Inventory Management Optimization Study Case: Reducing Costs Through Packaging Bag Supply Efficiency Using Root Cause Analysis Approach

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Abstract

Efficient inventory management is a crucial aspect that companies must consider to reduce unnecessary costs. XYZ CORP, a fertilizer company, currently faces an issue of packaging bag overuse. The aim of this study is to identify the root causes of this issue and provide solutions to mitigate it. Furthermore, the proposed solutions will be simulated to evaluate their effectiveness, along with a calculation of the costs and benefits for the company. The research methodology includes Root Cause Analysis, incorporating the 5 Whys approach, and various inventory management methods such as Safety Stock, Just-in-Time, Bin Size, and Reorder Point. Data for this study is derived from the company's historical data and interviews with relevant parties. The results reveal a true occurrence of packaging bag overuse at XYZ CORP, amounting to a total of 180 bales of packaging bags or equivalent to 90,000 pieces. The application of Safety Stock, Bin Size, and Reorder Point in Proposed Improvement 2 proves beneficial to the company, both in optimistic and pessimistic scenarios. In optimistic conditions, the implementation of Proposed Improvement 2 yields a profit of Rp 388,750,000, while in pessimistic conditions, it still results in a profit of Rp 92,750,000.

Keywords
Inventory management, supply chain, safety stock, cost optimization, root cause analysis

1. Introduction
The fertilizer industry is an industry that has been developing over the years. This development is based on the increasing need for fertilizer along with the development of the agricultural industry in Indonesia. Apart from that, the fertilizer industry is also one of the industries whose development continues to be encouraged by the government because it plays an important role to realizing national food security. One of the largest fertilizer companies in Indonesia is the state-owned company XYZ CORP. There are various kinds of fertilizers produced by XYZ CORP, one of the most well-known products is the NPK fertilizer product called the ABC BRAND.

NPK fertilizer is a compound fertilizer consisting of the elements Nitrogen (N), Phosphate (P), and Potassium (K) so it can be used for various purposes from agriculture to plantations. Based on Adiele et al. (2020), the use of N, P and K elements in plants can have an impact on significantly increasing crop yields. To meet these needs, in 2022, XYZ CORP succeed in producing more than 2.5 million tons of NPK fertilizer. In order to achieve such a large production amount, XYZ CORP has several production units that can produce NPK fertilizer. Among them are the NPK I, NPK II NPK III, and NPK IV. The NPK I-IV units contributed more than half a million tons of NPK fertilizer in 2022, or more than 20% of XYZ CORP's total NPK fertilizer production.

In the NPK fertilizer production process, NPK I-IV use the granulation method, which is a process carried out to convert fine powder material into granules with certain desired physical properties (Litster & Ennis, 2004). After going through the granulation process in the granulator machine, the NPK fertilizer then moved by a conveyor to be dried and cooled in the dryer and cooler machine. Once it dried and already at normal temperature, NPK fertilizer will go through a screening process to ensure the granule size meets the specification and will then be packaged. The packaging process for ABC BRAND is completed by placing the fertilizer into a packaging bag which is then sealed using sewing machine. Unlike the production process which is performed using conveyors and machines without human intervention, the packaging process is performed involving human power, especially in the process of putting fertilizer into bags and in the process of sewing the bags.

Unfortunately, the factory's dirty and dusty conditions mean that workers are often seen using packaging bags not for their proper needs. They use packing bags as a tool to protect their clothes from dirt, as a cushion to sit on, or to cover puddles of water. Misuse of these bags can have an impact on the Company because it will increase the operational costs. As operational costs increase, the profits that the Company can obtain will also decrease. Misuse of Packaging bags is a waste and must be eliminated in order to maximize profits for the Company. However, currently there is no definite data regarding the amount of misused packaging bag or the suggestions for how to deal with it, so this problem cannot be resolved properly. Therefore, this research focuses on the problem of packaging bag overuse along with a proposed inventory management system to minimize packaging bag overuse.

1.1 Objectives

The primary objectives of this study are to determine the amount of ABC BRAND packaging bags overuse that occured at XYZ CORP. Not only to quantify the overuse problem, this research also identify the root causes of the ABC BRAND packaging bag overuse problem. Furthermore, it will propose effective solutions to mitigate ABC BRAND packaging bags overuse, while also calculate the costs associated with implementing these proposed improvements.

