Sustainable Supply Chain of Roses from East-Africa

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Sustainable Supply Chain of Roses from East-Africa

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Acknowledgement

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During the last 8 months I have acquired knowledge on the supply chain of roses from East-Africa and the processes within this supply chain. Next to the gained knowledge, I developed a skill to manage a design project. I owe all committee members and supervisors lots of thanks. Acquiring these skills and knowledge would not have been possible without them.

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Koen Deckers
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Summary

This thesis is conducted at Royal FloraHolland, the largest horticultural market place of the world. RFH is keen on improving sustainability. Throughout the sector much improvements have been made. Four of their main ambitions as a cooperation are based on improving sustainability. Therefore they asked 'What does the ideal sustainable logistic supply chain from the flowers of Eastern Africa look like?'. For the import of roses only small scale adjustments are made. For RFH it would be interesting to see what modifications could improve the complete supply chain with the focus on sustainability. This was researched in this design thesis.

Kenya is taken as origin location of the roses. Kenya is the largest party regarding the export of roses which makes it a logical choice for the location to investigate the supply chain. The new design should be implemented within around 10 years to make it possible for upcoming innovations to be implemented in the new design. The adjustments are based on the physical flow and are limited to the period the roses are cut to the moment they are sold and stored for the buyer for pick-up. This time period can be seen in figure 1. Clock flow and direct flow are both considered. Since many stakeholders are involved in the supply chain, the scope of this thesis is limited to only considering the first order stakeholders, in combination with with the governance. This group of stakeholders have the most impact on the supply chain.

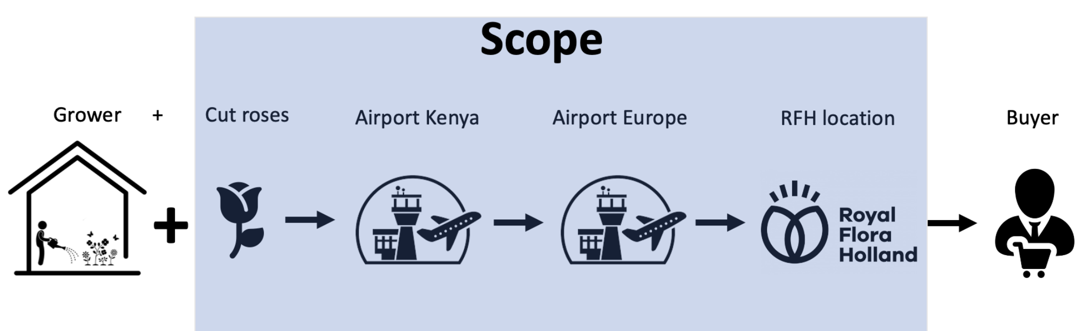

Figure 1: The current supply chain with the scope in the blue area.

To give structure to this research a design methodology is followed. This methodology begins with the question of the cooperation which must be a concrete formulation to make sure the research will meet the demand. This is followed by an inquiring and analyzing phase, which includes the first design activity, 'Analyse the current situation regarding the supply chain of roses' and a part of the third design activity, 'List the possible design alternatives for the supply chain of roses'. Next the second design activity, 'List the design requirements for the new design of the supply chain' and the second half of the third activity are done in the developing ideas phase. Consequently, the creating solution phase is conducted with design activity four and five, 'Combine the design alternatives to develop new possible designs' and 'Score the level of sustainability of the new supply chain' respectively. Evaluating is the final phase and includes the last design activity 'Evaluate the feasibility to implement a new design'. When the design activities are conducted it should result in the main objective of this thesis: *A design for a more sustainable supply chain of roses from East-Africa*. An overview of the methodology is given in figure 2.

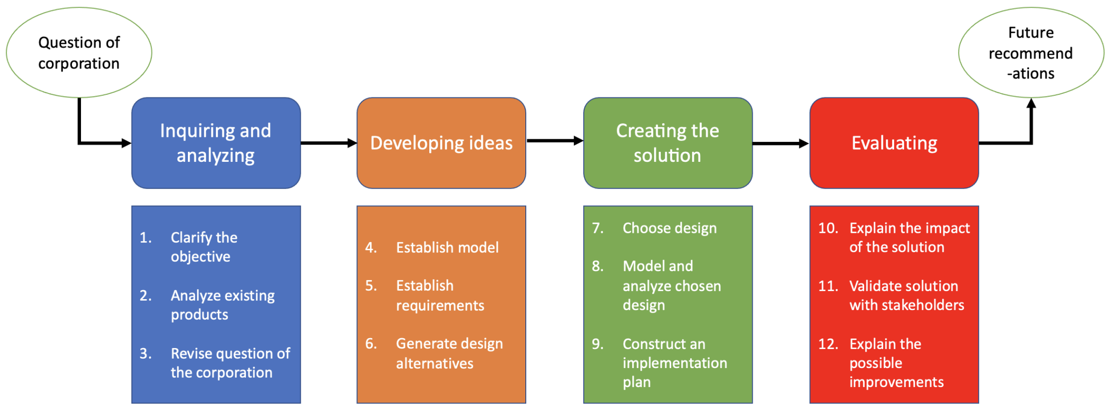

Figure 2: Thesis design methodology formed by the author

The first phase, inquiring and analyzing, starts with the current supply chain. This chain starts with the Growers in Kenya, which are located around the country. The roses are cut and put in boxes stacked in a truck to transport the roses to a freight forwarder located at the airport in Nairobi. Here the roses are kept until they can be shipped to Europe by the airline. Arriving in Europe the roses must be transported to RFH dock services. Here the custom checks are done and the boxes are sorted. For direct sale the rose boxes are directly transported to the customers box where the roses can be collected. For the clock flow, the boxes will go to the unpackers. The roses are unpacked, sleeved and put in a fust on water. The fusts are put on a trolley to transport the roses to the auction. Here the order picking system is used to collect the sold roses on the clock after which the products are stored at the customer box where the roses can be picked up. Throughout this process the quality of the rose will decrease. The starting vase life of an average rose is around 13 days. throughout the mentioned process, this decreases with around 1.2 days, resulting in a vase life of 11.8 days before the roses are collected by the buyer.

During this process, many stakeholders are involved. The most important actors are the actors with much power. They could make or brake changes in the supply chain. in this thesis, the power of the respective stakeholders is determined, as well as their expected interest on the field of sustainability. It can be seen that the government of Kenya and the Netherlands are powerful parties, but differ much in interest. Furthermore, the unpacker, growers, retailers and consumers are in a close triangle. These actors are dependent on each other which makes this an interesting group to keep in mind during the process.

To specify a definition of sustainability, which is the main driver for this thesis, a literature research is done. This is still executed in the analyzing phase. According to literature, sustainability can be improved by reducing negative impact on the environmental part while at the same time making sure it will be profitable to sustain business and not harm the social aspects. For this thesis the priority lies with the environmental part of sustainability, but in order to improve the overall sustainability, the other two parts must be taken into consideration. With further research on topics within environmental sustainability and the definitions within RFH, a definition is formed and used in this thesis. This is formulated as follows: 'sustainability is a mixture between not harming social parts, not making too expensive changes, but most of all being environmentally sustainable by reducing emission, using green/less energy and making re-usable/recyclable transport packaging with less raw materials'. This definitions introduces the key performance indicators for scoring the sustainability in a later stadium. The KPIs are:

- Emission expressed in CO_2 equivalents
- Materials
- Quality
- Economical sustainability
- Social sustainability

The design requirements are formed in the developing ideas phase. Here there are four main requirements with a list of constraints and objectives per requirements. The main requirements are:

1. The design has to be more environmentally sustainable than the current supply chain.
2. The design must be feasible to implement.
3. The quality of the roses should be as high as possible.
4. The design should be future proof after implementation.

These requirements are used in the MCA in the creating solutions phase.

Next a small step back is made to the analyzing phase for developing a list with concept design alternatives. Research is executed on different companies involved in being more sustainable. Also, research is done on out of the box ideas to eventually form a list of alternatives in the developing ideas phase. The alternatives are divided into three categories. The first category being the transport modes. The current design knows three large transport moments where alternatives are possible. The transportation from grower to the port, from Kenya to Europe and from Europe to RFH in the Netherlands. Next to the transport modes a list with packaging alternatives is formed. This has direct impact on the quality of the roses and the usage of materials. The third category does not have direct impact on one of the KPIs and is called remaining supply chain modifications. A combination of alternatives from the three categories form a new design in the creating solutions phase.

Five new designs are formed with each a different goal for improvement.

- **Design 1**, the Low Emission Update. This design focuses on reducing emissions in combination with quick fixes and small adjustments to the current supply chain.

- **Design 2**, the CCC design. The focus is on improving the quality of the roses.
- **Design 3**, the Futuristic Supply Chain. The goal of design 3 is to have an out of the box design to stimulate the sector and RFH to not hold on to things that already exist.
- **Design 4**, the Extra Hub in Europe. The objective will be to minimize the emissions, but this time by minimizing the travel distances.
- **Design 5** the Kenyan Auction. A decrease in waste of energy and emission is desired by reducing the amount of unnecessary transportation.

Each design consists of a combination of alternatives formed in the developing ideas phase. The alternatives will meet the demand per design. A detailed overview per design can be obtained in chapter 6.5. Subsequently the designs are scored in a multi criteria analyses. Three MCAs are done, with the main requirements as the general subject. The five designs are scored in a scale from - - to ++ with a 0 as neutral score. The scores are summed and plotted in a Pareto front shown in chapter 7. Trade-offs need to be made by RFH to choose a design. Design 3 and 5 have a high score on the quality and the environmental sustainability, but have the lowest score on implementation feasibility. Design 3, the Futuristic Supply Chain, has much uncertainties for implementation. Besides, the hyperloop will be extremely expensive to implement. For design 5 the logistic feasibility will be low. This is a constraint which need to be met. Therefore this design will not be feasible to implement. Design 1, the Low Emission Update, has the highest score on implementation, but the other scores are lower. Also, this design is not future proof which is a disadvantage. The CCC design and the Extra Hub in Kenya both score high on quality. The second design has a higher score on the environmental sustainability and the feasibility to implement. This results in design 2 being preferred compared to design 4.

The designs are discussed with different stakeholders and experts. This resulted in some new insights in the evaluation phase. Most of the alternatives are theoretically possible and will result in an improvement of the supply chain. However, the main reaction was that in practice, it will be difficult to implement. Design 2 is most likely to be implemented, since this is currently in developing within the floricultural sector. Sea freight is a promising solution for the high air freight prices. The largest bottleneck for the implementation is the business case for the designs. Money still is the most important part for most of the stakeholders, so as long as the business case is not financially beneficial the alternative will most likely not be implemented.

It can be concluded that the second design is most promising according to the experts and the author. Consequently, the fourth design can be an addition on the second design in the future. Furthermore, the alternatives of the Futuristic Supply Chain can be interesting when there are more implementation possibilities in the future. Also design 5 can be interesting when the logistics will be arranged. The Low Emission Update will not be future proof, but can be a solution for the near future to improve the sustainability of the current supply chain. Nevertheless, in order for a new design to be implemented either the business case should be profitable, or an external push must force the supply chain to make changes. This could either be from the government/European Union, or the consumers.

Future research can be done on improving the flaws in the current supply chain before a new design is implemented. To make the most progress, each actor should have the same mindset. More discussion sessions can be arranged to score the different designs. With more expertise the best solutions can be elaborated and tested to see what the bottle necks are and how they can be solved. Furthermore, the impact on the land use in Kenya as well as the transport from clock to the buyer should be considered for the alternatives. For this research these parts are scoped out, but in order to have a complete view the impact should be examined. Lastly, the qualitative study should be more quantified. With the horticultural footprint, which will be developed, the footprint of the alternatives can be calculated in order to improve the research.

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Chapter 1

Introduction

1.1 Royal FloraHolland

This thesis is conducted at Royal FloraHolland (RFH), the largest horticultural market place of the world. With an export value of 7.3 billion euros, the horticultural sector is important for the Dutch export (VGB, 2022). RFH is a cooperation of growers of plants and flowers. For over 100 years, RFH has been connecting supply and demand from all around the world. RFH arranges the order, payment and gives the option to transport flowers and plants. However, RFH is never in possession of the products. Their vision is to evolve sustainability to be future proof. To be able to achieve this goal, RFH collaborates with all actors in the horticultural sector, since they believe collaborating results in developing faster while reducing costs.

It started in 1968 when the flower auction was founded in Aalsmeer by merged companies forming the Verenigde Bloemenveiling Aalsmeer (VBA) (Ingenbleek & Christensen, 2007). It was the largest flower auction company in the world until 2002. Between 1973 and 2002 other flower auction houses emerged throughout the Netherlands. These are located between Rotterdam and The Hague, Eelde and in Venlo. Flora Holland (FH) is the result of these auction houses merging together. This made FH outgrow the rival in the flower auction industry VBA. In 2008 FH and VBA merged to become the largest horticultural market place of the world, now known as Royal FloraHolland. The merge improved the prices by having a better competition for growers and buyers. Furthermore, the effectiveness to compete on a global scale has improved.

Since digitization is needed to keep a favourable market position, RFH started with developing Floriday in 2018. An online market place for flowers and plants, with the main goal to make the horticultural sector more accessible world wide. This innovation will have consequences for all parties within the horticultural sector and it will be important to be efficient for all actors in this sector. Therefore, RFH provides assistance in shaping and implementing future plans (Over Floriday, 2022).

In 2021 it was announced that 'De Winter Logistics', 'Wematrans' and 'Van Zaal Transport' were merging to become Floriway. Floriway is a specialist in horticultural transport which is close to the market. As a cooperation the goal is to minimize the prices for the buyer while minimizing the costs.

By organizing the transport in combination with a merged group of carriers, it could be more efficient and service could be improved (Howes Smith, 2021).

1.2 RFH project objective

For this project the question of Royal FloraHolland is: 'What does the ideal sustainable logistic supply chain from the flowers of Eastern Africa look like?'. The reasoning behind this question is discussed underneath.

As mentioned before, RFH is keen on improving sustainability and lists their four main ambitions regarding this sustainability in their annual report (Royal FlorraHolland, 2021). Some achieved results are discussed to gain knowledge on the ambitions, and come to a main thesis objective. An extensive discussion is further elaborated in chapter 5.2. They want to be a reliable market place for certificated sustainable flowers and plants. They stimulate to increase the amount of certificated production. This has led to 56% of the suppliers having a digital environmental registration which represents 86% of the total income. In addition, 78% of the revenue comes from a certificated production. Furthermore, RFH does not want to contribute to the climate changes and therefore strives for minimizing the CO_2 emission. They use green energy, which resulted in a decrease of CO_2 emission of 3000 tonnes/year, and geothermal heat, which resulted in a decrease of 1200 tonnes CO_2 emission/year. All together this is around 20% of the total CO_2 emission which is 21105 ton for the year 2021 (Royal FlorraHolland, 2021). However, not all the ambitions are considered for this project, but it gives an overview on the willingness to make changes regarding sustainability. The exact scope of this project is discussed in section 1.3.

For the supply chain of roses currently small steps have been taken, such as recycled plastic, but this is still only on a small scale. For this project the whole supply chain must be taken into account to redesign the supply chain with the focus on sustainability. Furthermore, the project should not only consider the incremental solutions. It should be an inspiration for stakeholders in the supply chain and coming projects for this supply chain. This results in the following main thesis objective: *A design for a more sustainable supply chain of roses from East-Africa*.

1.3 Scope

For this project a specific scope is set due to time restrictions. First, the origin location of the supply chain will be limited to Kenya, since Kenya is the largest party regarding the export of roses. Around 46% of all import value comes from Kenya. This is a market value of around 265 million euros. The rest of East-Africa is scoped out for this project. However, it will be researched if and how the new design can be implemented in other countries within the horticultural sector. Second, the implementation of the new design should be between the years 2030 and 2035. This is necessary, regarding the feasibility for implementation. This time period gives a chance to implement new possible constructions and design changes. Third, the supply chain covers the moment the roses are cut to the moment roses are sold and stored, ready for the buyers to collect (see figure 1.1). For the roses which are sold via the Clock, this means the transport after the Clock is not taken into account. For direct orders, the transport to the buyer will be taken into account to the pick-up point at RFH. Only the long distance transport modes will be taken into account, since these have most impact on the sustainability. The small trucks for small transportation have relatively small impact. Besides, part of these trucks are already electric and do not have impact at all. Furthermore, the inventory management is scoped out, since the capacity will not have influence on the design choices and the energy usage of the buildings, just like the cold stores, is not taken into account. Also, the focus will be on the physical production supply chain, so data flow will not be considered and the financial flow is not discussed in detail. Next, only the first order stakeholders in combination with the government are in the scope. Since the government has much interest and power regarding the changes made in sustainability, it will be necessary to include them. Second order stakeholders, like box manufacturers or garbage collectors, are scoped out, since they do not have much influence on the physical supply chain for this project. Consequently, the main focus will be on the environmental sustainability. Also economical sustainability is considered. These are mostly related. The research on social sustainability will be mentioned but research will be less extensive. Finally, as stated in chapter 2.4 sustainability has a broad definition. This will be further researched in sub-question number 2. After answering this question a scope will be determined on which sustainability subjects are scoped out and what will be taken into account as main priority.

