Improvement Banana Warehouse Operation using Business Process Reengineering

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Abstract

Supply Chain in the agribusiness industry is strongly influenced by warehouse facilities. Bananas that have been harvested need to be stored properly before being distributed to buyers. This study aims to design business process improvements by utilizing Internet of Things (IoT) and expected to increase warehouse time efficiency. The Business Process Re-engineering (BPR) method was used to design improvements to warehouse operational process using the iGrafx software. Improvements to warehouse operations are carried out on the inbound and ripening process. This study resulted in two scenarios in the inbound process, scenario A using an automated inventory system based on RFID becomes the scenario with the greatest time efficiency of 18%. The ripening process has three scenarios, scenario C which combines the use of an automated inventory system based on RFID and an automated monitoring system has the highest efficiency of 24%.

Keywords
Supply Chain, Warehouse Facilities, Internet of Things, Business Process Reengineering, iGrafx.

1. Introduction
From 2011 to 2014, fruits were the commodity that contributed the most to Indonesia's GDP compared to other horticultural sectors. Indonesia became the country with the 7th largest producer of fresh fruit in the world in 2018. In Indonesia banana was the fruit with the highest number of exports in 2019 which was in line with banana production that continues to increase until 2020 (Statistics Indonesia, 2021).

This research conducted at a company that supplies fresh fruit and vegetables to traditional and modern markets in Greater Jakarta and Bandung. Cavendish banana is a primary product of the company. Banana was categorized as easily damaged fruit with 5-10 days shelf life (Akter et al., 2015). Therefore, bananas need careful handling in their supply chain and optimal conditions in a perishable warehouse (Barraco, 2018). Based on interviews with experts, banana warehouse operations currently took a lot of time so the quality control and sorting processes for other fruits were often hampered. The inefficiency of warehouse operations also occurred in unloading, temperature & humidity, and inventory management aspects.

Internet of Things (IoT) became a solution. IoT had been predicted to be a new era of information technology with a lot of potential development. IoT played a role in increasing inventory management efficiency (Riad et al., 2018). IoT could be implemented in warehouse management, for example, to track and monitor products, forecast demand, inventory management, and real-time data revenue from all processes in warehouse operations (Hamdy et al., 2018). The advantage of using the IoT was the presence of real-time information which helped solve problems faster than traditional warehouses. The automation of manual tasks made the workforce more efficient and IoT increased operational scalability (van Geest et al., 2021).

1.1 Objectives
This research aims to improve banana warehouse operation using Internet of Things (IoT) technology with Business Process Reengineering approach to improve warehouse time efficiency in the current banana warehouse operations.

2. Literature Review

Bananas were harvested at the preclimacteric stage when green and firm. Bananas must be free from foreign odors and tastes, healthy, clean, whole, fresh, intact, and free from uncommon moisture for transportation (Barraco, 2018; Transport Information Service, n.d.). The color of the banana must match the level of ripeness. Bananas can be apart into seven levels of ripeness according to their outer color (Yap et al., 2017). Bananas usually ripen at temperatures 15°C and 20°C with 80-95% humidity (Bantayehu, 2017).

Business Process Reengineering (BPR) was a tool for radical change by changing current business processes for the purpose of improving company quality(Dachyar & Praharani, 2016; Seher, 2014; Zaini & Saad, 2019). It was very important to identify areas of improvement to facilitate process performance improvements (Dachyar & Praharani, 2016). Best practices of BPR were the reference used in designing the dissolving process in business process reengineering. There were 10 BPR best practices (Mansar & Reijers, 2007).

IoT was an interconnection of objects that connected to networks through embedded and always-on sensors. IoT had the ability to share data and as a remote control (Dachyar & Risky, 2014). There were four main things that characterize IoT for industrial organizations, Traceability, Visibility, Interoperability and Interaction (Dachyar et al., 2019). perception layer, network layer, and application layer were the three layers in IoT (Atzori et al., 2012; Sethi & Sarangi, 2017; Zhao & Ge, 2013).