2. Literature Review

Inventory management plays an important role in a company's business processes considering that it will directly affect operational costs. For this reason, a literature review was carried out as the basis for this research. This research focuses on inventory management, cost minimization, and root cause analysis approaches. Inventory is goods owned by a company with certain goals and objectives to support the production process or for other purposes (Swasono and Prastowo 2021). Considering the importance of inventory in business processes, many companies need to implement out inventory control.

According to Soeltanong and Sasongko (2021) inventory control is a method used to ensure inventory can be sufficient for production by considering the supply of raw materials in order to make sure there is no excess. Considering the close relationship between inventory management and the production process, inventory management is an important point that must be considered in production activities (Evitha 2019). There are several aspects to pay attention to inventory control according to Dadaneh et al. (2023), including planning, implementation and controlling inventory related to customer demand.

These aspects are closely related to costs, so it can be said that inventory control has an impact on the costs that will be incurred by the company. Costs themselves are important in a company because they are closely related to the company's profit potential. By reducing costs, companies can have the opportunity to gain more profits. Hartono and Andaresta (2021) state that raw material inventory management affects the efficiency of a company's inventory costs. Ji et al. (2018) also stated that supply chain integration starting from the process of providing raw materials to sales can have an impact on the costs that the company will bear.

With the ABC BRAND packaging bag overuse occurs at XYZ CORP. To solve this problem, there needs to be a framework of thinking that can find the root of the related problem. To achieve this, this research uses Root Cause Analysis (RCA), which is a problem solving method aimed at identifying the root causes of a problem, not just identifying symptoms (Yani and Lina 2015). The analysis process in RCA consists of investigating the problem, collecting data, analyzing data, identifying the root of the problem, and providing solutions. One method that can be used to carry out RCA is to use the 5 Whys method.

3. Methods

The research was executed by initial stage identification by conducting field studies at XYZ CORP in the NPK I-IV production units as well as reviewing the literature. Field studies were conducted by observing the production process and conducting interviews with workers and supervisors. Through field studies and literature, problems were found regarding packaging bags overuse for ABC BRAND brand NPK fertilizer. Then the background, problem formulation, and research objectives are built based on the problem.

The next stage is the process of collecting data so that it can be used as a basis for research. At this stage, data collection is carried out using historical company data to determine production and receipt data for packaging bags. Apart from that, interviews and observations were conducted to obtain information regarding the flow of the packaging bag restocking process currently implemented. Production data and bag receipt data will be used at the data processing stage to calculate overused bags. The results of interviews and observations were used as the basis for creating an information flow diagram in the container bag restocking process. Data processing is realized using 5 whys, Safety Stock, Bin Size, and Reorder Point calculations which are then validated with simulations and cost calculations.

3.1 5 Whys

5 Whys is a structured method that can be used in analyzing the root cause analysis process. This method is done by asking "why" a problem can occur and then the answer to the question is asked again until it reaches 5 repetitions or until the root of the problem has been found (Kuswardana et al. 2017). The main purpose of asking "why" repeatedly is to ensure the main root of a problem can be identified (Chemweno et al. 2016). The advantage of this method is that it is easy to use because it does not require special tools and can be done by individuals or teams.

3.2 Just in Time

Just in time is an inventory management method that is conducted by replenishing raw material inventories (restock), only when the raw materials will be used in the near future (Pristianingrum 2017). The aim of just in time is to reduce existing inventory because excess inventory is waste that must be eliminated. That way, productivity can increase, reduce costs, and increase profits for the company (Sulastri 2014). The implementation of just in time is achieved by ordering or sending raw materials only when they have reached the reorder point and are approaching safety stock with the delivery quantity determined by looking for the bin size.

3.4 Safety Stock

Safety Stock (SS) is inventory goods that are prepared to avoid running out of raw materials by anticipating fluctuations in both demand and supplier aspects (Sucipto et al. 2023). The aim of implementing safety stock is so that the production process can continue to run normally even if fluctuations occur in the supply chain. The safety stock value can be calculated using the following King's method in Equation 1. Calculation of safety stock using the King method is executed by considering a combination of average production with delivery waiting time as well as safety factors whose values are taken based on the company's service level (King 2011).

$$Safety\ Stock\ (SS) = Z \times \sqrt{t \times S_d^2 + d^2 \times S_t^2} \tag{1}$$

With:

Z = Safety factor
t = Lead time
S_d = Standard deviation of Unit's production
d = Average Unit's production
S_t = Standard deviation of Lead time

The following is a service factor table (Table 1) that can be used in calculating safety stock based on the service level adjusted by the company.

