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Improvement of the customer order fulfillment process

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Improvement of the customer order fulfillment process.

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Preface

Dear reader,

During the course of my thesis, I had the privilege of working at De Vijvermeester located in Emmeloord, the specialist in pond cleaning and maintaining the water in ponds in an ecological manner, under the guidance of Jiry de Waal.

First, I want to thank J. de Waal B WM for giving me the opportunity to do my research in his company, unwavering support and his valuable insights and support throughout this thesis. I hope that with this thesis I contributed to making De Vijvermeester a more efficient company.

I also want to extend my thanks to my main supervisor, Dr Ir. L.L.M. van der Wegen, for his expertise, guidance, and support throughout the whole thesis process. His profound knowledge and his feedback have been invaluable in shaping this thesis.

I extend my appreciation to my second supervisor, M. Koot MSc, for his valuable contributions and input. His expertise and critical evaluation have strengthened the quality of this work.

Additionally, I would like to acknowledge and thank all the employees at De Vijvermeester who generously shared their time, knowledge, and experiences, which greatly enriched my research. Their collaboration and willingness to assist were very important in the successful completion of this thesis.

Lastly, I would like to express my heartfelt thanks to my family and friends for their unwavering support, encouragement, and understanding throughout this thesis. Their belief in my abilities has been a constant source of motivation.

Jasmijn Bloemendaal

University of Twente, Enschede, June 2023

Management Summary

Problem introduction

This bachelor thesis focuses on improving the customer order fulfillment process of De Vijvermeester, a company specializing in ecologically responsible pond water cleaning and maintenance. The company has trouble in meeting delivery commitments on Mondays due to increased orders over the weekend. Currently, packers can complete 90% of orders on time. Therefore, the research question is "*How can De Vijvermeester decrease its average from 90% of the orders ready for delivery on time to* 95% *of the orders ready for delivery on time?"*.

Method approach

The study utilizes lean management principles to identify and eliminate waste within the customer order fulfillment process. Through a combination of observation, interviews, and lean management several wastes are identified. These include problems related to packers' attention to products, product knowledge, walking distances, packing scripts, box availability, placement of water basins, picking trolley dimensions, communication, appropriate footwear and workspace cleanliness.

Solutions are proposed for each problem, considering their impact on packing time and feasibility of implementation. These solutions include strategies like using visual management tools, enhancing employee knowledge, optimizing workspace organization, providing packing guidelines, ensuring proper box availability, improving communication with whiteboards, optimizing water basin placement, adjusting trolley dimensions, and maintaining a clean workspace.

Results

Implementing these solutions could potentially reduce the average packing time for complex orders by 54.23 seconds, which is an improvement in the process. Although the goal of 95% on-time deliveries was not fully achieved, the research shows the power of continuous improvement and lean management principles.

Discussion of the final result

By showing these inefficiencies and implementing the recommended solutions, De Vijvermeester can improve its customer order fulfillment process. While the achieved on-time delivery rate is 91.5% rather than the goal of 95%, the study's insights and improvements serve as a strong foundation for future improvements despite limitations such as building constraints and external factors.

Conclusion

In conclusion, this bachelor thesis demonstrates the value of applying lean management to identify and find waste within the customer order fulfillment process of De Vijvermeester. Although the solutions fall slightly short of the original goal, they present noteworthy opportunities for operational efficiency, waste reduction, and customer satisfaction improvements.

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1. Introduction

This chapter introduces the structure of the research. Section 1.1 describes an overview of the company. Following this, Section 1.2 outlines the motivation behind this study. The research goal is outlined in Section 1.3. To answer the research goal presented in Section 1.3, the research design is detailed in Section 1.4. Section 1.5 presents both the internal and external stakeholders, as well as the problem owners. Moving forward, Section 1.6 provides insight into the study's limitations.

1.1 Brief description of the company 'De Vijvermeester'

De Vijvermeester was initiated by Jiry de Waal in June 2011. The company is located in Emmeloord. De Vijvermeester's core business is cleaning and maintaining water in ponds in a biological and ecologically responsible manner. The products used to clean and maintain the water in ponds are water plants and water animals gathered from local ponds and streams (Waal, sd). By cleaning and maintaining the water in this manner, the company does not have to use any chemical products. Therefore, it does not interfere with natural biological processes which is great for the environment.

De Vijvermeester has a permit for gathering water plants and water animals from specific ponds to relocate these to other ponds. The employees of De Vijvermeester who are responsible for gathering the water plants and water animals in other ponds are referred to as harvesters. After the harvesters have gathered the water plants and water animals, they will bring them back to the company via company vans. Once the products arrive at the company, they will either be bundled together and then put in the refrigerator/cold store or are put in the refrigerator straight away. The bundling of water plants and water animals is done because these products are not sold individually but are sold as bundles. Sometimes the bundles are put into water basins to keep them fresh for customers.

All orders that De Vijvermeester receives are through their website. The orders are handled based on when they need to be delivered to the customer. To deliver the order the company uses a third party to ship their products to their customers.

1.2. Motivation

De Vijvermeester manages customer orders through their website, where they commit to specific delivery timelines. According to the company's delivery policy: if an order is placed before 11 a.m. on any weekday, it will be delivered on the next working day. However, if an order is made during the weekend, it will be processed on Monday and subsequently delivered on Tuesday.

On most days, De Vijvermeester can pack the orders on time for delivery. However, during the summer months when more customers are engaged in gardening activities, including tending to their ponds, the demand for orders increases. This increase in demand is the largest over the weekends. While the company does not engage in packing activities during weekends, the orders received over the weekend are scheduled to be packed on Monday. However, due to the significant surge of orders during the weekends, the company occasionally struggles to meet its packing commitments on Mondays.

The owner of De Vijvermeester acknowledges that on average 90% of orders placed in June are successfully packed and prepared for delivery on Mondays. This shows that it happens that the company cannot uphold its delivery commitments, which can lead to a failure to meet customer expectations. Not being able to deliver the products on time could cause reputation damage to De Vijvermeester over time. This reduced market reputation can lead to customers choosing another company over De Vijvermeester.

To deliver more packages on time without expanding the workforce, De Vijvermeester is focusing on increasing the efficiency of its packaging process. This aims to boost productivity by optimizing the existing workforce's performance rather than adding more staff.

1.3. Research goal

Section 1.2 presented the motivation behind this study. The research goal investigates ways in which De Vijvermeester can reduce its average throughput time so that it will be able to manage larger amounts of orders.

On a typical Monday in June, De Vijvermeester manages to pack 90% of its orders in time for scheduled delivery. This implies that 10% of orders require rescheduling with customers due to delayed delivery. If the average throughput time can be reduced enough so that the company is able to manage 95% of the orders then the company only has to reschedule 5% of the orders, which decreases lagged delivery times.

Lean management techniques, as explained in Chapter 3, are essential to achieve this goal. Lean management techniques will help to eliminate waste in the packing processes. In theory the reduction in waste results in a decrease in the time required for the packing process.

While it desirable is to achieve 100% on-time delivery for all orders, it's important to acknowledge that unforeseen circumstances might occur. Consequently, it has been decided to set a goal of 95% of the orders fulfilled in-time.

That leads to the research question of this research:

"How can De Vijvermeester decrease its average packing time from 90% of the orders ready for delivery on time to 95% of the orders ready for delivery on time on Mondays?"

This question will be answered through sub-questions. These sub-questions can be found in Section 1.4 about the research design.

1.4. Sub questions

Section 1.4 presents the research design. To answer the research question from Section 1.3 sub-questions, need to be answered first. The sub-questions of this research are:

I. What does the actual customer order fulfillment process look like?
II. What are the methods proposed by lean management to identify and eliminate waste in the customer order fulfillment process?
III. What and where is the waste in the customer order fulfillment process at De Vijvermeester?
IV. How can waste in the customer order fulfillment process be decreased?
V. How can the solutions brought forward by this research be implemented?

These sub-questions will be answered in the order presented above.

Question I is about the current situation. To give insight into the current situation the model used to show the customer order fulfillment process is the Business Process Model Notation (BPMN). Also, the current map with the products given is shown.

Sub question II is about what methods are proposed by lean management to eliminate waste in the customer order fulfillment process. Through literature study, this question will be answered. Lean management specifically is chosen, because this technique focuses on providing as much value as possible whilst reducing the amount of waste to minimal levels. Because lean management will help with increasing the number of packages De Vijvermeester can pack on average for delivery on time.

Sub-question III will be researched by conducting interviews with both the owner and employees of the company. The interviews yield valuable insights into the specific areas within the customer order fulfillment process where waste occurs. In this sub-question, the calculation of the additional average packing time resulting from waste is shown.

How can the waste in the customer order fulfillment processes be prevented and solved? This question will be solved in sub-question IV. For the previous three sub-questions, the foundation has been laid to answer this fourth sub-question. Once, it is known how the process works, what can have been proposed by literature and what the actual waste is in the customer order fulfillment process, a solution can be presented. To fully answer this sub-question, I will make use of the literature study in sub-question III. At the end of this sub-question, the new process for decreasing waste is included. And this sub-question will give an estimation of how much time the new proposed customer order fulfillment process.

After answering sub-question IV the estimation of the new proposed customer order fulfillment process is known. Then Sub-question V can be answered by a presentation of the newly proposed process through an implementation plan.

1.5. The internal and external stakeholders and the problem owners

Section 1.5 discusses the extent of involvement from both internal and external stakeholders, and the problem owners contribute to this research.

Visual representation of these stakeholders is presented in Figure 1, where they are positioned along both the y-axis and the x-axis. Along the y-axis, their relative influence is presented, while the x-axis represents the degree of interest the stakeholder has. They are ranked on the power/interest they have in this study.

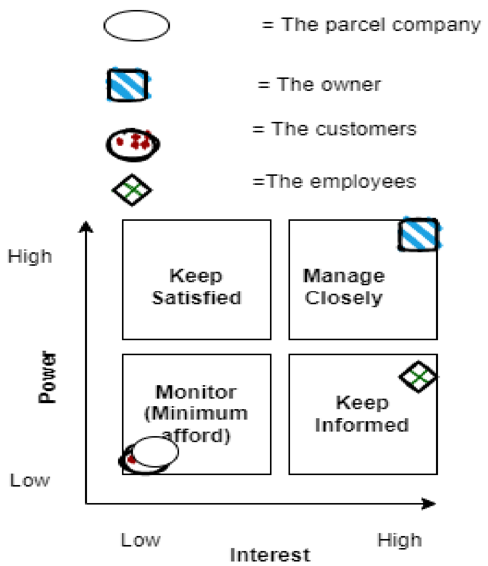


Figure 1:stakeholder interest and power mapping for this bachelor assignment.

In Figure 1, the parcel company is positioned in the lower-left quadrant, as their participation in interviews is not planned due to their fixed pickup times. Similarly, customers are also located in the lower-left quadrant, as they won't be interviewed and fall outside the scope of this process improvement study.

Employees, on the other hand, occupy the zone of average power and high interest. Their elevated interest stems from their crucial role in conducting interviews, a vital part of this study.

At the apex of the graph, the owner is situated in the upper-right quadrant. As the interest is the highest for the owner and the power is also the greatest as the owner helps a lot with this study.

1.6. Restriction of the solution (Limitations)

- The company's operations are limited within the existing building, with no plans for renovation. This entails that the building's walls and windows will remain unchanged.
- The quality of the products must continue to be guaranteed after the changes considering the living conditions of the products. For example, some products need sun and other products less or no sun. Therefore, we cannot change the entire setup of the factory hall because we need to place the products that need sun under the windows. If we do not consider the circumstances of the products the quality of the product will be less.
- The company's preference is to have a maximum of four packing employees.
- De Vijvermeester uses a third party to deliver its products. The company is bound to the time that the third party gives them, which is 17.00h. This means that working overtime is not an option. Starting the day earlier is not admirable because that would mean that every employee would need to work more hours than admissible in a day to get the orders done, which would decrease profitability.
- The company only packs orders from Monday to Friday. The reason why the company does not pack orders on other days is because of the parcel company. The parcel company does not deliver the package the next day at the weekends. Delivering the packed orders, the next day is vital for the quality of the products because the products are fresh.

2. Current Situation

This chapter answers the first sub-question: “What does the actual customer order fulfillment process look like?”.

The first section, namely Section 2.1, presents the BPMN representation of the packing process. Subsequently, in Section 2.2, an explanation of this BPMN is provided. Moving forward, Section 2.3 offers an insight into the current floor map of the factory hall. Section 2.4 presents the locations of the top 10 best-selling products through the floor map. In Section 2.5 an explanation of the spaghetti diagram concerning a complex order is provided. Section 2.6 discusses the heatmap. Continuing, Section 2.7 covers the average packing time per package.
Section 2.8 calculates the maximum number of orders that can be packed on a Monday. Finally, Section 2.9 offers a conclusive summary.

2.1 The Business Process Model and Notation of the packing process.

This research is focused on increasing the efficiency of the packaging process while maintaining productivity with the existing complement of 4 packing employees. To illustrate the packaging process, the current packing process at De Vijvermeester is depicted using the Business Process Model and Notation (BPMN), as depicted in Figure 2. Additional processes involved in customer order fulfillment, namely Harvesters and Arrangers, are presented in Appendix A for reference.

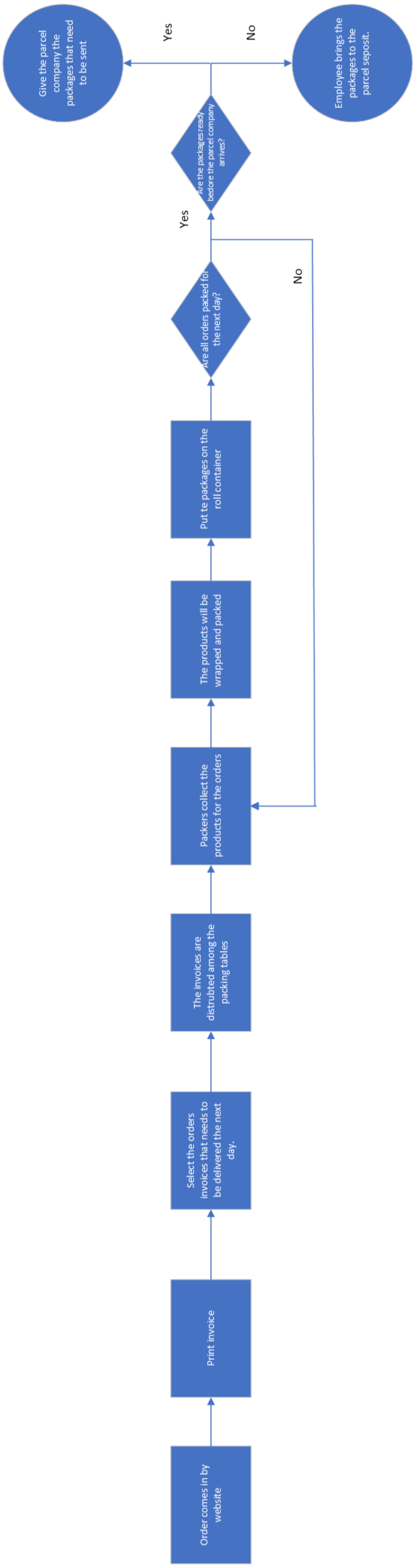


Figure 2:The BPMN model of the packing process.

2.2 Explanation of the BPMN for the packing process

Upon receipt of an order from the webshop, the first step involves printing the corresponding invoice. Subsequently, the priority will be checked, which decides that the packages should be sent first for the next day. The invoices that are for another day will be sorted and will be packed a day before the package should be delivered. When the priority is checked, the distribution of invoices among various worktables occurs. Every regular packer has a packing table. The packer is free to make their packing table setup. The other employees, like the harvesters, are there to help on busy days to pack the orders. They do not have their packing table.

After that, the packers will start packing the order, and the packers will collect the products for the order. The order can be an easy package, like 'zuurstofplantenpakket' but also a complicated package. Ultimately, products are prepared and placed within appropriate packaging materials. Then the products should be put in the box together with information on paper about the products. Subsequently, the address label is affixed to the box. When that step is executed, the order is ready for delivery.

Around 17:00, the parcel company arrives at the factory to collect packages, or an employee transports packages to the parcel deposit. If an employee brings the parcel deposit this depends on if the packages are ready before 17:00 o clock. Then the parcel company can take the packages to the parcel deposit. But if an employee brings the packages to the parcel deposit it is not only because of the lack of time but also, for guaranteeing the quality of the products because the products are fresh that are in the packages are very fragile. This practice minimizes the handling of packages by the parcel company, mitigating the risk of product damage. This method aims to minimize the number of times packages are transported, ensuring the utmost care for the products and reducing the potential for loss.

2.3 The current floor plan of the products in the factory hall

Figure 3 presents an overview of the existing layout, shown in the map. The legend in yellow provides clarity for the symbols used on the map. Distinctive symbols differentiate between the Growing Green House (GGB) and the cubitainers, with the latter using blue lines to indicate their outdoor placement.

Buckets are utilized for cultivating new products. The growing greenhouse benches are used for products that need lots of water. The GGBs tables are designed to keep products submerged in water. Plants in bins are used to denote an arrangement of diverse products positioned on the ground. Cubitainers are useful for products which need a lot of water, the cubitainers are noted for their depth and capacity.

The wheelbarrow is used for high-demand seasonal products, easily accessible due to the wheel. The strategic placement is close to the packing tables. This ensures fast access to frequently required items.

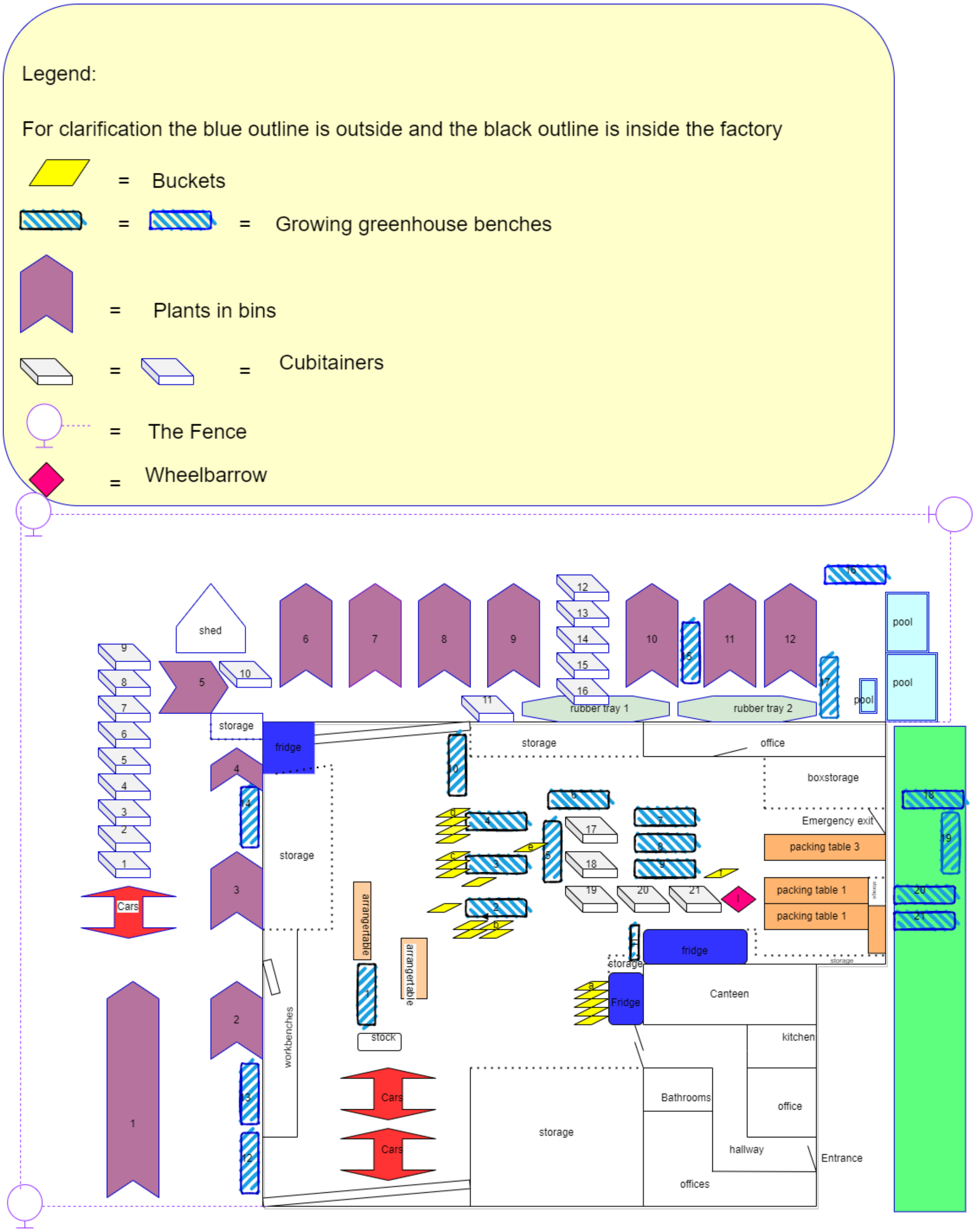


Figure 3: The map of the current setup.