RFID (Radio Frequency Identification) was a system that transmitting a specification of an object with a unique serial code utilizing radio waves (Gotmare et al., 2019). RFID Tag, Reader, and application were three components of RFID (Jia et al., 2012). The use of RFID provides many advantages when implemented in warehouse operations, such as product tracking, better expiry date management, reduced material handling, reduced labor, increased data accuracy, and improved information sharing between supply chain partners (Chuang, 2017; Coustasse et al., 2013; Lim et al., 2013).

QR (Quick Response) code was a two-dimensional code that can store data information on a product or item and was designed to be read by smartphones (Jathar et al., 2019). QR codes can be used to increase efficiency in warehouses, especially in inventory management, there are several advantages in implementing QR codes in warehouses, such as scanning products quickly, easy to use, minimizing errors, and fast automation (Hedge, 2021).

Automated Monitoring System was a technology used to monitor the temperature and humidity in the warehouse without the presence of the user and user would get a warning notification if the temperature and humidity out of treshold range (Yadav, 2020). The components used to obtain data were sensor and communication protocol. Sensors were used to capture and detect temperature and humidity while communication protocols were used to collect information obtained from sensors and transmit it to a server. (Ou et al., 2017; Yadav, 2020).

3. Methods

There were four major stages to conduct this research. First stage, the study of literature was carried out to formulate the background, problems, and objectives of this research. Second stage, a time study in the warehouse and an in-depth interview with employees were conducted to collect and to understand the current process resulted in Flow Process Charrt. Then, iGrafx Software was used to model and simulate the current process. Third stage, analysis of result was done to find the problems of current model. Goal Problem Solution Analysis was conducted to get right solution and BPR Best Practices. The solutions were designed in scenarios, then iGrafx software was used to model and simulate the proposed solution. Fourth stage, each scenario's result was compared with the result of the as-is processed to obtain the best scenario to be implemented.

4. Data Collection

The data was carried out by doing time study and interview with 3 experts to know the end-to-end activity of the operational process. The process of banana warehouse was divided into 3 processes which were inbound, ripening, and outbound. All the activities and time would be the input for the simulation of the As-Is model in the iGrafx software. Figure 1 represents Flow Process Chart for inbound process. Inbound process is the incoming of banana to warehouse until the banana is saved in cold storage. Figure 2 represents flow process chart for ripening process. the ripening process is the process of ripening bananas in the ripening chamber until the condition of the bananas is at the desired level. Figure 3 represents the flow process chartfor outbound process. the outbound process is the process of preparing orders to sending bananas to customers. Figure 1,2, and 3 can be seen below.

No	Activity	Operation	Movement	Inspection	Delay	Storage	Time
1	Receiving a delivery form from a driver	●	⇨	□	D	▽	0,28
2	Documenting the incoming banana	●	⇨	□	D	▽	0,19
3	Preparing for unloading process	●	⇨	□	D	▽	3,34
4	Waiting for employee to unload the banana	○	⇨	□	◗	▽	58,32
5	Transferring banana's boxes to anthe room	○	➡	□	D	▽	2,77
6	Printing the banana label	●	⇨	□	D	▽	5,16
7	Putting the label to each box	●	⇨	□	D	▽	1,61
8	Re-counting the box	●	⇨	□	D	▽	7,41
9	Recording the amount of banana box	●	⇨	□	D	▽	4,25
10	Updating the inventory	●	⇨	□	D	▽	10,57
11	Reporting the updated inventory to alocator	●	⇨	□	D	▽	4,95
12	Waiting for transfering product to cold storage	○	⇨	□	◗	▽	6,04
13	Transferring product to cold storage	○	➡	□	D	▽	0,70
14	Locating the banana box in cold storage	●	⇨	□	D	▽	0,28
15	Updating the inventory at the cold storage	●	⇨	□	D	▽	6,50