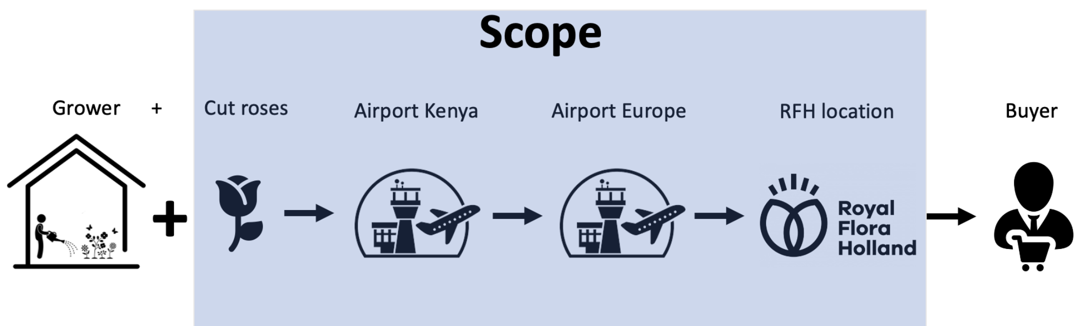

Figure 1.1: The current supply chain with the scope in the blue area.

1.4 Deliverable

The deliverable consists of three parts. First, the design of the new supply chain. With sub-activity 5, 'Combine the design alternatives to develop new possible designs', a new design is chosen. This design will then be scored via a multi criteria analyses to evaluate the level of sustainability. The result will show all improvements on sustainability, as well as potential for further improvement of the new design. An implementation plan is made which shows how the new design can be applied and what the bottlenecks are for the implementation. Second, a method is created to score the sustainability. This gives an overview on how sustainable the new design is and where the hot-spots are regarding environmental pollution. To conclude, the new supply chain must be checked on feasibility. This is done with an implementation plan which will be discussed with stakeholders. In sub-activity 7, an evaluation is done on the implementation of the new design. For each part in the supply chain the relevant stakeholder is interviewed. This results in an overview on the possibility to implement the new design and potential alternatives for parts which are not feasible to implement according to the stakeholders.

1.5 Thesis outline

This thesis starts with forming the design methodology. This methodology is used to give structure through the outline of this thesis. The main objective is defined with the design activities necessary to achieve the objective. After the main objective is set with the corresponding methodology to reach the objective, a background analyses is done on basic knowledge of the sector. This makes it easier to understand the current supply chain which is explained in chapter 4. This chapter consists of an explanation of the current supply chain step by step, followed by a more detailed version of the supply chain. This chapter ends with a stakeholder analyses which gives insight in the involved actors and their interests and power. After the knowledge on the current supply chain is gained, the driver for improvement: Sustainability, is discussed. A literature research is done on the definition of sustainability. This is combined with the definition of sustainability for RFH to create a definition for this design thesis. When the definition is formed, the requirements for the new design are formed. This is broken down into four basic needs, with a list of objectives and constraints for each of these criteria to elaborate on the themes of the main requirements. The list of objectives and constraints is discussed with two experts to validate. Next, the concept design alternatives are listed. Research is conducted on businesses that are concerned with sustainability. With this research and the gained knowledge during this thesis, a list of design alternatives is composed. The alternatives are divided in three subjects. First the transport modes used during the supply chain. Second, the packaging used to transport the roses in. And third, the remaining modifications which not have direct impact on one of the sub parts of sustainability. With those lists, five new designs are formed. Each design has its own focus point to improve. These designs are discussed in detail after which a MCA is done to compare the designs. This MCA gives insight in the strong and weak points of the designs. In chapter 7.4 interviews are held with different experts and stakeholder about their opinion of the new formed designs. This gives insight in what ideas are theoretical beneficial, but in practice have much bottle necks. Finally, the discussion, recommendations and conclusion are given. The discussion and recommendations give elaborate on the results of this thesis and what are possible future researches. The conclusion gives an overall summary of the thesis including the results of the main objective.

Chapter 2

Thesis design methodology

In this chapter, two existing design methodologies are discussed. Both Dym and Little and the Watson design cycle are combined to form the thesis design methodology. This methodology brings structure to the process. To achieve the objective of this thesis, a list with six design activities is formed. The four steps of the thesis design methodology give guidance for the methodology used to complete the design activities. Per design activity it is discussed how this activity is completed and in which stage of the methodology this will be tackled. The combination of the thesis design methodology and the design activities will be merged in the thesis throughout the chapters.

2.1 Watson design cycle

The first inspiration is the Watson design cycle in figure 2.1 (Watson, 2022). This design is chosen for having a clear view on the four main phases. A design thesis is also divided in parts. First a literature study is done followed by listing new ideas creating solutions and evaluating the solutions. Since the Watson design cycle has much overlap with those steps of the thesis it is used as an inspiration for the design methodology. A design cycle is used to give structure on a design project. The structure is divided in four phases which need to be followed to create a new design. Each colour in the cycle represents a different phase in the project and all phases are divided in four actions to execute the relevant phase. First, the blue part is the inquiring and analysing phase. In this phase the current situation is analysed by justifying the needs, prioritize the research, analyse exciting products and development of a brief design. Next, the design specifications should be developed and design ideas should be developed to present a chosen design. After which a planning should be developed. This is done in the developing ideas phase (orange). Third, in the creating solutions phase (green), a logical plan should be constructed and followed to make the solution and to justify the changes. The red phase is the last phase of the design cycle where the process is evaluated. Here the design is tested and the successes are evaluated. It is explained what further improvements could be made and what impact the design has. The whole process is an iterative process, which means it is possible to switch back and forward between phases when necessary. This gives an opportunity to improve the process by adding and changing parts to earlier design stages. Furthermore, after evaluating the new design, possible improvements are listed and can be executed directly.

It has to be noted that some sub parts of the cycle are not applicable. Due to limited time and scope, for this project the process will not circle back from the evaluating phase to the analysing phase. After evaluation this project will end with a design recommendation, including recommendations for further research.

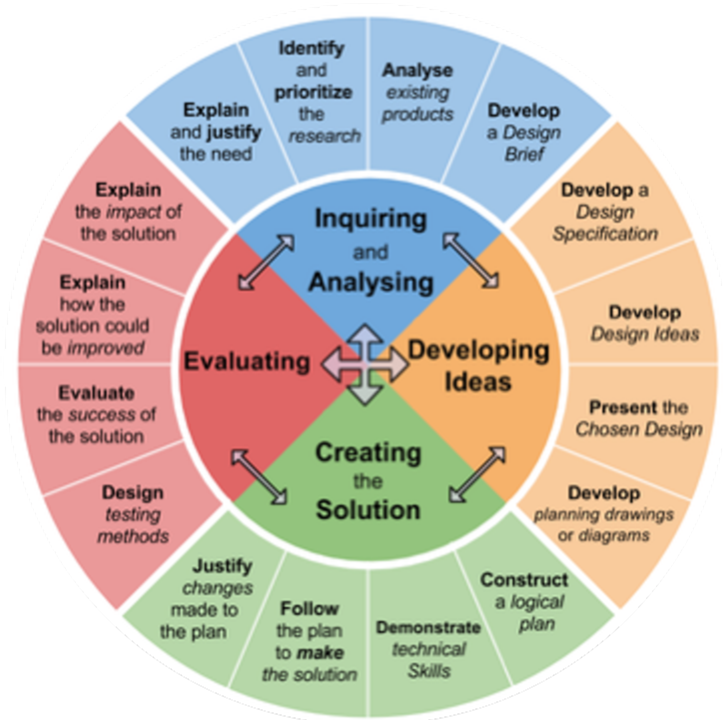

Figure 2.1: Design cycle (Watson, 2022)

2.2 Dym and Little

The second design methodology used, is Dym and Little. A second existing design methodology is used to create a complete design methodology. Not all methodologies fit all the design projects. Therefore, with the use of Dym and Little the new design methodology can be completed by considerations on the necessary parts to add. Dym and Little has been chosen to be the second methodology since it has more in dept tasks to add in the new design, however they are much alike. Just like the Watson design cycle, this is a method used to structure a design project. Compared to the previously mentioned design cycle, there is an overlap in the steps that are covered. However, some steps covered by Dym and Little are absent in the Design cycle. The methodology is shown in figure 2.2. It is divided in fifteen different tasks to come to a final design. The task one to fifteen in the figure are (Ng, 2013):

1. Clarify objectives

2. Establish metrics for objectives
3. Identify constraints
4. Revise client problem statement
5. Establish functions
6. Establish requirements
7. Establish means for functions
8. Generate design alternatives
9. Refine and apply metrics to design alternatives
10. Choose a design
11. Model and analyze chosen design
12. Test and evaluate chosen design
13. Refine and optimize chosen design
14. Assign and fix design details
15. Document final design

Especially tasks like, identify constraints and establish requirements will be a necessary addition to implement in the design methodology. These are important to create a design which satisfies the question of RFH and meets the demand of this project.

2.3 Thesis design methodology

Both methodologies described above are used to make a new methodology for this project. This methodology is shown in figure 2.3. The opening part is slightly different from the Dym and Little methodology, since this research does not start with a problem, but with a question of RFH. The same main subjects as the design cycle of Watson are used. However, they are not in a cycle, since the limited scope does not allow to switch back to the other phases after evaluating. The outcome of the evaluation will be discussed and imperfections are elaborated in the future recommendations.
Each subject consists of 3 tasks, where Watson and Dym and Little are used as an inspiration. Tasks that are part of either of the two mentioned methodologies, but which are left out in the new methodology, will not be of use for this project. First the Inquiring and analyzing phase starts with clarifying the objective to create a clear goal for the project. This objective will be formed in cooperation with RFH. The second task is analyzing existing products. Where the current situation is investigated, definitions are formed and literature research is done. Third and last task of this phase is the revision of the corporation's question. This will give the scope of this project.
Second, the developing ideas phase. In this phase it is decided what kind of model will be used to measure the sustainability. The requirements for the new design are established and design alternatives are generated.
Creating the solution is the third phase, starting with a new design, chosen with the help of the design alternatives from task 6. This design is analyzed with the help of the established model in task 4. Thereafter an implementation plan is constructed for the new design.
Last is the evaluating phase. In this phase the impact of the solution is explained. Which is discussed with stakeholders. The stakeholders give their opinion on the new design to validate. This phase ends with a brief discussion on the possible improvements, which will be incorporated in the future recommendations.

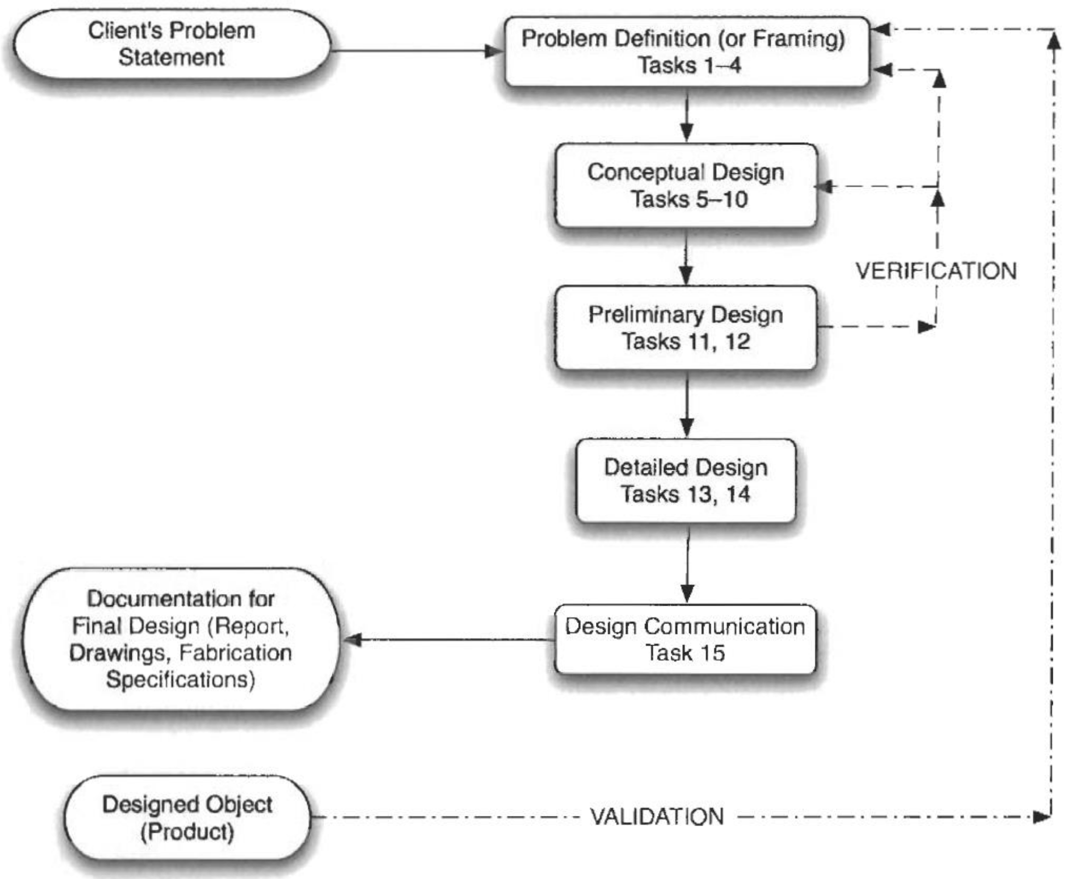

Figure 2.2: Dym and Little design (Ng, 2013)

2.4 Design activities

As stated in section 1.1, RFH strives to be a more sustainable cooperation. However, according to expert 3 the sustainability of the supply chain of roses is never completely investigated. Therefore, the goal of this thesis is to design a more sustainable supply chain for the roses from East-Africa to the Netherlands. This is achieved by completing the main thesis project objective:

A design for a more sustainable supply chain of roses from East-Africa.

This could be a completely new design, which means it is not necessarily in line with the current supply chain which will be discussed in chapter 4. However, it is possible that some parts of the current situation stay the same for the new designs. This will be dependent on the level of sustainability of the current supply chain with respect to the design alternatives discussed in chapter 5.5 and chapter 6.

The following design activities are composed to gain knowledge on the main thesis project objective. These activities are in line with the design methodology discussed in chapter 2.

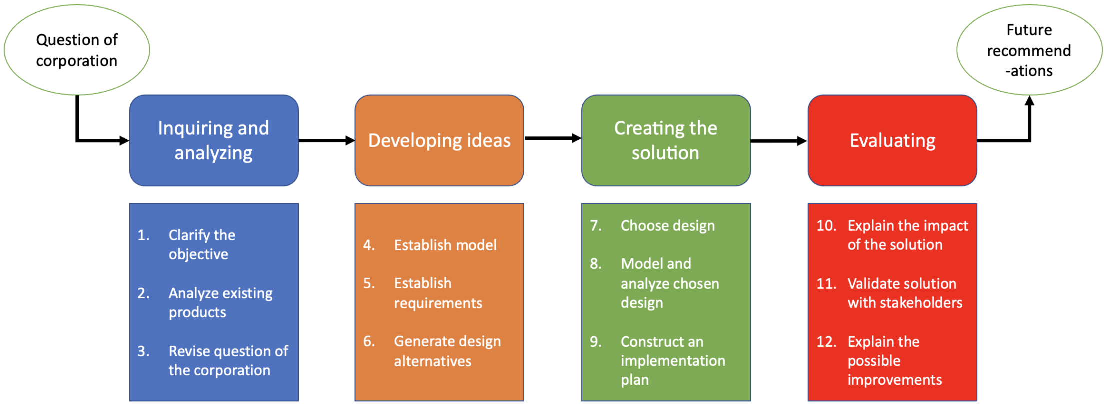

Figure 2.3: Thesis design methodology formed by the author

1. *Analyse the current situation regarding the supply chain of roses.*
   This will be a large part of the analysis phase. The analyses consist of the problem statement, an overview of the current supply chain and the current requirements in the horticultural sector. To illustrate the current situation, a swimlane diagram is used.
2. *List the design requirements for the new design of the supply chain.*
   This activity is mostly done in the developing ideas phase. The requirements are formed together with experts of RFH to make sure the new design will fulfill the demands of RFH. With these requirements, the new design can be evaluated.
3. *List the possible design alternatives for the supply chain of roses.*
   This objective will partly be done in the analysis phase and partly in the developing ideas phase. In the analysis phase, other (similar) supply chains will be investigated to gain inspiration and knowledge for the list of design alternatives which will be set up in the developing ideas phase.
4. *Combine the design alternatives to develop new possible designs.*
   This objective will be done in the creating the solution phase. The obtained alternatives will be combined to make different designs. Each design will have a focus on improving the sustainability on its own way. This will result in different designs which can be compared in the next activity. The designs will be illustrated in a swimlane diagram, like was done for the current supply chain.
5. *Score the level of sustainability of the new supply chain.*
   The formed designs will be put in a multi criteria analyses (MCA). Here the designs will be scored and compared. The requirements formed in the second activity are used as key performance indicator (KPI). This will be done in the creating solutions phase.
6. *Evaluate the feasibility to implement a new design.*
   The last activity will be done in the evaluation phase. Stakeholders and experts will be asked whether the design will be feasible in the year 2030 to 2035. Furthermore, when the design is not feasible, it will be discussed what the alternatives could be.