2.4 De Vijvermeester's top 10 most sold products

In this section, the 10 most sold products and their location are presented. These top 10 products consistently appear in nearly every order. Also, the list of products that De Vijvermeester sells is reported. It's noteworthy that the product names are exclusively in Dutch, as the company operates within the Dutch context and employs Dutch terminology. To maintain consistency and avoid potential translation-related discrepancies, this research adheres to the original Dutch product names.

The list of the top 10 most sold products:

1. Slakken.
2. Mosselen
3. Krabbenscheer
4. Kikkerbeet
5. Glanzend fontein kruid
6. Gele lis
7. Moeras vergeet-me-nietje
8. Kalmoes
9. Kattestaart
10. Watermunt

This list is given to show where the top 10 most sold products are located in the company, refer to Figure 4. Inside the floorplan, there is a black rectangle with pink highlights, indicating the exact locations where the location of the top 10 most sold products. This map is given to show the efficiency of the setup of the top 10 most sold products. A broader overview of the product layout within the factory hall is presented in Appendix A.

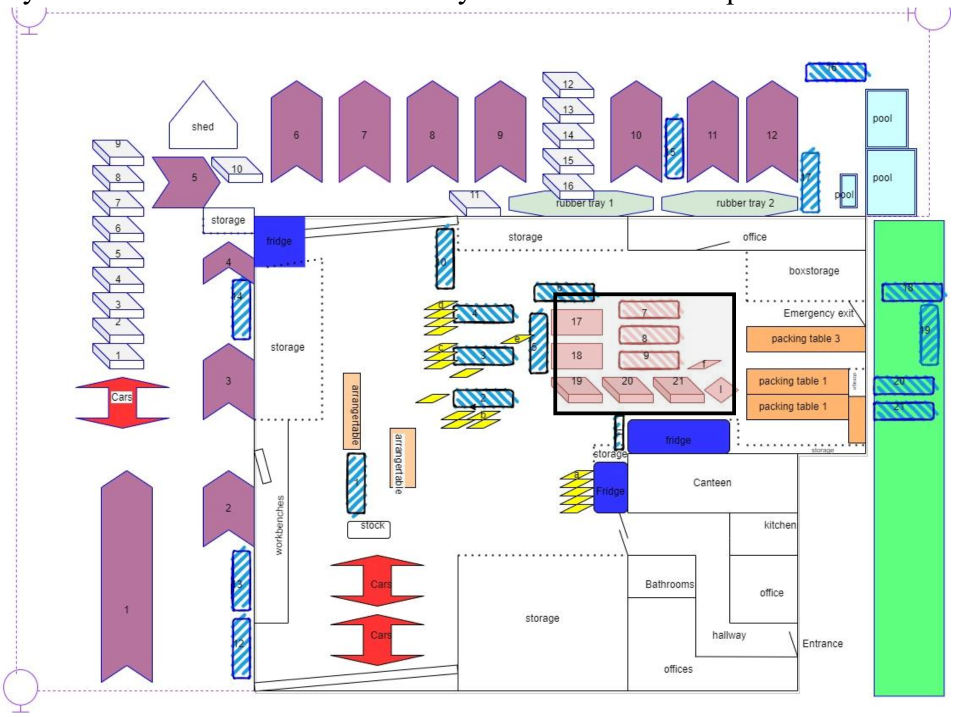


Figure 4: Location of the top 10 sold products on the map.

2.5 Spaghetti diagram

An easy order solely exists of the top 10 most frequently sold products, detailed in Section 2.4. These top-selling products are positioned near the packing tables. Complex packages exist of products beyond the top 10 most sold items. Overall, approximately 37.4% of all orders fall within the easy package category. Conversely, complicated packages are around 62.6% of orders, as indicated in Section 2.7.

A spaghetti diagram is used to illustrate the complex route taken for fulfilling a complex order. To effectively evaluate potential time savings, two package groups have been categorized. The first category exists of "easy" packages, which require minimal improvements because of their location. Section 2.4 demonstrates that products within easy packages are closely located near the packing tables. On the other hand, "complicated" packages offer opportunities for improvement, leading to increased time savings.

Figure 5 portrays a spaghetti diagram illustrating the walk a packer undertakes to collect a sample of a complex order. The black line depicts the route an employee follows to pack the complicated order. When dealing with complex orders, employees often walk the same path repeatedly, indicated by the presence of multiple black lines. In this particular example, the entire process of collecting and placing the order onto the roll container takes approximately 20 minutes and 11 seconds. Notably, this is a representative example, and orders may vary in size, ranging from smaller to much larger compositions.

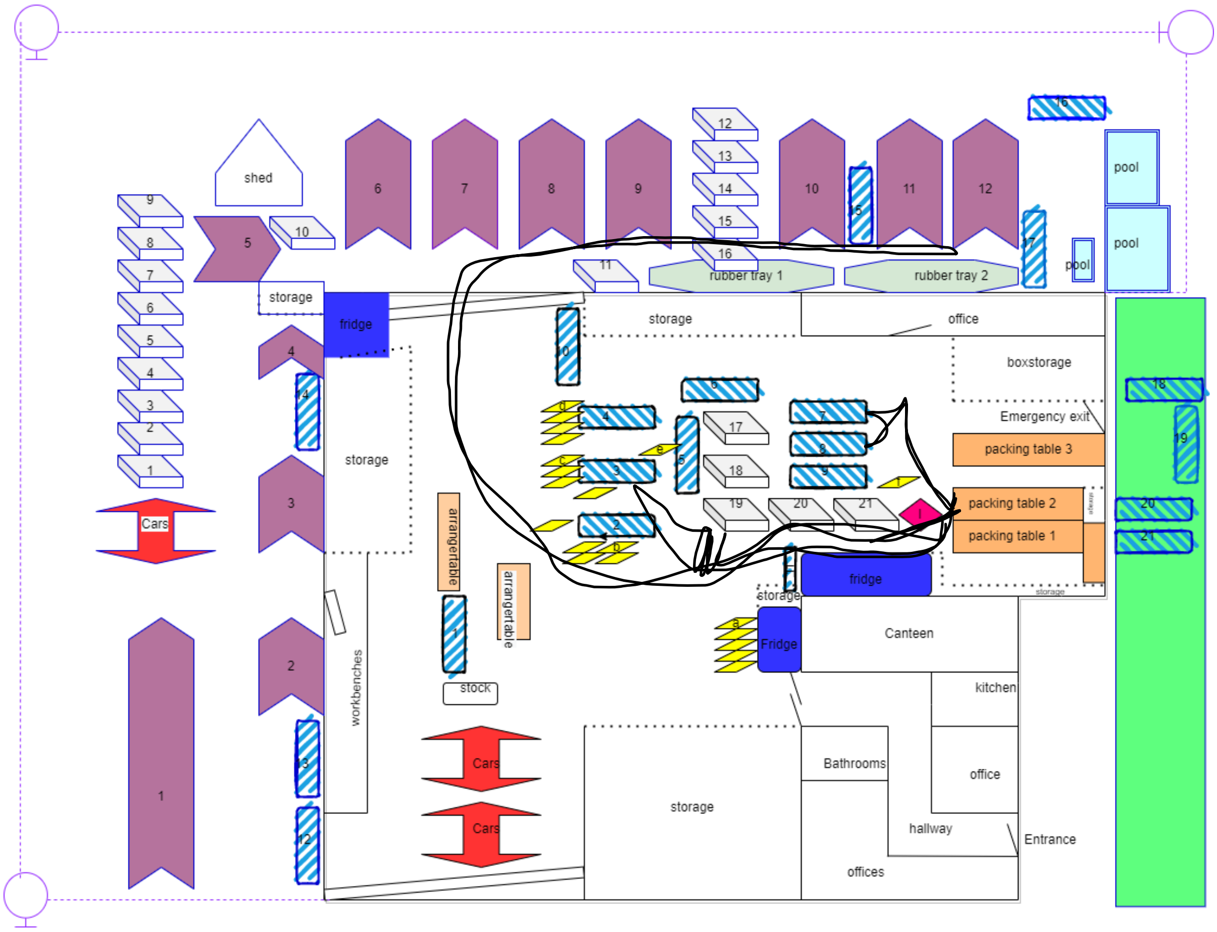
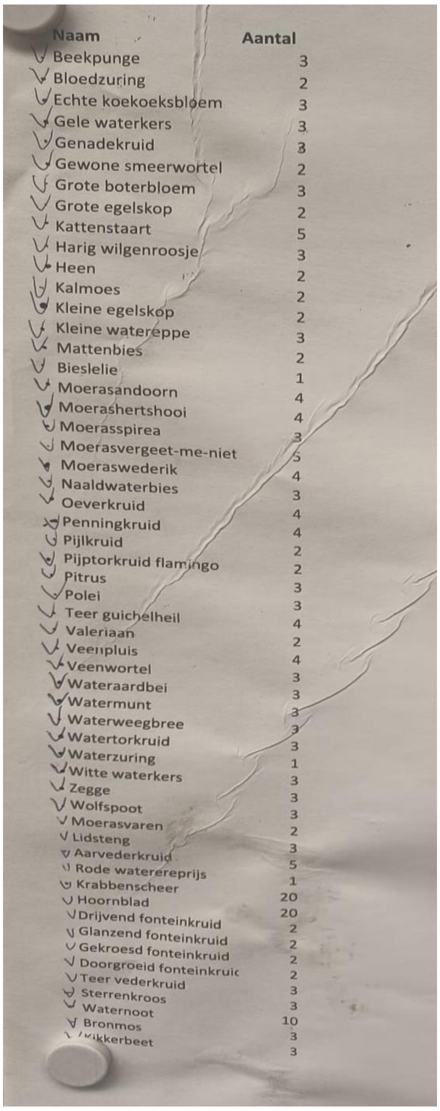


Figure 5: Spaghetti diagram illustrating a random example of a complex order.

A notably complicated order might resemble, on the left the picture of the list in Figure 6, where the specific products to be packed are displayed on the right. Notably, this took approximately 3 hours to completely pack. However, it's worth highlighting that such substantial orders are infrequent and do not occur regularly.



Naam	Aantal
Beekpunge	3
Bloedzuring	2
Echte koekoeksbloem	3
Gele waterkers	3
Genadekruid	3
Gewone smeerwortel	2
Grote boterbloem	3
Grote egelskop	2
Kattenstaart	5
Harig wilgenroosje	3
Heen	2
Kalmoes	2
Kleine egelskop	2
Kleine watereppe	3
Mattenbies	2
Bieslelie	1
Moerasandoorn	4
Moerashertshooi	4
Moerasspirea	3
Moerasvergeet-me-niet	5
Moeraswederik	4
Naaldwaterbies	3
Oeverkruid	4
Penningkruid	4
Pijlkruid	2
Pijptorkruid flamingo	2
Pitrus	3
Polei	3
Teer guichelheil	4
Valeriaan	2
Veenpluis	4
Veenwortel	3
Wateraardbei	3
Watermunt	3
Waterweegbree	3
Watertorkruid	3
Waterzuring	1
Witte waterkers	3
Zegge	3
Wolfspoot	3
Moerasvaren	2
Lidsteng	3
Aarvederkruid	5
Rode watererereprijs	1
Krabbenscheer	20
Hoornblad	20
Drijvend fonteinkruid	2
Glanzend fonteinkruid	2
Gekroesd fonteinkruid	2
Doorgroeid fonteinkruic	2
Teer vederkruid	3
Sterrenkroos	3
Waternoot	10
Bronmos	3
Kikkerbeet	3

Figure 6: Products for a complicate order.

2.6 Heatmap

In this section, a heatmap is used, to visually present the frequency at which water basins are used for packing complex orders, illustrated in terms of percentages, refer to Figure 8. The colour bar beneath the map serves as a reference guide for indicating colours to their corresponding percentage values. For instance, water basins highlighted in yellow are utilized for packing approximately 20% of the time.

In this heatmap, it was decided to divide the water basins into distinct regions. Considering the closely grouped percentages of water basin utilization, an average is used for the water basins within each distinct region. The heatmap effectively illustrates that high demand for products corresponds with their proximity to the packing table. Conversely, products positioned at greater distances from the packing table have a lower demand.

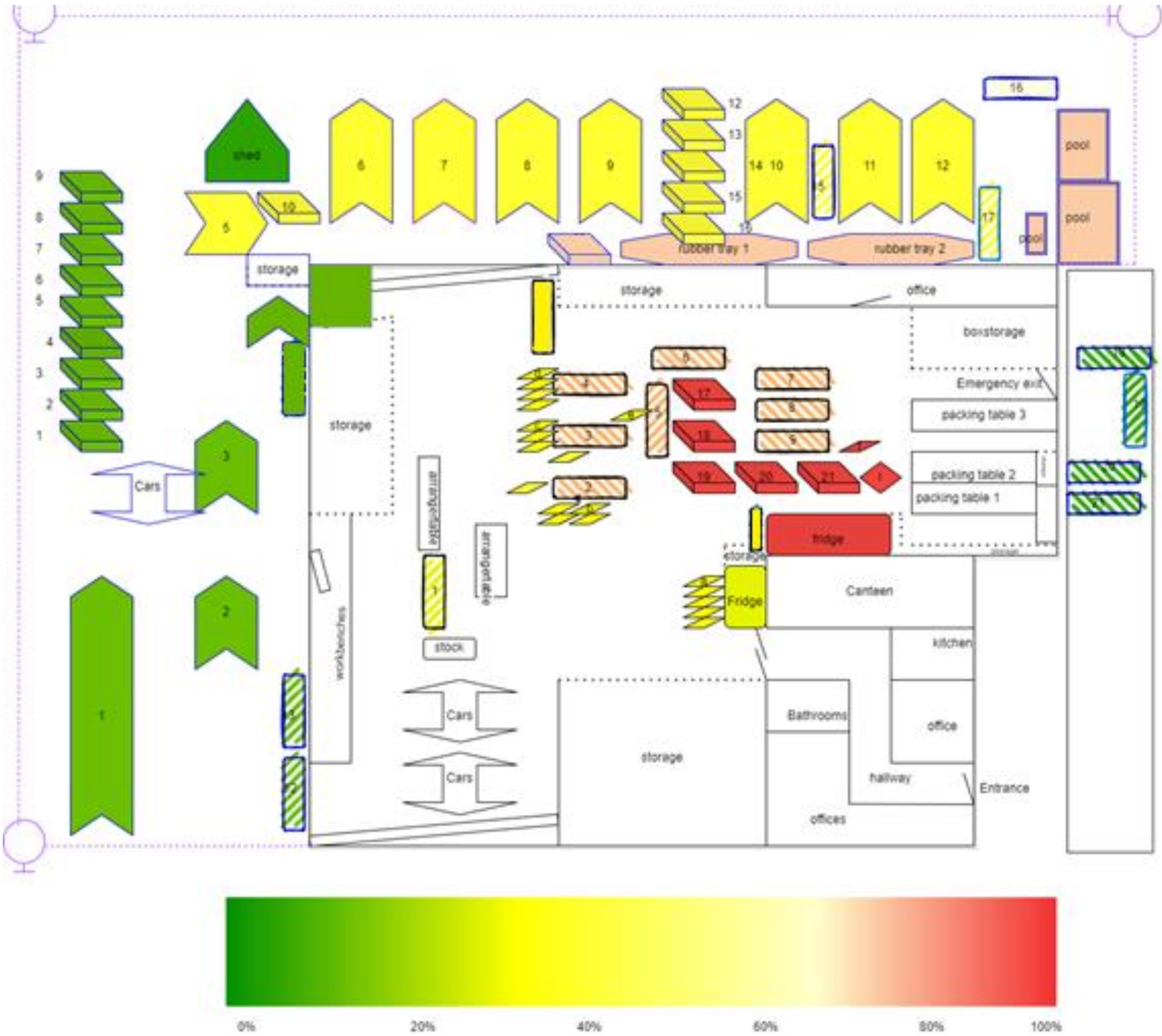


Figure 7: Heatmap of the visual representation of the frequency of use for each water basin in packing complex orders in percentage terms.

2.7 The average packing time per package

On Mondays there are consistently more orders than the company can pack, refer to the research goal outlined in Section 1.3. The company cannot pack all of the orders on Mondays because of the weekend. Since weekends are non-packing days and many customers participate in pond-related activities during the weekend, the majority of orders come in over the weekends. To achieve this, the first step involves computing the mean packing time per package. By calculating the average packing time per package, it becomes possible to determine the number of orders that the company can pack on Mondays.

The average packing time for an order is established at 13 minutes. This computation is derived from a measurement over a period of two Mondays with each about 100 packages, in June. This time of the year is chosen because June is the initiation of the upcoming peak season. To give a representative picture of the average time it takes per order, a sample of 100 orders was subjected to the packing process should be packed.

The used measurement technique for the average packing time is by measuring the time it takes to pack each order. The packers recorded the start and end times for each package in terms of minutes on paper.

2.7.1 Occurrence frequency of easy and complicated packages

This research does not focus on the easy packages because there is not much to change to decrease the throughput time. This is supported by the heatmap, refer to Figure 7 and from the map where the top 10 sold products are located, refer to Figure 4. From these figures can be concluded that the products which sold the most are closest to the packing table. Therefore, there is hardly a reduction in packing time to make from changing the setup of the most sold products, also known as the easy packages.

To provide a comprehensive understanding of the mean packing durations for both easy and complex packages, as well as their corresponding frequencies, please refer to Table 1. The average time required to pack an easy order stands at around 5 minutes and 30 seconds. However, this study places its emphasis on complicated packages due to the potential for enhancing average throughput time through improvements.

The average packing time for complex packages is approximately 17.5 minutes. Note that easy packages occur with a frequency of 37.4%, whereas the rate for difficult packages is 62.6%. Consequently, the culmination of these factors results in an average packing time of 13 minutes per package, see Table 1.

Table 1: Average packing times of easy and difficult packages and the frequencies they occur.

	Easy package	Complicated packages	Average package
Average packing time in minutes	5.5	17.5	13.0
The frequency of the packages occurs	37.4%	62.6%	--

2.8 Information about the packing hours.

At De Vijvermeester 4 packing employees are employed. The company only packs orders during weekdays, from Monday till Friday. This equates to a total of five packing days within a week. As presented in Table 1, the weekly packing hours amount to 80 hours. The number of orders that are needed to be handled differs per day. This variance can be explained by the influence of the weekends. This is because of the weekend. During weekends, customers typically engage in leisure activities, often involving their gardens and ponds, leading them to notice and attend to the condition of their ponds during their free time.

Table 2: Weekly packing overview in June at De Vijvermeester.

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Total
Hours available per employee	6.25	5	4	6.25	2	23.5
Number of packing employees	4	4	2	4	1	---
The average number of orders	90 - 130	60	20 - 35	90 - 110	8 - 15	268 – 350
Hours available per employee **x** number of employees	25	20	8	25	2	80
Maximum number of packed orders per day*	117	94	37	117	9	374

NOTE: --- indicates a variable that is not suitable for mathematical operations.

*The maximum number of packed orders per day is calculated as follows: 'Hours available per employee **x** number of employees' **x** 60 minutes**:** average packing time in minutes.