Figure 1. Flow Process Chart of Inbound Process

No	Activity	Operation	Movement	Inspection	Delay	Storage	Time
16	Receiving ripening plan	●	⇨	□	D	▽	3,66
17	Printing ripening plan	●	⇨	□	D	▽	0,43
18	Waiting for mutation process	○	⇨	□	◗	▽	4,81
19	Memindahkan ke ruang anthe	○	➡	□	D	▽	2,20
20	Pre-gassing banana box	●	⇨	□	D	▽	4,03
21	Waiting to transfer product to ripening room	○	⇨	□	◗	▽	14,72
22	Transferring product to ripening room	○	➡	□	D	▽	1,58
23	Updating the inventory	●	⇨	□	D	▽	8,79
24	Reporting the updated inventory to alocator	●	⇨	□	D	▽	6,44
25	Controlling temperature	●	⇨	□	D	▽	10,45
26	Lowering the temperature	●	⇨	□	D	▽	14,96
27	Checking banana condition for gassing	○	⇨	■	D	▽	19,90
28	Opening the ripening room	●	⇨	□	D	▽	0,34
29	Venting Activity	●	⇨	□	D	▽	21,40
30	Closing the ripening room	●	⇨	□	D	▽	0,31
31	Checking banana condition for venting	○	⇨	■	D	▽	21,70
32	Checking banana condition for cooling 1	○	⇨	■	D	▽	19,70
33	Transferring product to anthe room	○	➡	□	D	▽	1,14
34	Checking banana step condition	○	⇨	■	D	▽	4,90
35	Recording the banana into sorting form	●	⇨	□	D	▽	3,88
36	Updating the inventory	●	⇨	□	D	▽	8,20
37	Reporting the updated inventory to alocator	●	⇨	□	D	▽	6,67
38	Transferring product to the right step	○	➡	□	D	▽	0,79
39	Transferring product to the previous room	○	➡	□	D	▽	1,08
40	Checking the banana randomly	○	⇨	■	D	▽	3,00

Figure 2. Flow Process Chart of Ripening Process

No	Activity	Operation	Movement	Inspection	Delay	Storage	Time
41	Waiting for the fixed delivery plan form	○	⇨	□	◗	▽	57,33
42	Receiving delivery fom	●	⇨	□	D	▽	2,19
43	Printing the order label	●	⇨	□	D	▽	20,37
44	Transerring product to anthe room	○	➡	□	D	▽	2,06
45	Order Picking	●	⇨	□	D	▽	8,32
46	Printing delivery order	●	⇨	□	D	▽	147,18
47	Sorting delivery order	●	⇨	□	D	▽	29,94
48	Transerring pallete product to anthe room	○	➡	□	D	▽	1,87
49	Checking delivery order	○	⇨	■	D	▽	6,96
50	Documenting the banana condition	●	⇨	□	D	▽	0,14
51	Loading the order to the delivery truck	●	⇨	□	D	▽	3,81

Figure 3. Flow Process Chart of Outbound Process

5. Results and Discussion

Figures 1, 2, and 3 were then translated into as is model using iGrafx software. In iGrafx software, activity is a process that takes place in a lane. Time is the data entered for each activity.

5.1 Current Process (As-Is)

There were 3 As-Is model to represent the operational process. There was a total of 9 sub-activity in as-is model to describe the repetitive activities and activities that contain more detailed activities. The inbound process is illustrated in Figure 4. The ripening process is illustrated in Figure 5 with 5 lanes. The outbound process illustrated in Figure 6. The simulation was validated using the face and event validity method to see whether the model had been made appropriate and described the actual process.