Table 1. Service factor based on service level

Service Level	Service Factor	Service Level	Service Factor
50,00%	0,00	90,00%	1,28
55,00%	0,13	91,00%	1,34
60,00%	0,25	92,00%	1,41
65,00%	0,39	93,00%	1,48
70,00%	0,52	94,00%	1,55
75,00%	0,67	95,00%	1,64
80,00%	0,84	96,00%	1,75
81,00%	0,88	97,00%	1,88
82,00%	0,92	98,00%	2,05
83,00%	0,95	99,00%	2,33
84,00%	0,99	99,50%	2,58
85,00%	1,04	99,60%	2,65
86,00%	1,08	99,70%	2,75
87,00%	1,13	99,80%	2,88
88,00%	1,17	99,90%	3,09
89,00%	1,23	99,99%	3,72

3.5 Kanban

One aspect that needs to be considered when implementing just in time is kanban. Kanban is a lean manufacturing approach that is carried out by implementing a pull system for production raw materials (Arbulu et al. 2003). This approach is implemented by ensuring that a raw material will only be restocked when inventory approaches safety stock in order to minimize inventory build-up. This method also uses bin size which is used as a reference in determining quantity during the restocking process. The bin size value can be calculated based on the Equation 2.

$$Bin\ size = d\ \times restock\ frequency \tag{2}$$

Where *d* is demand, in this research it is the average production, and *restock frequency* is the number of restocking that are usually completed or targeted by the company.

3.6 Reorder Point

Another factor to consider while adopting just in time is the reorder point (ROP). ROP is the moment in inventory situations where restocking should be performed (Irwadi 2015). The goal of applying ROP in the production process is to avoid inventory shortages while minimising inventory. The ROP value is calculated by multiplying the safety stock by the bin size, as shown in the following equation.

$$Reorder\ point = SS + Bin\ size \tag{3}$$

4. Data Collection

4.1 ABC BRAND Production Data and Received Packaging Bag Data

ABC BRAND production data in NPK I-IV units and received packaging bag data were obtained by looking at the company's historical data. The recorded production data is daily production data in tons. Figure 1 displays production data that has been processed in bales measure unit which are equivalent to 500 pieces of 50kg bags. Figure 1 can show fluctuations in bag deliveries both in the number of deliveries and in the frequency of deliveries.

4.3 Packaging Bag Inventory Data

Packaging bag inventory data is obtained by looking at historical packaging bag inventory data for each NPK Unit. The data taken is data at the beginning of the year and at the end of the research period. This is done to calculate packaging bag overuse that occured in NPK Units I-IV (Table 2).

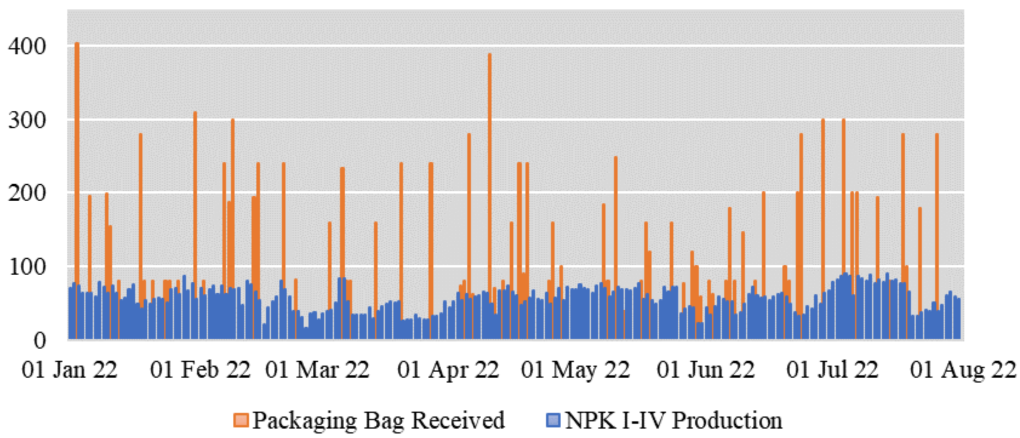

Figure 1. NPK I-IV production and packaging bag received (daily)