As noted above the total weekly average number of packing hours is 80. Mondays and Thursdays are the days that the bulk of hours are made, these are also the days that De Vijvermeester can pack the most orders. On Mondays, the average number of orders falls within the range of 90 to 130. However, the maximum number of packages that De Vijvermeester can process on Mondays is 117. This implies that there's a shortfall of the $\frac{117-130}{130} = -10\%$ in orders that cannot send on time. In other words, 90% of the orders can be sent on time while 10% cannot be sent on time. The research goal is to pack *95%* of the orders on time.

The research objective is focused towards achieving a 95% on-time packing rate. To accomplish this, the complex packages need to become, on average, 86 seconds faster than their previous packing time. This calculation is derived from the total working time of a Monday, which is $25 * 60 = 1500$ minutes. The aim is to have 95% of the orders sent on time, equivalent to $130 * 0{,}95 = 123{,}5 \approx 124$ orders. Dividing 1500 by 124 yields approximately 12 minutes and 5.8824 seconds, resulting in 54 seconds. However, this improvement applies only to the complex orders, which constitute 62.6% of the packages. Therefore, dividing 54 by 0.626 equates to 86 seconds. Over the entire day, this time reduction leads to $\frac{117}{60*60} = 2.8\ hours.$

De Vijvermeester can manage the orders on Tuesdays through Thursdays with the following quantities: 60, 20-35, and 90-110 respectively, and the respective maximum capacities are: 92, 37, and 117. On Fridays, there's a possibility that orders may exceed the maximum capacity due to an average of 15 orders against a capacity of 9. This situation is less challenging than on Mondays, as arranging for additional employees to handle the excess orders is more feasible. While these employees might not match the speed of regular packers, Fridays usually experience lower activity levels, rendering this approach acceptable. It's worth mentioning that this research might also positively impact Fridays by reducing packing times. Nevertheless, the primary focus remains on Mondays, due to employee limitations and a high likelihood of exceeding the maximum capacity.

2.9 Conclusion

This chapter has answered the question, "What does the actual customer order fulfillment process look like?" Through the utilization of the BPMN model representing the packing process, it has shown the sequence of steps involved in preparing an order for delivery. The process begins with the order's entry through the website, followed by the printing of the invoice. After that, the orders will be selected that need to be delivered the next day, and the invoices are allocated to respective worktables.

Then the packers start packing the products that are needed for the order. Once packed, products are wrapped and the entire order is placed within a box. Then the finished wrapped packages are put in the roll container. This process iterates until all orders are successfully packed. Then the orders can go with the parcel company, or an employee brings the packages to the parcel deposit.

A spaghetti diagram gave insight into what a walking path of a packer packing a complex order can look like. Additionally, the heatmap has depicted the frequency of water basin usage in terms of percentages. The average packing times for both easy and complex packages were determined. Based on the average packing time calculations, it was established that the company could manage 117 packages on Mondays as opposed to the required 130 packages.

To achieve the goal of 95% on-time deliveries, a crucial observation is that complex orders need to be packed approximately 86 seconds faster on average. It's important to note that this improvement only applies to complex orders, while the packing time for easy packages remains unchanged due to the absence of identified time-saving changes.

3. Literature study

In this chapter, the sub-question: "What are the methods proposed by lean management to eliminate waste in the customer order fulfillment process?" will be answered. The chapter aims to provide insights into lean management and the methodologies employed to address the specified sub-question. The first two sections explain the prominent lean management concepts. From Section 3 through Section 7, a systematic literature review is conducted. Section 3.1 explains lean management. Following this, Section 3.2 outlines the five lean management principles. Moving on to Section 3.3, an exploration of the spaghetti diagram is undertaken, while Section 3.4 provides a comprehensive description of a heatmap. Continuing, Section 3.5 presents the concept of Just-in-Time. Section 3.6 discussed the 5S methodology. In Section 3.7, the Kanban system is explained. Followed by the explanation of the two-bin Kanban system in Section 3.8. Ultimately, in Section 3.9 the conclusion is given by answering the sub-question above.

3.1 Lean management

There are multiple definitions of lean management. For this bachelor assignment, the description of Plenert's (Plenert, 2007) lean management fits the best. The definition of lean management according to Plenert is:

"Lean is a systematic approach that focuses the entire enterprise on continuously improving quality, cost, delivery, and safety by seeking to eliminate waste, create flow, and increase the velocity of the system's ability to meet customer demand" (Plenert G. J., Reinventing lean: introducing lean management into the supply chain, 2007).

This means that lean management serves as a tool for driving continuous improvement through the systematic elimination of wasteful elements within processes. Eliminating waste means preserving only the value-adding process and eliminating the value-decreasing processes.

Value-adding includes three terms (Bicheno & Holweg, 2009): 1. Value Adding (VA), 2. Avoidable Non-Value Adding (NVA) and 3. Necessary Non-Value Adding (NNVA).

1. Value Adding is the term which is used for anything as long as the customer is prepared to pay for it. For example, adding folders with information on how to take care of the products.
2. Avoidable Non-Value Adding can be seen as waste. For example defective products.
3. Necessary Non-Value Adding is an activity which is mandatory but does not add value to the customer, for example, paying taxes.

There are also different types of waste. The different types of waste according to P. Tarvin (Tarvin, 2016) including an explanation (Skhmot, 2017) is listed below and pictured in Figure 8. The acronym DOWNTIME is used to remember the types of waste:

- Defects: “waste from a product or service failure to meet customer expectations”.
- Overproduction: “waste from making more product than customer demand”.
- Waiting:” waste from time spent waiting for the next process step to occur”.
- Not utilizing employee talent:” wastes due to underutilisation of people’s talents, skills, and knowledge”.
- Transportation:” wasted time, resources and cost when unnecessary moving products and materials”.
- Inventory:” wastes resulting from excess products and materials that aren't processed”.
- Motion:” wasted time and effort related to unnecessary movement by people”.
- Excess processing:” Wastes related to more work or higher quality than is required”.

Figure 8: types of waste and their explanation (Do, 2017).

3.2 The Five lean principles:

There are five lean principles. The work below is based on Doanh Do from the Lean Way (Do, 2017). The Five lean principles are designed for continuous improvement of efficiency in the workplace.

The five lean principles are listed below, and they are also depicted in Figure 9:

1. Defining value
2. Mapping the value stream
3. Creating flow
4. Using a pull system
5. Pursuing perfection

The explanation of the five lean principles:

1. Defining value.

Value is the amount of money the customer wants to pay for the product/service. The products/services that satisfy existing customer expectations, as well as those catering to latent desires. This value term is the same as in Section 3.1 Value Adding.

2. Mapping the value stream.

Before mapping, identification of the value stream is essential. A clear understanding of the customer's value for a product/service is essential. For identification, the company should know the customer's value for a product. If the value is identified, then investigate which activities contribute to the customer's value for the product/service. After that, the non-value-adding activities should be removed. There are diverse types of non-adding activities waste. Namely, necessary, and unnecessary wastes. The unnecessary non-value-adding waste should be removed, refer to Section 3 Avoidable Non-Value Adding is the same definition. The necessary non-value-adding waste should be minimized, refer to Section 3.1 Necessary Non-Value Adding for the meaning of this term. This results in the valued product/service but then with the minimum amount of waste.

3. Create flow:

This principle holds that the next parts of the process run without any difficulties. There are strategies for this, for example: breaking down steps and training employees to be multi-skilled and adaptive.

4. Establish Pull:

This principle is about limiting the inventory and the Work In Process. Therefore Just-in-Time applies here. That means ensuring products are available in the right quantity at the precise location with the expected demand.

This means that the products are just in time in the right amount at the right place.

5. Pursuing perfection: the last step is making lean management part of the company. Lean management is a continuous process. Therefore, it is important to make lean management part of the company culture.

Figure 9: The five principles of lean.

3.3 Spaghetti diagram

The spaghetti diagram serves as a graphical representation, visualizing the precise routes that packers walk while collecting products for an order (Spaghetti-diagram, sd). For example, it can be detected if the packer walks two times on the same path in the same direction for one package.

3.4 Heatmap

Heatmaps utilize colour gradients to visually represent variations in values within a two-dimensional space (Kenton, 2022). This graphical approach helps in quickly recognizing the distribution and patterns of statistical or data-driven information. This technique can be applied to visualize the frequency of usage for each water basin.

3.5 Just-in-Time

Just-In-Time means that the needed products are there in the expected time, place and quantity (Chan, 2001). Just-in-Time is fundamental for implementing the Kanban system and the 5S methodology. To make the Kanban possess and the 5S pillars possible Just-in-Time deliveries need to be there. Otherwise, there is no stock to sell.

In this bachelor assignment is assumed that the products which are needed are available within the factory hall, adhering to the criteria of Just-In-Time. Just-in-Time is assumed because the harvesters are responsible for the stock and this bachelor assignment does not focus on the harvesting process but on the packing process.

3.6 5S phases

The 5S process exists of five phases that aim to enhance workplace efficiency and organization. These phases, as outlined by Plenert (Plenert G. , 2007), are as follows:

1. Sort: sort only the things that are needed, like equipment.
2. Straighten: specify what the locations should be for each item that is used in the process.
3. Shine: always keeping the place clean.
4. Standardize: monitor and maintain the three phases before, sort, straighten and shine.
5. Sustain: Commit the employees to the 5S culture.

For a comprehensive checklist of the 5S process in a workplace, check Figure 10, which illustrates the Workplace Scan Diagnostic Checklist. This checklist can be used for assessing and implementing the 5S principles within the workplace. Serving as a tool for organizing an efficient workplace.

Workplace Scan Checklist

Area:

Number of Problems	Rating Level		Date	Date	Date	Date	Date
5 or more	Level 0						
3-4	Level 1						
2	Level 2						
1	Level 3						
none	Level 4						

Category	Item	Level				
Sort	**Distinguish between what is needed and what is not needed**					
	Unneeded equipment, tools furniture, etc. are present					
	Unneeded items are on walls, bulletin boards, etc.					
	Items are present in aisle ways, stairways, corners, etc.					
	Unneeded inventory, supplies, parts, or materials are present					
	Safety hazards (water, oil, chemical, machines) exist					
Set in Order	**A place for everything and everything in its place**					
	Correct places for items are not obvious					
	Items are not in their correct places					
	Aisle ways, workplaces, equiment locations are not indicated					
	Items are not put away immeadiately after use					
	Height and quanity limits are not obvious					
Shine	**Cleaning, and looking for ways to keep clean and organized**					
	Floors, walls, stairs, and surfaces are not free of dirt, oil and grease					
	Equipment is not kept clean and free of dirt, oil and grease					
	Cleaning materials are not easily accessible					
	Lines, labels, signs, etc. are not clean and unbroken					
	Other cleaning problems (of any kind) are present					
Standardize	**Maintain and monitor the firsr three categories**					
	Necessary information is not visible					
	All standards are not known and visible					
	Checklists don't exist for all cleaning and maintenance jobs					
	All quantities and limits are not easily recognizable					
	How many items can't be located in 30 secs?					
Sustain	**Stick to the rules**					
	How many workers have not had 5S training?					
	How many times last week was daily 5S not performed?					
	How many times are personal belongings not easily stored?					
	How many times are job aids not available or up to date?					
	How many times last week were daily 5S inspections not performed?					
	Total	0	0	0	0	0

Figure 10: Workplace Scan Diagnostic Checklist (Omiliah, 2010).

3.7 Kanban system

In the context of Japanese manufacturing, "Kanban" translates to "signboard" and is synonym with demand scheduling. The signboard is divided into three parts: “To-do, “Doing” and “Done”. The Kanban process is a visual process it is defined as a demand scheduling process. The products are produced based on the actual demand instead of the forecasted demand. Only produce the products based on the products that have been sold to the customers and by customer demand. The Kanban scheduling is an execution tool. It is a day-to-day basis.

The benefits of Kanban scheduling will help to improve the throughput of the products in the packing process (Gross & Kenneth R., 2003). The benefits of Kanban scheduling:

1. Reduces inventory

2. Improves flow

3. Prevents overproduction

4. Places control at the operations level (with the operator)

5. Creates visual scheduling and management of the process

6. Improves responsiveness to changes in demand

7. Minimizes risk of inventory obsolescence

8. Increases ability to manage the supply chain

However, for this bachelor assignment, the Kanban system will not be utilized for improving the stock due to the assumption that the required stock is already present in the factory hall.

3.8 Two-bin system from Kanban

The Two-Bin System aims to optimize inventory management by ensuring on-time replenishment based on actual demand (Wanitwattanakosol, Attakomal, & Suriwan, 2015). The system has a minimum of two bins. In each bin, there is one product. The first bin is for satisfying the demand on time and if the second bin is needed that indicates that a new order is necessary for satisfying the demand.

Placed at the bottom of each bin is a Kanban ticket. What is a Kanban ticket? A Kanban ticket indicates the availability of the product in the bin. If the bin is empty, then the employee who makes the bin empty sees the Kanban ticket. Then the employee needs to make clear to the manager that the bin is empty, and the products should be replenished. Once acknowledged, the second bin takes the place of the first, with the former first bin now holding a Kanban ticket. This cyclical process ensures an uninterrupted supply chain. As the empty bin is restocked, the cycle starts over, maintaining a continuous flow of inventory (Hoe werkt Kanban-voorraadbeheer in mijn magazijn?, sd). This method prevents having excessive or insufficient stock.

However, the Two-Bin System from Kanban will not be applied in this bachelor assignment, given the underlying assumption that the required stock is already available in the factory hall.

3.9 Conclusion:

Sub-question 2 is answered in this chapter. The sub-question to answer is "What are the methods proposed by lean management to identify and eliminate waste in the customer order fulfillment process?".

Lean management is defined by Plenert as "Lean is a systematic approach that focuses the entire enterprise on continuously improving quality, cost, delivery, and safety by seeking to eliminate waste, create flow, and increase the velocity of the system's ability to meet customer demand". To identify and eliminate waste within the customer order fulfillment process, various methods are proposed by lean management.

Find value involves understanding customer value for a product or service and identifying activities contributing to that value. By removing non-value-adding activities, the process is streamlined. The Five Lean Principles: defining value, mapping the value stream, creating flow, using a pull system and pursuing perfection create the foundation for continuous improvement.

The spaghetti diagram gives insights into the walking paths, showing the excessive routes that can be optimized. The heatmaps use colour gradients to visually show fluctuations in values across a two-dimensional area.

In terms of waste elimination, the 5S methodology proves to be a notable approach for organizing packing tables within the customer order fulfillment process. The 5S phases exist of Sort, Straighten, Shine, Standardize, and Sustain, providing a structured framework for optimizing workspace efficiency and reducing waste.

The method of Just-In-Time emphasizes the timely availability of products at the right location and quantity to reduce excessive inventory. The Kanban system is used for demand scheduling. The Two-Bin System from Kanban ensures an uninterrupted supply chain by cyclically restocking bins upon depletion. However, these methods are not applied in the context of this bachelor assignment due to existing assumptions about stock availability.

Ultimately, these lean management strategies provide a framework for identifying and eliminating waste, optimizing processes, and enhancing efficiency within the customer order fulfillment process.

4. The waste in the customer order fulfillment process.

In this chapter the sub-question: “What and where is the waste in the customer order fulfillment process at De Vijvermeester?” will be answered. To know what and where the waste is observation and taking interviews are needed. In Section 4.1. the observed problems with their waste can be found. Next, in Section 4.2 according to the interviews, what the problems are and their wastes. In Section 4.3, the expected average additional packing time per package resulting from inefficiencies in the existing process is presented. Then at last in Section 4.4 the conclusion is given by answering what the problems are and where the waste is.

4.1. Where and what the waste is of the observed problems

To identify the waste of the problems Chapter 2 is used. For a detailed overview of the lean management techniques refer to Section 2.1, and for a detailed overview of the types of waste, refer to Section 2.2.

To identify the problems in the customer order fulfillment process, a combination of observation and semi-structured interviews with the employees took place. The observation focused on the packing employees involved in the entire process, starting from receiving the invoice until the package is ready for shipment. Various aspects were examined during the observation. Noteworthy issues and inefficiencies were noted down, particularly focusing on actions that consumed more time than necessary. This observation led to the identification of two prominent problems in the packing process, refer to Table 3.

Table 3: The observed problems

1. The packers have to walk unnecessary steps.
2. The boxes are not appropriately sorted to their size.

To analyse the waste resulting from these problems, the concepts and techniques of lean management from Chapter 2 were used. For a comprehensive understanding of lean management techniques, refer to Section 2.1, while Section 2.2 provides detailed insights into the various types of waste.

The first observed problem in the packing process: the packers walking unnecessary steps, leading to inefficiencies and these steps have no value addition to the process. This occurs when packers need to access products located outside the area of the top 10 most sold products, as mentioned in Section 3.3. The packers often find themselves walking back and forth because they cannot carry all the required products at once, forget the products' locations, or are unaware of the optimal number of products they can carry in one walk. These unnecessary steps, along with the difficulty in remembering optimal carrying capacity and product locations, result in orders taking more time than necessary. This problem is visually represented in the spaghetti diagram from Chapter 2.

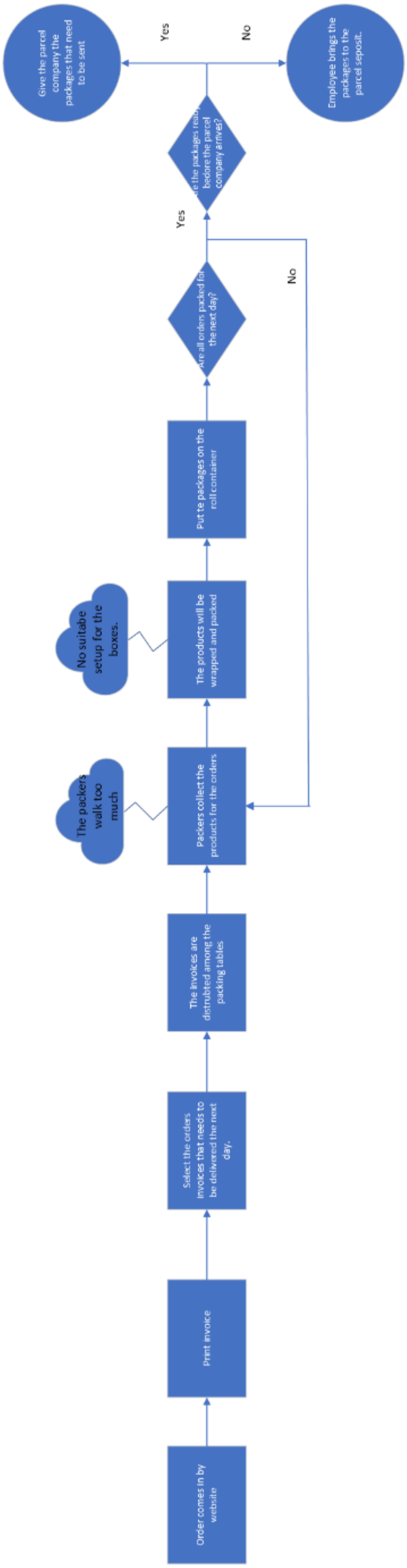
<u>The type of waste:</u> identified in this problem is motion. The packers take more steps than required to complete an order, indicating inefficiency and wastefulness in the process.

The second observed problem in the packing process: The setup of different sizes of wrapping boxes, which is not optimized. The company purchases boxes of specific sizes, and while recycling boxes from other stores, these boxes come in various sizes that are not sorted by size. As a result, packers often spend time searching for the appropriate boxes that fit the order. The uncertainty in box sizes for each order leads to guesswork, further contributing to inefficiencies.

The type of waste: identified in this problem is also motion, as packers are spending time searching for suitable boxes, which adds no value to the process.

Upon comparing Figure 11 (BPMN diagram) with (waste identification diagram), it is clear that the clouds are replaced with paper icons in the right figure, and the waste type associated with each cloud is now mentioned on these paper icons. For instance, in Figure 11 on the left, there is a cloud labelled "Have to walk too much," and on the right, the paper icon in the same location indicates the waste type as motion.

In conclusion, the waste identified for the observed problems is primarily motion, as the packers' unnecessary walking and searching for suitable boxes add no value to the packing process. By addressing these inefficiencies and optimizing the layout and organization of products and boxes, the packing process can be streamlined, reducing motion and enhancing overall productivity by effectively utilizing employee talent.