2.5 Methodology per design activity

In this section, a brief overview of the suitable methodology to achieve the main thesis project objective is given. The design activities are divided in table 2.1 with the methodology used to fulfill this activity. In the remainder of this section, these methodologies are discussed in more detail.

Table 2.1: Methodologies used per design activity

A new design for the supply chain of roses from East-Africa which is more sustainable.	
Design activities	**Methodologies**
1. Analyse the current situation regarding the supply chain of roses.	Literature research and Expert consulting
2. List the design requirements for the new design of the supply chain.	Literature research and Expert consulting
3. List the possible design alternatives for the supply chain of roses.	Literature research and Expert consulting
4. Combine the design alternatives to develop new possible designs.	Form specific designs
5. Score the level of sustainability of the new supply chain.	Multi criteria analyses
6. Evaluate the feasibility to implement new design.	Expert consulting

Literature research and Expert consulting

The first sub-activity makes use of both literature research and expert consulting. Both literature research and expert consulting will be used to understand what the current supply chain looks like and what the bottlenecks are. Literature is used to do a background analyses. To make this analyses more complete, meetings with experts are held to clarify uncertainties. Next the supply chain is step by step discussed with experts to create a clear view of the supply chain. After the analyses, the requirements can be listed. This is partly done by using literature for general horticultural requirements. However, most of the requirements are listed with the help of experts. The previous held interviews are used as an inspiration for the requirements. This formed list of requirements is tested by experts to see if they agree with the requirements and what additions they would have. Last, for the fourth sub-activity, a combination of literature and experts will be used to make a list of design alternatives. Literature study on supply chains of similar sectors are used for inspiration. Followed by an expert consult, which will be used to brainstorm for more out of the box ideas on alternatives.

Form specific design

The design alternatives are combined for specific designs. The focus point of the design is determined after which the alternatives, fit for this design. are added to this design. First it is checked if there will be a logistic difference in the design which limits the possibilities for selecting design alternatives. The transport modes will be chosen and the packaging type is selected to fit the demands. Last the remaining modifications are implemented to further improve the design. For all the alternatives a scoring method is used to identify the best fit per design. This will result in design completely focused on a specific improvement.

Multi criteria analysis

To score the new designs formed in the previous section, a multi criteria analysis is done. The new designs will be rated on the basis of the formed requirements. The multi criteria analyses gives insight in what new design scores best regarding environmental sustainability, implementation possibilities and quality preservation. These scores will be plot in a Pareto front to visualise the trade-offs to be made before choosing a design.

Expert consulting

The final sub-activity makes use of expert consulting. While the goal of this thesis is to develop a more sustainable supply chain, the proposed supply chain should also be feasible to realize. This will be discussed with experts and stakeholders to see what is feasible and what not. Feasibility of individual elements of the supply chain will be discussed, including alternatives in case of unfeasible elements.

Chapter 3

Basic perspectives in the floricultural sector

This section consists of background research done to gain knowledge on the current situation of the import of roses from East-Africa. It starts with discussing the horticultural sector and the auction of flowers, followed by the reasoning of why the roses are imported and when it was decided to do so. This gives insight in where the roses come from, why they are coming from this area and how they are sold. The next subparagraph discusses incoterms, which establish who is responsible for transport and can therefore have significant impact on sustainability. Consequently, a new design on packaging is already made within RFH to be more sustainable and discussed in this chapter. This will give insight on how RFH is trying to be more sustainable and and whether there are possible bottlenecks for implementing new ideas within the existing supply chain. To conclude, research is done on the cooling cycle and what the influence of the cooling cycle could be on sustainability. Given that the cool chain is important for the quality of the roses and higher quality is an important part for the roses to have a long enough vase life, the cool chain will play an important role for the transportation of the roses.

3.1 Horticultural auction

In 1902 the auction clock was invented in the Netherlands. Five days a week over 30 million plants and flowers are sold via this clock. The products mostly arrive during the night or the evening before the auction. They are stored at the RFH locations until the auction starts and during the auction the flowers are collected for the buyers. Buyers can rent a box at the RFH auction site, where the purchased flowers and plants are stored for the buyer to collect them. It is also possible to collect these products in a box and get them picked up by a carrier. These boxes are on the location where the auction is held. Auctions of RFH take place in Naaldwijk, Aalsmeer, Eelde and Rijnsburg in the Netherlands.

An example of an auction clock is shown in figure 3.1. In the various locations of RFH a total of 35 clocks are working every day. Each clock sells different items at the same time. The clock screen is divided in six different parts.

1. Information on the next six items to be sold.
2. Photo of the current product.
3. The name of the grower and the name of the product. To the right of the product name there is the country of the production and underneath the quality of the product. The quality is presented as A1 (best product), A2 or B (worst product). To the right of the quality there is the QI (quality index) which indicates the reliability of the grower. An A is given when the grower is always reliable. If a complaint is given from a customer about the product, the QI will be lowered. Furthermore, the QI is scored by te reliable data the growers deliver with their products. If there are mistakes in the data, like differences in amount or length, the QI will be lowered.
4. Extra information about the product
5. The actual clock, where the red dot is moving counter clockwise on the circle. The circle has 99 dots where each dot is 1 cent. The red dot moves from maximum to minimum until a buyer presses a button to buy the product. The price is determined by the location of the red dot. The blue dot on the circle is the minimum price of the product. Once the blue dot is being passed, the auctions stops. The product will be destroyed. In an exceptional case the auctioneer can decide to auction the product again. This will only happen when mistakes are made during the auction. After the product has been sold, or the blue dot has been passed, a new auction will start on the clock.
6. The top part gives the value of each dot. This can vary between 1 cent, 5 cent and 10 cent. When this is switched to 5 cent, each dot on the circle now represents a step of 5 cents instead of 1. Underneath, the last bid price of the product is shown. Furthermore, the amount of cars, fusts and the total amount are given. A fust is a bucket in which the roses are transported during the auction. More information about the fusts is given in section 3.4. Last the fustcode and minimum order are given.

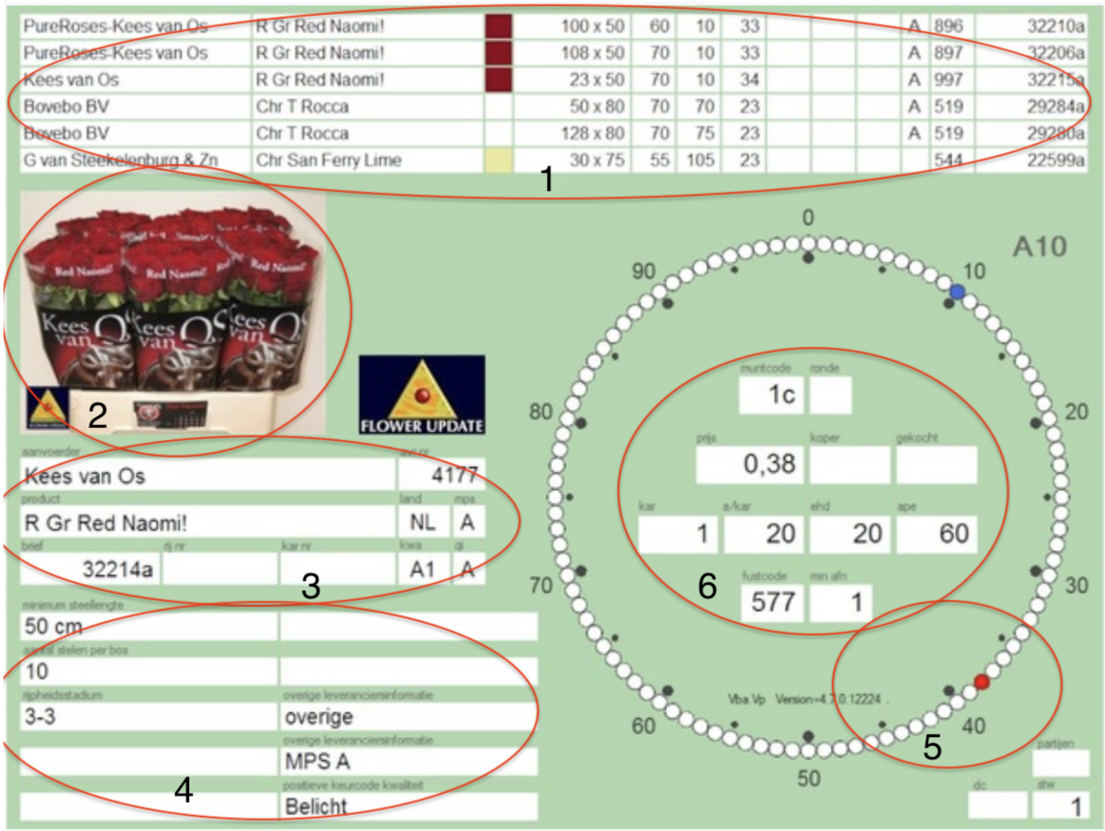

Figure 3.1: Auction clock (Uitleg over de veiling klok, 2011)

In short, a product is sold on the clock. All information about the product can be found and the price starts at the maximum price the auctioneer thinks the product could be sold. The red dot starts moving and a customer presses a button to buy the product. The red dot indicates the paid price for the product. A new product is sold on the auction until there are no more products of this batch. Then a new batch with products will be sold on the clock. This process continues until all the products of that day are sold.

3.2 Roses from East-Africa

Between the year 2000 and 2015 the amount of rose growers in the Netherlands had been reduced from 770 to 120. The reason being high prices for energy in the Netherlands on one side and the low prices of import on the other (Rozenteelt dreigt uit Nederland te verdwijnen, 2016). Currently, RFH imports 3.3 billion roses per year. The roses are mostly imported from Kenya and Ethiopia. The growing conditions in east Africa are perfect, which results in low costs to produce the roses. Furthermore, the wages of the employees are much lower than in the Netherlands. Since the roses were imported, most of the Dutch rose growers changed their product in a different vegetation. The rose growers who still produce roses in the Netherlands, now distinguish themselves by focusing on growing specific species which are large and of high quality. (NCRV, 2022)

3.3 Incoterms

For international trade it is necessary to have clear agreements on responsibility for the products, transport and insurance to streamline the process. The incoterm rule is a term of contract of sale (Ramberg & International Chamber of Commerce., 2011) where is decided which party is responsible for ownership, insurance, freight and transportation and how the costs are divided between the parties. For example, if the roses are bought in Kenya, it could be decided that the buyer picks them up at the grower. This way the buyer gets the full responsibility for the product during the transport and is in charge of arranging the transport himself. On the other hand, it could be decided that the flowers are delivered by the grower to the buyer. This way the grower will be responsible for making sure the transport is arranged and the product is delivered with the right quality. In this situation, the price for the buyer will generally be higher, since the responsibility, and thus the risks are for the grower. In addition to these two extreme examples, there are also incoterms that fall in between which are listed below. In total there are eleven different incoterms, which can be divided in different groups (Ramberg & International Chamber of Commerce., 2011):

- EXW, the goods should be collected at the seller by the buyer. This regards minimum obligation for the seller.
- FCA/FAS/FOB, the seller has obligation to hand over the products to a carrier of the buyer's choice.
- CFR/CPT, the seller has obligation to hand over the products to a carrier of his choice at own cost.
- CIF/CIP, the seller has obligation to hand over the products to a carrier of his choice at own cost, with an insurance against risks and transit.
- DAT/DAP/DDP, the seller takes the product to a specific destination. This regards maximum obligation for the seller.

What kind of incoterm is used, can influence the sustainability. As discussed, in the incoterms the responsibility for transport has been established. The party in charge of the transport, decides what transport modes are used. This could differ in environmental sustainability and costs.

3.4 Packaging

To transport the roses, they are packed in cardboard boxes. Within these boxes the roses are stacked in bunches of 10 or 20 held together by a rubber band. Around the flower buds there is an extra sleeve of carton to protect them from damaging. Sometimes the roses are sleeved with plastic for extra protection. In figure 3.2 an example is given of packed roses. Here no plastic sleeves are used. However, an extra carton sleeve is used to keep the bunches of roses together, and protect them against damage, by the white plastic strips.

Figure 3.2: Packed roses for transport (Exporting roses to the Netherlands, 2017)

In 2019 RFH a new pilot started in association with KLM and Schiphol, the Holland Flower Alliance, on the packaging of the roses from East-Africa. Currently the loading of the unit load devices (ULDs) is not optimal. A ULD is a standardized unit like a transport pallet, container or box used to load goods. In this case a standardized aircraft pallet. The boxes have different measurements which results in different spacing between the boxes. This increases the chance of harming the roses inside the boxes. A new design for the boxes has been made in combination with the idea of palletising. The boxes are all the same dimensions and have a perfect fit on a pallet. Furthermore, the pallets fit directly on the ULDs which increases the efficiency. Also the effort in handling of the boxes is less, because they do not have to unstack and stack the boxes from the trucks which in turn results in less damage of the roses. However, this pilot has not been implemented yet. According to expert 5 the most important reason was the difference in advantages. It is most beneficial for the actors after the growers in the chain, while the growers have higher costs by purchasing the new boxes. In the end this will not be beneficial for the growers. Next to the boxes the roses are transported in, much profit in sustainability could be gained from recycled packages and reduction of the amount of plastic used for sleeves. After they are unpacked from the cardboard boxes the roses are cut and sleeved in plastic, or resleeved if they are already sleeved in Kenya. These sleeves protect the roses, are used for advertisement and protect the consumers from the thorns of the roses. The sleeved roses are put in a fust with water to transport the roses during the auction. A fust is a generalized re-usable bucket. In 2019 a new version of the fust was developed by RFH which resulted in a higher load factor, lower costs and less emission by production. In figure 3.3 a picture of a fust is shown with the corresponding attachment for different sizes in flowers. After the auction the roses are either put back in the cardboard boxes, or kept in the fust to transport to the buyer. A deposit on the fusts makes sure the fusts are returned after which they are cleaned and re-used during the auction.

Figure 3.3: Fust with corresponding attachment

3.5 Cooling cycle

When interviewing expert 6, it is said that increasing the vase life is an important part of sustainability. Roses should last for 7 to 10 days in a household. However, this is not always the case. When a vase life of 10 days is guaranteed this will result in a decrease of waste of roses as well as the amount of roses necessary to meet the demand. To keep the condition of the roses better it will be important to have a good cooling cycle. The research of Voort et al. (2016) discusses the impact of the cooling chain on the vase life. This research clearly shows that the quality of the flowers is affected when high temperatures are reached and the degreehours are more. The degreehour is the unit to rate the cooling chain. This is in line with the temperature in combination with the time the flowers will be on this temperature (Harkema, Paillart, Lukasse, Westra, & Hogeveen, 2017). By improving the cool chain the amount of degreehours can be reduced and the vase life can be increased. Furthermore, it will be interesting to investigate the possibility to make this cool chain a closed cool chain to minimize the temperature changes when the roses are switched from modality. A closed cool chain means that the roses are cooled during the complete chain. They will not be exposed to heat at any moment in the supply chain. This could for example be done by keeping the roses in the same cooled container for the whole process. A closed cool chain will decrease the degreehours, which improves the quality of the roses. It will be important to put the roses in the cooled chain with the right temperature to have the most positive impact. Also, a closed cool cycle could decrease the amount of replacements of the roses and the boxes the roses are in, which can result in less damage by handling.

Chapter 4

Current supply chain of roses from Kenya

This chapter gives insight in the current supply chain of roses for RFH. The first section gives an overview on all steps of the supply chain of roses from Kenya to the Netherlands. The second section contains a stakeholder analyses. For each stakeholder the importance of sustainability is discussed as well as how much power these stakeholders have to potentially make changes in the process. This chapter will give an answer to the question of the first design activity, 'what is the current situation regarding the supply chain of roses?'

