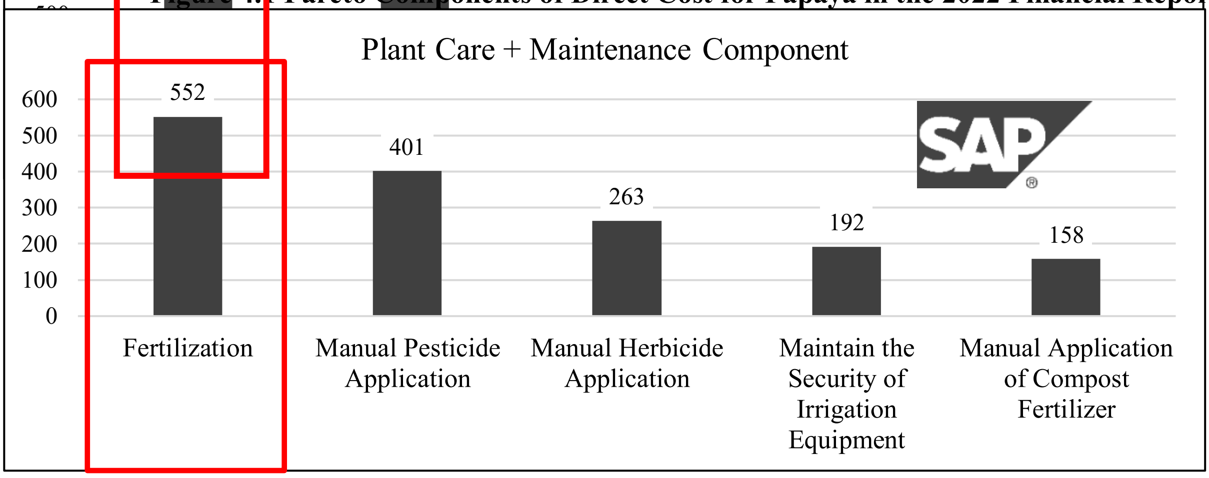

Figure 4.2 Pareto Largest Costs (Plant Care + Maintenance Component) in Papaya Operations in 2022 (Source: GGP's SAP)

Table 4.2 5 Largest Costs (Plant Care + Maintenance Component) in Papaya Operations in 2022 (Source: GGP's SAP)

Activity	**Rank**	**Total Cost Labor+Material (Mio IDR)**	Labor (Mio IDR)	Material (Mio IDR)	**Labor (%)**	Material (%)
Fertilization	**1**	**552**	44	507	**8%**	92%
Manual Pesticide Application	**2**	**401**	241	160	**60%**	40%

Manual Herbicide Application	**3**	**263**	100	162	**38%**	62%
Maintain the Security of Irrigation Equipment	**4**	**192**	78	114	**41%**	59%
Manual Application of Compost Fertilizer	**5**	**158**	23	134	**15%**	85%

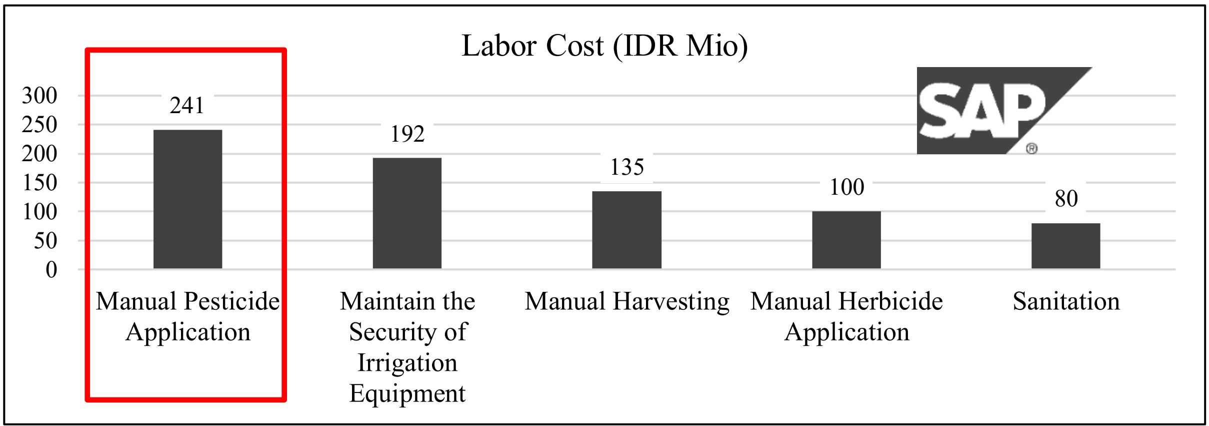

Figure 4.3 Pareto Activities in Papaya Operations with the Largest Labor Costs in 2022 (Source: GGP's SAP)