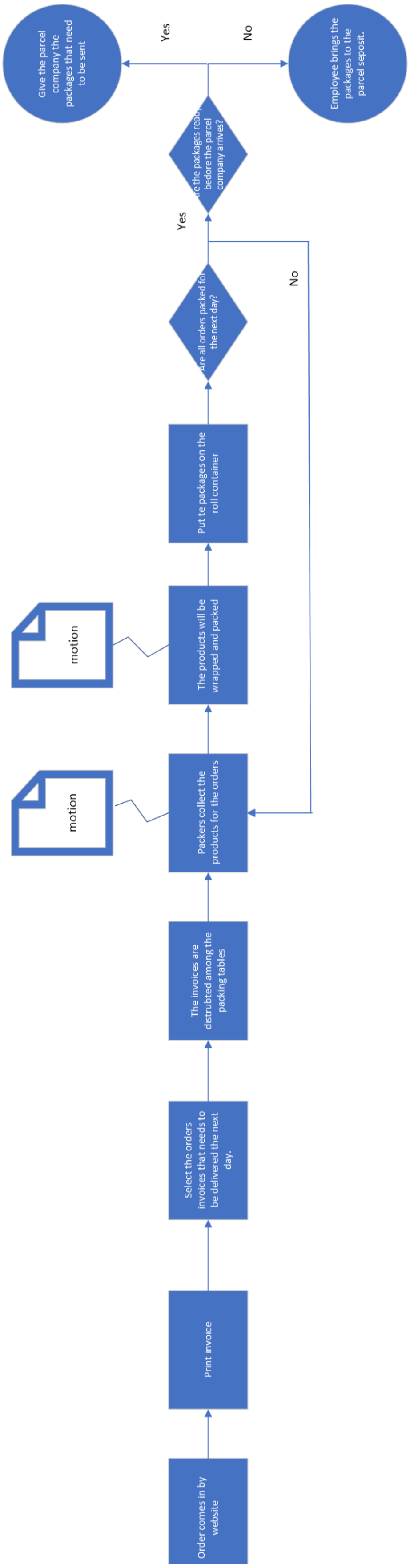


Figure 11: BPMN of the customer fulfilment (on the left) and the BPMN model including the type of waste (on the right).

4.2 The identified problems and their wastes are according to the interviews.

This section aims to discover the type of waste associated with the problems identified through the semi-structured interviews, refer to Section 3.1. The interviews were conducted using open-ended, probing, and opinion-based questions, with the objective of gaining deeper insights into the employees' perspectives. The interview process and the questions asked are detailed in Appendix C.

The purpose of the interviews was to gain a comprehensive understanding of the challenges faced during the packing process. To create a comfortable environment for sharing thoughts, the interviews were conducted in the canteen when there were no other employees. Interviews were conducted with individuals in various roles, including directors, harvesters, arrangers, and packers. This diverse selection of interviewees was chosen to ensure that viewpoints from different areas of the process were represented, as these employees interact with each other frequently throughout the day.

Based on the interviews with employees from various work fields, including directors, harvesters, arrangers, and packers, the following problems were identified. To provide a comprehensive overview of the problems identified during the interviews, the following list is in Table 4. Subsequently, each problem will be explained in further detail:

Table 4: The problems identified through the interviews.

1. The packers are paying insufficient attention to the products during warmer weather when products that need refrigeration are outside of the fridge.
2. The packers lack sufficient product knowledge.
3. The packers do not remember the optimal quantities that can be picked in one go for each order, leading to unnecessary walking.
4. There is no packing script for new packers.
5. Absence of appropriate large boxes for packing large orders.
6. The water basins outside are close to the packing tables but they are not close in walking distance because the wall of the building is between them.
7. Picking trolley dimensions do not fit within the company's set-up.
8. Insufficient communication regarding orders for the following day.
9. Packers require a change of footwear to collect certain products, necessitating waders for plants in deeper water.
10. Inconsistent cleaning of packing tables by employees on a daily basis.

4.2.1 Identified problems and their types of waste.

The first problem: “The packers are paying insufficient attention to the products during warmer weather when products that need refrigeration are outside of the fridge.”

Given that De Vijvermeester deals exclusively with natural products, such as plants, their chance to decay increases in warmer temperatures. This issue arises when products are exposed to hot temperatures for prolonged periods, leading to accelerated decay. The realization that products that should have been refrigerated were left outside the fridge typically occurs when all products for an order have been collected. At this point, while cleaning the workspace, packers may notice products that should have been refrigerated. Unfortunately, it's often too late to salvage most of these products, resulting in less quality or complete decay. In some cases, these decayed products might need to be discarded altogether.

<u>The types of waste:</u> defects, transportation, overproduction, motion and extra-processing. The explanation of the types of waste associated with the first problem:

1. Defects: Because products decay rapidly in high temperatures, leading to reduces quality or complete decay.

2. Transportation: If products that are in poor condition due to inadequate refrigeration are delivered to customers, there's a high chance they will be returned. This means that the resources invested in picking, shipping, and packing these products were in vain, making transportation a waste.

3. Overproduction: since customers expect high-quality products, delivering products in not high-quality condition would lead to replacements. This results in more products being produced than necessary, leading to overproduction waste.

4. Motion: Motion is present because the product has passed through various work fields, from harvesters to arrangers and then packers. However, due to decay, the product must go through the same steps again. The customer often receives the originally ordered product along with something extra to compensate for the decay. This entails unnecessary time, movement, and effort, contributing to motion waste.

5. Extra-Processing: Extra-processing arises from the fact that the effort invested in producing the product becomes wasted due to decay.

The second problem: “The packers lack sufficient product knowledge”.

De Vijvermeester specializes in selling fresh products, which change in appearance throughout the year due to seasonal changes. If the packers have a better understanding of these products and their transformations over different seasons, they will better identify the product's appearance at any given time of the year. This enhanced knowledge would help the need to extensively search around the facility to locate the correct product. The lack of knowledge regarding the change of products over the year results in less selection of incorrect products and/or extended time spent on product retrieval.

The type of waste: defects.

The lack of knowledge in recognizing product appearances is due to the changing nature of the products, resulting in changes in their appearance over time. As a consequence, employees often need to spend additional time searching for the right product or might even select the wrong product. This waste emerges primarily during the product collection phase. For instance, during the winter season, packers may not be familiar with how a product looks during the summer, leading to errors or inefficiencies during the collection process.

The third problem: “The packers do not remember the optimal quantities that can be picked in one go for each order, leading to unnecessary walking.”

The optimal number of products that can be collected in a single walk is not remembered by the packers, resulting in unnecessary trips. Increase this issue, packers are unable to carry invoices with them due to environmental concerns, as the company deals with natural products that can soil the invoices. Additionally, the company does not want to print the invoice twice due to environmental reasons. As a result, invoices can become dirty and unsuitable for sending to customers.

The challenge is increased by the distracting work environment, including personal conversations among employees, the loud noise of the cooling engine, and the constant radio volume. These factors contribute to the packers' inability to accurately remember the optimal number of products to collect during a single walk, ultimately leading to increased walking distances and higher packing time than needed.

The types of wastes: motion, waiting and defects. The explanation of the types of wastes associated with the third problem:

1. Motion: Motion is evident due to the unnecessary movements of packing employees during the product collection process.

2. Waiting: Waiting becomes a concern when unnecessary movements lead to delays in packing orders. If the packing process has efficiencies, orders might not be completed on time, causing deliveries to wait until the next working day.

3. Defects: The inefficiencies in product collection can result in defects, not in the physical sense of the product, but in terms of the overall process. When orders are not filled accurately due to multiple trips, customer expectations may not be met. This failure to meet customer demands can be viewed as a defect in the customer order fulfillment process itself.

The fourth problem is: "There is no packing script for new packers."

When new packers join the company, they often face a non-usual learning curve. Without a standardized packing script to guide them, they frequently find themselves needing to ask numerous questions. This situation is undesirable as it not only hampers the efficiency of the new packer but also causes distractions for the experienced packers who are in the midst of their packing tasks.

<u>The types of wastes</u>: waiting, unused talent, motion and extra-processing. The explanation of the types of wastes associated with the fourth problem:

1. Waiting: this is evident when new packers, lacking a standardized packing script, require assistance from experienced colleagues. This waiting period interrupts the packing process and extends the packing process.

2. Unused talent: Moreover, this circumstance leads to the waste of unused talent. Instead of utilizing their expertise for productive tasks, experienced packers must divert their attention to answering questions, thus compromising their efficiency.

3.Motion: The waste of motion is prominent as new packers navigate the factory to locate the necessary products for each order. This unnecessary movement not only consumes time but also contributes to inefficiency.

4. extra-processing: The waste of extra-processing is observed in both the product collection and packaging phases. Inefficient product collection arises due to the absence of a clear product placement map, causing new packers to spend excess time searching for items. Furthermore, during the packaging phase, the absence of a standardized script bothers the efficient use of consumables, and the lack of clear instructions regarding the proper sequence for packing each package leads to additional processing time.

The fifth problem is:" Absence of appropriate large boxes for packing large orders."

The existing problem is around the absence of appropriately sized large boxes to pack large orders. This is a time-consuming process when dealing with large orders. Initially, the packer go on a search for the largest available box, to fit the entire order in the box. However, they cannot always succeed, because they discover that all of the products together of the order exceed the box's capacity. Consequently, packers are compelled to split the order across multiple boxes. This approach costs more time then needed.

The inefficiencies further increase during warmer weather conditions when the inclusion of cooling elements becomes necessary to preserve product quality. To fit these cooling elements, larger boxes are required, compounding the problems related to box availability and suitability.

<u>The types of wastes:</u> motion and extra-processing. The explanation of the types of wastes associated with the fifth problem:

1. Motion: As a result of the absence of appropriate large boxes it leads to two phases: searching for the right box and then repackaging to ensure proper fit. This sequence of actions contributes to motion waste, as packers move back and forth to find and utilize suitable boxes.

2. Extra-processing: The use of larger boxes introduces extra processing waste due to the additional steps required for repackaging and adapting to the size of the box.

The sixth problem is: “The water basins outside are close to the packing tables but they are not close in walking distance because the wall of the building is between them.”

The problem arises from the proximity of GGBs 18 until 21 to the packing tables in terms of walking distance. However, due to the presence of a building that acts as an obstacle between the packing tables and the GGBs, the packers need to take a longer route around the building to reach GGBs 18 to 21. Consequently, this detour significantly increases the time required for collecting the products.

The type of waste: motion because the packing employees have to walk unnecessarily much. This problem is noticed during the collecting of the products. Because the employees must walk too often to the products that are not close to the packing tables.

The seventh problem: “Picking trolley dimensions do not fit within the company's set-up.”

Every packer has a picking trolley where the packer can place several products when sorting the products for the order. So that the packer does not have to walk back and forth as often. The picking trolley does not fit through every pathway in the set-up of the company.

The type of waste: motion. The explanation of the type of waste associated with the seventh problem:

The waste is motion because the inefficiency arises from the fact that the picking trolley cannot smoothly fits through the company's pathways, leading to packers having to repeatedly walk back and forth between the picking trolley and the products. This results in unnecessary extra motion, which could have been avoided with wider pathways.

The eighth problem is: “Insufficient communication regarding orders for the following day.”

Insufficient communication regarding the necessary preparations for the upcoming day, including tasks like arranging boxes, preparing required papers for packing for example snails, and ensuring the products are positioned for the next day where they should be.

The type of waste: motion. The explanation of the type of waste associated with the eighth problem:

The waste which fits to this problem is waiting. In cases where the necessary preparations have not been completed before, the packing process must be delayed until these preparations are finalized.

The ninth problem is: “Packers require a change of footwear to collect certain products, necessitating waders for plants in deeper water.”

Some products that are needed for the orders are in a place where a packer cannot walk with normal footwear on. The products that are outside of the water bins are very wet and can stand up to 10 cm high with water. The packers cannot go through this with normal footwear what the packers wear. Otherwise, the packers will get wet feet, which is not pleasant for the packers. As a result, the packers must change their footwear for waders they need some of it.

The type of waste: motion. The explanation of the type of waste associated with the ninth problem:

The waste associated with this issue is motion. The requirement to change footwear to navigate through waterlogged areas for collecting products results in unnecessary movement. This waste is evident in the additional time spent changing footwear, which could have been avoided if the paths were accessible with regular footwear.

The tenth problem is: “Inconsistent cleaning of packing tables by employees on a daily basis.”

At the end of a busy day the employees are tired resulting delays in cleaning and packing tables at the end of a busy day. When the packages are picked up by the parcel company they go home.

The type of waste: the tenth problem is motion. The explanation of the type of waste associated with the tenth problem:

The waste that does apply here is waiting. The waste waiting fits here because the first thing what the packing employees have to do the next day is cleaning their packing table. The packers have to wait till their packing table is fully dry from cleaning, otherwise the wrapping material like the invoice sticks to their packing table. This means that they cannot process the orders and the packing process stands still. This waste is noticed the next morning when the packing tables are not organized. The packers must clean their workspace before the start of the packing process.

4.2.2 The observed and interview problems in the packing process combined

Notably, the issues observed and identified overlap with those derived from the interviews. This overlap becomes obvious as all the observed problems align with the problems during the interviews.

The first observed problem corresponds to an issue identified through the interviews: the unnecessary walking distance for packers (observed problem) correlates with the packers do not remember the optimal amounts per order when they are collecting the products during the packing process (interview-derived problem).

Similarly, the second observed problem falls under the same category as the fifth issue raised during the interviews. Both issues pertain to box sizes. In the observed problem, the boxes are not properly sorted in size. In the interview, the problem involves the absence of adequately large boxes for certain orders.

Therefore, refer to Table 5 below, of the observed and interviewed problems in the packing process combined. All problems were validated with the owner.

Table 5: The final problems

1. The packers are paying insufficient attention to the products during warmer weather when products that need refrigeration are outside of the fridge.
2. The packers lack sufficient product knowledge.
3. The packers do not remember the optimal quantities that can be picked in one go for each order, leading to unnecessary walking.
4. There is no packing script for new packers.
5. Absence of appropriate large boxes for packing large orders.
6. The water basins outside are close to the packing tables but they are not close in walking distance because the wall of the building is between them.
7. Picking trolley dimensions do not fit within the company's set-up.
8. Insufficient communication regarding orders for the following day.
9. Packers require a change of footwear to collect certain products, necessitating waders for plants in deeper water.
10. Inconsistent cleaning of packing tables by employees on a daily basis.

4.3 Average additional packing time per package

This section provides an overview of the expected average additional packing time per package due to inefficiencies in the current process. These inefficiencies have been identified through the problems listed in Tables 3 and 4.

The data used below originates exclusively from interviews conducted with Jiry. As precise data for these occurrences are unavailable due to the company's lack of records, the information provided relies on the comprehensive knowledge possessed by the owner, who possesses a profound understanding of the entirety of the company's operations. Henceforth, the data provided by Jiry is expressed in minutes. Consequently, the decision has been made to represent the measurement times of the time it takes to pack an order in minutes as well.

The first problem: "The packers are paying insufficient attention to the products during warmer weather when products that need refrigeration are outside of the fridge.":

Based on the data collected over two Mondays, the company has identified an incorrect product decay rate of 1% (Waal, Data recieved by Jiry de Waal, 2023). Consequently, the time required to prepare replacement packages with the correct products is estimated to be 7 minutes.

During the analysis of the data, a total of 100 packages were examined. Considering the 1% failure rate, the average additional packaging time required due to this issue can be calculated as follows: average additional packaging time = (7 minutes * 60 seconds per minute * 1%) / 100 = 4.2 seconds.

Hence, the average additional time per package, caused by the 1% failure rate due to product decay, amounts to 4.2 seconds.

The second problem: "The packers lack sufficient product knowledge.":
Due to the knowledge gap among the packers, they need to resend packages with the correct products. The data reveals that the fixed packers, they encounter an average of 1 incorrect order per 100 packages (Waal, Data recieved by Jiry de Waal, 2023). As a consequence, the additional packing time required to rectify these errors is comparable to the additional packing time in the first problem, which was calculated to be 4.2 seconds.

Therefore, based on the information provided, the additional packing time resulting from the knowledge gap and the need to replace packages with the correct products would also be 4.2 seconds.

The third problem: "The packers do not remember the optimal quantities that can be picked in one go for each order, leading to unnecessary walking."

Refer to Figure 7 for the heatmap illustration. The heatmap visually demonstrates the frequency of utilization for each colour-coded area where products are located, expressed as a percentage. To calculate the average walking time per colour, the following information is considered:

Green basins: Present in two distinct areas, the left and the right side. Specifically, the 18 basins on the left and 4 basins on the right are utilized approximately 10% of the time. The average walking time from the packing tables to the left area back and forth is approximately 68 seconds, while the average walking time from the right area is approximately 74 seconds.

Yellow basins: Similar to the green colour, the yellow colour is found in two areas, the middle of the factory hall and the upper side of the company. With about 20% usage, the 17 upper basins and 21 middle basins are considered. The average walking time for the middle basins from the packing tables back and forth is around 32 seconds, and for the upper basins, it's about 55 seconds.

Orange basins: Are divided into two sections, the upper right corner and the middle of the factory hall. The usage rate for these is about 70%. The average walking time from the packing tables to the right upper basins back and forth is approximately 62 seconds, and to the middle basins, it's about 17 seconds.

Red basins: The 8 red basins, situated in the middle of the factory hall, are utilized at 100% frequency. The average walking time to these basins is approximately 12 seconds.

To calculate the overall average walking time for each colour category, the following formula is used:

((18 * 10% * 68 seconds) + (4 * 10% * 74 seconds)) + ((17 * 20% * 55 seconds) + (21 * 20% * 32 seconds)) + ((6 * 70% * 62 seconds) + (8 * 70% * 17 seconds)) + ((8 * 100% * 12 seconds)) = 925 seconds.

With a total of 82 basins, the average walking time per basin is derived by dividing the total walking time by the number of basins: $\frac{925}{82} \approx 11.28\ seconds$.

Considering that in 50 out of 100 orders, packers forget a product and need to walk back, the average time for forgetting a product in an order is in half of the orders. Therefore, the average time it costs per package for forgetting a product is 11.28 seconds / 2 = 5.64 seconds.

The fourth problem: “There is no packing script for new packers” :

New employees initially require an average of 2 hours per day for a span of 2 weeks from the experienced employees' time. During this period, they tend to rely on the guidance and assistance of the regular packers. It's projected that during the first two weeks, the efficiency of new joiners stands at approximately 25%. This translates to new joiners being able to pack 25 packages within the same time frame that an established packer completes 100 orders. Over the time of the first two months, this efficiency is expected to increase to 50%. Then the time the new employees decrease to half an hour on average. By the third month, the efficiency is increased to around 75%. Then the new employees will sometimes asks questions but that is negligible. As these new employees enter their second year of employment, their efficiency levels are projected to hit 100%. Notably, the hiring of a new employee takes place once a year according to data received from Jiry de Waal in 2023.

Following the initial two weeks of adjustment, it's observed that the majority of questions are posed. As time progresses, these new employees gradually become more self-reliant and proficient at locating packages on their own. Implementing a packing script can help in this process. Although a packing script might not necessarily accelerate the pace of new employees, it serves to minimize disruptions after the first to weeks caused to the regular packers. The packing script essentially assists new employees in navigating their tasks with increased familiarity, leading to a more streamlined process overall.

The absence of a packing script led to additional time being spent on answering questions from new packers. Specifically, during the last 6 weeks of the first 2 working periods, it is estimated that regular packers would spend an average of half an hour per working day addressing questions from new packers. Calculating the hour's regular packers are answering questions is $6 * 5 * .5 = 15\ hours$. Assuming there are 52 weeks in a year with 2 days of the weekend each week, the number of working days in a year is approximately 261 days.

The the time it costs that there is no packing script is $\frac{15*60\ seconds}{261}$ ≈3.45 seconds per package.