4.1 Current design schematic

To gain better knowledge of what the current supply chain looks like, several interviews have been carried out. These interviews help sketching the supply chain as pictured in figure 4.1. There are two different flows of sale for the roses. One where roses are sold directly from the growers in Kenya and one where roses are sold via the clock. In both cases, the physical process is mostly the same. Figure 4.1 shows a schematic view of the current supply chain. The round parts are the activities before the roses arrive at RFH and the squared parts are the activities at one of the RFH locations. Furthermore, the dotted arrows are small handling moments to transport the roses at the same destination to a different actor. These are done by smaller and different types of trucks, where the green trucks are electric. Last, the blue parts are moments where the roses are kept or handled in a cold store and where inventory can be held. However, the small transport moments and the inventory management are not discussed in detail, since these parts are scoped out for the new designs (see the scope in chapter 1.3). Figure 4.1 will be used to explain the process step by step. After this explanation, a more detailed overview is given in section 4.2.

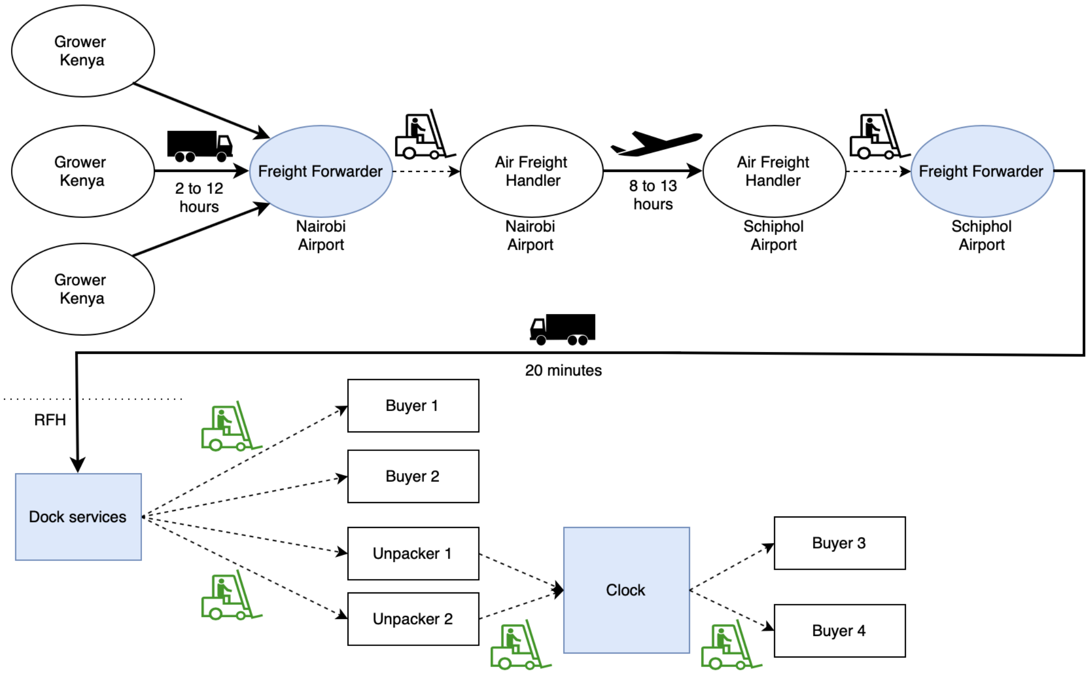

Figure 4.1: Current supply chain of the roses from Kenya to the Netherlands

4.1.1 Clock sales flow

The process for the clock sales flow starts with the growers (figure 4.2). In Kenya there are over a hundred growers and they are located around the country, mostly west from the capital city Nairobi (see figure 4.1). According to expert 1, most of these locations are near a river or lake, which can be used as water supply. The size of the growing areas differ from large growers, which can grow on an area as big as 200 hectares, to small growers, with an area of ten hectares (as stated by expert 2). In general, most growers grow on an area with a size between 20 to 80 hectares. At the growers, the roses are sorted, bunched and, after the quality grading, they are packed in cardboard boxes. The cardboard boxes are labeled and loaded into trucks and transported to the freight forwarders at Nairobi airport. As the distance between the growers and the airport differs, the time span to reach the freight forwarder lies between two and twelve hours.

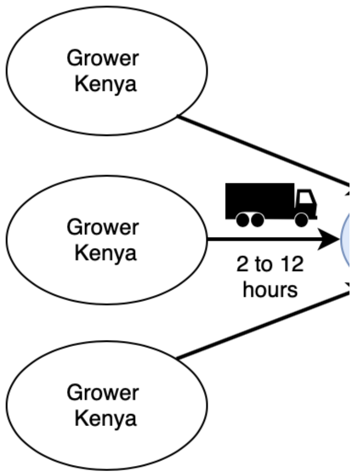

Figure 4.2: First part of the current supply chain

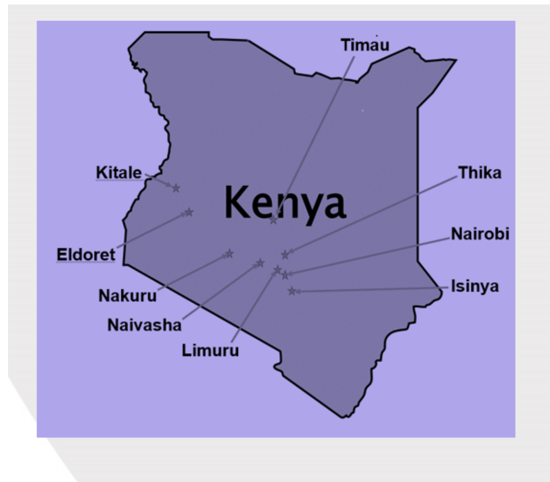

Figure 4.3: Location of the growers in Kenya

There are many different freight forwarders. Expert 1 states that only four to five large parties are used for the horticultural sector. The boxes with roses are stored in cool stores. Consequently, they are placed on ULDs before transportation to the air freight handler. The air freight handler will load the ULDs in the plane. Now the roses are shipped to the Netherlands and to Belgium, where the ULDs are unloaded and transported to the freight forwarders by the air freight handlers (figure 4.4). A freight forwarder, which is most of the times the same freight forwarder as in Kenya, will handle the products and ship them to dock services. Dock services is located at the RFH auction centers and is part of the logistic department for international flow.

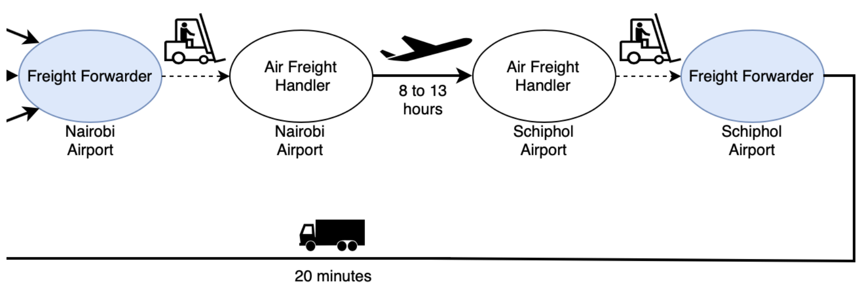

Figure 4.4: Second part of the current supply chain

At dock services the ULDs are unloaded and placed in cold stores. Here a customs check is done, before the shipment can continue. If the shipment is denied during the check, the shipment will be quarantined. In this case, necessary paperwork must be completed before the shipment can enter the rest of the process. However, if the paperwork is not, or cannot be, completed, the shipment will be destroyed. When the paperwork is accepted, the boxes of roses will be sorted on trolleys. A sample will be taken to do a phytosanitairy check. A phytosanitairy check is a check on bugs and banned pesticides. If the check gives a negative result, so bugs are found or banned pesticides are used, the batch will be destroyed. These checks are done by the 'kwaliteits controle bureau' (KCB), which is part of the dutch food safety authority under responsibility of the Dutch government and part of the customs check. This is why the actor is called 'government' in the figures 4.8 and B.1. Only if both the customs check and the KCB give an agreement the shipment can continue. These customs checks and KCB checks are done at dock services (RFH property) since RFH has a license to have those checks done at their own property. Other parties, which do not have this license, must do the checks on the airport at a freight forwarder. In appendix C a more detailed overview is given on the customs process.

After customs, the sorted trolleys are taken to the unpackers (figure 4.5). They will unpack the boxes, cut the roses to the correct length and put the roses in a fust on water. These are re-usable deposit fusts. After use, the fusts are brought back to RFH, where they are cleaned and re-used. In these fusts, the roses are put on the auction through the Clock. This regards an online process where people all over the world can buy the roses. Next to the roses, all sorts of horticultural products are sold via the clock. More information on the Clock is discussed in chapter 3.1.

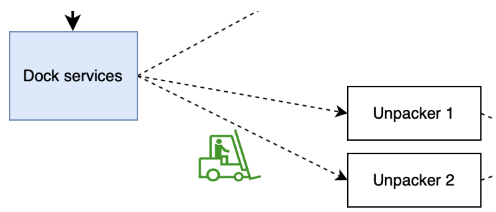

Figure 4.5: Third part of the current supply chain

During the auction the products are stored in cold stores. In the cold stores, all sorted products are on trolleys. An employee of RFH drives by the trolleys with an order-pick truck (see figure **??** to see what this looks like). During the auction, the employee grabs all the purchased products of one buyer and puts them on the trolley he is driving around with. When this trolley is full, or the complete order is collected, this trolley will be stored at the customer box, which is rented by the buyer and where the products can be collected. This process is called order-picking (figure 4.6).

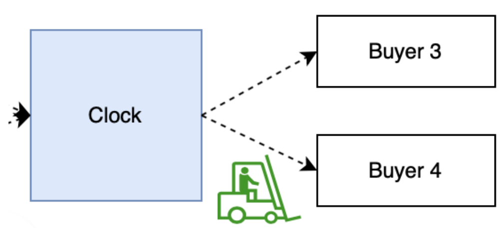

Figure 4.6: Fourth part of the current supply chain

4.1.2 Direct sales flow

Most physical parts are the same for the direct sale flow, yet there are some differences. First of all, the flowers are sold at the beginning of the process, that is when the roses are still at the growers in Kenya. When the roses are sold, the incoterms need to be discussed between grower and customer. It depends on the incoterms who is responsible for the transportation. According to expert 1 the most common incoterms for this process are CIF and FOB. For FOB the freight forwarder is chosen by the buyer. The grower takes the flowers to the freight forwarder with the same preparations as discussed for the clock sale. The responsibility for the grower ends when the roses are delivered at the freight forwarder. FOB could lead to multiple deliveries at different freight forwarders when different buyers choose different freight forwarders. The transportation to dock services is done in the same way as for the clock sale flow. From dock services the roses are necessarily going via unpackers, but directly to the buyers. Unless, the buyer wants the roses delivered on water. However, for direct sale it is possible that the roses are not going via dock services. The shipment will be checked at the freight forwarder to make sure the paperwork is okay and a phytosanitairy check will be done at the freight forwarder. Then the roses are directly shipped to the buyer, or stored at RFH where the buyer can collect the order. For CIF it is slightly different, since the grower is responsible for transport and insurance of the flowers all the way to the harbour/airport of destination. The freight forwarder is chosen by the grower and he will be held responsible for the roses during transport. So, when the roses are damaged during transport, the grower must ensure that the buyer is compensated. The rest of the process is handled the same as for FOB.

4.2 Detailed current supply chain

With the help of the schematic explanation a swimlane is made of the physical flow of the supply chain. A swimlane diagram gives the tasks per stakeholder. This is visualized by putting one stakeholder in one lane where all the tasks during the process will be listed. Figure 4.8 shows the swimlane of the current supply chain for the clock flow. In appendix B figure B.1 the direct flow is shown. The swimlane diagram shows all stakeholders which are physically present in the supply chain in the left bar. All stakeholders have there own lane with tasks. The rectangles are the tasks which are done and the arrows represents the order of the tasks over time. So the swimlane starts with the grower placing the roses in boxes and load them in trucks, and ends with the buyer picking up the roses in their customer box. This is also in line with the scope discussed in chapter 1.3. The red rectangles represent the handling moment on a box level or directly touching the roses. If a complete pallet, ULD or container is shipped it will not be counted as a handling moment where a quality loss takes place. So if the roses are touched directly, or if a box is touched, there will be risk to harm the quality of the roses. That occurs seven times during this process. For new designs it will be visualized the same way to compare the handling moments.

Next to the handling moments the degree hours are important to identify the quality of the roses. There are studies done on the first part of the supply chain (from grower to dock services) but there are no studies done on the rest of the supply chain. Therefore an estimation is made on the time and temperature per task, to have an amount of degree hours for that part of the supply chain. With the degree hours, the vase life can be estimated Voort et al. (2016). When the roses are cut they have an expected vase life of around 13 days (dependent on the type of rose). This is based on 20 degree Celsius of room temperature and 24 hours a day. So in total the amount of degree hours the rose start with is $13 * 20 * 24 = 6240$. When the degree hours of the total supply chain are subtracted from this number it will result in the vase life of the rose in degree hours. So the method used to calculate the vase life is: $StartingDegreehours - (FarmTemperature * FarmTime) - (TruckingTemperature * TravelTime) - (FFTemperature * FFTime) - (AirlineTemperature * AirlineTime) - (ConsigneeTemperature * ConsigneeTime) - (UnpackingTemperature * UnpackingTime) - (AuctionTemperature * AuctionTime)/(20 * 24)$ This calculation is also used in a later stadium for the new designs.

Research of Voort et al. (2016) shows the degree hours from grower to consignee. The average of the degree hours is given per part in table **??** which is derived from figure . For the supply chain of this research the consignee is the auction of RFH. This part is not considered in this measurement. So the degree hours of the auction and the unpacking process must be added to this total. The unpacking process per box does only take some minutes, but the roses are transported on a trolley, so the roses are kept in an are which is not cooled until the trolley is moved back to a cold store. On average this take 1 to 2 hours. The auction itself is currently done in cold stores. This will take around 3 to 5 hours at a temperature of around 4 degree Celsius. So the unpacking process and the auction combined give up to 60 degree hours. Adding the 60 degree hours to the found 505 degree hours will give a decrease in degree hours of 565.66 degree hours. $6240 - 565.66 = 5674.34$ degree hours vase life. This must be divided by 24 hours and by 20 degree Celsius, which results in a vase life of around 11.8 days. This is the vase life for the roses leaving the auction. This means the vase life will decrease by transportation to the wholesaler or retailer, where the roses must be stacked until they are sold. Afterwards the vase life decreases even more when the consumer buys the roses and brings it back to their home. Furthermore, this is a theoretical estimation of the vase life. When the roses are standing outside somewhere for a longer period than necessary, or if the roses are damaged in the boxes the vase life will be less.