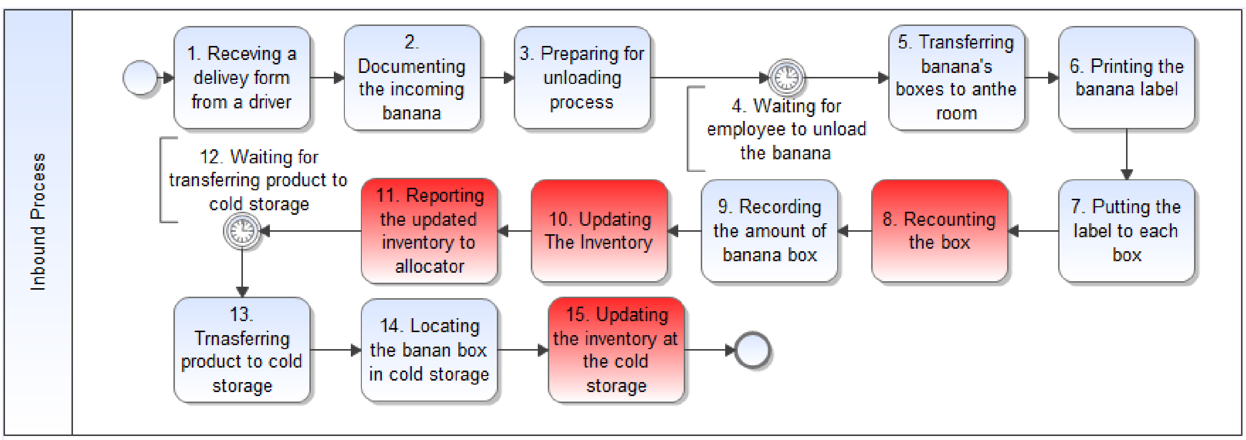


Figure 4. Inbound Business Process (As Is Model)

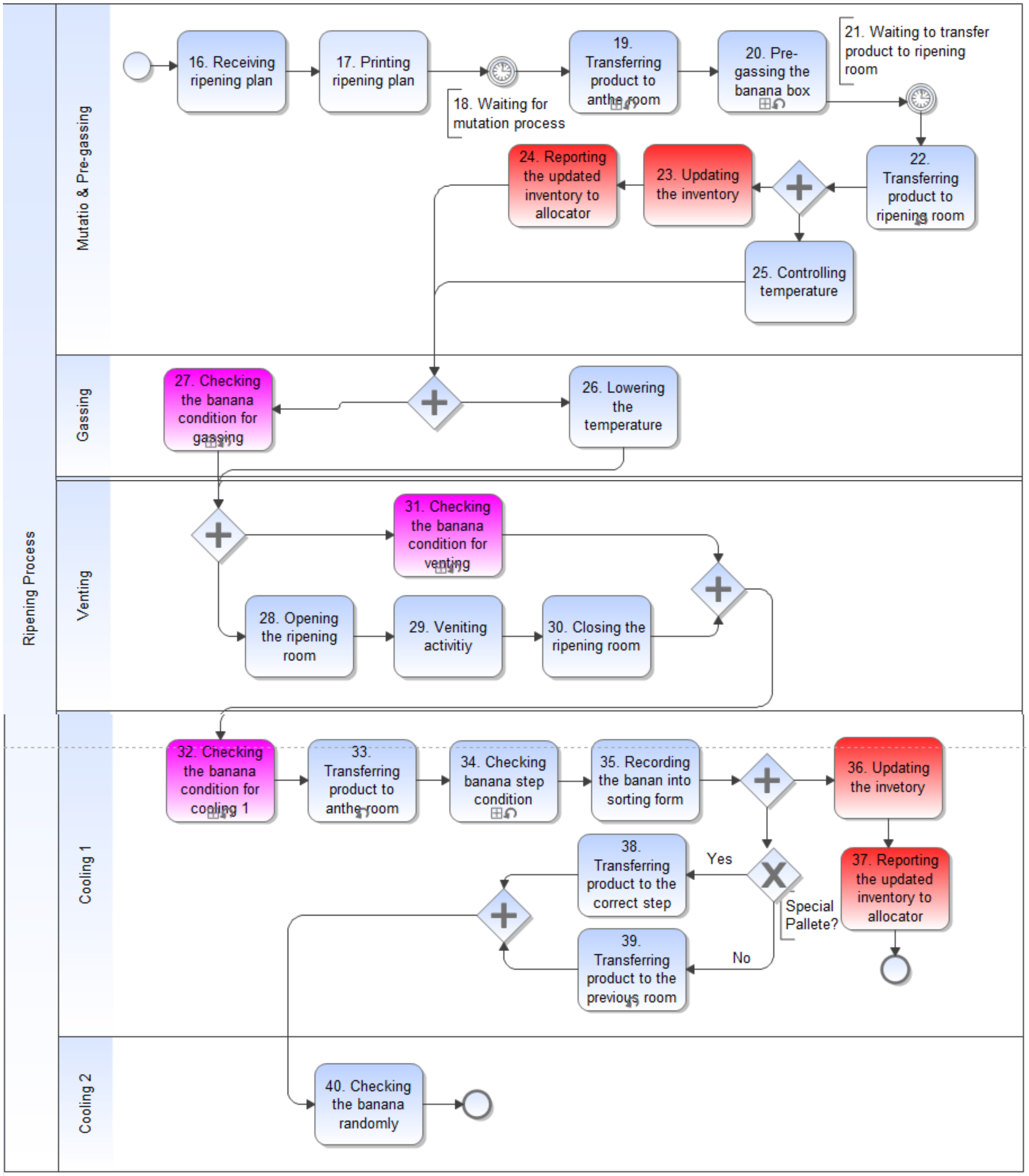


Figure 5. Ripening Business Process (As Is Model)