The fifth problem:” Absence of appropriate large boxes for packing large orders.”
On average, packers need 8 seconds to find the appropriate box, according to the measurement in June. If there is not a box large enough for the order, the packers have to find, fold, and wrap more boxes. This process takes, on average, 45 seconds per box. On average, if there is not a box large enough, the packer needs 2 boxes for packing the order. This happens when there is not a box large enough, happens approximately 5% of the time (Waal, Data recieved by Jiry de Waal, 2023).To calculate the expected average additional packing time, two scenarios can be considered: one where the packer finds the appropriate box (which takes 8 seconds), and the other where they need to find, fold, and wrap more boxes (which takes 2 boxes * 45 seconds per box = 90 seconds). We take the average of these two scenarios, multiply it by the probability of this situation occurring (5% of the time), and divide by 100 to get the average additional packing time:

Therefore, the expected average additional packing time will be $\frac{8+(2*45)}{2} * .05 = 2.45\ seconds$

The sixth problem: "The water basins outside are close to the packing tables but they are not close in walking distance because the wall of the building is between them.":
The time required for walking between packing table 2 and GGB 21, back and forth, is an average 76 seconds. This duration considers the quickest route, given that GGB 21 is situated farthest walking distance from the second packing table, refer to Figure 12. An estimate of the time taken when utilizing the emergency exit route from packing table 2 to GGB 21, back and forth, is at 9 seconds. Considering that GGB 21 is needed for around 10% of the entire process, as depicted in the heatmap in Section 2.6, the calculation is as follows: subtract 76-9 because this shows the additional time. The calculation is as follows:$(76 - 9)\text{seconds} * 10\% = 6.7$ seconds.

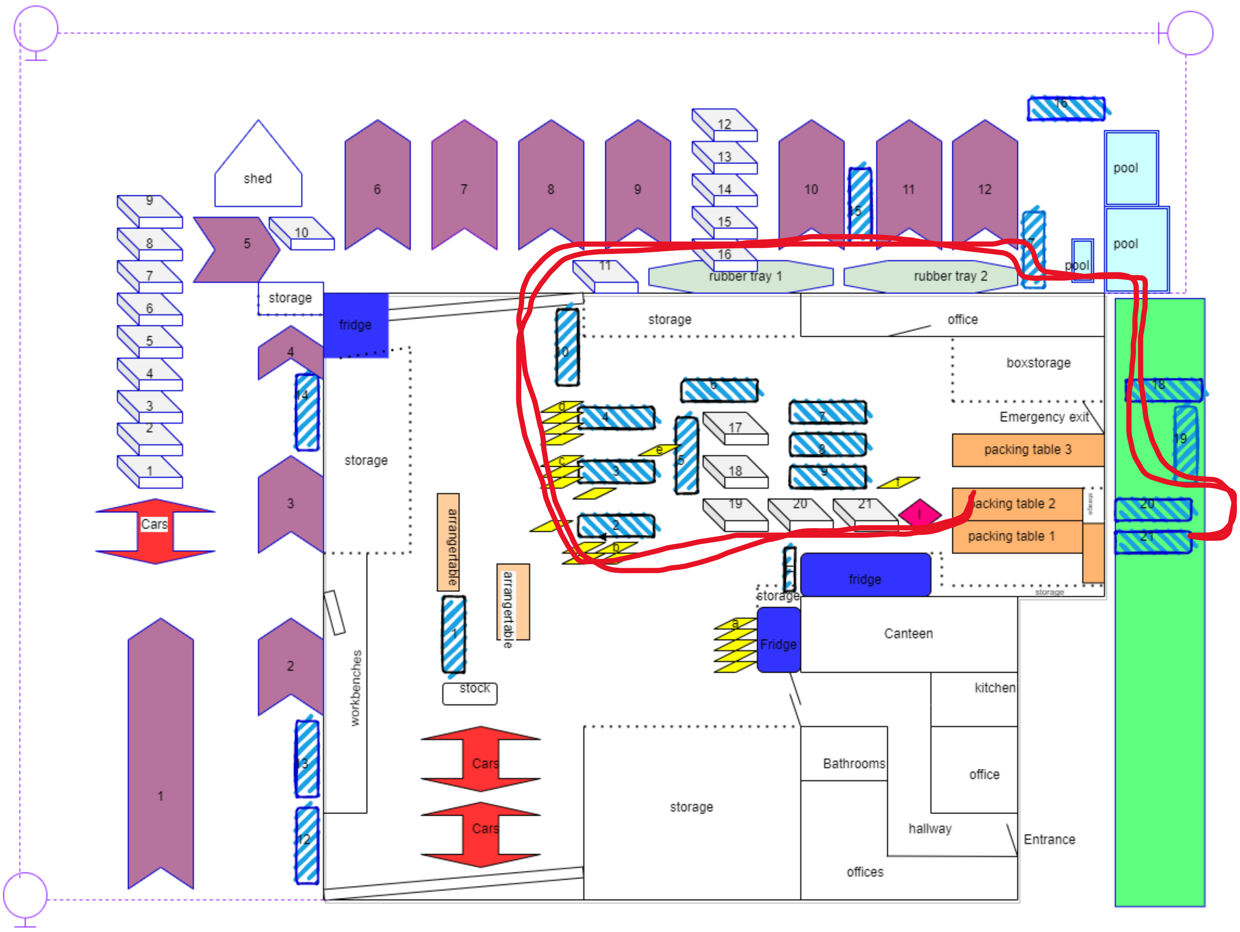


Figure 12: Walking paths of the minimum and maximum walking routes.

The seventh problem: "Picking trolley dimensions do not fit within the company's set-up":
Based on the provided data, the additional time taken by the employee to walk back and forth to the trolley is measured to be 8 seconds, according to the measurement in June. On average, this walking back and forth happens 2 times per order.

Therefore, for each order, there is an expected decrease in packing time of 8 * 2 = 16 seconds (Waal, Data recieved by Jiry de Waal, 2023).

The eighth problem: “Insufficient communication regarding orders for the following day.” Only the containers for the snails and mussels can be prepared. If the containers for the snails and mussels are not prepared, the additional packing time will have an approximate increase of 5 seconds per container. Additionally, each complex order typically requires an average of 2 containers (Waal, De Vijvermeester, sd).

Consequently, the cumulative packing time for each package will amount to 10 seconds (2 containers * 5 seconds per container).

The ninth problem:” Packers require a change of footwear to collect certain products, necessitating waders for plants in deeper water, the pink rectangle in Figure 13 shows the location where waders are required. For these plants waders are required”.

In approximately 20% of the orders, the packers are required to switch to waders, as indicated in the heatmap presented in Section 2.6. The average time taken for a footwear change is 15 seconds.

Consequently, for each order, the additional time incurred due to this footwear transition amounts to ((2 * 5) / 5) = 6 seconds per order.

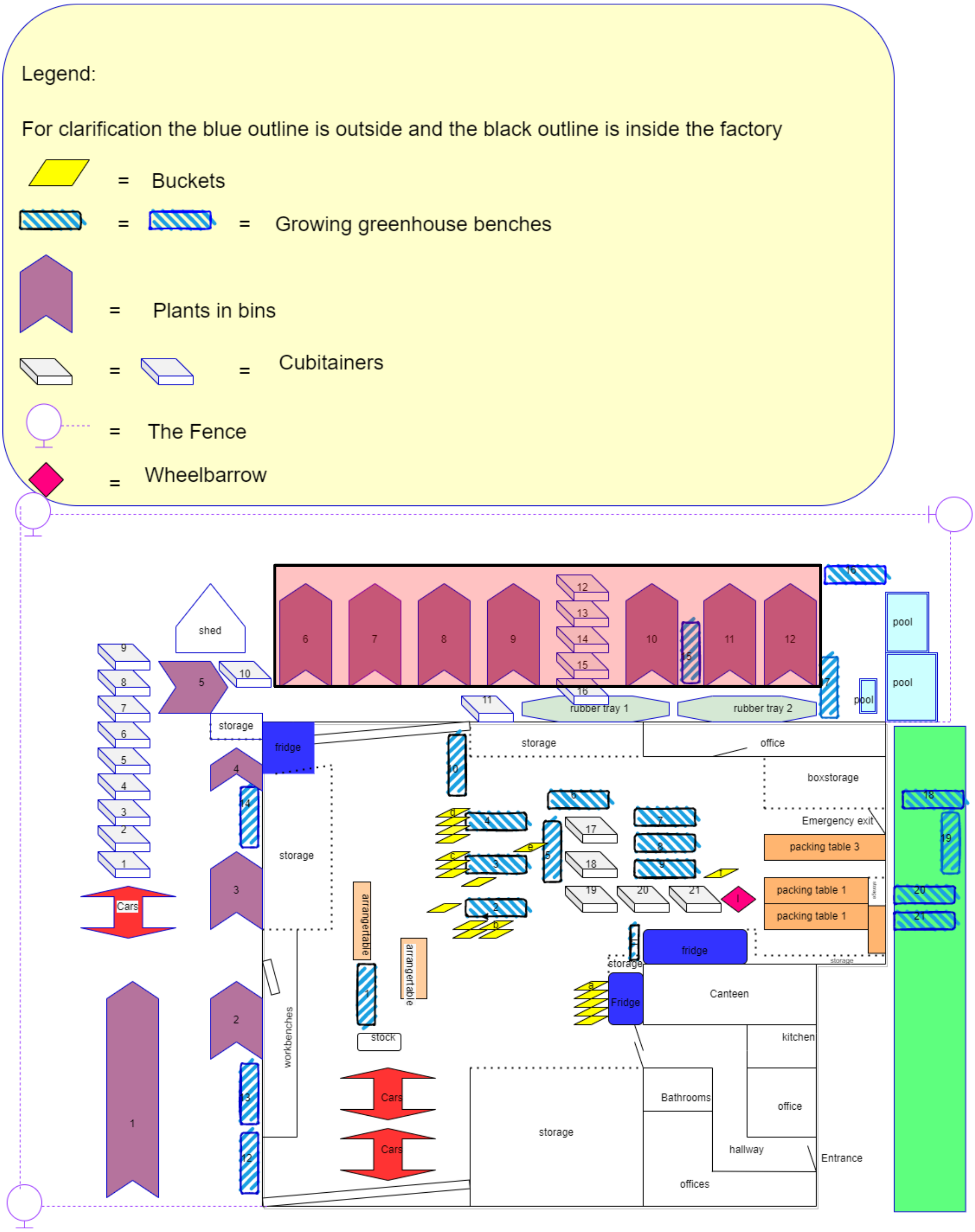


Figure 13: The location where waders are required.

The tenth problem: “Inconsistent cleaning of packing tables by employees on a daily basis.”

Each packer requires approximately 10 minutes to clean their workspace, and this can be considered a fixed time needed for the cleaning process. (Waal, Data recieved by Jiry de Waal, 2023). However, when the packers clean the packing tables the following day, an average drying time of 2 minutes is encountered. It is crucial to ensure the worktable is dry, as the papers may otherwise stick to the surface, potentially leading to disruptions during packing.

As a result of the drying process, the additional packing time per order is $\frac{120}{100} = 1.2$ seconds.

4.4 Conclusion of the identified problems of the packing process and what the wastes are.

In this chapter, the sub-question "What and where is the waste in the customer order fulfillment process at De Vijvermeester?" is answered.

The waste in the customer order fulfillment process at De Vijvermeester is primarily related to inefficiencies in the packing process. These inefficiencies have been identified through observation and semi-structured interviews with the employees. The waste has been categorized into various types based on lean management principles, see Chapter 3 and the specific identified problems. For each of these problems, the additional time required for packaging due to inefficiencies has been calculated, see Table 6 The waste types associated with each problem highlight the areas where improvements are needed to streamline the order fulfillment process and reduce wasteful activities.

It is clear that the most waste in the process relates to unnecessary motion, where packers are walking back and forth, looking for products, changing footwear, or accessing tools like picking trolleys.

From Table 6 can be concluded that tackling the problems with the most unnecessary packing time per package should be addressed as a priority. The sequence for resolving these problems ranked from the highest to the lowest additional time per package, is as follows: 7, 8, 6, 9, 3,1,2,4, 5, 10.

The identified waste types and corresponding problems provide a roadmap for De Vijvermeester to implement targeted improvements in their customer order fulfillment process. By addressing these inefficiencies, the company can decrease the average packing time, reduce delays and improve overall customer satisfaction.

Table 6: Additional waste per problem

Problem number according to Table 5.	The type(s) of waste(s) according to the problem.	The additional packing time for each problem per package.
1	Defects, Transportation, Overproduction, Motion, Extra-Processing	4.2 seconds
2	Defects.	4.2 seconds
3	Motion, Waiting, Defects	5.64 seconds
4	Waiting, Unused Talent, Motion, Extra-Processing.	3.45 seconds
5	Motion, Extra-Processing.	2.45 seconds
6	Motion	6.7 seconds
7	Motion	16 seconds
8	Waiting	10 seconds
9	Motion	6 seconds
10	Waiting	1.2 seconds

5. Decrease waste in customer order fulfillment.

This chapter considers the fourth sub question ‘How can the waste in the customer order fulfillment process be decreased?’. Through the earlier observations, interviews and literature studies, practical solutions are proposed, also the impact and difficulty to implement a possible solution were investigated. Section 5.1 provides the possible solutions for decreasing the problems and their waste. The solutions range from for example training programs to changing work procedures. Section 5.2 presents the conclusion.

5.1 Possible solutions for solving and preventing waste

The sub-question will be investigated within the context of the aforementioned problems outlined earlier. These problems have been addressed with potential solutions that were identified through a combination of observations, interviews, and the principles of lean management, as discussed in Chapter 3. Additionally, the time needed to prevent these problems using the proposed solutions has been calculated.

1. Possible solution for: “The packers are paying insufficient attention to the products during warmer weather when products that need refrigeration are outside of the fridge.”

One possible solution is found through observation and engaging in conversations with the packers to gather insides. employees during the observation.

<u>One potential solution:</u> Require modifying the existing Kanban system, using it as a visual management tool. Replacing traditional signboards, a whiteboard could be used instead. Strategically positioned within the workspace, this whiteboard should catch the attention of packers multiple times throughout the day. Displayed on the whiteboard are short and informative task descriptions. These tasks utilise just a few words to make clear the essence of each task. For instance, the task "crates in the refrigerator" means the need to return crates to their designated location within the refrigerator.

The estimated additional packing time per solution:

The process involves correctly placing items in warmer temperatures. To implement this, the tasks outlined on the whiteboard should be executed prior to the lunch break and at the end of the workday. On average, it takes approximately 9 minutes per packer to ensure the proper placement of items in warmer conditions, based on data obtained from the owner (Waal, 2023). This activity, performed before employees leave for the day, can be accomplished after handing over packages to the delivery company. Consequently, this solution incurs an estimated daily packing time increase of just 9 minutes, which translates to 540 seconds leading to an average additional packing time of approximately 5.4 seconds.

2. Possible solutions for: "The packers lack sufficient product knowledge."

The two solutions were found through conducting interviews.

The first possible solution: The owner of the company gives evening courses focused on pond plants. Normally these courses attract customers and individuals working in the relevant field seeking more knowledge of pond products. However, such courses can also be highly beneficial for the packers. Having more knowledge about the products throughout the year would help packers in product recognition.

The second possible solution: An alternative solution could involve the implementation of nametags on each type of product.

The estimated additional packing time per solution:

The estimated additional packing time for the first solution:

The packers' participation in the owner's courses would occur during the off-season. The direct course costs for the owner are negligible, but the hours invested by the packers in attending the courses would need to be compensated. During less busy times, the owner might allow packers to stay home in the morning, compensating for the hours spent on the courses. Consequently, the overall impact on packing time is projected to be zero.

The estimated additional packing time for the second solution:

The estimated additional packing time is determined by the time required to attach a nametag to each product. On average, this process takes approximately 1 minute per product (Waal, Data recieved by Jiry de Waal, 2023). Every month, around 20 new products arrive without nametags and lack designated space at the original water basin. This monthly 20 new products, resulting in an annual $2 * 12 = 0$ new products. Considering there are 365 days in a year and deducting 52 weekends (2 days each), there are approximately 261 working days in a year. To calculate the average number of new labels require working dy: $\frac{240 \text{ new products}}{261 \text{ } working \text{ } days} \approx 0.919$ new labels per day.

This results in approximately 55.14 seconds of additional packng timeer workig day. That is $\frac{55.14}{100} \approx 0.6\text{econds}$ additional packing time on average per package for the task of placing nametags to new products.

3. Possible solutions for: "The packers do not remember the optimal quantities that can be picked in one go for each order, leading to unnecessary walking."

The possible solutions were identified through taking interviews, with the first three solutions arising from the interviews themselves. And the last two solutions arise during the interview.

The first possible solution: Lowering the volume of the radio, implementing this solution involves simply adjusting the radio's volume to a level that maintains a pleasant atmosphere without causing distraction. No additional time or resources are required for this solution.

The second possible solution: Providing noise-cancelling headphones for packers, to minimize distractions caused by background conversations and noise, noise-cancelling headphones can be procured. This solution necessitates purchasing four Sony WH-1000XM4 headphones online, which would take approximately 5 minutes to complete the online order.

The third possible solution: Installing a quieter cooling motor for the refrigerator, replacing the existing noisy cooling motor with a quieter alternative would necessitate the owner's involvement and expertise, requiring around 2 hours for installation.

The fourth possible solution: Introducing a holder for plastic folder invoices, installing a holder with a plastic folder for an invoice on the cart improves the packing process. This action would entail attaching invoices to the cart with a 3-second click action, and the same amount of time would be needed to detach them.

The fifth possible solution:

The packers write down the names of the products that need to be packed onto labels. Subsequently, these labels are placed inside the corresponding products. This is used for the customers that they can identify each product. Instead of leaving these labels on the packing table, the packers can carry the labels with them. The labels serve as a reminder, enabling the packers to recall which products they need to collect.

The estimated additional packing time per solution:

The estimated additional packing time for the first solution:

Lowering the radio volume: No time investment.

The estimated additional packing time for the second solution:

Noise-cancelling headphones: Approximately 5 minutes to order online. This won't result in any additional time for the packers; thus the additional packing time will be 0.

The estimated additional packing time for the third solution:

Quieter cooling motor for the refrigerator takes around 2 hours to installation (Waal, Data recieved by Jiry de Waal, 2023). This won't result in any additional time for the packers; thus the additional packing time will be 0.

The estimated additional packing time for the fourth solution:

It takes 3 seconds to attach and detach invoices. This meas $6 \text{econds} * 100 \text{ packages} = 600 \text{ seconds}$. That is 10 minutes additional per packing day. Leads to 6 seconds of additional packing time per package.

The estimated additional packing time for the fifth solution:

The packers taking the labels to remember the products takes no additional time required.

4. Possible solutions for: "There is no packing script for new packers":

The possible solution: let a trainee write a packing script.

The estimated additional packing time for the solution:

The estimation is that a trainee needs 10 hours from the packers in tot for asking questions for understanding how the process works. Thus, the expected average packing time per package is $\frac{10*60*60 \text{ seconds}}{61 \text{ work days}} \approx 13.79$ seconds.

5. Potential solutions for: **"**Absence of appropriate large boxes for packing large orders."

The first possible solution: The company receives recycled boxes one time a week from REVA lastechniek BV located in Joure (Friesland) without any cost. An employee from REVA delivers these boxes to the owner's home.

The second possible solution: The company has the option to purchase new boxes, including larger boxes from JIP B.V. When dealing with a substantial order, it's more efficient for packers to place the items in smaller boxes and then put them within an over box from REVA lastechniek BV.

The estimated additional packing time per solution:

The estimated additional packing time for the first solution:

Loading all the boxes into the company van takes approximately 5 minutes. Subsequently, these boxes are transferred to the box storage area, which has an average time requirement of about 9 minutes. In total, the process takes approximately 14 minutes to complete. This won't result in any additional time for the packers, thus the additional packing time will be 0.

The estimated additional packing time for the second solution:

The act of ordering these new boxes takes the owner approximately 7 minutes. This won't result in any additional time for the packers, thus the additional packing time will be 0.

To illustrate, the different types of boxes see Figure 14. In Figure 2, 2 over boxes, 3 recycled boxes, and the remaining boxes being purchased from JIP B.V. are presented.

Figure 14: The different types of boxes.

6. Possible solution for: “The water basins outside are close to the packing tables but they are not close in walking distance because the wall of the building is between them.”

<u>The possible solution:</u> In order to increase the process efficiency, the emergency exit could be used. This results in that the packers being closer to the outdoor basins.