Part	Degreehours [-]
I: Farm	55.5
II: Trucking	40.57
III: Freight forwarder	63.19
IV: Airline	173.06
V: Consignee	173.34
Total:	**505.66**

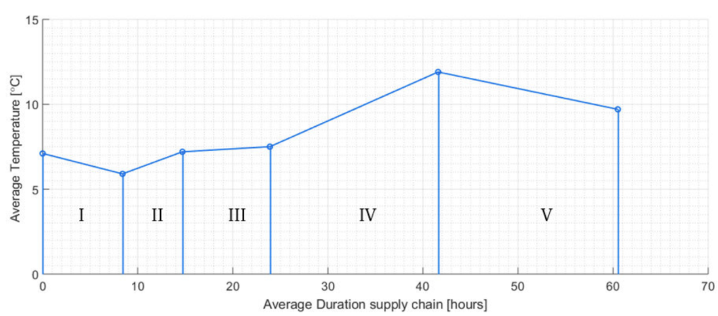

Figure 4.7: Average degree hours per part of the supply chain (Voort et al., 2016)

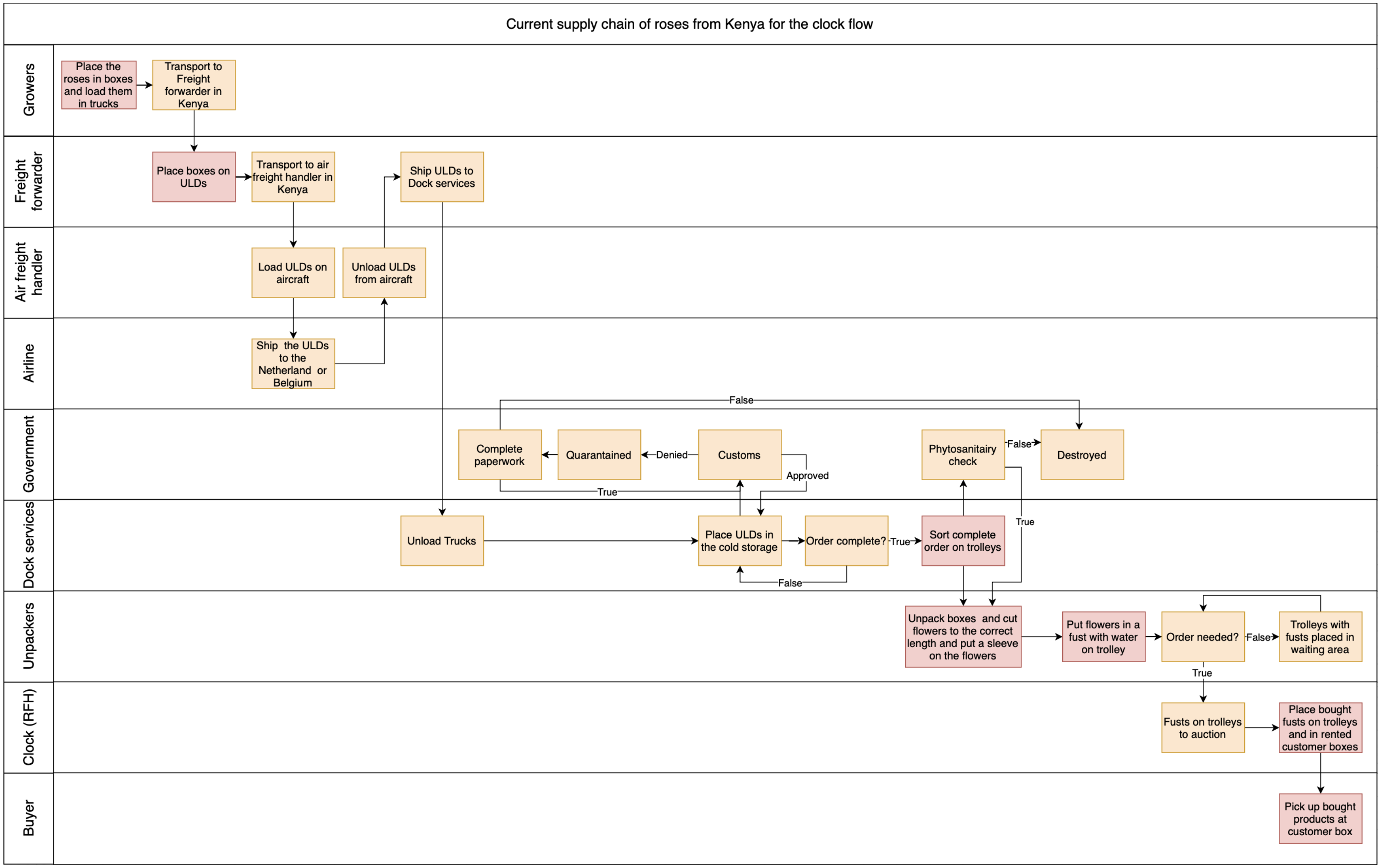

Figure 4.8: Swimlane diagram of the current supply chain of roses for the clock sale

4.3 Stakeholder analyses

A stakeholder analyses is done for the current supply chain. As can be seen in the previous section there are many actors participating in the whole process. This makes the opinion of the actors important to create a steady flow for the process. Furthermore, RFH is an cooperation which works together with all actors to create an efficient and reliable market place. For this reason it is important to create a clear overview of all stakeholders and their power and interest regarding sustainability. For a new design for the supply chain the stakeholders must agree and cooperate to keep the process streamlined.

For the stakeholder analyses of the supply chain of roses a standard format is used (this form can be seen in the appendix figure D.1). The vertical axis shows the power of the stakeholder, where the horizontal axis shows the interest in sustainability of the stakeholders. A stakeholder with much power, has much influence on changes in the supply chain. The diagram is divided in four combinations of interest and power. In the combinations each approach to the stakeholder is shown; stakeholders with low interest and low power should only be monitored. They do not have interest in the process, so they will probably not interfere. Also, they do not have any power to harm the process if they are not satisfied. On the other hand, stakeholders with high power and low interest must be kept satisfied. Since these stakeholders have high power they can easily change the process if they are not satisfied. Stakeholders with high interest and low power should be kept informed. They will interfere with the process, but will not have the power to harm it when not satisfied. Last, high power and high interest. These stakeholders should be managed closely. They are interfering in the process and can have influence on the process because of their power.

The stakeholders in this process can be divided in direct and indirect stakeholders. The direct stakeholders are directly involved in the process and the day-to-day activities. The indirect stakeholders focus on the final products and are not directly involved in the process. Activities they are interested in are pricing, packaging and availability (Minning, 2021).

The direct stakeholders are:

- Growers
- Freight forwarders
- Air freight handlers
- RFH dock services
- Dutch government
- Unpackers
- Airport
- Retailers
- Wholesaler

The indirect stakeholders are:

- Kenyan government
- RFH cooperation
- Customer
- Garbage processors
- Packaging suppliers

- Breeder

Figure 4.9 shows the complete image of the stakeholders. This figure is discussed with expert 3 and 4 to validate. The stakeholders in black are the direct stakeholders and in grey are the indirect stakeholders.

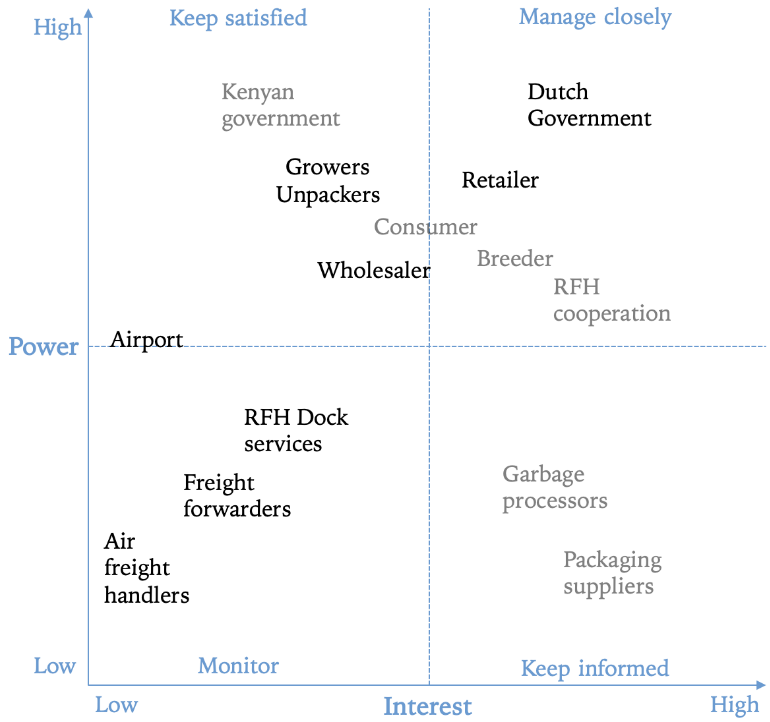

Figure 4.9: Stakeholder analyses of the supply chain of roses

Stakeholders with low interest and low power

First of all, the actors with low interest and low power. Air freight handlers are just loading and unloading the cargo in and out the aircraft. Sustainability is not in their interest. Also they do not have any power, since they do not have any influence on the whole process. Freight forwarders have some more power. They have a more important role in the supply chain. There are examples of freight forwarders who are interested in sustainability like Kuehne+Nagel, who has a project with zero carbon transport alternatives (Maass, 2022). However, these alternatives are only used when their customers want it, so the freight forwarders are dependent on the Growers or the buyers to choose the transport type. This explains why their power is low. Last in this area of low interest and low power is RFH dock services. Since their power and interest is partly strengthened by being part of a cooperation, they have more power and interest than the previously mentioned actors. As an individual actor they can make some proposals, but they do not have the power to push through.

Stakeholders with high interest and low power

Garbage processors and packaging suppliers are part of the group who should be kept informed. They have to deal with the choices made by the direct stakeholders. They have high interest in sustainability but do not have much power, to make changes in the process. For the package supplier, the choices made regarding sustainability are very important. The choices made regarding the material types and what kind of packages are asked for, will have great impact on their work. It is important to create a high quality sustainable package to make their customers happy and gain status. On the other hand, making re-usable products could lead to a decrease in the amount of work. The garbage processors are also dependent on the material choices. They have to handle the waste stream and recycle where possible. This activity could vary for different kinds of material. Both actors have interest in being informed to react on the choices that will be made.

Stakeholders with high power

The stakeholders with high power are considered as one group. The consumers are taken as reference point to place the other actors in the chart. The consumers have much power in the process, since they eventually are buying the products and need to be satisfied. If they demand any adjustments it is most likely to happen. Their interests are exactly in the middle of the chart. Since there are many consumers and all with different interest it balances out around the middle. One single consumer does not have the ability to make any difference and it is not possible to rate the interest of one consumer in the chart. Diversity of the consumers lead to the placement in the middle of the chart, when looking at interest. However, the larger the group of consumers with the same view on a specific topic, the more it will shift their placement to the right top with high power and high interest.

The consumers are directly connected to the retailers and wholesalers. The retailers have more power to make changes in the process. They will probably listen to demands of the consumers, but have the power to choose which consumers they are listening to and what decisions they eventually make. The retailers do have interest in sustainability, since they want to be future proof and they see an upcoming trend regarding the demand for sustainability. The wholesalers are a bit behind, regarding sustainability. Most of them are not working on sustainability yet. They are more concerned on what is happening now and less concerned on what is coming in the future. In addition, they are less prominent in the supply chain, making them less powerful than they could have been. The growers are similar to the retailers with regards to the power, only they do need to satisfy the demands of the retailers and wholesalers. There are some differences in interest, within the growers group. The interest of the growers in Kenya will be in accordance with the interest of the Kenyan government in combination with the needs of their buyers. According to the experts, the Kenyan government is not interested in sustainability as long as the profit is less than the costs in an economical point of view. However, the Kenyan government has much power to influence the process. If they for example forbid to use any kind of plastic, this demand needs to be met. In the case that the consumers have some interest in sustainability, the growers will probably be in the middle of those two, regarding interest. For the wholesalers and retailers this is almost the same. However, the Dutch government is more interested in sustainability. So, the retailers are in the middle of consumers and government regarding interest and the wholesalers will be there too in a couple of years, but at the moment they have less interest. As with the Kenyan government, the Dutch government has much power and can easily make a difference in the process.

The unpackers are also the agents of the growers which explains the high power of the unpackers. They interact a lot with the growers and many choices are discussed between them. The interest will also be the same as they have similar priorities. For the physical tasks of the unpackers, it could have impact to be more sustainable, dependent on the new packaging. This could make the unpacking tasks easier or more difficult, dependent on the changes. The airport does not have much interest in sustainability, since they provide what their costumer asks for. However, they do have power since there is not much choice to change the airport. If they do not agree with any part of the process, they have the power to stop the process and it will not be easy to solve. The breeder does have high interest and high power since they are the beginning of the whole process. They deliver the seeds to grow the roses. They have large interest in not using pesticides and deliver high quality flowers. However, this will be less power than the consumer, as they still need to deliver according to consumer demands. Last, RFH cooperation has much interest. As discussed in chapter 1.1, their vision is to evolve in sustainability. It is a cooperation of many growers, therefore it has the power to make changes. However, this should be discussed with the growers, and it will only happen if there is an agreement. This is the reason why they only have limited power, because they are dependent on other actors to be able to make changes.

4.4 Conclusion

In this chapter the first design activity is accomplished. The current situation regarding the supply chain of roses is analysed. For the current supply chain there are to flow types. The clock flow where the roses from Kenya are transported by air transport to the Netherlands. Here it arrives at RFH where the roses arrive at the auction. The roses are transported to the customer box where they are picked up. And second, the direct flow. This can either be via RFH, where the same process is has been completed, except for skipping the auction. Or directly from Kenya to the buyers destination. In order to have structure in the responsibilities, incoterms are used. The vase life of the current supply chain is decreased with 1.2 days with respect to the starting vase life when the roses are just cut. This excludes the period from RFH to the wholesaler/retailer and from the wholesaler/retailer to the consumer. In this period the vase life will decrease more.

Within the supply chain there are much actors involved. The interest for sustainability and the power of the stakeholder differ throughout the supply chain. The most powerful stakeholders are the government in both the Netherlands and Kenya, the growers, the unpackers, the retailers and the consumers. These actors form a triangle regarding the demands and the responses. These actors are directly connected which makes the cooperation important. Those actors will have control in changes and innovations in the supply chain.

Chapter 5

Define the design requirements

To gain knowledge on the definition of sustainability, it is researched what the definition of sustainability is according to literature and RFH. The combination of these definitions is used to create a definition for this project. This definition is used as a scope, to narrow down the different factors of sustainability. When a clear definition is stated, research is done on how to score the sustainability. This will be used to make a list of design requirements. The new design should meet these requirements. The requirements are divided in constraints and objectives which have been discussed with experts to validate. This chapter is performed in the developing ideas phase discussed in chapter 2 to fulfil the second design activity. With the list of requirements a frame will be formed for the final design.

5.1 Sustainability in literature

Sustainability is divided in three different pillars (Moldan, Janoušková, & Hák, 2012):

- Environmental is the most obvious one. The importance of environmental sustainability is growing. An example is the coalition agreement regarding the CO_2 reduction of 60 percent in the year 2030 (Klimaat en Energie, 2022). Other examples of environmental sustainability are: amount of plastic, energy consumption, usage of pesticides and many more.
- Economical is important when innovations are implemented. The costs of these innovations should be taken into account, whether these costs are not increasing over time and whether it will be realistic. For example, when a railway is manufactured to change the modality, the production costs as well as the cost decrease of using the railway instead of a different modality should be considered. Will it be realistic to eventually have a profit or is it not worth it to build the railway? On the other hand, if the railway is already there and only the modality is changed, it could be profitable.
- Social is a more difficult part of sustainability. Where economical and environmental are mostly in line, social is more an individual part. However, changes in the environmental and economical part can influence the social part. Examples of social sustainability are: a safe working environment, enough salary, enough food and drinks, enough rest and reasonable

working times.

Eventually, the goal of improving overall sustainability is achieved by reducing negative impact on the environmental part while at the same time make sure it will be profitable to sustain business and not harm the social aspects (Hermundsdottir & Aspelund, 2021).

To gain knowledge on the three different pillars of sustainability, a short literature research has been done. The research was done in different ways. First of all the literature given by RFH, which they used in earlier research on sustainability. Furthermore, backward snowballing is used from this research to see what articles are used to form this information. Next to these articles, google scholar has been used with the searching terms; 'What is sustainability', 'How is sustainability scored', Sustainability in supply chains' and 'Sustainability in the horticultural sector'. First the time restriction was set from 2020, and later this time period was left out when backward snowballing let to some interesting papers from the earlier periods. From each source the key aspects are discussed with the focus on sustainability.

Danatzko and Sezen (2011):
The engineering community has been working to create more environmentally friendly structures in an effort to use less energy and raw materials throughout the whole design process. Five sustainable structural design techniques are examined and discussed in this paper: Life-Cycle Analysis/Inventory/Assessment, Minimizing Embodied Energy, Minimizing Material Use, and Maximizing Structural System Reuse. In order to identify which, if any, of the proposed design techniques will result in the most sustainable structural designs, the purpose of this study is to define and resolve difficulties related to them. Since every design has problems of its own, no design is perfect on its own. More sustainable structural design concerns can be addressed by combining the features and design approaches mentioned in this paper than by using only one.

Jamwal, Agrawal, Sharma, Kumar, and Kumar (2021):
Sustainability has become a significant problem on the international market as a result of the growth of industrialization. Any organization that ignores sustainability issues experiences significant financial losses and harms its reputation in the market. Because of their robust infrastructure, industrialized economies have been able to sustain their industry sectors with the emergence of new technology. However, there is still room for improvement in emerging economies' adoption rates of sustainable practices. The findings showed that the primary drivers of sustainability obstacles in Industry 4.0 are supply chain and environmental enablers.

Middelburg (2021):
The transportation of fresh products must increase in sustainability. However, making the transportation for fresh products more sustainable is rather difficult. It is often time consuming and the amount arriving cooled containers is increasing in the port of Rotterdam. More and more products are imported from countries around the world. The question is, how long will it be tolerated to transport these products via air transport. Furthermore, the prices of air transport are increasing which makes it more interesting to look for alternatives. On the other hand, importing products is not per definition less sustainable. It can be beneficial regarding land use; the energy usage can be less because of more sun and the social aspect can be an advantage to provide work for residents. Switches in modality often results in less reliability and flexibility.

Janssen (2022):
An impartial quality label called "De Barometer Duurzame Bloemist" is used by florists to demonstrate the sustainability of their operations. Only florists who meet all the conditions are eligible to receive the certificate. The requirements are in six different themes: Sustainable product range: A minimum percentage of purchases must be made from sustainable sources. Waste separation and packaging: separating waste and collecting single-used packaging for recycling/processing. Sustainable energy and energy saving: Fully green energy must be employed by trademark holders. Environmentally friendly cleaning: no chlorine-containing and well stored products to prevent improper use, and no harmful fumes for humans. More environmentally friendly delivery and transportation: All transport vehicles must be equipped with at least a Euro 5 motor. Care for employees: Collective labor agreement for flower retail must be followed.