Table 2. Packaging bag inventory level

Date	Unit	NPK I	NPK II	NPK III	NPK IV	NPK I-IV
Start (31 Des 2021)	Bale	141	189	141	168	639
End (31 Jul 2022)	Bale	74	99	74	89	336

4.4 Packaging Bag Restocking Process Flow

The packaging bag restocking process is performed involving 3 departments, which are Production, Production Planning Control (PPC), and Warehouse. Where the role of the production department is to count the remaining packaging bags on the production floor every day and report to the PPC department. Then PPC will determine whether restocking is needed or not. If restocking is needed, PPC will ask the Warehouse to execute the delivery process to Production shown in Figure 2.

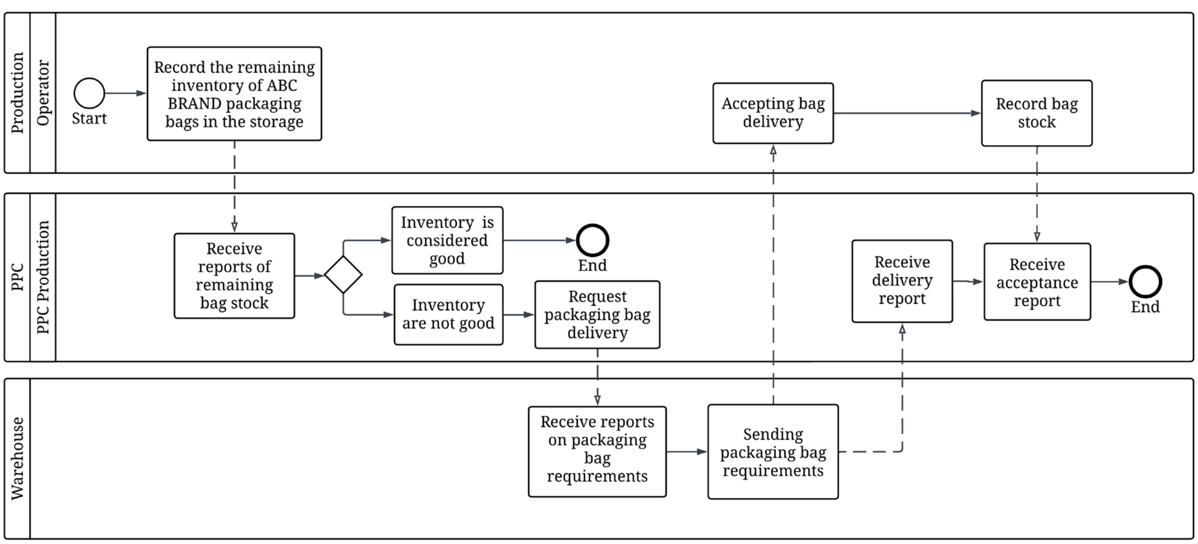

Figure 2. Packaging bag restocking process flow (current condition)

5. Results and Discussion

5.1 5 Whys Analysis

The 5 whys analysis are used as a basis for finding the root of the problem in cases of overused packaging bags. Based on the 5 whys analysis, there are 8 root problems with 5 root problems will be elaborated more, which are categorized as inventory management scope. Figure 3 displays each root problem with solutions that can be implemented to overcome them.