Figure 15 shows the new setup of the workspace if the emergency exit is opened. Products with the highest sales volume should be kept as close to the packaging tables as possible (taking the circumstances of the products into account), while those with lower sales are located at a greater distance. Therefore Cubitainer 11 and rubber trays 1 and 2 have replaced GGBs 18,19,20 and 21. The GGBs 18,19,20 and 21 are placed on another place in the 10% region because those GGBs are also needed for around 10%. But the Cubitainer 11 and the Rubbertrays 1 and 2 are used for 70% of the orders, this is shown in the heatmap in Figure 7 Therefore those water basins are switched. The new place of the GGBs 18 and 19 are next to the shed and GGBs 20 and 21 are next to GGB 12 and 13.

<u>The estimated additional packing time for the solution:</u>

Opening the emergency exit in the morning takes 4 seconds, which amounts to 0.04 seconds per package. Walking around the building to access the water basins positioned next to the packing tables consumes more time compared to taking a direct route through the emergency exit. Therefore, there this saves time, and it does not add any additional packing time. The process of relocating the water basins involves a significant time commitment of 2 hours per basin (Waal, Data recieved by Jiry de Waal, 2023). This is due to the need to empty and clean the basins, a task that takes time given the weight of the water they hold. The plan entails moving 3 water basins outside next to the emergency exit and relocating 4 from the emergency exit to another area. Consequently, this operation totals approximately 7 basins, resulting in an overall time investmnt of 7 $*$ 2 hourshours. Since the owner and another assisting employee will manage the basin relocation, this time won't contribute to the average packing time.

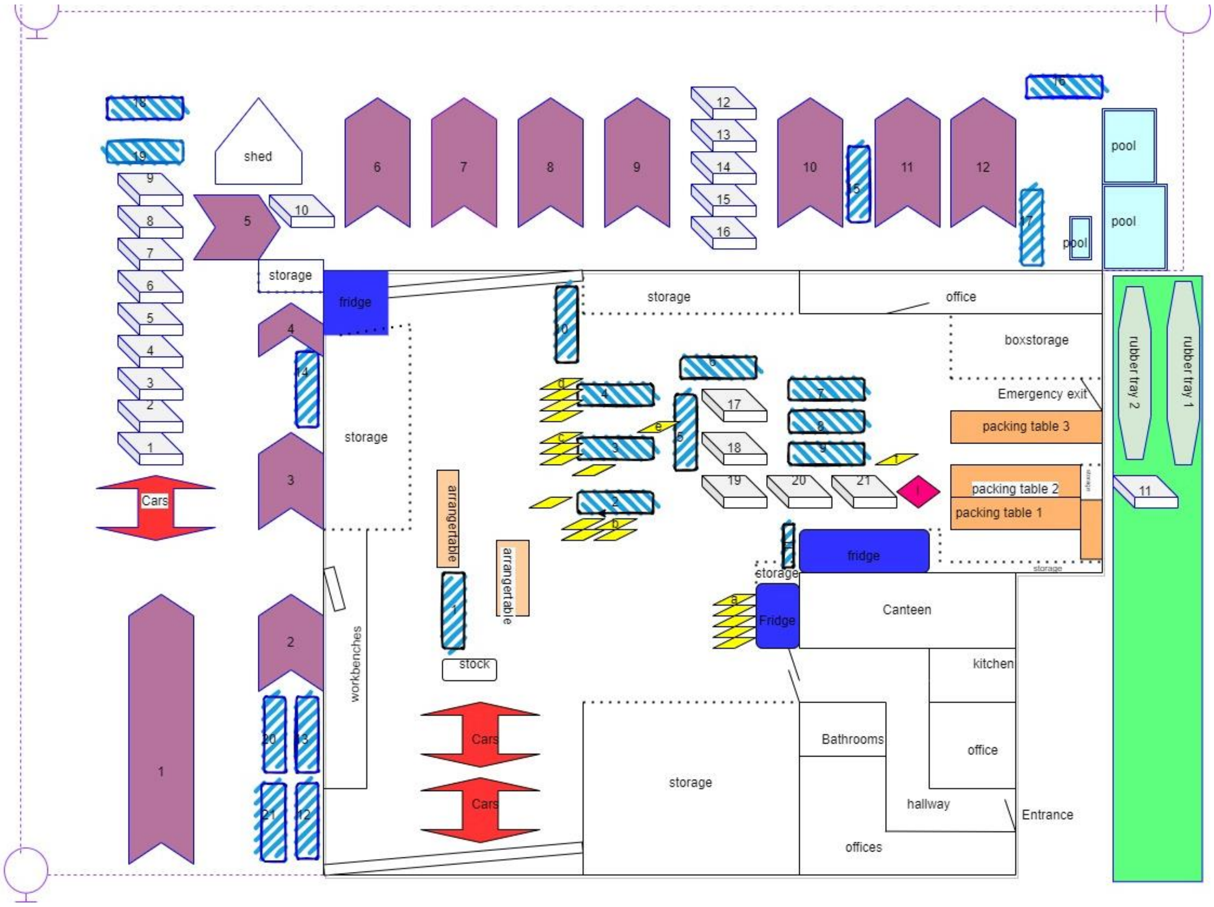


Figure 15: The new workspace setup

7. Possible solutions for: “Picking trolley dimensions do not fit within the company's set-up.“:

The trolley, seen in Figure 16 used by the packers does not fit through every pathway.

Figure 16: Picking trolley

It is inconvenient because the picking trolley does not fit in the most used aisles, refer to figure 17 for an example. Not using a trolly results in the packers having to walk back and forth to the trolly, which is then placed in the nearest possible location.

The possible first solution: could be is to widen the pathway. The width of the pathway should be the width of the trolly plus some additional space to prevent any potential damage to the water basins caused by the picking trolleys.

The possible second solution: could be buying smaller carts. The cart which fits through each pathway.

Figure 17: Pathways

The estimated additional packing *time per solution:*

The estimated additional packing time for the first solution:

To widen the pathways will take approximately 2 workdays. Since water basins must be emptied before relocation and each basin takes about 2 hours. Packers won't participate in relocation; instead, the owner and another employee will manage it. This results in no additional packing time per order.

The estimated additional packing time for the second solution:

Purchase a smaller order picking trolley online. This will take around 15 minutes. The owner's task involves finding and ordering the suitable trolley online. The packers aren't involved in this process. Consequently, no additional packing time is added.

In both scenarios, there is no impact on the packing time as the tasks are carried out by non-packers.

8. Possible solution for: “Insufficient communication regarding orders for the following day.”: The possible solution to this problem is derived from interviews and observations.

The possible solution: To decrease this problem, a whiteboard, comparable to the one discussed in problem 1 could be utilized also an adjustment of the Kanban system. A short task, such as "Prepare the boxes for the snails," should be included on the whiteboard by the packers, so the next morning preparations for the next day could be conducted to streamline the order picking process the next day. Additionally, the owner should have a separate whiteboard in his office, for regular tasks that must be completed by the end of the workday. This whiteboard should be positioned in a location where the owner frequently sees it throughout the day.

The estimated additional packing time for the solution:

Writing down the tasks will take about 30 seconds. These tasks will remain on the board as they require daily execution. The responsibility of recording these tasks falls on the owner. Therefore it won't result in any additional time for the packers, thus the additional packing time will be 0.

9. Possible solution for:” Packers require a change of footwear to collect certain products, necessitating waders for plants in deeper water.”:
The solutions for the ninth problem are received by conducting the interviews.

The possible first solution: to decrease this inconvenience is to install Ecorasters along the pathways where a change in footwear is currently required. Ecorasters can be best compared to a footbridge. They offer a dry and secure walking surface for packers, eliminating the necessity of switching to waders. This solution is important due to the potential adverse effects of consistently having wet feet, which can lead to health concerns such as rashes.

The possible second solution: purchasing watertight water basins for plants requiring deeper water in the Biovijver at Otterlo (Gelderland). This adjustment ensures that water remains contained within the basins, preventing water accumulation on the ground. To further reduce water presence, the water sprinkler system is deactivated during work hours. In instances of rainfall, efficient drainage is facilitated through designated flumes.

The estimated additional packing time per solution:

The estimated additional packing time for the first solution:

This task is solely the responsibility of the owner, involving the arrangement and engagement of a suitable company to carry out the installation. As a result, packers do not incur any additional time for this solution.

The estimated additional packing time for the second solution:

Using the assistance of other employees for the relocation of watertight water basins implies that packers will not need to allocate additional time for this process. The collaboration among staff members eliminates the need for packers to contribute additional packing time.

10. Possible solutions for: "Inconsistent cleaning of packing tables by employees on a daily basis."

The possible first solution: Is derived through literature study, and it involves implementing the 5S methodology as described in Section 3.5. This methodology ensures a clean and organized workplace, and it will be applied to the packing employees' packing tables. The 5S system will be executed at the end of the working day to maintain a clean and tidy workspace. Maintaining a clean and tidy workplace is crucial as it enables packers to work in a more organized matter, resulting in increased productivity. When everything is in its proper place, packers can work faster without having to search for the required item.

The possible second solution: Could be the implementation of a rotation system where one person is responsible for cleaning everything. This task would be rotated among the packing employees.

The estimated additional packing time for both solutions:

If the implementation of both solutions is scheduled to occur at the end of the working day after packages have been handed over to the delivery company, there will be no impact on the average packing time for the packers. This approach ensures that the necessary tasks are carried out without affecting the regular packing process.

5.2. Conclusion

This chapter has answered the sub-question: “How can waste in the customer order fulfillment process be decreased?”

In answering the sub-question on reducing waste in the customer order fulfillment process, a comprehensive exploration of possible solutions has been undertaken. These solutions have emerged from a combination of observations, interviews, and the principles of lean management, as discussed in Chapter 3.

The first problem: “The packers are paying insufficient attention to the products during warmer weather when products that need refrigeration are outside of the fridge.”

One possible solution involves modifying the existing Kanban system by using a whiteboard to display concise task descriptions. This serves as a visual management tool to increase packers' awareness of important tasks. The estimated additional packing time: Approximately 5.40 seconds per package.

The second problem: “The packers lack sufficient product knowledge.”
Two possible solutions were identified: the owner offering evening courses to increase employees' knowledge of pond products and implementing nametags on products.

The estimated additional packing time: The first solutions additional packing time is 0.00 seconds, and the second solution's additional packing time is 0.60 seconds. Both solutions have no impact on packing time.

The third problem “The packers do not remember the optimal quantities that can be picked in one go for each order, leading to unnecessary walking.”

Five possible solutions have been proposed, including turning down the volume of the radio which resulted in 0 seconds of expected additional packing time. Purchasing noise-cancelling headphones which leaded to an expected additional packing time of 0 seconds. Purchase a quieter cooling motor which also leads to 0 seconds expected additional packing time. Use card holders which will take 6 seconds of expected additional packing time. And the last proposed solution is to bring the labelling during the collection of products, this has an expected additional packing time of 0 seconds.

The fourth problem: “There is no packing script for new packers.”

A possible solution involves a trainee creating a packing script. The expected additional packing time is approximately 13.80 seconds per package.

The fifth problem: “Absence of appropriate large boxes for packing large orders.”

The two solutions include receiving recycled boxes from a supplier and purchasing new boxes as needed. The estimated additional packing time: Both solutions have 0.00 seconds impact on additional packing time.

The sixth problem: “The water basins outside are close to the packing tables but they are not close in walking distance because the wall of the building is between them.”

The solution involves using the emergency exit to have the water basins closer to packing tables. The estimated additional packing time is 0.04 seconds per order.

The seventh problem: “Picking trolley dimensions do not fit within the company's set-up.”
The two solutions include widening pathways and purchasing smaller carts. The estimated additional packing time: Both solutions have 0.00 seconds impact on packing time.

The eight problem: “Insufficient communication regarding orders for the following day.”
The possible solution involves using whiteboards to list tasks and responsibilities. The expected additional packing time is 0.00 seconds.

The ninth problem:” Packers require a change of footwear to collect certain products, necessitating waders for plants in deeper water.”
The two solutions involve installing Ecorasters or purchasing watertight basins. The estimated additional packing time: Both solutions have 0.00 seconds of additional packing time.

The tenth problem:” Inconsistent cleaning of packing tables by employees on a daily basis.”
The two solutions include implementing the 5S methodology and a rotation system for table cleaning. The estimated additional packing time is 0.00 seconds per order.

6. Recommendation and Conclusion

This chapter presents the recommendations and the conclusion for the reduction of the average packing time. In Section 6.1, the recommendation is formulated based on the insights from previous chapters. Additionally, Section 6.2 delivers the conclusion, assessing whether the research goal has been successfully reached or not.

For convenience the list of the problems is provided below, the same as table 5.

1. The packers are paying insufficient attention to the products during warmer weather when products that need refrigeration are outside of the fridge.
2. The packers lack sufficient product knowledge.
3. The packers do not remember the optimal quantities that can be picked in one go for each order, leading to unnecessary walking.
4. There is no packing script for new packers.
5. Absence of appropriate large boxes for packing large orders.
6. The water basins outside are close to the packing tables but they are not close in walking distance because the wall of the building is between them.
7. Picking trolley dimensions do not fit within the company's set-up.
8. Insufficient communication regarding orders for the following day.
9. Packers require a change of footwear to collect certain products, necessitating waders for plants in deeper water.
10. Inconsistent cleaning of packing tables by employees on a daily basis.

6.1 Recommendation

The recommendation for the first problem is against applying the solution with a whiteboard for warmer weather. The time required to prevent the problem is 5.40 seconds, while the time saved is only 4.20 seconds. Therefore, it is advisable not to proceed with this solution. Which leads to an increase of 1.20 seconds in the expected average packing time.

Regarding the second problem, the recommendation is to opt for the first solution involving courses. The estimated time requirement for this solution is 0.00 seconds, and it leads to a decrease of 4.20 seconds. Which leads to a decrease of 4.20 seconds in the average packing time. Thus, using the first solution is recommended. The second solution using labels takes 0.919 seconds for use. Which leads to a decrease of approximately 3.28 seconds in the average packing time. This makes the choice clear in favour of the first solution.

For the third problem, the first solution turning down the volume of the radio is not expected to yield significant changes. Hence it is not recommended for applying. The second solution with the noise cancelling headphones are easy to adopt but they could disrupt the comfortable working atmosphere, which is important for employee satisfaction. Therefore, it is not advisable to proceed with this solution either. However, the third solution holds importance due to its potential to prevent breakdowns caused by a cooling motor failure. This will save additional packaging time, considering the need to relocate products to another fridge, likely requiring more walking distance. Despite its high cost, it is recommended to replace the freezer at the earliest opportunity. This leads to a decrease of 6.64 seconds in the expected average packing time, because the time it takes to install is 0.00 seconds for the expected average additional packing time. While the fourth solution with the cardholder for the picking trolley requires an average of 6.00 seconds per package for use, it is expected that it will decrease by 5.64 seconds from the expected average packing time. Which leads to an increase of 1.00 seconds in the average packing time. Therefore, do not use this solution. The fifth solution, taking the labels during the collection of products. It is simple to apply since the company already has the labels. Given its approximate 0.00 second time and expected to reduce 5.64 seconds of the average packing time. Which leads to a decrease of 5.64 seconds in the expected average packing time. Therefore, it is strongly recommended to apply the third and the last solution.

The fourth problem has a single solution give the packers a packing script, and it is recommended to apply it due it takes 3.45 seconds in the average estimated packing time. While the average packing time is 13.79 seconds in the first year, projecting it over a longer term, say 10 years, results in an average of 1.37 seconds. Which leads to a decrease of 2.08 seconds in the expected average packing time. Considering that the techniques are unlikely to change significantly in the first decade, this solution justifies the time investment.

In the fifth problem, both solutions are recommended for applying, use of recycled boxes and buy larger boxes. Since both have no estimated additional packing time, 0.00 seconds and contribute to the convenience of having appropriately sized boxes, they collectively lead to an expected reduction of 2.45 seconds in the average packing time.

The sixth problem has a singular solution, open the emergency exit, and it is advisable to use it. This problem uses 6.70 seconds of the average packing time per package. Opening the emergency exit only consumes 0.04 seconds of the expected package time. This leads to a decrease of 6.66 seconds in the average packing process. Therefore, apply this solution.

In the seventh problem, both solutions are worth implementing, widen the pathways and purchasing smaller picking trolleys. They both do not increase the average packing time. They have the potential to collectively decrease the expected average packing time by 16.00 seconds.

The eighth problem presents a single solution, place a whiteboard for preparations, which should be applied. This solution is not expected to increase the average packing time, because the time it takes from the packers is 0.00 seconds, rather it is likely to lead to a reduction of 10.00 seconds in the packing time.

For the ninth problem both solutions can be considered, place eco-rasters and purchase watertight water basins. As both require no additional time from the packers and are projected to potentially reduce the packing time by 6.00 seconds, they both hold. However, due to the money investment, only one solution should be chosen because the watertight water basins will hold longer than the eco-rasters.

In the tenth problem both solutions, using the 5S system and the rotation cleaning system, require no additional time from the packers and are expected to reduce the average packing time by around 1.20 seconds per package. While both solutions are viable, it is recommended to choose for the first solution. The second solution, which involves one employee cleaning another's workspace, could potentially lead to employee dissatisfaction and is not advisable.

In conclusion, the expected reduction in average packing time for a complex order is projected to be 54.23 seconds. This thesis concludes that the research objective has not been fully attained.

The initial aim was to enhance De Vijvermeester's customer order fulfillment process to achieve a packing accuracy of 95% on Mondays, compared to the previous 90%. This would correspond to an average reduction of 86 seconds per complex order. However, this research fell short by 31.77 seconds in achieving this goal.

The resulting average packing time is determined to be 12 minutes and 32.839212 seconds, computed using the subsequent formula: please refer to Table 1 for the frequency of easy and complex packages. The calculation follows as: $((17.3 - 0.5423) * 62.6\%) + (5.5 * 374\%) = 1$ minutes and 32.839212 seconds, approximately 12 minutes and 33 seconds. As a result of this 54.23 second reduction, an impressive 91.5% fulfillment rate is achieved.

The computation is as follows: considering that here are $2 * 60$ minute available for packing packages within a working day, and the newly established average packing time is 12.5473202 minutes, this would theoretically amount to around 119.5 packages. However, as the number of packages must be whole, the figure rounds down to 119 packages. Consequently, the discrepancy between the targeted 130 packages and the actual 119 packages equates to a deficit of 8.46%. This translates into accomplishing a 91.5% fulfillment rate.

6.2 Conclusion

In conclusion, the expected reduction in average packing time for complex orders is forecasted to be 54.23 seconds. This thesis underscores that while substantial progress has been made, the research objective has not been entirely met. The initial goal was to enhance De Vijvermeester's customer order fulfillment process to attain a packing accuracy of 95% on Mondays, surpassing the previous of 90%. This would have translated to an average time reduction of 86 seconds per complex order. However, this study fell short by 31.77 seconds in achieving this ambitious target.

The derived average packing time is calculated to be approximately 12 minutes and 33 seconds, This decrease of 54.23 seconds results in an admirable fulfillment rate of 91.5%.

Considering the newly established average packing time, approximately 119.5 packages should be completed on Mondays. However, given that the package count must be whole, the figure is rounded down to 119 packages. Consequently, the disparity between the targeted 130 packages and the actual 119 packages amounts to a shortage of 8.46%. This results in achieving a fulfillment rate of 91.5%.

7.The implementation plan

In this chapter the sub-question ‘How can the solutions brought forward by this research be implemented?’ will be answered. In Section 7.1 a step-by-step guideline is provided to implement the possible solutions in the customer order fulfillment process. Section 7.2 presents the implementation schedule for the solution. Section 7.3 addresses the conclusion.

7.1 implementation schedule

To gain the support of the packers for applying the proposed solutions, it is needed to show to them how these solutions can lead to a reduction in average packing time. This can be achieved by introducing a structured schedule, as outlined in Table 7. The schedule is divided into three distinct solution clusters, each with varying levels of complexity adapted to the packers' convenience.