Epstein and Wisner (2001):
A strategic management tool called the balanced scorecard uses a variety of financial and nonfinancial performance variables to link performance measurement to strategy. KPIs are used to put sustainability strategies into practice. Environmental health and safety managers are able to discover the critical performance indicators that connect the work of their department to the strategic goals of the organization with the aid of the development of social and environmental balanced scorecard measures.

Fatima, Li, Ahmad, Jabeen, and Li (2021):
This study analyzes data gathered from a questionnaire survey using partial least squares-based structural equation modeling and multi-facet content analysis to identify key influences on the development of renewable energy generation (REG). The main impediments to REG growth are revealed to be a lack of strong administration, a lack of adaption to renewable energy sources, and national energy policy. The key factors influencing the development of REG are discovered to be endowed resources, power production methodology, renewable energy demand, investment environment for renewable energy projects, economic returns of renewable energy projects, environmental implications, and public acceptability. According to relative significance, environmental consequences are determined to be the least significant element, while a lack of good governance is revealed to be the most significant one. Additionally, it is discovered that public approval is one of the main factors influencing REG development. However, among significant hindrances, poor governance has demonstrated to have the biggest impact on REG development.

Groot, Westra, and Snels (2013):
A vast number of consumers in Europe and beyond receive fresh flowers thanks to the vibrant flower trade between Kenya and the Netherlands. In the long run, a transition from the air to the sea will be accomplished. Now, with a focus on - in the context of this study - CO2-emissions, optimize the supply chain, which at the moment (still) relies on air transport. Gaining knowledge of the CO2 emission chain from Kenya, through the Netherlands, to Poland is the aim. Route, aircraft, and capacity use may all change. The "Dutch Horticulture Carbon footprint protocol" is applied, and Wageningen UR Food & Biobased Research supplements are included. The majority of the CO2 emissions across the transportation system are caused by air travel. The answer to reducing emissions while maximizing capacity utilisation is to deploy newer planes. Producers, exporters, and importers have little sway over whether or not another aircraft is used. The conclusion of this research is: When

considering road transportation, the switch from "wet" to "dry" transportation is particularly beneficial. This is considerably more advantageous when flowers are 'double' bunched in flower boxes rather than'single' bunched.

Helmes et al. (2020):
The aim is to develop a system for measuring the environmental footprint of the horticultural industry. Consumer and retailer demand for horticultural products made with sustainability in mind is rising. All supply chain participants are increasingly requesting uniform, impartial, and fact-based footprint estimates for horticultural products. A product's sustainability, potential for improvement, and comparison to similar products can all be determined by computing a product's footprint using a set of 16 environmental impacts. Climate change, ozone depletion, particulate matter, ionizing radiation, photochemical ozone formation, acidification, eutrophication (terrestrial), eutrophication (fresh water), eutrophication (marine), ecotoxicity (fresh water), land use, water use, resource use (minerals and metals), and resource use (fossils). This project is still in the development phase.

Fisser (2021):
The objective of this research was to determine how to use Internet of Things (IoT) to raise the horticultural industry's sustainability potential. The horticultural industry has more sustainable potential with the use of IoT. IoT is typically used to automate operations and boost their effectiveness, but it can also aid the horticultural industry by reducing the number of resources required and raising productivity.

He, Li, Cao, and Li (2020):
Product sustainable design is the process of creating a product while considering its long-term social, economic, and environmental viability. As seen from the perspectives of the environment, the economy, and society, this paper analyzes the state of the art in product sustainable design approaches and tools. The three subjects are defined as: Environmental: design for environment methodologies and tools would enable products in a more environ-mentally friendly manner in the manufacturing. Economics: design methodology based on cost, assembly, manufacture and supply chain. Social: social design and social responsibility. Social intervention and social innovation.

Macdonald (2021):
The Vulnerable Supply Chain Facility (VSCF) provided funding for a 12-month project to examine the viability of shipping Kenyan flowers via sea freight to the UK and other parts of Europe. The project aimed to safeguard the livelihoods of flower farm workers, farmers, and suppliers while aiding the Kenyan flower industry in recovering from the severe loss of air freight delivery of flowers to Europe during COVID-19. Tests showed that sea freight could deliver flowers of a similar quality to those shipped by air, and subsequent research revealed that it was more affordable and reduced carbon emissions by 84 to 95%. The ability to use both air and sea freight boosts the adaptability and resilience of Kenyan flower farms, safeguarding the livelihoods and jobs of workers in the sector which is a social benefit. Besides it has economic benefits by saving money.

Hermundsdottir and Aspelund (2021):
This article's goal is to summarize the present body of knowledge on the connection between sustainability innovations and competitiveness as well as to pinpoint the contextual variables that influence and moderate this relationship. In order to determine whether and under what conditions there is a

positive relationship between sustainability innovations and business competitiveness, this study evaluates the methodology, industry, sustainability innovation terms and competitiveness variables.. According to the study's findings, the vast majority of studies discovered beneficial correlations. But this is a difficult procedure. Many businesses prioritize short-term earnings, which are frequently unsustainable, as a result of pressure from shareholders and intense competition in global marketplaces.

Moldan et al. (2012):
Three pillars make up sustainability (economic, social and environmental). The report examines the many methodologies and types of indicators created for the evaluation of environmental sustainability. Setting targets and then "measuring" the distance to a target to obtain the necessary data on the present condition or trend is one crucial part of this. Humanity must learn to adapt to the restrictions of the biophysical environment in order to benefit from and utilize the services throughout the years.

Dijkstra (2022):
Sea freight is an upcoming trend. Air transport prices are increasing, and the footprint of airfreight is higher than for sea transport. However, sea transport can be challenging. A single error could cause all the flowers to be rotten when they reach the harbor. Furthermore, there is no direct route from Kenya to the Netherlands. The flowers should be transferred from cargo vessel in the middle east, which is sensitive to congestion. Also, a global shortens in cargo vessels causes this mode of transportation to be less reliable. This year there are 300 containers shipped by sea transport. This resulted in saving money and lowering CO2 emission. Still, it is believed that flowers shipped by sea freight will be of inferior quality, and as a result, will sell for less money than flowers shipped by air. However, the flowers are cooled during the process in a container, which puts them to sleep. The quality is indistinguishable from the flowers transported by airfreight. It is concluded that sea freight is becoming more expensive. However, this won't be as expensive as air freight. Moreover, sustainability will become increasingly important. This can result in a demand for shipping flowers from Kenya to the Netherlands via sea freight.

Oudheusden (2019):
A collection of 14 benchmarked social and agricultural sustainability compliance requirements are now included in the FSI (Floriculture Sustainability Initiative) Basket of Standards. It serves as a tool for locating, evaluating, and promoting ethical suppliers of flowers and plants. The FSI basket is strengthened as a global standard for sustainable practices by this set of benchmarking criteria, which encourages the mainstreaming of environmental principles across compliance standards. 1. the adoption of standardized record keeping on key inputs; 2. the assurance of quality performance of standards and audits; 3. transparency and the comparison of performance over time and space

MPS driven by sustainability (2022):
The MPS Group facilitates horticultural entrepreneurs worldwide in their ambition to become more sustainable. At MPS they find a total package to make quality and sustainability transparent, to measure and to prove. For this, MPS creates cutting-edge (online) tools and certification programs that must adhere to the FSI.

In table 5.1 the list of resources is shown followed by the subjects on the three pillars as a summary of the literature research. For each source a '1' is placed if the source contains the subject. This gives an overview on what subjects are mentioned in literature and how often. Since this project focuses mostly on the environmental part, this part is split in more sub-parts. It is divided in the subjects emissions expressed in CO_2, amount of energy used in the total process, used materials and if they can be recycled/re-used, the product life cycle, the amount of waste and the amount of used pesticides. On the other hand economical and social sustainability are less in depth discussed and given as one subject. For economical it means the implementation costs are taken into account in combination with the time it takes to recoup the expenses. For social sustainability the working conditions are used as definition for this project.

Table 5.1: Literature review on sustainability

	Environmental						**Economical**	**Social**
Source	**CO_2**	***Energy usage***	***Materials***	***Product life cycle***	***Waste***	***Pesticides***	***Cost/time***	***Working conditions***
Danatzko and Sezen (2011)		1	1	1				
Jamwal et al. (2021)							1	
Middelburg (2021)	1						1	1
Janssen (2022)	1	1	1		1	1		1
Epstein and Wisner (2001)	1	1	1		1		1	1
Fatima et al. (2021)		1						
Groot et al. (2013)	1	1		1				
Helmes et al. (2020)	1	1	1	1	1	1		
Fisser (2021)		1	1				1	
He et al. (2020)	1		1				1	1
Macdonald (2021)	1						1	1
Hermundsdottir and Aspelund (2021)		1					1	1
Moldan et al. (2012)			1		1		1	1
Dijkstra (2022)	1							
Oudheusden (2019)	1	1	1			1		1
MPS driven by sustainability (2022)	1					1		1
	10	**9**	**8**	**3**	**4**	**4**	**8**	**9**

5.2 Sustainability in RFH

For RFH the three pillars of sustainability are comparable with the literature. They have the pillars, environmental, social and governance where they strive to balance the financial results with respect for people and environment. This is the same as Hermundsdottir and Aspelund (2021) state with the goal of improving overall sustainability.

In section 1.2 some achievements of RFH have already been discussed. It can be concluded that reducing CO_2 emission has high priority. Stated by the annual report of RFH, this is one of the four ambitions regarding sustainability. The others are, to be a reliable marketplace for sustainable certificated plants and flowers, circular use of raw materials, stimulation of green innovations with partners. These ambitions are formed with the help of the sustainable development goals of the United Nations. RFH is currently working on the four ambitions to improve the sustainability in the sector. To stimulate growers to be in possession of an environmental certificate, by guidance and simplifications in participation. Furthermore, a uniform calculation tool is formed to calculate the footprint of horticultural products. The goal of this tool is to create uniform standards for the complete sector, where the subjects differ from climate change to toxicity, water scarcity and land use. This tool is expected to be up and running in 2023. Second, a new design of a fust for cut flowers caused a reduction of raw materials. This re-usable fust not only created a reduction in waste but also a reduction of 5000 truck rides. Moreover, the packaging should be recycled for at least 70% and 20% less plastic should be used in 2025. (Royal FlorraHolland, 2021)

5.3 Sustainability for this design thesis

Overall the same goal holds as in Hermundsdottir and Aspelund (2021), reducing negative impact on the environmental part while at the same time make sure it will be profitable to sustain business and not harm the social aspects. For this project the main focus is environmental sustainability. However, in literature and for RFH, economical and social sustainability play an important role. Therefore, economical and social are taken into account, only with low priority. This means for economics that it is not calculated what the exact costs are, only in order of magnitude and if something is more or less expensive. For social it will be rated on, if the society is harmed or not. The question is, what parts of environmental sustainability are taken into account? For both literature and RFH, reducing emission is important for environmental sustainability, so this will also be an important part for this research. The emission consists of methane, nitrogen, particulate matter and carbon dioxide. These are the main emission factors for transportation together with the energy usage. In literature, energy usage is one of the most common subjects regarding sustainability (see table 5.1). It will not only be important what the amount of energy usage is, it will also be important what kind of energy is used. To make the energy usage sustainable, green energy must be used. Next, materials and waste can be combined. What materials are used and are they re-usable or recyclable? These characteristics will influence the waste cycle. Besides, this also is an important part regarding sustainability for RFH. Last, the product life cycle and pesticides can also be considered when focusing on materials and waste. With a higher product life cycle, there will be less waste and fewer flowers needed in total. And when there are no pesticides used, this will be less waste. However, both could be used as an objective in the requirement analyses, but do not have priority in this research.

In short, for this design thesis, sustainability is a mixture between not harming social parts, not making too expensive changes, but most of all being environmentally sustainable by reducing emission, using green/less energy and making re-usable/recyclable transport packaging with less raw materials.

5.4 How is sustainability scored?

There are two types of scores, quantitative and qualitative. In quantitative measurements numbers are used. For example the amount of CO_2 emission in kg. A qualitative score is based on words, so divided in gradation steps of high CO_2 emission, low CO_2 emission and medium amount of CO_2 emission.

The sustainability discussed in the previous section is divided in 5 KPIs. These categories are scored with different units and different scoring methods. Eventually an overall score needs to be calculated to compare the different designs. The KPIs are:

- Emission expressed in CO_2 equivalents

  - Transport
  - Energy usage
- Materials
  - Raw materials
  - Re-usable and recyclable materials
- Quality
- Economical sustainability
- Social sustainability

CO_2 equivalents

The general way to calculate the CO_2 emission by transport is to multiply the amount of fuel with the emission factor (Orvo Pels, 2022). However, this does not consider methane, nitrogen and particulate matter. To consider these substances, a more detailed calculation has to be done. According to the FSI (Oudheusden, 2019) methane and nitrogen can be converted to CO_2 equivalents with a multiplication factor of 25 and 298 respectively. One CO_2 equivalent is equal to the global warming potential (GWP) of one kg CO_2. Particulate matter is not included and does not have an emission factor to express particulate matter in CO_2 equivalents. Therefore it will be scored qualitatively for this project. Particulate matter can have direct impact on the human health and can pollute the environment. Hence, it is important to consider it and minimize the emission. Moreover, the energy usage should be taken into account. There is energy usage across the whole supply chain. All cold stores over the supply chain use much energy, during the transport the roses need to be cooled and all services for the supply chain make use of energy. Furthermore, energy can be used to power the different modalities. This energy can be gained in multiple ways. Possible resources can be solar panels, wind energy and grey energy. These types of energy can be converted to CO_2 emission equivalents. Lijst Emissiefactoren (2022) gives a list with emission factors for different types of fuel and energy. Converting energy to CO_2 equivalents makes it easy to compare in a quantitative matter. Except from particulate matter all transport and energy usage can be converted to CO_2 equivalents which gives a clear overview on the hot-spots regarding emission. Mapping these hot-spots will be important for creating the new design to make the largest differences regarding sustainability.

Materials

The sustainability in materials is scored qualitatively, since it is not realistic to have a quantitative score for a new box design. For a new box design all the consequences should be taken into account, which is a study on its own. For example, using 200 grams less on the cardboard box, can result in a lower quality box, which can result in lower quality roses or less possibility in stacking the boxes on a ULD. This will not be in the scope of this project. For this project there will be searched for new types of designs where it will be qualitatively scored on the requirements stated in chapter 5.5. With some larger changes, like a switch in material, or leaving some of the materials out, it will be possible to discuss the consequences of these changes. It will be important to see if the design is re-usable, if the materials can be recycled and if the design in made of recycled materials.

Quality

The quality is determined in the vase life of the rose and the appearance of the rose. For this research the appearance quality of the rose will be scored in number of handling moments/number of actions. The number of actions can be scaled in a qualitative manner, which is scale divided in the level of damaging the roses. All actions will decrease the quality of the rose, but not all actions cause the same damage. If the rose is directly touched it will harm the rose more than when the box of the rose is touched. A scale is used to determine the damage to the rose. The worst action will be directly touching the rose, followed by touching the boxes of the rose. Next moving an ULD and moving a complete container. Finally, the take off and landing of a plane and ship. Each handling moment is given on a scale of negative points per handling. So directly touching the roses once will give minus 5 points, which will be multiplied by the times the rose is directly touched. This gives an overview on how much the rose is damaged by handling moments. The vase life of the roses is dependent on the degree hours (see chapter 3.5 for information about the degree hours). The degree hours can be quantitatively scored. The lower the amount of degree hours the longer the vase life will be. And a longer vase life is the result of higher quality roses. Voort et al. (2016) gives a linear graph for the phase life against the degree hours. This graph can be used to see the exact difference in vase life for different degree hours.

Economical Sustainability

The economical part of the supply chain can be divided in four parts. With the help of experts and literature, assumptions will be made and key figures are used for the costs of each part. This way a quantitative score can be given from the right order of magnitude. The first part, is the production cost. For a new design it could be expensive to make changes in the supply chain. For example new infrastructure or new packaging designs will cost money. Second, the operating costs. It could be expensive to implement a new design, but safe a lot of money in operating costs. Or the other way around, where the operating costs are higher than the current operating costs. Third, the maintenance costs should be considered the same way as the operating costs. It is possible that the maintenance costs are much lower than the current situation which eventually safes much money. Those three costs (production, operating and maintenance) should be listed and compared to see the overall implementation cost for a new design. Finally, the time losses can be converted to money. Following the 'time is money' principle, all the saved time can save money, and all the lost time will cost money. For example, if the new design causes much more delay than the previous one, this could be expressed in money. All costs and savings together will present an overview on the economical sustainability of a new design.