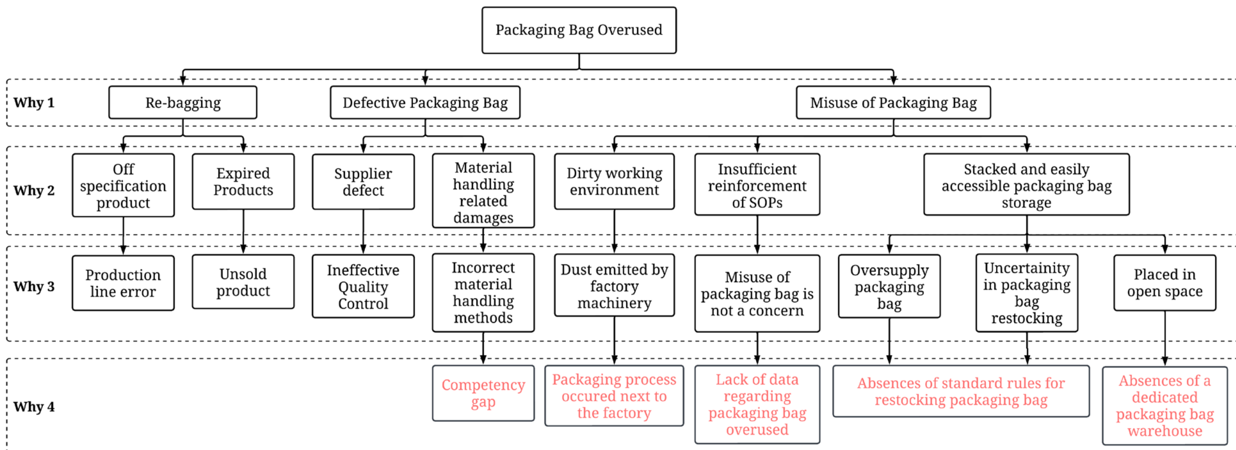

Figure 3. Result of the 5-Whys analysis

In order to obtain improvements for the related problem, each root cause should be carefully examined and provided with recommended corrective actions. The following Table 3 presents eight identified root causes along with actionable recommendations that can be implemented.

Table 3. Recommended corrective action for each identified root cause

No	Identified Root Cause	Recommended Corrective Action
1	Production line error	- Conduct a focused research study on the production process
2	Unsold products	- Conduct a focused research study on the marketing process
3	Ineffective quality control	- Conduct a focused research study on the quality control process
4	Competency gap	- Provide material handling training for workers
5	Packaging process occurred next to the factory	- Provide protective equipment for workers - Provide a proper clean space for workers to rest - Ensure clean working environment
6	Lack of data regarding packaging bag overused	- Conduct data collection regarding packaging bag overuse - Conduct data processing to calculate packaging bag overuse
7	Absences of standard rules for restocking packaging bag	- Construct standard rules for restocking packaging bag - Provide training for workers to implement the standar rules
8	Absences of a dedicated packaging bag warehouse	- Allocate space for a dedicated bag warehouse - Set up barrier to ensure controlled acces to packaging bag storage

5.2 Packaging Bag Overuse Calculation

The packaging bags overused that occurs because there is a difference between the amount of received packaging bags and those used for the production process. The calculation is carried out using equation 4. The result of this calculation is that there is a total waste of 180 bales of overuse packaging bags as shown on Table 4.

$$Overused\ Amount = Initial\ Inventory + Packaging\ Bag\ Received$$
$$-Total\ Production\ - Ending\ Inventory \tag{4}$$

Table 4. Packaging bag overuse calculation

Initial inventory	639
Packaging bag received	12,093
Total production	12,216
Ending inventory	336
Overused Amount	180

5.3 Safety Stock Calculation

Safety Stock calculations are performed so that there is always a supply of packaging bags in storage by minimizing inventory but still considering supply chain fluctuations. This calculation is done using Equation 1 with the service level expected by the company is 99.99% to ensure that there is no running out of inventory. So, referring to Table 1 the Z value is 3.72. The t value used by the company is 1.5 with S_t of 0.5. The d and S_d values are obtained by calculating the average and standard deviation of daily production for each Unit. Table 5 below is the result of the Safety Stock calculation for each Unit.

Table 5. Safety stock calculation

Remarks	NPK I	NPK II	NPK III	NPK IV
d	11.54	17.90	12.67	15.51
S_d	4.04	5.43	4.78	3.83
SS	29	42	33	34

5.4 Bin Size Calculation

Bin size calculations are performed to determine the number of packaging bags that must be sent each time a restocking is carried out. Equation 2 is used to perform this computation. The *restocking frequency* is calculated by rounding the average time interval between current restockings. The Bin Size calculation results for each Unit are shown in Table 6 below.

Table 6. Bin size calculation

Remarks	NPK I	NPK II	NPK III	NPK IV
d	11.54	17.90	12.67	15.51
Restock Frequency	3	3	3	3
Bin size	35	54	39	47

5.5 Reorder Point Calculation

Reorder point calculations are performed to determine the point at which restocking is required. Equation 3 is used to perform this calculation. Table 7 below displays the results of the Reorder Point calculation for each Unit.