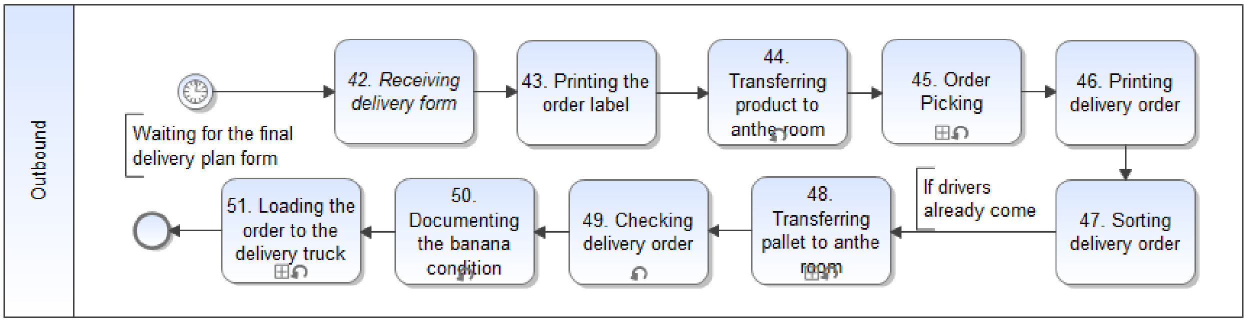


Figure 6. Outbound Business Process (As Is Model)

The simulation was then carried out to determine the operational time of the banana warehouse. Cycle time is the combined time between work time and waiting time for all activities in the business process. Cycle time simulation results for each process is presented in table 1 below.

Table 1. As Is Simulation Results

Process	Avg. Cycle Time (minutes)
Inbound	170,60
Ripening	432,48
Outbound	502,48

5.2 Analysis of Current Model and Designing Improvement

Based on the current model's simulation results, improvement was made by identifying process and interviewing with employess. Several issues were found at the banana warehouse, including:

- The frequency of monitoring the ripening room was done repeatedly but currently monitoring and recording were still done manually.
- Access to information related to the amount was still done manually so it is less effective.
- The process of calculating the number of products was carried out several times also done manually.

After conducting interviews and seeing the results of the simulation model as is, the improvement design focused on the inbound process and the ripening process only. Goal problem solution analysis is carried out to analyze the alignment of the problem and the required solution. Table 2 describes the analysis of goal problem solution.

Table 2. Goal Problem Solution Analysis

Goal	Problem	Solution	BPR Best Practice
Efficiency and Responsiveness	The frequency of monitoring the ripening room was done repeatedly but currently monitoring and recording were still done manually	Automate the monitoring activity with automatic data recording and by adding a warning feature for temperature anomalies.	Elimination, Paralellism, and Integration Technology
Accuracy	Access to information related to the amount was still done manually so it is less effective	Automate the counting activity automatically	
Integration of Data & Information	The process of calculating the number of products was carried out several times also done manually	Accessible system that could be accessed by all of employee	

5.3 Proposed Improvements (To – Be Model)

Based on interviews, there were two technologies to solve problems, Automated Inventory System-based RFID and Automated Monitoring System. Alternative scenarios were made based on two processes as the main problems, the inbound process and the ripening process.

5.3.1 Inbound Process (To – Be Model)

Alternative scenarios designed for the inbound process were to solve inventory problems. RFID-based Automated Inventory System was the technology chosen and recommended by the company. To see a comparison of RFID, QR Code was included in the scenario because currently the company uses this technology but still not connected yet to IoT. The alternative scenario design for inbound process is presented in the table 3 below.