The schedule elaborates on the estimated time required for implementing each solution-cluster, a framework that has already received the owner's approval. Importantly, the order of execution for these solutions is flexible, thereby allowing the company to begin with those solutions that don't necessitate direct involvement from the packers themselves. This involves starting with the solution for the second solution of the seventh problem, followed by the solution for the ninth problem, and then with the first solution for the fifth problem. The schedule has been strategically devised so that the average reduction in time displays a descending trend. By adopting this approach, we aim to ensure that the packers promptly observe the noticeable time-saving benefits. Gradually building their confidence and enthusiasm.

Once the packers are on board with the initial solutions, the subsequent phase initiates with the implementation of the tenth problem's solution. This solution, being a once-a-day requirement, takes priority. Subsequently, attention shifts to the solution for problem six, which is implemented into this week's cluster due to the necessity of familiarising the packers with the new route. Then the schedule incorporates the first solution for the seventh problem, a task requiring considerable time but conveniently slotted for weekends that need to be scheduled to give the implementers time.

The schedule proceeds with the implementation of the fifth solution for the third problem. This solution involves an adjustment in their routine where packers take written labels with product names during the process of collecting products for an order. Then the implementation of the solution for the eighth problem. These adjustments entail minor modifications to the packers' regular routine.

The third problem's solution-cluster follows, addressing a requirement of longer duration that requires moderate implementation into the existing system. As the plan unfolds, the focus moderately shifts to the more complicated challenges that occur multiple times during the packers' workday. First, the implementation of the third solution of the third problem is introduced. Due to the high costs of purchasing a cooling engine motor, the company had the opportunity to allocate resources towards saving funds.

Then the solution for the second problem is introduced. It is essential for packers to undergo training spanning five course days to acquire fundamental knowledge.

Acknowledging the value of incorporating a trainee, the schedule proceeds to implement the solution for the fourth problem. The process of hiring and integrating a trainee into the workforce is introduced. After that the implementation of the second solution for the fifth problem. This phase focuses on familiarizing packers with the trainee's script, particularly emphasizing the box-related chapter. This process is strategically initiated during the off-season, ensuring a seamless transition and optimal integration.

This comprehensive approach to the implementation schedule strives to optimize packing efficiency while carefully addressing each challenge with strategic timing and consideration.

Table 7: Implementation schedule

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
solution-cluster 1										
solution-cluster 2										
solution-cluster 3										

7.1 Implementation plan of the proposed solutions.

The table below gives an overview of the problems, solutions and possible implementation and in which solution cluster the solution is.

Table 8: Overview of the final problems, solutions in short and implementation

Problem	**solutions**	**Implement? Yes or no if the answer is yes then in which solution-cluster?**
1. The packers are paying insufficient attention to the products during warmer weather when products that need refrigeration are outside of the fridge.	Implement a whiteboard for the packer.	No
2. The packers lack sufficient product knowledge.	Let the packers attain the pond course.	Yes, solution-cluster 3
	Implement labels on each type of product.	No
3. The packers do not remember the optimal quantities that can be picked in one go for each order, leading to unnecessary walking.	Lowering the volume of the radio.	No
	Purchase noise-cancelling headphones for the packers.	No
	Installing a quieter cooling motor for the fridge.	Yes, solution-cluster 3
	Put a holder on the trolley with a plastic folder for the invoices.	No
	Take the written labels with the product names during collecting the products for the order.	Yes, solution-cluster 2
4. There is no packing script for new packers.	Give the new employees a packing script.	Yes, in solution-cluster 3
5. Absence of appropriate large boxes for packing large orders.	Purchase larger boxes.	Yes, solution-cluster 1
	Arrange recycled boxes from REVA	Yes, solution-cluster 3
6. The water basins outside are close to the packing tables but they are not close in walking distance because the wall of the building is between them.	Open the emergency exit for a smaller walking distance.	Yes, solution-cluster 2
7. Picking trolley dimensions do not fit within the company's set-up.	Widen the pathways so that the trolleys can fit through the pathways	Yes, solution-cluster 3
	Purchase smaller trolleys which will fit through the pathways.	Yes, solution-cluster 1

8. Insufficient communication regarding orders for the following day.	Place a whiteboard for preparations the next day.	Yes, solution-cluster 3
9. Packers require a change of footwear to collect certain products, necessitating waders for plants in deeper water.	purchase Ecorasters.	No
	Purchase watertight water basins	Yes, solution-cluster 3
10. Inconsistent cleaning of packing tables by employees on a daily basis.	Apply the 5S methodology	Yes, solution-cluster 2
	Rotation system where each packer is responsible for cleaning the workspace once in a while.	No

The implementation of the possible solution for the first problem:

Do not implement this solution.

The implementation for the second possible solution of the seventh problem:

The second solution is to purchase smaller trolleys which will fit through the pathways:

Steps	Action
1	Purchase smaller carts that can fit through all pathways.

The implementation for the recommended solution of the ninth problem:

The recommended solution is to purchase watertight water basins.

Steps	Action
1	Purchase watertight water basins from Biobijver in Otterlo, priced at 5 euros per basin. The company requires a total of 645 basins. Given the designated placement area measuring 20.5 by 10 meters, these basins are destined for the rectangular region highlighted in Figure 18. Each basin measures 40 by 60 centimetres. Calculating the potential basin count, an area of 205 cm^2 per basin divided by 0.24 cm^2 gives 854 basins. However, accounting for walkways, each 0.5-meter wide pathway consumes 50 cm^2. Hence, (205 - 50) / 0.24 results in 645 basins.
2	Prior to implementation, ensure the drainage of water from the existing water basins. Subsequently, proceed to relocate the plants into the newly watertight basins.
3	Transfer the plants to the watertight basins.
4	Connect the flume to the sewer system for efficient water management.
5	The first employee outside deactivates the water sprinkler, while the employee responsible for closing the factory hall initiates the sprinkler system.

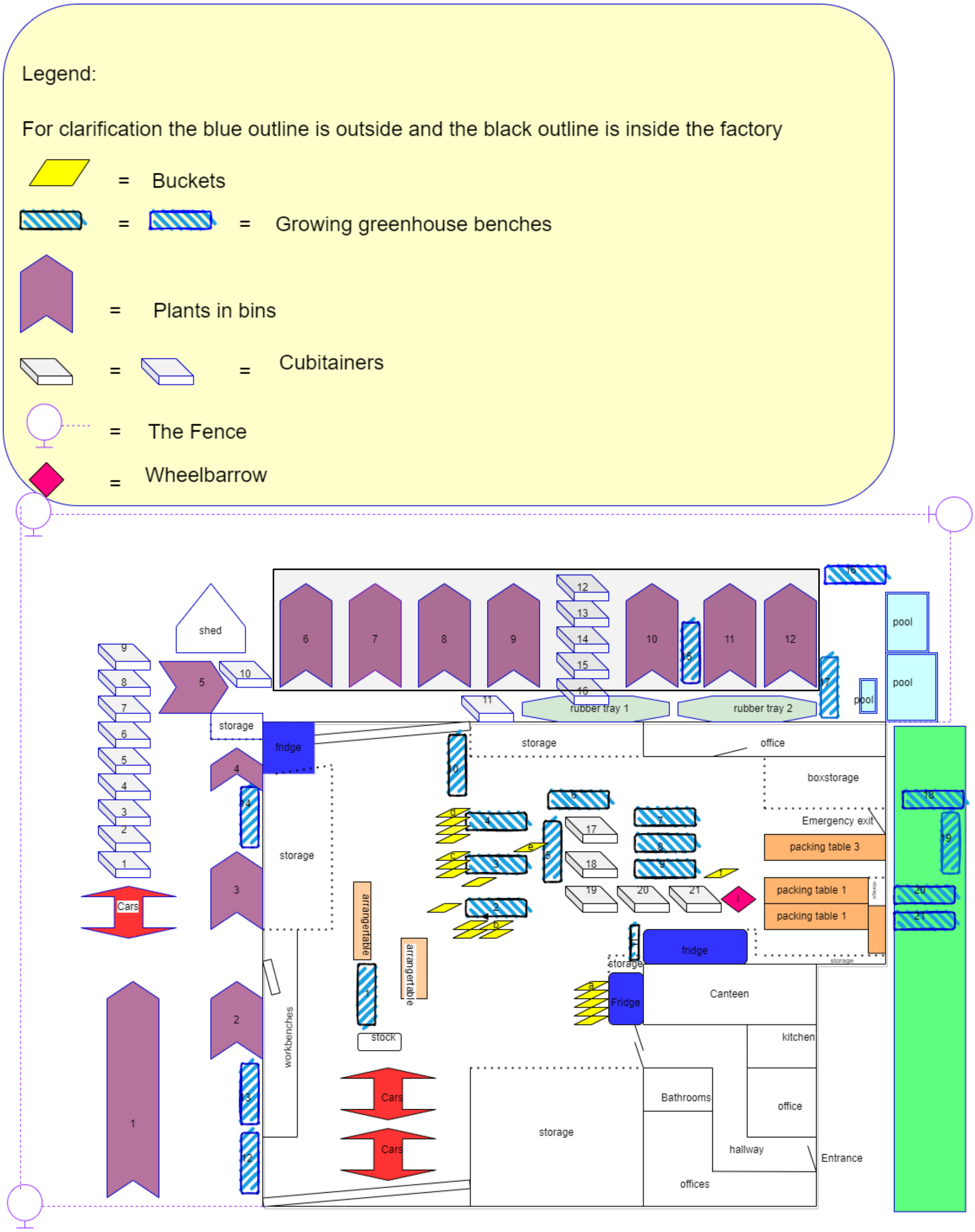


Figure 18: The location of the watertight basins

The implementation of the recommended first solution to the fifth problem

The first solution which is suitable for processing into the script, is about the method of selecting the appropriate box for each order:

Steps	Action
1	Order online larger boxes from JIP B.V.
2	Upon the delivery of the order, arrange the boxes in the designated sequence as outlined within the script if the box chapter is already available.

The implementation of the possible solutions to the tenth problem:

The first solution is applying the 5S methodology.

Steps	Action
1	the owner explains to the packers the 5S methodology.
2	Implement the 5S methodology to ensure clean and organized packing tables. The steps are: a. Sort: Retain only the necessary equipment, such as cellar tape for the boxes. Straighten: Organize the packing table and consumer table according to the packer's preference. b. Shine: Clean all items, including Kanban tickets that need to be cleaned when placed on the Kanban whiteboard. c. Standardize: Ensure that the previous three steps have been properly executed. d. Sustain: Maintain the 5S system by consistently adhering to its principles.
3	The 5S system should be repeated throughout the day. To remind the packers the owner will announce that the 5S task needs to be finished before taking a break or going home.

The implementation of the possible solution of the tenth problem:

The first solution is applying the 5S methodology.

Steps	Action
1	the owner explains to the packers the 5S methodology.
2	Implement the 5S methodology to ensure clean and organized packing tables. The steps are: a. Sort: Retain only the necessary equipment, such as cellar tape for the boxes. Straighten: Organize the packing table and consumer table according to the packer's preference. b. Shine: Clean all items, including Kanban tickets that need to be cleaned when placed on the Kanban whiteboard. c. Standardize: Ensure that the previous three steps have been properly executed. d. Sustain: Maintain the 5S system by consistently adhering to its principles.
3	The 5S system should be repeated throughout the day. To remind the packers the owner will announce that the 5S task needs to be finished before taking a break or going home.

The implementation for the possible solution of the sixth problem:

The implementation for the solution is to open the emergency exit for a more efficient setup:

Steps	Action
1	The first packer who enters the factory hall should open the emergency door.
2	The packer who completes the final order of the day should ensure the closure of the emergency door once the order is ready for delivery.

The implementation for the recommended first possible solution to the seventh problem:

The first solution involves widening the pathways so that the trolleys can fit through the pathways.

Steps	Action
1	Widen the pathways to suit the trolley dimensions. Determine the width of the picking trolley, which is 45 centimetres, and add 10 centimetres to prevent any harm to the water basins during transit.
2	As part of the third solution cluster, implement this modification over a weekend with the assistance of an employee.
3	Allow water drainage from one basin at a time, taking a span of 2 hours for each. The absence of a direct connection to a water source results in this time for cleaning and relocation.

The implementation of the recommended fifth solution of the third problem.

The fifth solution: packers take the written labels with the product names with them as they collect products for the order.

Steps:	Action
1	The packers write the names of the products on the labels which need to be collected for the order.
2	During the product collection for orders, packers bring the labels.
3	Upon collection, packers attach the name tags to the products.

The implementation for the possible solution of the eight problems:

The solution is to provide the packers with another whiteboard for tasks.

Steps	Action
1	Utilize a whiteboard, similar to the one used in used in problem 1.
2	Position the whiteboard, situated as the rectangle depicted in Figure 19 within the owner's office. The black stripe in the rectangle is the whiteboard. This serves as a platform for listing routine tasks that need completion by the day's end.
3	The owner/packers write short messages such as "Prepare the boxes for the snails".
4	By day's end, the owner sets a reminder alarm on their phone to announce to the packers that the tasks listed on the whiteboard should be accomplished.

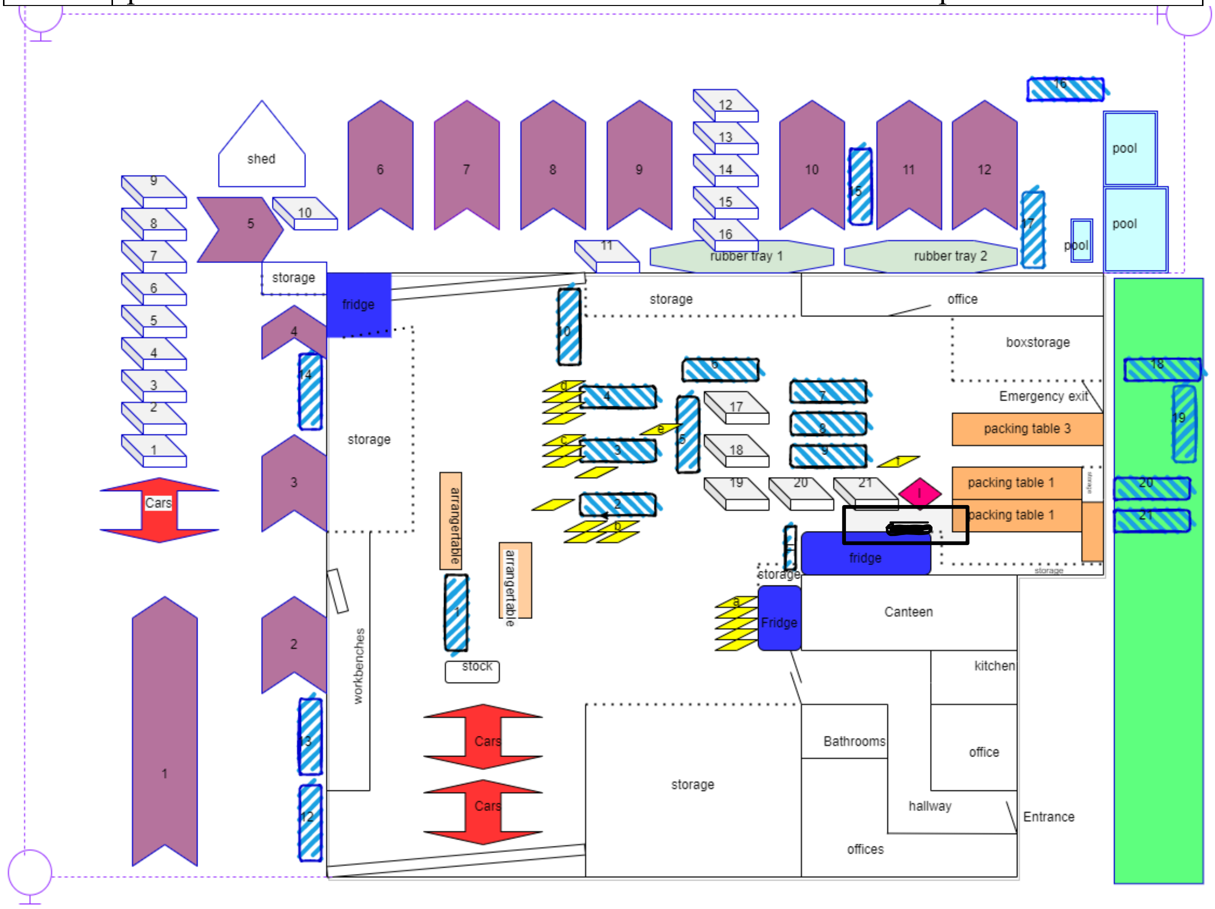


Figure 19: Placement of the preparation whiteboard.

The implementation of the third recommended solution of the third problem.

The third solution: Installing a quieter cooling motor for the fridge.

Steps	Action
1	The owner searches online to find a quieter cooling motor suitable for the refrigerator.

2	Once the cooling motor arrives at the factory hall
3	The owner, assisted by a non-packer employee, proceeds to install the motor within the refrigerator.

The implementation of the recommended solution for the second problem:

The first solution involves the participation of the packers in the pond course.

Steps:	Action
1	The owner of the company gives evening courses focused on pond plants, which are open for participation by the packers as well. These courses are held twice a year and span across five sessions each.
2	To facilitate packers' participation in the training course, an opportunity for additional compensation is provided. This additional compensation is important for letting the packers know that the company wants to invest in their employees.

The implementation for the recommended solution to the fourth problem:

The solution is to give the new employees a packing script.

Steps	Actions
1	A trainee writes the script, De Vijvermeester is already an internship company. This script should include the packing procedures (e.g., packing boxes) and offer insights such as guidelines for estimating the required surface area when placing products within a box. This will help the packers in selecting the appropriate box size.
2	The developed script undergoes validation by the company's owner and the packers to ensure accuracy and alignment with the packing process.
3	The finalized script is also handed out to new packers for educational purposes, facilitating their understanding of efficient packing practices.

The implementation for the second recommended solution of the fifth problem:

The implementation for the first solution, purchasing larger boxes is:

Steps	Action
1	The owner is responsible for collecting the recycled boxes obtained from REVA lastechniek BV, situated in Joure, Friesland, to bring them into the company van.
2	On the next day, the owner proceeds to transfer the acquired recycled boxes to the designated box storage area, as indicated in Figure 20 This storage location is identified within the dark green rectangle.
3.	If the script will be implemented, it would be helpful to include a section in the script that provides help with selecting the right box size for each order.

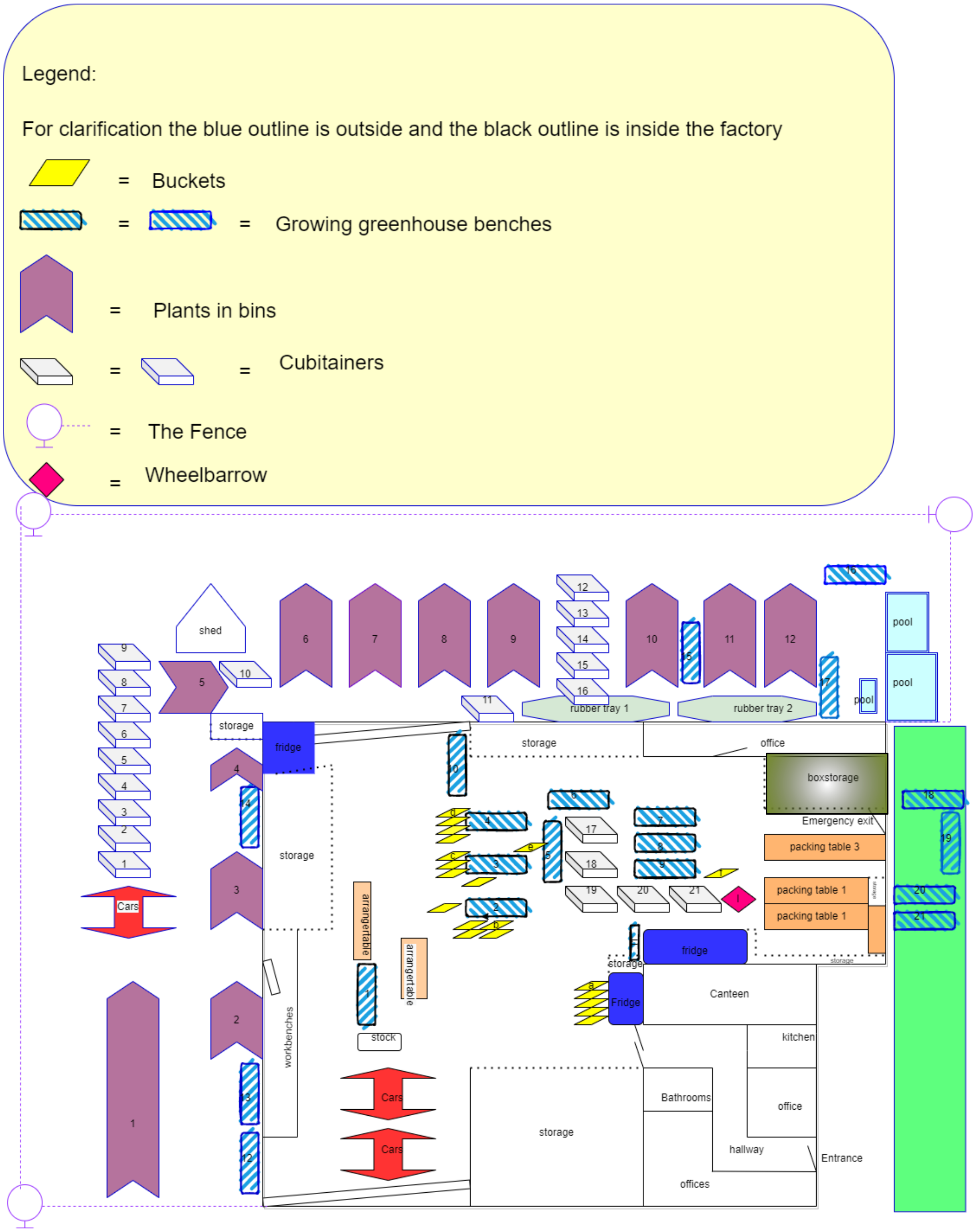


Figure 20: The box storage is located within the dark green rectangle.