Table 7. Reorder point calculation

Remarks	NPK I	NPK II	NPK III	NPK IV
SS	29	42	33	34
Bin Size	35	54	39	47
ROP	64	96	72	82

5.6 Proposed Improvement 1

The calculations for Safety Stock (SS), Bin Size, and Reorder Point (ROP) were applied to the packaging bag restocking process following the flow outlined in Figure 2. Figure 4 illustrates the proposed process improvement for the packaging bag restocking process, incorporating the logic associated with SS, Bin Size, and ROP. Through the implementation of Proposed Improvement 1, where each Unit conducts restocking independently. With this, the process flow aims to reduce average inventory levels by eliminating the need to wait for other units to perform restocking.

The outcomes of applying Proposed Improvement 1 are presented in Table 8, which includes the current condition for reference, highlighting the value of the improvement. The Improvement column displays the enhancement achieved when implementing the proposed changes, with positive values indicating improvement and negative values indicating performance decline.

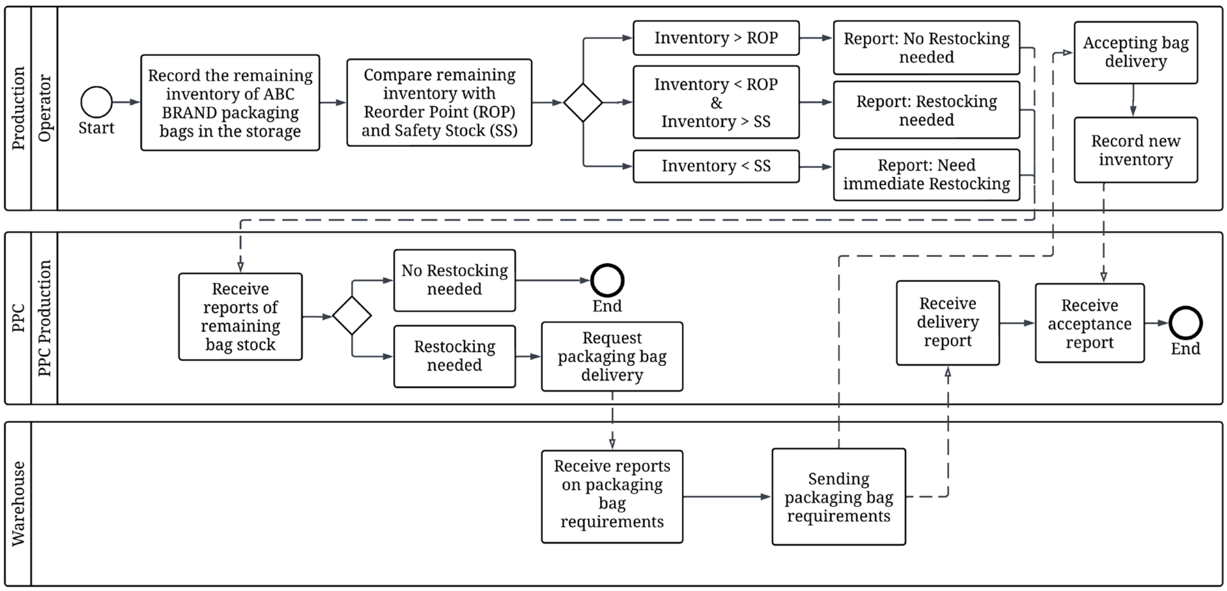

Figure 4. Proposed Improvement 1's packaging bag restocking process flow

Table 8. Simulation results of implementing the proposed improvements (numerical)

Remarks	Unit	Current Condition	Proposed Improvement 1		Proposed Improvement 2	
			Value	Improvement	Value	Improvement
Average Inventory	Bale	517.86	344.84	33%	233.06	55%
Inventory's Standard Deviation	Bale	197.26	40.00	80%	73.27	63%
Total Received Packaging Bag	Bale	12,093	12,129	-36	11.964	139
Number of Packaging Bag Shipping	Each	78	162	-84	116	-38

The results of implementing Proposed Improvement 1 can also be observed in Figure 5, which illustrates the daily inventory levels.