Social Sustainability

Previously in this chapter, it is discussed that social sustainability does not have high priority for this project. However, it should be considered, since safety and working conditions are important for RFH Royal FlorraHolland (2021). They want to produce with respect for environment and human kind. For this thesis the social sustainability will be scored qualitatively. The new design should not harm the society by creating unsafe working conditions, but there are no numbers used to score the new design on a social level. Besides, it will not be the goal to improve the social level, therefore the weight factor for improving the social sustainability will be low.

5.5 List the design Requirements

For the new design a list with requirements has been formed. The requirements have been divided in constraints and objectives. The constraints must apply for the design and can not be part of a trade-off, while the objectives should ideally comply and can be part of a trade-off. Furthermore, they are both divided in functional and non-functional parts. Functional is a task, so something should do or has to do. Non-functional is a characteristic, so something should have or has to have.

The requirements are divided in four main subjects with the KPIs of chapter 5.4 in mind. These subjects are two functional constraints and two functional objectives. The functional constraints and the first functional objective are in line with the main goal of this research: A new design for the supply chain of roses from East-Africa which is more sustainable (1.2). The second functional objective is to make the new design resistant in the future, but this is not further elaborated in this project.

Main FC 1. The design has to be more environmentally sustainable than the current supply chain.
Main FC 2. The design must be feasible to implement.
Main FO 1. The quality of the roses should be as high as possible.
Main FO 2. The design should be future proof after implementation.

In table 5.2, for each subject a list with constraints and objectives has been made to accomplish the main constraints and objectives. In black the requirements have been formed by the author. The blue and red additions have been made after discussing the requirements with experts. Underneath the reasoning and references of the requirements have been stated.

For FC 1. most of the requirements have been formed with the definition of sustainability in chapter 5.3. The environmental sustainable parts (CO_2 emission, green energy, re-usable/recyclable materials, raw materials) are used to form the constraints and objectives. Furthermore, there are three requirements that provide insight. These requirements are formed based on the design methodology (chapter 2). The constraints and objectives are part of steps 6 and 8 in figure 2.3.

The first requirement of FC 2. is discussed in chapter 1.3. The implementation should be in 2030 to 2035, so it has to be feasible to implement the design in 10 years. The second requirement is based on chapter 2 step 11 of figure 2.3. The design must be validated by experts to improve the value of this project. The third and fourth requirements are based on the definition of sustainability. However, for this project they are only considered for the feasibility of the implementation and not discussed in depth and optimized. Last, it should be able to implement the design in other horticultural areas, since RFH is involved in many horticultural products. This project focuses on roses, however, the ambition of RFH (chapter 5.2) is to increase sustainability in all sectors and not only in roses.

FO 1. is completely based on chapter 3.5. The amount of actions, and the closed cooling cycle increase the quality. With an increase in quality the vase life will be increased. Since this is an objective and no constraint, the level of importance is lower than the function constraints 1 and 2. This results in trade-offs. The quality should be as high as possible, but not on all costs. This will further elaborated in chapter 6.5, where the new design is chosen and scored.

For Main FO 2. there is no list of requirements. As stated before, this objective will not be further elaborated in smaller sub requirements. Nevertheless, it will be an objective to make the design future proof after implementation. When the design is made it should be prevented that a new design has to be formed short after.

Table 5.2: List of requirements per main subject

FC 1: The design has to be more environmental sustainable than the current supply chain.
Possible environmental friendly design changes must be provided.
The process must provide insight in what design changes have the most impact on the environmental sustainability.
Green energy must be used. According to Europa Nu (2022) there should be an increase of 32%.
The process should provide insight in the level of environmental sustainability in comparison with other similar supply chains.
~~Chemical pesticides should not be used.~~ The design changes should not have negative impact on the use of pesticides.
The design should have recyclable or re-usable packaging as much as possible.
The design should have as little raw materials as possible.
The supply chain should be a closed circular system.
The efficiency in energy usage should be increased.
~~There has to be less CO_2 emission than the current situation.~~There has to be less CO_2 equivalents than the current supply chain.
FC 2: The design must be feasible to implement.
The design has to be physically feasible in the coming 10 years.
The feasibility of the design must be validated by experts.
~~The society should not be harmed.~~ The design should not have negative impact on the society.
The design should be economically feasible to implement.
It should be possible to implement the design in other horticultural areas.
The design should be technologically feasible to implement in the coming 10 years.
The design must be logistically feasible in the coming 10 years.
The design should be economically feasible to use.
FO 1: The quality of the roses should be as high as possible.
High quality roses with a minimum vase life of 7 days must be delivered.
The vase life should be increased to a minimum of 10 days.
~~The design should have a closed cooling cycle.~~ The amount of degree hours should be as small as possible.
The number of actions should be as small as possible.
FO 2: The design should be future proof after implementation. Implement a feedback loop

The list of requirements has been discussed with experts 3 and 5 to validate the requirements. This project is done in cooperation with RFH, so this validation makes sure the design meet their demand.

The blue text is the addition of expert 3. The overall comment was to make sure, which requirements can be measured and scored and which requirements are answered with a yes or a no. This resulted in the design should have recyclable and re-usable packaging as much as possible, instead of just having recyclable and re-usable packaging. Moreover, in the coming section it is discussed how the requirements are scored. Second, the requirement 'chemical pesticides should not be used' is changed in 'the design should not have negative impact on the use of pesticides'. Since pesticides are mostly used at the grower, it will not be in the scope of this project. However, in some cases the pesticides are used at arrival. The logistic differences could lead to more use of pesticides at arrival which should be prevented. The last addition for environmental sustainability is the requirement 'there must be less CO_2 equivalents than the current supply chain. This is a replacement for the decrease in CO_2 to consider nitrogen, methane and particulate matter in the requirements next to the CO_2. For the feasibility, the economical feasibility is split in feasibility to use the new design and feasibility to implement the new design. Moreover, the technological and logistics are added to the feasibility. Last, for the quality of roses, 'the design should have a closed cooling cycle' is changed to 'the amount of degree hours should be as small as possible'. This is done to make it possible to have quantitative measurements instead of a yes/no requirement.

The additions and comments of expert 5 are in red. The requirement: 'green energy must be used' must be specified. This is done by following the goals of the green deals of the European Union. Furthermore, two requirements are added. In the ideal situation the whole process is a closed circular system. All materials are re-used and there will be no losses. Also the efficiency of the process should be increased. For the quality of roses this is taken into account, but this will also increase the sustainability. The society should not be harmed was a vague statement. This is changed to: 'The design should not have negative impact on the society' which makes it a clear requirement. Last, to be future proof, a feedback loop could be implemented. This will create an up to date supply chain.

5.6 Constraints and objectives

All requirements are listed in the four types (FC, NFC, FO and NFO). Most of the requirements are based on the design. What must/should the design do and what must/should the design have. However, FC3 and FO3 are based on the process. In the final design it is not possible to see what changes have the most impact on sustainability and the level of sustainability compared to similar supply chains. These are researched during this project and can be seen in the process to the design. The rest of the requirements are divided on level of importance. Some objectives, like economical feasibility and pesticide usage, can be important for the overall supply chain, but they are less important for this project, since the scope is different. The requirements will be scored in a multi criteria analyses in chapter 6.5.

Functional constraints (FC):

FC 1. High quality roses with a minimum vase life of 7 days must be delivered.
FC 2. Possible environmental friendly design changes must be provided.
FC 3. The process must provide insight in which design changes have the most impact on the sustainability.
FC 4. Green energy must be used.
FC 5. The design must be logistically feasible in the coming 10 years.

Non-functional constraint (NFC):

NFC 1. The design has to be physically feasible in the coming 10 years.
NFC 2. The feasibility of the design must be validated by experts.
NFC 3. There has to be less CO_2 emission than the current situation.

NFC 4. There has to be less CO_2 equivalents than the current situation.

Functional objectives (FO):

FO 1. The design should be economically feasible to implement.
FO 2. The vase life should be increased to a minimum of 10 days.
FO 3. The process should provide insight in the level of sustainability in comparison with other similar supply chains.
FO 4. The design changes should not have negative impact on the use of pesticides.
FO 5. The number of actions should be as small as possible.
FO 6. It should be possible to implement the design in other horticultural areas.
FO 7. The supply chain should be a closed circular system.
FO 8. The efficiency in energy usage should be increased.
FO 9. The design should be technologically feasible to implement in the coming 10 years.
FO 10. The design should be economically feasible to use.

Non-functional objectives (NFO):

NFO 1. The design should not have negative impact on the society.
NFO 2. The amount of degree hours should be as small as possible.
NFO 3. The design should have recyclable or re-usable packaging as much as possible.
NFO 4. The design should have as little raw materials as possible.

5.7 Conclusion

To form a definition on sustainability for this project, a literature research is done. This is combined with the definition within RFH to make a definition for this thesis. In literature it was found that sustainability is divided in three pillars (environmental, economical and social). To improve the sustainability the negative impact on the environmental part needs to be reduced while being profitable to sustain business and not harm social aspects. For each pillar it is researched what aspects have influence. For RFH the pillars are comparable. The combination of important aspects within the pillars is taken to form a definition for this theses. For this design the focus will be on the environmental pillar where the emissions must be reduced, green or less energy should be used and make re-usable and recyclable packaging with less raw material. At the same time the alternatives should not be too expensive and the social parts should not be harmed. The scoring of sustainability will be done on five different subjects. The emission expressed in CO_2 equivalents, materials, quality, economical sustainability and social sustainability. Both qualitative and quantitative scores will be used for the final results. With this clear definition, a short list with four main requirements is formed, followed by a longer list of design requirements. The main requirements contain two functional constraints and two functional objectives. The first functional constraint is based on the main focus of this thesis, improving the environmental sustainability of the supply chain. The second focuses on the feasibility to implement the new design. The objectives are, improving the quality of the roses and make a future proof design. Each of these requirements are backed up with a list of objectives and constraints except for the fourth requirement (being future proof). This will not be scored, but will be considered in the discussion on the new design. The list of constraints and objectives is validated with two experts.

Additions and modifications are made to have a complete list which meets the demands of RFH. This is the result of the second design activity.

Chapter 6

Design alternatives

The third and fourth design activities are elaborated in this chapter. This chapter starts with research on a list of companies which are in the top ten of innovation regarding sustainable supply chains. With the help of this research and the knowledge gained during this thesis, a list of possible design alternatives is given which is divided in the following three parts.

- Transport modes
  - Grower to Kenya airport
  - Kenya to Europe
  - Europe to RFH
- Packaging
- Remaining supply chain modifications

These three parts are in line with the way the alternatives are scored, as discussed in section 5.4. The transport modes have direct impact on the emissions, the packaging has direct impact on the materials used and the quality and the remaining modification do not have direct impact on any of those. Most alternatives also have influence on the costs. The transport mode section is split in the three main transportation moments in the supply chain. Each of these three are discussed with corresponding design alternatives. Next the packaging is discussed in the same section. Most of the packaging alternatives have influence on the quality and alternatives to increase the quality often make use of changes in the packaging. Last, the remaining supply chain modification consists of scenario based advice, gaining and sharing information and stimulating environmental friendly changes. For all alternatives the advantages and disadvantages are given based on comparisons with the current supply chain. Thereafter, the design alternatives are combined to form five new designs. The designs consist of differences in transport modes, packaging alternatives and remaining modifications. After the combinations are made and the designs are formed, each alternative will be scored on 4 KPIs (emissions, costs, quality and material usage). This will give insight in whether all alternatives fit the goal of each design.

6.1 Companies with innovative sustainable supply chains

The companies discussed in this section are all in the top ten of most innovative companies with respect to sustainability, according to the 'supplychain digital' platform (Top 10: Innovative & ESG-friendly global supply chains, 2022).

The first company is UPS. The alternative fuel and cutting-edge technology fleet, or "rolling laboratory," as the firm calls it, is one of UPS's major undertakings. This includes electric cars and bikes with electric assistance, representing more than 10,000 vehicles worldwide. With the help of AI the route planning is optimized to be efficient and minimize used resources.

The environmental obligations of FedEx, one of the top logistics companies in the world, are an important component of the organization's international supply networks. Its activities have integrated ethical environmental practices that aim to increase productivity while reducing waste and emissions. In addition, it is pursuing a number of challenging climate-related goals. These goals must be reached by implementing zero emission vehicles and use automation to minimize paperwork in airway bills.

The Deutsche Post DHL Group has made significant efforts to improve its supply chain in accordance with strict social and environmental guidelines. One of many examples of the company's development is its 13,500-strong fleet of vehicles with alternative drive mechanisms powered by green energy and sustainable fuels. With efficient route planning the amount of emission is decreases. DHL also offers community action programs, training to individuals along the entire supply chain, and socio-economic assistance and development efforts across its facilities and suppliers to promote employment and fill gaps in skills.

Coca-Cola, the biggest beverage manufacturer in the world, relies on a decentralized supply chain that promotes agility, innovation, and flexibility. For example, its main bottler in Europe uses IoT-enabled technology like intelligent coolers that monitor and control temperature while collecting sales statistics. They also want to reduce waste by concentrating on recycling. All the used materials are 100% recyclable, and all bottles produced under one liter are made of 100% recycled plastic. This way they want to minimize single use plastic. Last they intend to improve the waste stream of other plastics, so these plastics can be used for manufacturing bottles.

Toyota, a Japanese automaker, has been openly incorporating ethical and environmental principles into its business processes since 1992, with a focus on promoting sustainable development globally through corporate social responsibility. This is demonstrated by its dedication to the Sustainable Development Goals set by the UN, which include reducing pollution and waste, enhancing water quality, and encouraging sustainable lifestyles, environmental management measures, and educational programs. Toyota is keen to minimize waste by recycling, decrease emission with improved fuel technology and share all their knowledge on how to do this in an efficient matter.

The supply chain of General motors is transparent and has dedicated initiatives for environmentally friendly innovation and safety regulations. It is recognized as a pioneer in the field of automotive sustainability and operates under the corporate philosophy of "zero crashes, zero emissions, and zero congestion." They use new and more sustainable materials, and are standing for a electric future. Their main focus is electric vehicles.

The Creating Shared Value strategy of Nestlé, the Swiss food and beverage multinational, promotes sustainability through collaborations with suppliers, environmental organizations, and other businesses. Examples of Nestlé's work include its Sustainable Agriculture Initiative and Caring for Water initiatives, which both encourage water conservation throughout its supply chain.

To conclude, the world's biggest brewer Ab InBev. The brewer participates in trade associations and organizations like the World Business Council for Sustainable Development, the World Economic Forum, the Beverage Industry Environmental Roundtable, the Climate Group, the Water Resources Group, and Sustainable Food Lab to strengthen its collaborative approach to sustainable development. Programs like smart agriculture, water stewardship, circular packaging, and climate action are all part of its supply chain sustainability initiatives. Furthermore, they intend to make the supply chain a more local supply chain where possible, to minimize transport distance.

6.2 Transport modes

For the current situation there are four main transport moments to ship the roses from the grower to the buyer. However, as stated in chapter 1.3, the transportation from RFH to the buyer is not considered for this thesis. The three remaining moments are discussed in chapter 4. These transport moments are called transport mode 1,2 and 3 in order to clarify. First, the transport from grower to the airport (1). Currently this is done by a diesel truck. It is loaded at the grower and unloaded at the airport. For the design alternatives it could be that the delivery destination is changing dependent on the alternatives for the second transport mode, from Kenya to Europe (2). For some of the alternatives it would be beneficial to change the delivery destination while for others, it will be more advantageous to transport the roses to the airport. This will be discussed per alternative. Last, the transportation from the airport to RFH is, just like in Kenya, done buy a diesel truck. The freight forwarder loads the truck at the airport and it will be unloaded at dock services in the RFH facility.

Possible changes in transport modes are:

- **Electrical truck.**
  An electrical truck can be powered with green energy, which results in less emission. Furthermore, according to Nijenhuis (2021), the usage cost of an electrical truck are less than for a diesel truck as well as the maintenance costs. In Kenya there are relatively many hours of sunshine during the year, so solar panels can be used to power the trucks. On the other hand, the charging infrastructure needs to be implemented which is expensive and time consuming. Also the purchasing costs of an electrical truck are very high. Eventually this is compensated with the lower usage costs, but this will take some years dependent on the time the truck is used. Last, compared to a diesel truck with one tank of fuel, an electric truck has a shorter range before needing to charge. For growers near the airport it does not have to be a problem, but for growers located at a larger distance, it will be time consuming to charge halfway. Besides, if the destination is somewhere else because of a switch in transport mode 2, the travel distance can be even further. It is possible that, the truck needs to charge multiple times per trip. There have to be enough charging options during this trip and these charging options need to be reliable. In Kenya it is not always reliable whether all electricity works despite the amount of sun to charge solar panels.

- **Truck with bio fuel.**
  For a change in fuel to biological fuel it will be important to have enough of the bio fuel available in Kenya. It is important to note that bio fuel is more costly than diesel. The cost per liter are higher and on average the consumption is slightly more per kilometer. On the other hand, the emission will be less which makes it more environmental friendly. For differences in travel distance it will not change. If the travel distance is longer, the costs will be higher and the total amount of emission will be lower.