4.3 Analyze Phase

To help analyze the root cause of why the cost of labor in Manual Pesticide activity is high, an analysis is carried out with the help of a fishbone diagram, shown in Figure 4.4. To fill in this fishbone diagram, 10 internal employees of the Sub Department are involved in a Brainstorming session. Most of these employees have had long experience and have been involved for at least 3 years in the field operational activities of Papaya fruit production. Based on the weighting results in the Brainstorming session, the root problems with the highest weighting points in sequence are Narrow spacing between plant rows with a weight of 72, Limited capacity of work equipment, only 16 L with a weight of 71, and Low labor capacity with a weight of 67. With this, the internal team in the Sub Department agreed that the first cause of the high cost of manual pesticides in Papaya is the narrow spacing between plant rows, which results in larger units or the possibility of mechanization not being able to enter between the plant rows so that pesticide application activities are still carried out manually. The second root cause is the limited capacity of the work equipment, only 16 L, which causes workers to lose productive time because they have to go back and forth repeatedly to refill the solution to the work equipment due to capacity limitations; this causes the work capacity to be low. The third cause is the low labor capacity. In the Brainstorming session, it was agreed that this root problem was also caused by several causes, especially the two root problems mentioned above, which also had an impact on this. The narrow spacing between plant rows makes the mechanization process difficult. Besides that, the capacity of the work equipment used is limited, resulting in low labor capacity.

In the brainstorming session, the parties involved also identified the opportunity for the 7 wastes of lean. With the agreement of the three main root problems above, several wastes were found that are currently found in the manual pesticide application process in Papaya, shown in Table 4.3.

Table 4.3 Identification Results of 8 Wastes of Lean in Manual Pesticide Application

8 Waste of Lean	Findings
Motion	Repeatedly refilling pesticide solution due to limited work equipment capacity (16 L). Pesticide solution required for 1 hectare is 1500 L, then if only 1 worker is employed, that worker must go back and forth 93 times.

4.4 Improvement Phase

Based on the root cause analysis, three main root causes were identified as the reasons for the high labor usage in papaya operations. The first main root cause is narrow spacing between plant rows. An improvement that can be made is to change the plantation layout by increasing the distance between plant rows. This is done so that larger agricultural machinery can enter the work area. These larger agricultural machines are planned to carry equipment containing larger amounts of pesticide solution.

The second main root cause is the limited capacity of work equipment, only 16 L. A potential improvement to address this issue is to change the work equipment to those with a larger capacity that can hold a greater amount of solution. This is done to minimize the time wasted due to frequent refilling of the solution into the work equipment, as the previously used equipment had limited capacity.

The third main root cause is low labor capacity. To address this issue, a potential improvement is to increase the work capacity of the labor force. Increasing the work capacity of the labor force can be achieved by striving for mechanization in the method of pesticide application in the plantation.