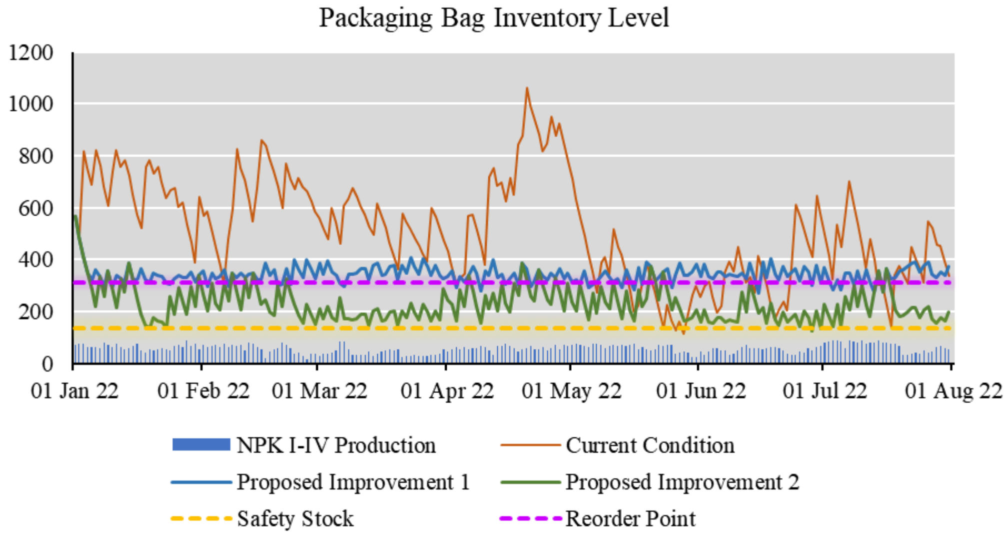

Figure 5. Simulation results of implementing the proposed improvements (graphical)

5.6 Proposed Imporvement 2

To achieve better results, Proposed Improvement 2 was implemented, which considers the coordination of each Unit to perform restocking simultaneously. Figure 6 depicts the flow of logic for determining restocking, where restocking will only occur when more than three Units have reached the Reorder Point (ROP) or when a Unit has reached the Safety Stock (SS). The results of simulating the implementation of Proposed Improvement 2 are presented in Figure 5, with the improvement values detailed in Table 8.