Table 3. Alternative scenario for inbound process

Scenario	*Automated Inventory System* RFID Based	*Automated Inventory System* QR Code based
Scenario A	✓	
Scenario B		✓

Scenario A utilized Radio Frequency Identification (RFID) as a platform to detect banana boxes automatically to speed up banana warehouse operations. Implementation of RFID consisted of three things, RFID Tag, RFID Reader, and Application Software. Each banana box affixed with an RFID Tag that stores banana information. The company need an RFID Gate Reader to read the information in the RFID Tag. One RFID Gate Reader would be placed in the Cold Storage Door. The system was automatically updating the incoming and outgoing products if there was a product movement that passes through the RFID Gate Reader and would be saved into the database. In this scenario, activities that are red in the as is model such as activity 8, 10, 11, and 15 were eliminated because with RFID it can be done automatically. Figure 7 represents the to be model for the scenario A that utilize automated inventory system based on RFID (see Figure 7). There were two additional activities in the to be model which were depicted in green. The addition was made because to be able to identify items, RFID tags need to be calibrated and encoding first.

Scenario B implemented a QR Code. QR Code Scanner was needed to scan the data on the QR Code. It was necessary to scan the QR Code on the banana box one by one to update the inventory product. After scanning the QR Code, the data for each banana box would be directly saved into the inventory database. Scenario B eliminated activity that are red in the as is model such as activity 8, 10, 11, and 15 because with RFID it can be done automatically. This scenario also adds 2 new activities, setting information on the qr code and scanning qr code.

To get a banana inventory report in the warehouse, the employee only needs to download the report on the application. The data available in the application software was the result of a query taken from the database.

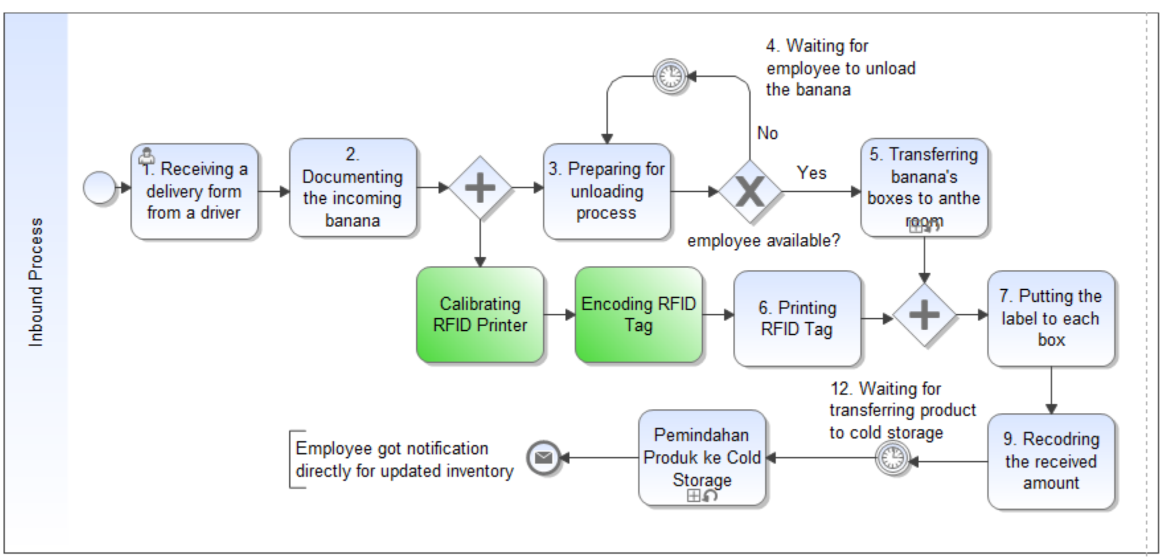


Figure 7. To be Model for Scenario A

After conducting the simulation, the result of each scenario was compared with the As-Is model to calculate the efficiency process. The comparison of efficiency processes from scenario 1 and 2 for inbound process can be seen in Table 4 below.