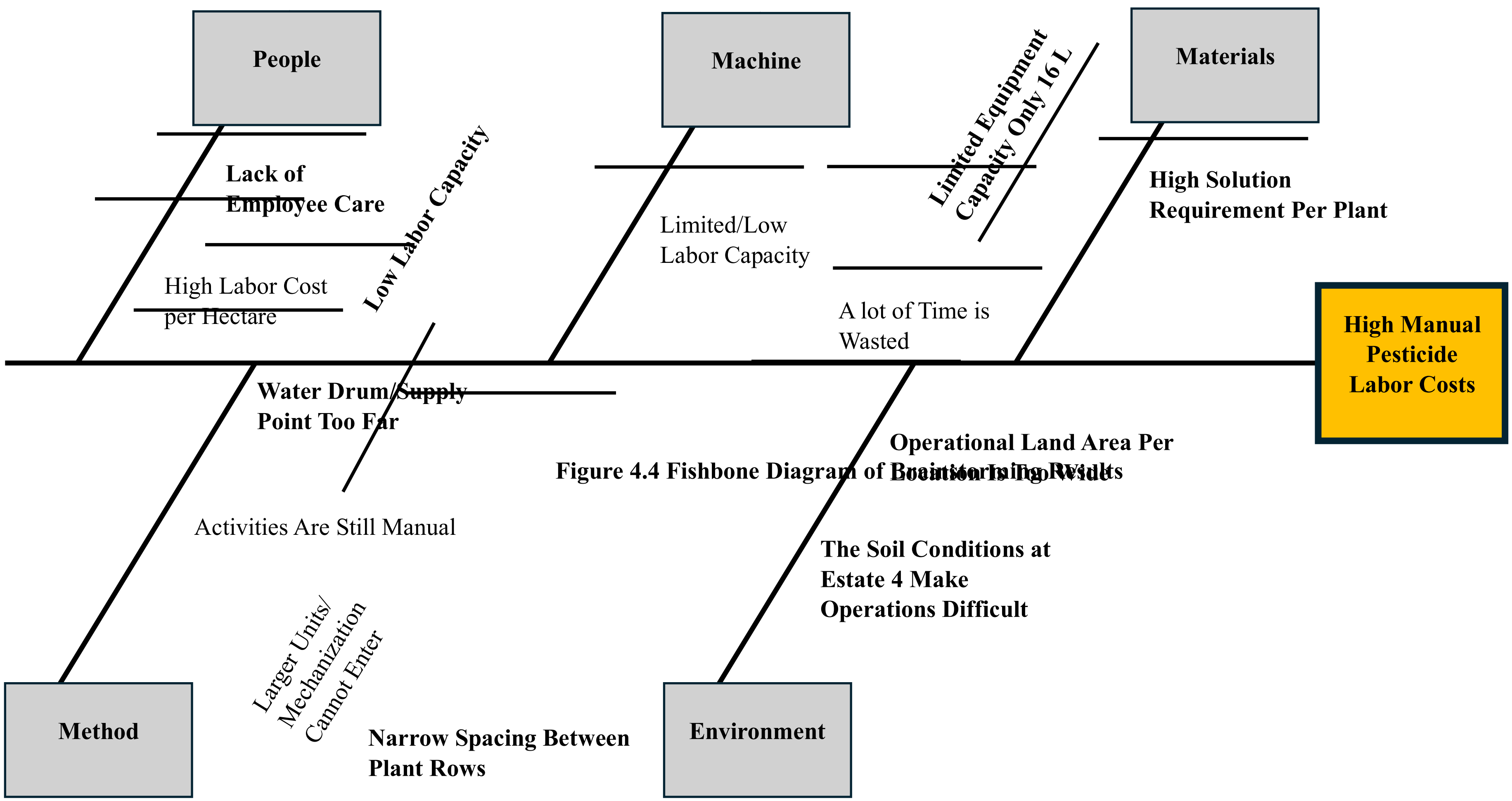

Figure 4.4 Fishbone Diagram of Brainstorming Results

Several improvement scenarios were proposed through brainstorming. The following are the three scenarios agreed upon by the forum, which will then undergo a Cost-Benefit Analysis process to select the best option for implementation in the field.

Table 4.4 Comparison Before Improvement with Two Improvement Scenario Options ***w=width**

	Before Improvement	Improvement Scenario 1	Improvement Scenario 2	Improvement Scenario 3
Spacing Between Plant Rows	Single-row 2,5 meter	Double-row 1,8 meter, 3,25 meter operational road	Single-row 3,85 meter	Single-row 3,25 meter
Estimated Population/HA	2000	2000	1298	1538
Farm Machinery	Fully Manual (Worker)	Hand tractor (w*: 1,2 meter)	Tractor WJ5 (w*: 2,0 meter)	Hand tractor (w*: 1,2 meter)
Equipment	Knapsack Sprayer	Plastic water tank, with Power sprayer	Alumunium water tank, with Power sprayer	Plastic water tank, with Power sprayer
Equipment Capacity	16 L	1000 L	5000 L	1000 L
Estimated Labor/HA	10	3	1,5	3
Labor Task/Job	All Sprayer	1 Machinery Operator 2 Sprayer	1 Machinery Operator 2 Sprayer	1 Machinery Operator 2 Sprayer
Estimated Labor Capacity	0,1 HA/Labor	0,3 HA/Labor	0,6 HA/Labor	0,3 HA/Labor

The creation of the above improvement scenario was carried out by first trying to utilize the equipment owned by the company. Some of the machinery that can be utilized includes the WJ5 tractor and an aluminum water tank with a capacity of 5000 L, which the company already owns.

During the brainstorming session, some participants also suggested new equipment such as a hand tractor and a power spray machine. Considering that the hand tractor is less powerful than the WJ5 tractor, it was also proposed to procure a plastic water tank with a capacity of 1000 L. Once the machinery and equipment to be used were agreed upon, the width of the machinery would affect the layout and population of papaya in the plantation.

The hand tractor was proposed by several participants because this machinery has a smaller size, thus its impact on the plantation layout is minimal, and the population does not decrease significantly.