7.3 Conclusion

In this chapter, the focus has been on addressing the sub-question: "How can the solutions brought forward by this research be implemented?" The implementation plan outlined in Section 7.1 provides a step-by-step guideline for integrating the proposed solutions into the customer order fulfillment process. This plan has been carefully developed to ensure that the packers are engaged and supportive of the solutions, with an emphasis on demonstrating how these solutions lead to a reduction in average packing time.

The implementation schedule presented in Table 7 is structured into three distinct solution clusters, each tailored to the packers' convenience and adapted based on complexity. The schedule not only outlines the estimated time required for implementing each solution-cluster but also strategically sequences the solutions for optimal impact. The order of execution has been designed to build packers' confidence and enthusiasm by showcasing noticeable time-saving benefits from the outset.

The initial phase of implementation involves solutions that do not require direct packer involvement, allowing the company to begin with more straightforward changes. This includes starting with the solution for the second problem of the seventh problem, followed by the solution for the ninth problem, and then the first solution for the fifth problem. As the schedule progresses, attention shifts to more complex challenges that are addressed with careful consideration.

The subsequent phases of implementation focus on key solutions, such as the solution for the tenth problem which takes priority due to its daily requirement. Additionally, solutions for problems six, seven, and eight are integrated into the plan, to enhance efficiency and communication. The implementation of the fifth solution for the third problem involves an adjustment to the packers' routine, where they take written labels with product names during the collection process. The solution cluster for the third problem addresses longer-duration requirements and moderately complex challenges, such as the installation of a quieter cooling motor for the fridge.

8. Discussion and further work

8.1 Discussion

Numerous factors have influenced the boundaries of the proposed solutions. One such factor is the presence of building constraints. If for example, the roof contains more glass in the middle of the hall then the setup of the water basins could have been changed.

Moreover, the continual maintenance of product quality remains a dominant priority. This affects the degree of changes that can be introduced without compromising the final product.

Workforce preferences also play a role, as the interest of employees in new strategies can impact the achievability of implementation.

External elements, including third-party delivery schedules, have further shaped the scope of the proposed solutions. Because then the packages need to be finished.

However, it is crucial to recognize that the research does have certain limitations. A significant constraint is the time frame within which this thesis was conducted. Due to this constraint, the focus was primarily on studying the reduction of time among packers in the order fulfillment process. A broader investigation including non-packer roles could have provided a broader view of the overall process.

The limited timeline also precluded a thorough evaluation of the implementation's effectiveness and its impact on operational efficiency.

The timing of data collection is another point of consideration. The measurement occurred over two Mondays in June, which is in the initiating peak season. This choice was not intentional but that was the time span in which the assignment took place. But it introduces a potential bias as packers might work faster during the real peak times compared to slower periods. To get their work done on time.

Additionally, the precision of time measurement should be acknowledged. The practice of packing employees recording start and end times in minutes. Rather than seconds, this might introduce a slight deviation, potentially influencing the initial packing time recordings.

the possible success of implementing these solutions depends on the motivation and engagement of the packing team. Moreover, employees' insights and suggestions for adjustments are helpful, as they possess firsthand experience and a deep understanding of the practical intricacies involved. This participatory approach contributes to the success of the implementation process.

8.2 Further work

Script

The potential benefits of introducing a trainee packing script as a solution, could greatly help packers in reducing packing time. The script should include various elements, such as a map and the product locations, strategies for efficient product collection, and guidelines for using the suitable box size. However, it was revealed from the interview findings that certain challenges extend beyond the packing process, namely in stock management. Through these interviews, two additional issues were identified.

On-time communication of stock shortages

During the interviews, it was observed that packers often notice stock shortages while collecting products for orders but fail to communicate these shortages on time. To address this problem, the implementation of the Kanban method is proposed. This approach involves the use of Kanban tickets, which provide essential information about the product requiring replenishment, the necessary quantity, and the replenishment deadline. This information would help the harvesters in determining the required stock. The proposed implementation entails packers creating Kanban tickets whenever they have insufficient stock for the day's orders. These tickets are organized on a Kanban whiteboard categorized into "To Do," "Doing," and "Done" sections. It's recommended that this whiteboard is placed in the harvesters' office, as they are responsible for restocking. While this solution requires adjustment from employees, it holds promise in preventing stock shortages and can potentially integrate into the company culture over time.

Dysfunctional crate storage system in the cold store

Another issue identified is the dysfunctionality of the current crate storage system in the cold store, particularly in scenarios where multiple crates containing the same product and the same date are present. This creates confusion in the order of crate opening, which is inefficient. To prevent this problem, a suggestion is to apply the two-bin method from the Kanban system, refer to Section 3.8, the goal is to establish a clear system for crate opening order and stock management. This method could involve attaching a post-id to open crates and placing laminated Kanban tickets within each crate during preparation. Empty crates affixed with Kanban tickets would be positioned in the "To Do" section of the Kanban whiteboard. Encouraging communication between packers and harvesters about empty crates is essential for successful implementation. Magnets could facilitate the placement of Kanban tickets on the whiteboard. This proposed solution is not only straightforward to implement but also visually aids in crate systems and inventory management. While it necessitates employee adaptation, it presents an effective and sustainable long-term solution.

In summary, these two issues identified during the interviews go beyond the scope of the packing process and require distinct solutions.

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Appendix

A

Refer to Figure 21 for the BPMN process of De Vijvermeester. The BPMN process diagram is divided into three swimlanes, corresponding to the roles of harvesters, arrangers and packers, the process from the arrangers is left out because it is shown in Figure 11. This devision clarifies the two other roles and involvement of each job within the overall process. The process initiates within the harvesters' swimlane.

1. Harvesters: The process starts with the harvesters gathering products from various water sources such as creeks and canals. The harvesters go into the waters to collect the required products for the company.Then the collected products are then transported to the company via their vehicles. Upon arrival, the products are either placed on the arrange tables or stored in the refrigerator/cold storage. Storing products in the cold storage helps maintain their freshness.

2. Arrangers: Arrangers take over the process, beginning with arranging the products required for specific orders.Once the products are arranged, products are either stored in the refrigerator/cold storage or placed in the GGBs, which signifies their readiness for orders. An exception exists for standard products, such as 'fonteinkruid,' which are arranged in advance due to their frequent inclusion in various orders. For orders placed via the website, arrangers arrange the necessary products before the order is officially received.

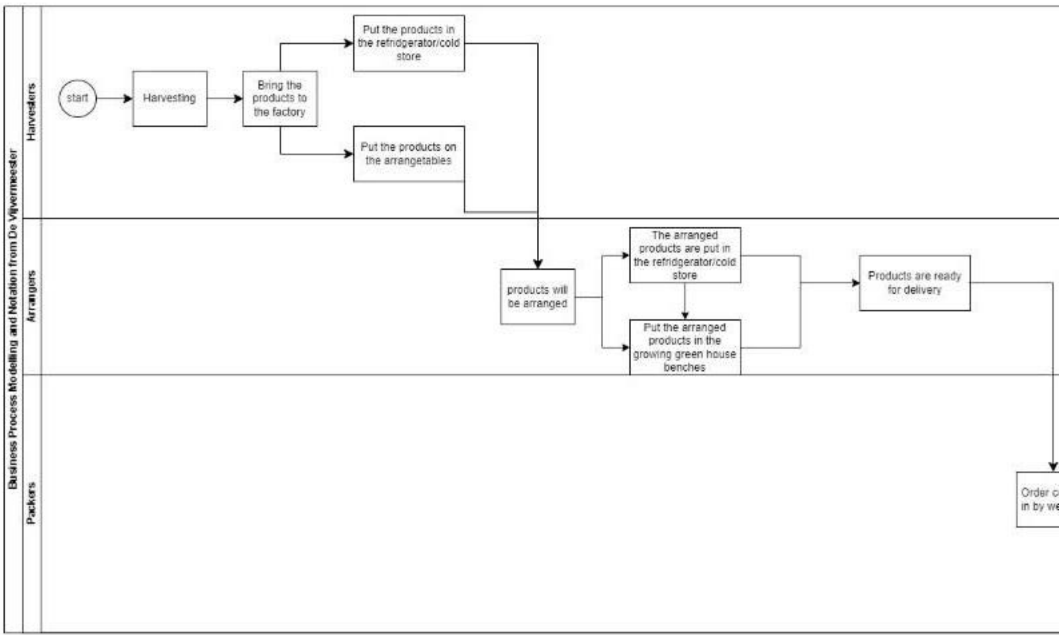

Figure 21:Figure 19 BPMN process of the harvesters and arrangers.

B

See Figure 3. The description of the locations of all products starts with the Growing Greenhouse Benches (GGB). All the GGBs are numbered.

In the GGB the following products are:

1. Watertorkruid, Moerasanemoon, Bloed zuring, Walstro, Speen kruid.
2. Bonte gele lis, Bonte iris, Zilver schoon, Penningkruid, Dotter bloem, Moeras hertshooi.
3. Smeer wortel, Moerashertshooi, Vergeet-me-nietje, Zomp vergeet-me-nietje, Moeras wederik, Krumpool zenegroen, Kleine watereppe, Blauw glidkruid, Pijlkruid.
4. Egelboterbloem, Dwerg holpijp, Moeras vergeet-me-nietjes, Veen pluis, Zegge, Slange wortel.
5. Genade kruid, Rode kafferlelie, Roze kafferlelie.
6. Lidsteng, Zwomrus.
7. Veen wortel, Moeras vergeet-me-nietje, Vergeet-me-nietje, Kattestaart, Waternavel, Wateraardbei, Aurea, Bonte kalmoes, Witte waterkers.
8. Waterweegbree, Grote boterbloem, Bonte kalmoes, Pijlkruid, Dotterbloem, Moeras wederik, Zwanebloem, Beekpunge, Moerasplant.
9. Watermosselen spits, Beekpunge, Gele lis, Kalmoes, Kleine water eppe.
10. Waterviolet, zegge, kalmoes.
11. Wolfspoot, Akkermunt, Gele lis, Kleine watereppe, Orchid, Zaai.
12. Kleine watereppe, Gele lis, Watermunt, Egelkrop, Grote boterbloem, Watergentiaan, Water violier, Doorgroeiend fonteinkruid, Glanzend fonteinkruid, Sterrenkroos.
13. Gele lis, Lang cyprus gras, Kleine egelskop, Grote egelskop, Moeras wederik, Watermunt, Aarvederkruid.
14. Pieters, Zuring, Drijvend fonteinkruid, Duizendknoop fonteinkruid, Stijve waterranonkel, Kransvederkruid, Teer vederkruid, Waterweegbree, Pijlkruid gekroesd fonteinkruid, Kleine watereppe, Bislelie, Glanzend fonteinkruid
15. Gele lis
16. Wilde gagel
17. Teer guichelheil, Kleine watereppe, Papyrusplant, Witte waterkers, Bog pimpernel, Teer guichelheil.
18. Pitrus.
19. Gele lis.
20. Gele lis.
21. Zegge.

All the plants in bins are numbered. In the bins are the following products:

1. Aval, Waterranonkel, Kaapse lelie.
2. Snoekkruid.
3. Mattenbies, Sterrenkroos, Plat fonteinkruid, Drijvend fonteinkruid.
4. Glanzend foneinkruid, Brede waterpest.
5. Witte waterkers.
6. Koekoeksbloem, Gewone brunel, Dotterbloem, Venwortel, Penningkruid, Mattebies, Zomprus, Kastanjeboom, Witte waterkers, Gele waterkers, Kleine water eppe, Cyprus longus.
7. Bamboe, Moerasandoorn, Zegge, Gele waterkers, Kleine watereppe, Kattestaart, Beekpunge, Witte waterkers.
8. Beekplunge, Pijptokkruid, Zegge, Valeriaan, Pijlkruid, Harig wilgenroosje, Iris blackgamecock, Dotterbloem.
9. Moeras vergeet-mij-nietjes, Kalmoes, Roze waterlelie, Rossig fonteinkruid, Drijvend fonteinkruid, Dwerg kalmoes, Aarvederkruid, Gele waterkers.
10. Kleine watereppe, Kattenstaart, Snoekkruid, Penningkruid, Hondsdraf, Kaapsewaterlelie, Rossig fonteinkruid, Paarbladig fonteinkruid, Kattenstaart, dwergkalmoes.
11. Watermunt, Heen, Moerspirea, Zegge, Zwanenbloem, Waterzuring, Moerasscherm, Witte water kers, Rode water lelie, Wateraardbei, Zantedeschia, Iris black gamecock
12. Kleine lis dodde, grote lis dodde, Japanse holpijp, Moerasgladiool.

What is in the Cubitainers are the following products:

1. Casino waterlelie.
2. Watererepleys, Casino waterlelie.
3. Rode waterlelie.
4. Roze waterlelie.
5. Witte waterlelie.
6. Paling.
7. Snoek.
8. Grofhoornblad.
9. Kroosvaarn.
10. Grofhoornblad.
11. Kalmoes, Blaasjeskruid.
12. Rood hoornblad.
13. Brede waterpest.
14. Aarvederkruid.
15. Aarvederkruid.
16. Slakken.
17. Moerasslakke.
18. Kikkerbeet.
19. Kalmoes.

20. Aangebroken inpak mosselen en moerasslakken, Kikkerbeet.
21. Gele plomp.

The contents of the rubber trays are the following products:

1. Krabbescheer

2 Krabbescheer

The content of the buckets are the following products:

a. Kroosvaarn
b. Cursusmateriaal -> niet doodgaan exoten: grote waternavel, crassula, waterwaaier, ongelijkbladig vederkruid, parelvederkruid
c. Kaapsewaterlelie,
d. Dwergwaterlelie,
e. Blaasjeskruid -> mag weg
f. kikkerbeet

The following products are in the pools:

- Smallest pool: roodhoornblad.
- Medium pool: Slangenwortel, Baars, Snoekbaars.
- Tallest pool: Waterdrieblad, mosselen

Wheelbarror:

I. Krabbescheer

C
Interviews:

Dit interview gaat over het vinden van de oorzaken van de problemen in het inpakproces. Met het inpakproces wordt bedoeld vanaf het moment dat de oogsters binnenkomen met de producten tot aan het pakket klaar is om verstuurd te worden. Zodat de inpaktijd van een pakket versneld kan worden.

Functie:

1. Wat is jouw hoofdfunctie in het bedrijf?
2. Wat zijn jouw taken naast jouw hoofdfunctie?
3. Zou jij nog andere functies in het bedrijf kunnen verrichten? In de zin van bijvoorbeeld je bent een bosser maar je kan ook inpakken.
4. Bevalt jouw huidige functie?

Inpakproces:

5. Hoe ziet volgens jou het inpakproces eruit? En daarmee bedoel ik de tussenstapjes vanaf de oogsters naar de bossers en dan naar de inpakkers. Of als jij ziet dat er een andere volgorde is tussen de oogsters de bossers en inpakkers dan vertel daarover hoe die eruit ziet inclusief de tussenstapjes.

Oogsters:

6. Nu richten we ons alleen op oogsters wat zijn volgens jou hun taken?
7. Wat zijn de taken die de oogster niet goed doen of beter gezegd kunnen verbeteren?
   - ➢ **Geen verbeterpunten, dan ga naar I.**

a. Als er verbeterpunten voor de oogsters zijn heb je ook ideeën om dit te kunnen verbeteren en zo ja? Wat zijn dan de ideeën om de taken van de oogsters te verbeteren.
b. Wat zijn volgens jou de hoofd problemen die de oogsteres veroorzaken en moeten gaan verbeteren?
c. Waarom zijn deze hoofdproblemen van de oogsters zo belangrijk volgens jou?

I. Er zijn mij enkele problemen opgevallen bij de oogsters:

- Duidelijk overzicht ontbreekt.
- Gebrek aan communicatie.
- Visueel voorraadbeheer ontbreekt.
- De ijzervoorraad ontbreekt.
- Gebrek aan FIFO.

➢ Zijn dit volgens jou allemaal problemen?
➢ Wat zijn hier denk je de oorzaken van?
➢ Wat voor oplossing(en) zou(den) hiervoor kunnen komen?

Bossers:

8. Nu gaan we ons alleen richten op de taken van de bossers, wat zijn de taken van de bossers volgens jou?
9. Wat zijn de taken die de bossers niet goed doen of beter gezegd kunnen verbeteren?
   Geen verbeterpunten, dan ga naar *II.*

a. Als er verbeterpunten voor de bossers zijn heb je ook ideeën om dit te kunnen verbeteren en zo ja? Wat zijn dan de ideeën om de taken van de bossers te verbeteren.
b. Wat zijn volgens jou de hoofd problemen die de bossers veroorzaken en moeten gaan verbeteren?
c. Waarom zijn deze hoofdproblemen van de bossers zo belangrijk volgens jou?

II. Er is mij 1 probleem opgevallen bij de bossers:

- De bossers zijn niet goed genoeg op de hoogte van de voorraad om op tijd in te kunnen springen als er van een product te weinig gebost is.

- ➢ Vind jij dit ook een probleem?
- ➢ Wat zijn hier denk je de oorzaken van?
- ➢ Wat voor oplossing(en) zou(den) hiervoor kunnen komen?

Inpakkers:

10. Nu gaan we ons alleen richten op de taken van de inpakkers, wat zijn de taken van de inpakkers volgens jou?

11. Wat zijn de taken die de inpakkers niet goed doen of beter gezegd kunnen verbeteren?

Geen verbeterpunten, dan ga naar III.

a. Als er verbeterpunten voor de inpakkers zijn heb je ook ideeën om dit te kunnen verbeteren en zo ja? Wat zijn dan de ideeën om de taken van de inpakkers te verbeteren?

b. Wat zijn volgens jou de hoofd problemen die de inpakkers veroorzaken en moeten gaan verbeteren?

c. Waarom zijn deze hoofdproblemen van de inpakkers zo belangrijk volgens jou?

III. Er zijn mij enkele problemen opgevallen bij de inpakkers:

- De inpakkers moeten onnodig veel lopen.

- Geen vaste routine, zoals een draaiboek.
- De inpaktafel heeft geen logische indeling.

- Vind jij dit ook allemaal problemen?
- Wat zijn hier denk je de oorzaken van?
- Wat voor oplossing(en) zou(den) hiervoor kunnen komen?

afsluiting

12. Heb je nog dingen toe te voegen of aanmerkingen aan dit gesprek?

Dan vertellen wat mijn aantekeningen zijn.

13 Heb je nog toevoegingen of aanmerkingen van mijn aantekeningen?

Hartelijk bedankt voor de deelname.