Table 4. Time Comparison Between As-Is Model and To-Be Model Results for inbound process

Scenario	Avg. Cycle Time (minutes)	Time Efficiency	%Efficiency
Scenario A	139,35	31,25	18%
Scenario B	170,70	-0,10	0%

5.3.2 Ripening Process (To Be Model)
The alternative scenario designed for the ripening process was to solve warehouse inventory problems and monitoring of temperature and humidity in the ripening room. RFID-based Automated Inventory System and Automated Monitoring System were the technology chosen and recommended by the company. The alternative scenario design for ripening process can be seen in the table 5 below.

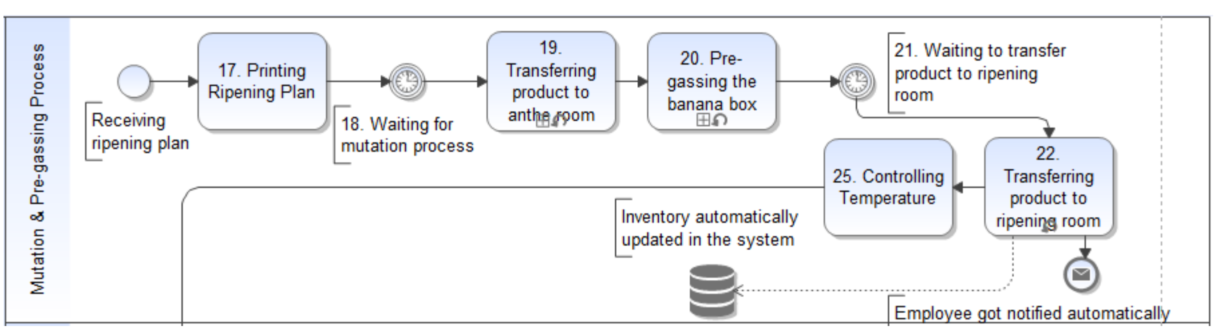
Table 5. Alternative scenario for ripening process

Scenario	*Automated Inventory System* RFID based	*Automated Monitoring System*
Scenario A	✓	
Scenario B		✓
Scenario C	✓	✓

In scenario A, RFID Gate Reader would be installed in each ripening rooms. This scenario eliminated several activities specifically for reporting and updating the amount of banana's box. Scenario A eliminated red activities in model as is such as activity 23, 24, 36, and 37 in the as is model because the process was changed to be automated. Those activities mainly located in the mutation & pre-gassing process and the cooling 1 process.

Scenario B would monitor in real time and non-stop. Manual checking of temperature and humidity using a thermography would be replaced automatically. This system consists of sensors that were used to capture and sense the temperature and humidity in the room, the cloud as a data store for monitoring results, application software as a data display dashboard, and an internet network for interconnection between sensors and the cloud. The monitoring data could be accessed at any time through the application. A warning alarm feature was also added in this scenario. Employee would get a notification if the temperature or humidity were out of threshold range. The improvements were made at three sub-activities, in activity that depicted in purple such as activity 27, 31, and 32 for automating the monitoring of temperature and humidity activity. The sub-activities in activity 27, 31, and 32 were the same so improvements were also the same.

Scenario C was a combination between the proposed scenario A and B of the ripening process. The combination was carried out because the two technologies solved different problems and solve inventory problems and monitoring the ripening process. This scenario eliminated activities 23, 24, 36, and 37 and improvements were also made at three sub-activities, in activity 27, 31, dan 32. The proposed model of scenario C can be seen in figure 8.