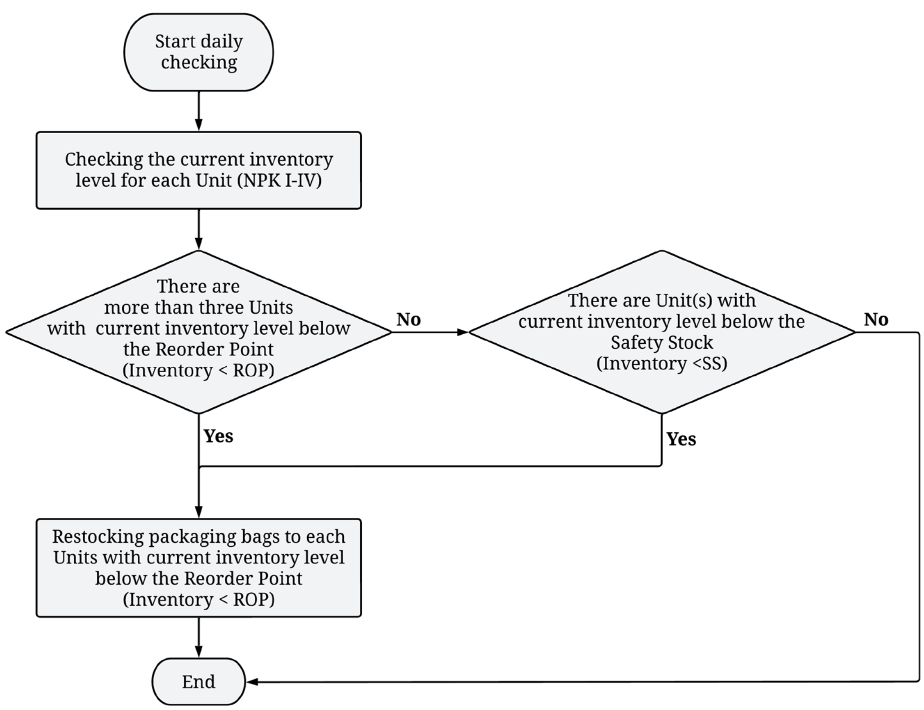

Figure 6. Proposed Improvement 2's packaging bag restocking process flow

5.7 Cost Validation

One way to assess the feasibility and benefits of implementing a proposed improvement is by calculating the costs and benefits involved. The cost components of the proposal implementation are outlined in Table 9, along with their corresponding values as displayed in Table 10. Using Table 9 as a summary for comparison, a cost-benefit analysis was conducted, and the results are presented in Table 11.

Table 9. Cost components

Costs	Cost Components
Packaging bag savings	Total Received Packaging Bags' Improvement * Packaging bag price
Order cost	Number of Packaging Bag Shipping' Improvement * Order cost per order
Delivery cost	Total Received Packaging Bags' Improvement * Delivery cost per bale
Implementation cost	Familiarization cost + Additional labor cost + Other costs

Table 10. Value of cost component

Cost Component	Value	Unit
Packaging Bag	Rp 1,850,000	per bale
Order cost	Rp 2,000,000	per order
Delivery cost	Rp 400,000	per bale
Familiarization cost	Rp 3,500,000	per Unit
Additional labor cost	Rp 5,000,000	per Unit Production per month
Other costs	Rp 10,000,000	each

In Table 11, an optimistic scenario is also included, assuming that the proposed improvement's implementation would have a 40% drop on packaging bag overuse, reducing the total packaging bag overuse. The 40 % is calculated by averaging the average inventory improvement of Proposed Improvement 1 and Proposed Improvement 2. The results indicate that in the pessimistic scenario, where no improvements occur in the case of packaging bag overuse, the implementation of Proposed Improvement 1 would result in a loss of Rp 393,000,000, while Proposed Improvement 2 would yield a profit of Rp 92,750,000. On the other hand, in the optimistic scenario, Proposed Improvement 1 would lead to a company loss of Rp 113,000,000, while Proposed Improvement 2 would result in a profit of Rp 388,750,000.

Table 11. Cost calculation results

Cost	Pessimistic		Optimistic (overuse drop by 40%)	
	Proposed Improvement 1	Proposed Improvement 2	Proposed Improvement 1	Proposed Improvement 2
Packaging bag savings	-Rp 66,600,000	Rp 257,150,000	Rp 170,200,000	Rp 493,950,000
Order cost	-Rp 168,000,000	-Rp 76,000,000	-Rp 176,000,000	-Rp 68,000,000
Delivery cost	-Rp 14,400,000	Rp 55,600,000	Rp 36,800,000	Rp 106,800,000
Implementation cost	-Rp 144,000,000	-Rp 144,000,000	-Rp 144,000,000	-Rp 144,000,000
Total	-Rp 393,000,000	Rp 92,750,000	-Rp 113,000,000	Rp 388,750,000

6. Conclusion

Based on this research, it can be concluded that there is a ABC BRAND packaging bag overuse in Units NPK I-IV. During the period from January to July 2022, there was a total of 180 wasted bales. Various factors contributed to this wastage, including employee negligence, misuse of bags, a dirty working environment, non-compliance with production quality standards, and lack of standard rules on the inventory management.

Several standard rules, such as Safety Stock (SS), Bin Size, and Reorder Point (ROP), can be applied for inventory management. According to the simulation results of the implementation of SS, Bin size, and ROP in Proposed Improvement 2, there is a potential 55% reduction in average inventory, a 63% decrease in inventory standard deviation, and a reduction of 57 bales in total bag shipments. This has the potential to result in cost savings of Rp90,750,000 under pessimistic conditions and Rp384,750,000 under optimistic conditions.

XYZ CORP may consider implementing inventory management based on SS, Bin Size, and ROP. Prior to implementation, proper employee training and socialization should be conducted. For future research, further investigation is needed regarding the production process leading to off-spec products, sales processes, and quality control processes with suppliers to reduce packaging bag overuse. Additionally, a more in-depth analysis of the relationship between inventory conditions, such as average inventory and inventory standard deviation, and bag wastage behavior is essential.

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Biographies

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