Next, the three improvement scenarios above will undergo a Cost-Benefit Analysis. The calculation is done by simulating papaya production for 19 months, from 7 months after planting to the plant's removal at 26 months after planting. The estimated production data for these 19 months is obtained from the Papaya Cultivation Standards owned by the company. Subsequently, a simulation of pesticide application costs is carried out for each scenario. The cost components calculated include labor costs and machinery fuel costs, assuming a spray schedule of once a week or at 7-day intervals from 7 months to 26 months of plant age, or for 19 months of operation. The results of the Cost-Benefit Analysis can be seen in.

Table 4.5 Comparison Result of Cost-Benefit Analysis ***w=width**

	Before Improvement	Improvement Scenario 1	Improvement Scenario 2	Improvement Scenario 3
Spacing Between Plant Rows	Single-row 2,5 meter	Double-row 1,8 meter, 3,25 meter operational road	Single-row 4,00 meter	Single-row 3,25 meter

Estimated Population/HA	2.000	2.000	1.250	1.538
Estimated Production/HA 19 Month (Kg) (z)	154.000	154.000	96.250	118.426
Labor Cost per Cycle Application (a)	1.150.000	345.000	172.500	345.000
Fuel Cost per Cycle (b)	-	35.500	97.500	35.500
Number of Cycle (19 Month) (c)	76	76	76	76
Total Cost 19 Month (d) = ((a)+(b))*(c)	87,4 Mio IDR	28,9 Mio IDR	20,5 Mio IDR	28,9 Mio IDR
IDR/Kg 19 Month =(d)/(z)	567 IDR	187 IDR	213 IDR	244 IDR
Lowest IDR/Kg Rank	4	1	2	3

Based on the results of the Cost-Benefit Analysis (Table IV.7), it is known that Improvement Scenario 1 has the lowest estimated IDR/Kg compared to other scenarios. Therefore, Scenario 1 is the selected scenario that can be applied or implemented to achieve cost efficiency in pesticide application in the papaya plantation.

4.5 Control

Standardize the selected layout, resources, and work procedures into work instructions (WI) and standard operating procedures (SOP) with the assistance of the Quality Assurance (QA) team from PT. Great Giant Pineapple. Update the resource requirements data, including labor and charges (unit fuel), listed in the SBT (Schedule Budidaya Tanaman) document of PT Great Giant Pineapple, so that the budgeting process can obtain more updated and relevant calculations, especially after the improvements.

Conduct regular monitoring and measurement of costs to ensure that actual costs do not exceed the budgeted or agreed-upon costs (improvement results).

Before the new location begins pesticide application, the workers who will be working at the new location are given training.

5. Conclusions and Recommendations

5.1 Conclusions

To achieve a sustainable papaya business at GGP, it is essential to implement cost-efficient strategies to enhance profit margins. Addressing the high production costs in GGP's papaya cultivation necessitates exploring several key research questions:

1. What are the primary cost drivers in the papaya production process at GGP?
   Labor cost of manual pesticide application activity on the farm
2. What are the root causes of the high production costs in GGP's papaya cultivation, as identified through fishbone diagrams and other root cause analysis tools?
   Low labor capacity, limited equipment capacity, narrow spacing between plant rows
3. How can the DMAIC (Define, Measure, Analyze, Improve, Control) methodology be effectively applied to develop and test cost-reduction strategies in GGP's papaya production? DMAIC helps in finding the root causes of problems and formulating several potential improvement steps that can be taken

4. How can lean principles be implemented to streamline the production process and eliminate waste in GGP's papaya cultivation? During the analysis, one identified waste was Motion, which resulted from the limited capacity of the work equipment in use
5. What is the measured effectiveness of the implemented cost-reduction strategies in improving profitability at GGP? Cost-Benefit Analysis Result: 3 times potentia

5.2 Recommendations

Key Resources Needed

Here is the list of tangible and intangible resources needed for the implementation of the selected improvement.

Table 5.1 Tangible and Intangible Resources Needed

No.	Tangible	Untangible
1	Machinery and Equipment, Hand tractor, 1000 L capacity plastic water tank, 1 set of power sprayer machine including stick sprayer, nozzle and hose	Training and Knowledge: For labor/workers, machinery and equipment operation
2	Infrastructure, New plantation layout including new width of the operational road	Management and Planning: Project management
3	Labor, Skilled in machinery operation and technical plant protection	

Implementation Plan

If Scenario 1 is decided by management to be implemented, the following is the timeline for the implementation of the improvement, as shown in Table 5.2.

Table 5.2 Timeline of Improvement Implementation

Activity	Feb 25	Mar 25	Apr 25	May 25	Aug 25	Nov 27
Determination of the Experiment Location						
Procurement of Machinery and Equipment.						
Activity	**Feb 25**	**Mar 25**	**Apr 25**	**May 25**	**Aug 25**	**Nov 27**
Land Preparation, Planting with New Layout						
First Pesticide Application						
Cost Evaluation						

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