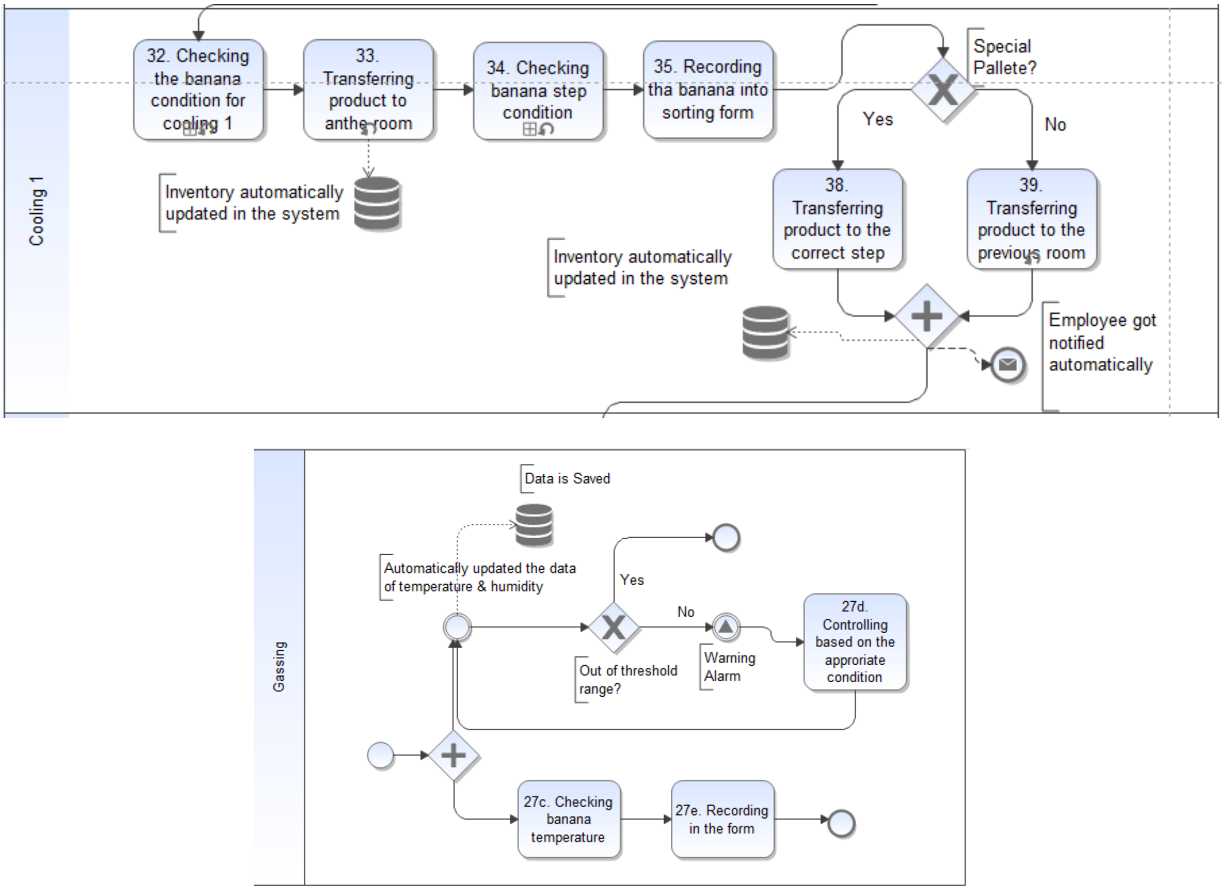


Figure 8. To be model for Scenario C

After conducting the simulation, the result of each scenario proposed was compared with the As-Is model to calculate the efficiency process. The comparison of efficiency processes from scenario A, B, and C for ripening process can be seen in Table 6 below.

Table 6. Time Comparison Between As-Is Model and To-Be Model Results for ripening process

Scenario	Avg. Cycle Time (minutes)	Time Efficiency	%Efficiency
Scenario A	420,70	11,78	3%
Scenario B	340,29	92,19	21%
Scenario C	328,51	103,97	24%

6. Conclusion

This research resulted in improvements in the banana warehouse. Improvements to the operational process of the banana warehouse were done in two processes, inbound process and outbound process. Two scenarios were developed in the inbound process to solve inventory problems, scenario A used an automated inventory system based on RFID and scenario B used an automated inventory system based on QR-Code. Three scenarios were designed in the outbound process to solve inventory and temperature humidity monitoring problems, Scenario A used an automated inventory system based on RFID, scenario B used an automated monitoring system, and scenario C used a combination of the two technologies in scenario A and scenario B.

Based on the simulation results, Scenario A in the inbound process produces the highest efficiency from 170.60 minutes to 139.35 minutes where the time efficiency is 31.25 minutes or 18%. In the ripening process, Scenario C produces the highest efficiency from 432.48 minutes to 328.51 minutes where the time efficiency is 103.97 minutes or 24%.

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Biography

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