- **Train.**
  The train is a cheap alternative for longer distances. Since the loading costs of a train are high it will not be beneficial to use the train for shorter distances (Visser, 2020). Next to that the purchase costs of a train are high. The maintenance costs are also slightly higher, but this is not much according to RSI Logistics (2020). Furthermore, building railways is expensive and time consuming. The railways can reach the port, but it will not be feasible to reach the growers by rail. There is transportation needed from the grower to the railway station which results in extra handling moments. On the other hand, it is possible to move a complete container on a truck, so the boxes are not touched. This gives more opportunities to have a complete closed cooling cycle, if the following transport mode is able to transport complete containers. To make this successful, the train must be capable of powering the containers. Otherwise the containers cannot be cooled. Besides, if all growers bring their products to a train station nearby the distance traveled by an individual truck is less. The train has higher capacity which makes it possible to transport the goods of multiple growers. This will result in higher peak moments at the port, but trains are less sensitive to congestion by other road users, so these peak moments can be predicted. Lastly, the emission of a train can be much lower than for trucks, because a train is more fuel efficient ("Freight Rail & Preserving the Environment", 2022).

- **Zeppelin.**
  The zeppelin has comparable advantages to the train. A zeppelin has more capacity than a truck. Again there is first mile transport needed, which also results in more growers transporting the roses with the same zeppelin. The difference is that for a zeppelin also the last mile transport is needed to bring the roses to the port. Or specific landing spots must be made at the port for the zeppelin. Either way, there are takeoff and landing spots needed for the zeppelin and these should be reachable by first and last mile transport. The bright side is the space needed is limited, since a zeppelin takes off vertically and is landing vertically. Using a zeppelin also results in less congestion by other traffic users, so it will be a predictable transport mode with zero emission. On the other hand it is a new transport mode for shipping products. So it will cost time to implement it and must be researched whether it is a save and efficient transport mode. There are still many uncertainties in using a zeppelin since it has not been used before, so it will be uncertain whether the theory is the same as the practice. Besides, purchase costs of a zeppelin are high.

- **Hyperloop.**
  An other new transport mode is the Hyperloop. This will even have more uncertainties regard-

ing the logistics, since it is a none existing transport mode. It is a difficult technology which will costs much time to have a working and save infrastructure. Also according to Stil and van Zoelen (2018) it will be very expensive to implement the hyperloop. On the other hand, it could be a solution to prevent congestion. With a new infrastructure in Kenya, the transport can be fast and with zero emission. Furthermore, there is no last mile transport needed, since it will be possible to end the infrastructure at the port. However, the freight forwarder must collect the shipment from the hyperloop and bring it to the cold stores. Also, first mile transport is needed to bring the roses from the growers to the hyperloop.

- **Solar train.**
  The use of a solar train will result in less emission. The train will be powered with solar panels which are directly coupled to the train network. This way the train can be directly powered by the solar panels. The energy does not need to be captured somewhere else which makes it an efficient process. Since the capacity of most batteries coupled to the solar panels is not large enough to save all energy generated by the panels, the expenses will be thrown away. If the train network is coupled, the excess energy can be used in the train network (Williams, 2017). However, this alternative is still in the development phase since the prices for battery supply and solar panels are dropping. In order to use the energy, a centralised power supply is needed to distribute the energy around the network, and there is a bias towards large scale infrastructure which makes it difficult to find a big energy supplier who is willing to start this. Furthermore, a dependable supply is needed in case there is not enough energy generated to power the train. This is to make the transport mode more reliable.

In table 6.1 all alternatives of transport mode 1 are listed with the pros and cons per alternative. This gives an overview which can be used to make a new possible design in chapter 6.5.

Table 6.1: Alternative for the transport from grower to the airport (1) with pros and cons

Grower to airport (1)	PRO	CON
Electrical truck	Can be green renewable energy Less emission Low costs for usage	Loading infrastructure needs to be implemented Possible travel distance is lower High purchase costs
Truck with bio fuel	Less emission	Usage costs are higher Fuel must be available
Train	Less emission More possibilities to make a closed cooling cycle Possibility to transport products of different growers Low costs for usage More capacity Less congestion by other traffic users	High purchase costs Cooling system must be installed in the trains More infrastructure for train needed Higher peak moments at airport Still first mile transport needed Higher maintenance costs
Zeppelin	Possibility to transport products of different growers More capacity Less congestion by other traffic users Zero emission	Space needed as post and for takeoff and landing High purchase costs Still first and last mile transport needed New transport mode for shipping products Lots of uncertainties
Hyperloop	Less emission No last mile transport needed Less congestion	High purchase costs New difficult technology Non existing infrastructure Lots of uncertainties regarding logistics First mile transport needed
Solar train	Less emission Directly powered Possibility to use excess energy	Still in the development phase Dependable supply needed Centralised power supply

As discussed for the alternatives for the first transport moment (from Grower to airport (1)), the outcome of the second alternative has influence on the other alternatives. For the first transport mode, the destination of the transport will be determined by the transport mode chosen for the second transport mode. Furthermore, the third transport mode will start from the destination of the second transport mode. For example, when the second transport mode is an airport, it will also arrive at an airport in Europe, so the last transport mode must transport the roses from the airport to RFH. But, if the second transport mode is a boat, the shipping will be from and to a harbour instead of an airport. This will have influence on all transport modes where the second is most dominant.

Design alternatives for the second transport mode are:

- **Boat.**
  Using the boat instead of an airplane is an existing process. It is done within RFH which makes it a feasible alternative to implement more. The boat generates less emission than an airplane and makes it easier to have a closed cooling cycle. On a boat the complete container can be loaded, so the roses do not have to be shifted from transport packaging. Besides, this makes the logistics for multi modal transport easier. A bottle neck is the transport time, which is much longer than for an airplane. This makes the boat sensitive for errors (Dijkstra, 2022). If the

cooling system does not function as expected the flowers will arrive RFH with a low quality or rotten. Furthermore, there will be larger peak moment. Since it is possible to transport more roses at the same time when using the boat, there are more roses arriving at the same time. This can cause difficulties in the logistics. However, currently there is about one shipment per week with 10 to 15 containers per shipment. This is not a large peak, but when the amount of containers increases, it will become a larger peak. Last, currently there is no direct route from Kenya to Europe. The vessel must be emptied in Saudi Arabia before the roses can be transferred to another boat that will transport them to Europe. This is a time consuming process.

- **Electrical airplane.**
  A different way of transporting the roses by air is the use of an electrical airplane. Currently this is not yet in use. That is why the electrical plane has many uncertainties. It is a difficult technology to deliver enough power while having light weighted batteries. This is the main bottle neck. If the batteries are larger to produce enough power, the weight will increase, so the batteries need to be even larger to compensate for the weight (Shell, 2022). However, it is announced that in 2026 the first electrical passenger flight is deployed (Bogle, 2022). But this will be a small passenger flight, which has less weight than a cargo flight. It will be a difficult process to increase the capacity of an electrical airplane. On the bright side, an electrical airplane has low costs for usage and the emission will be much lower than for a normal airplane.

- **Airplane with bio kerosene.**
  An alternative to the current airplane, an airplane with bio kerosene can be used. Bio kerosene can be used in the same airplane (Maï, 2021), but the bio fuel is not always available. This can make it difficult to implement. In order to make it a feasible solution, the availability must be reliable. Furthermore, the costs of bio kerosene are higher. But according to Maï (2021) the emission caused by the transport are much lower. When bio kerosene is used it is important to make sure the fuel is produced in a green way. Otherwise the production can cause even more pollution than using it.

- **Train.**
  As stated in the transport from grower to port, the train is a cheap transport mode to use. The emission is low and it can be easier to make a closed cooling cycle. However, if the train will be used to ship the roses from Kenya to Europe there are some different bottle necks. The train cannot pass the Mediterranean or the Red Sea, so it has to travel by land only. This makes the travel distance and travel time longer. Furthermore, there are many countries the train needs to cross. Different countries have different types of railway. A train does not fit on all types of railway, which makes it difficult to pass a border. The train needs to be unloaded to load a different train which can travel on the other type of railway. This is time consuming and brings large costs with it. Furthermore, the railways are not connected from Kenya to Europe. So new infrastructure needs to be implemented.

- **Zeppelin.**
  Similar to the train, the zeppelin is also discussed in the transport modes from grower to port. The advantages are fewer since the capacity of an airplane is larger than a truck, so the advan-

tage in capacity does not hold. In fact, the capacity of a zeppelin is lower than the airplane, which is a disadvantage. Furthermore, an airplane is also not sensitive to congestion by other traffic, so again this is not an advantage compared to the current situation. The reduction in emission is the benefit that applies to both situations. A zeppelin is a zero-emission transportation mode which significantly reduces emissions. The disadvantages discussed in the previous section are the same as for the transport mode from Kenya to Europe.

- **Hydrogen boat.**
  According to Balch (2019), there is a ship completely powered by hydrogen which is extracted from the sea. There always will be enough fuel and the engine is powered directly, which makes it an efficient process. Furthermore, it traveled with zero emission. However, this project is still in the development phase. In theory the boat has unlimited fuel and zero emission always, but it is a new technology with many uncertainties.

In table 6.2 all alternatives of transport mode 2 are listed with the pros and cons per alternative. This gives an overview which can be used to make a new possible design in chapter 6.5.

Table 6.2: Alternative for the transport from Kenya to Europe (2) with pros and cons

Kenya to Europe (2)	**PRO**	**CON**
Boat	Less emission Good logistics for multi modal transport More possibilities to make a closed cooling cycle Existing process Large capacity	Longer travel time Larger peak moments at arrival No direct shipping route Sensitive for errors
Electrical airplane	Less emission Low costs for usage	New difficult technology Lots of uncertainties Difficult to transport much weight
Airplane with bio kerosene	Less emission	Usage costs are higher Fuel must be available
Train	Less emission More possibilities to make a closed cooling cycle Low costs for usage	Many border crossings Longer travel time
Zeppelin	Zero emission	Space needed as post and for takeoff and landing High purchase costs Less capacity New transport mode for shipping products Lots of uncertainties
Hydrogen boat	Zero emission Always enough fuel Directly powered	Still in the development phase New difficult technology Lots of uncertainties

For the last transport mode, it will be dependent where in Europe the roses will be transported from. Currently the roses mostly arrive in Belgium and the Netherlands and sometimes in France or Germany. These are located relatively close to RFH. The most sustainable mode of transportation will change if the arrival varies as a result of design changes. The differences will be discussed per alternative in the list underneath:

- **Train.**
  The train can be used if the roses are transported to a different country than the Netherlands. If the roses arrive at the Netherlands the costs of the train will be too high. The train is not beneficial for short distances as discussed in the previous section (from grower to port). Furthermore, last mile transport is needed or a new railway network which reaches the facilities of RFH. For arrival outside the Netherlands the train will be cheaper. The usage costs are low and the emission will be less than for a diesel truck. Furthermore, it is a faster transport mode which is less sensitive to congestion by other traffic. Also as previously discussed, the train can bring possibilities to have a closed cooling cycle. On the other hand, the installation to power the containers must be installed. Also, an increase in travel time can occur when the train is crossing borders with different type of railway. As previously discussed in the section of Kenya to Europe, a train cannot drive on all types of railway. So when the type of railway changes, the train also has to change, which costs time and money.

- **Electrical truck.**
  One of the main disadvantages of an electrical truck is the shortage in travel distance. For this reason, it will not be ideal if the roses arrive in a different country than the Netherlands or a neighboring country. If the arrival is at a different country, the load infrastructure must be optimized to make sure the trucks are able to load during their trip to the Netherlands. In the Netherlands the load infrastructure is good. This encourages the use of electrical trucks in the Netherlands. An other bottle neck can be the purchase costs. These are higher than a diesel truck. However, the costs will be recovered with the low usage costs. So it will be a large investment, but in the end it will be beneficial. Furthermore, the energy can be green which results in zero or low emission.

- **Truck with bio fuel.**
  For the truck on bio fuel the same disadvantages and advantages hold as for the transportation from grower to the port. The only difference is, the availability of bio fuel. In the Netherlands there are more developments with bio fuel, which makes it easier to obtain.

- **Hyperloop.**
  The pros and downsides of the hyperloop are the same as those of the grower to the port. The distance makes a difference. Considering that it is not yet in place, the infrastructure needs to be developed. As a result, the cost of implementation increases with each additional kilometer. Therefore, it will be even more expensive to transport the roses to RFH from countries other than the Netherlands.

- **Electrical airplane.**
  This alternative is only feasible if the roses arrive in other countries than the Netherlands. Then the use of an airplane can be faster and more efficient. With short distances it will be not efficient at all. Otherwise the pros and cons will remain the same as for the transportation

from Kenya to Europe.

- **Airplane with bio kerosene.**
  Again the airplane will only be feasible for transportation from elsewhere in Europe to RFH. Also the advantages and disadvantages are the same as the previous part, form Kenya to Europe.

- **Solar train.**
  The solar train is, just like the normal train, expensive for short distance and cheaper for longer distances. So for transportation from Schiphol airport or Rotterdam harbor to RFH the train will be expensive, but for longer distances it can be a cheap alternative. The same disadvantages apply for the solar train regarding border crossing. With different railway types there will be logistical problems, which are time consuming. The rest of the pros and cons are the same as discussed in the section grower to port in Kenya.

In table 6.3 all alternatives of transport mode 3 are listed with the pros and cons per alternative. This gives an overview which can be used to make a new possible design in chapter 6.5.

Table 6.3: Alternatives for the transport from Europe to RFH (3) with pros and cons

Europe to RFH (3)	PRO	CON
Train	Less emission More possibilities to make a closed cooling cycle Faster Low costs for usage Less congestion by other traffic users	Longer time when the roses arrive in the Netherlands Railway needed between RFH and arrival places of the roses Railway differences for different countries in Europe Cooling system must be installed in the trains Higher maintenance costs
Electrical truck	Can be green renewable energy Less emission Low costs for usage	High purchase costs Possible travel distance is lower
Truck with bio fuel	Less emission	Usage costs are higher Fuel must be available
Hyperloop	Less emission More capacity Less congestion	High purchase costs New difficult technology Non existing infrastructure Lots of uncertainties
Electrical airplane	Can be faster Low costs for usage	Can only be useful when the roses arrive somewhere else in Europe Last mile transport needed New difficult technology High purchase costs Lots of uncertainties
Airplane with bio kerosene	Can be faster	Usage costs are higher Can only be useful when the roses arrive somewhere else in Europe Last mile transport needed Fuel must be available
Solar train	Less emission Directly powered Possibility to use excess energy	Still in the development phase Dependable supply needed Centralised power supply Expensive. Railway differences for different countries in Europe

6.3 Packaging

The design alternatives regarding packaging have direct impact on the material usage and the quality of the roses. Most of the alternatives are changes in packaging with as a result a change in quality or a reduction in material. A difference in packaging results in more or less protection of the flowers, and mostly has a difference in the amount or type of material used. Furthermore, a difference in air permeability can influence the quality of the roses.

The possible alternatives to implement are:

- **Palletising.**
  Palletising will be done at the growers. Here the boxes are placed on pallet which moves through the supply chain until dock services. The boxes are efficiently stacked on the pallet and the pallet is generalized for the ULDs to have an efficient fit. It can be possible to realise a pallet which can be used to replace the current ULD to make a general transport system for all transport modes. Palletising will decrease the handling moments, since a complete pallet is moved instead of all boxes one by one. Furthermore, the boxes are not directly touched, but the pallet is touched. This will result in less quality loss. It will be important to create a pallet that works efficiently and fits on all ULDs, which can be challenging to do. Also, the boxes must have an efficient fit on the pallets. Only when the measurements of the boxes and the pallets are synchronised with the ULDs it will be an beneficial alternative. Furthermore, the pallets need to be handled by a forklift truck. Not all growers posses a forklift truck and not everybody can drive a forklift truck. Last, the pallets must be transported back to Kenya or in Kenya a pallet manufacturer is needed.

- **Tunnel between cold stores.**
  Currently the switch between transport modes, and the transport between cold stores and transport mode are done without having the roses cooled. This can be prevented by having a tunnel which connects the cold stores and the transport mode or the different transport modes. The moment the roses are not cooled the degree hours will increase faster which results in lower quality. If a cooled tunnel, or isolated tunnel is added, the total amount of degree hours will be lower. The downside of the tunnel will be the limited space available. The tunnel must be placed in limited space between cold stores and transport mode. Furthermore, the distance must be bridged between the different locations. After using the tunnel it must be stalled somewhere and when the tunnel is used it has to be cooled directly to have any effect. It can cost time to cool the tunnel which will be inefficiently if it is used in different time spans. Last the purchase costs will be high for a specific tunnel. It is not determined who owns these tunnels since it is a functioning between different stakeholders. This makes it also difficult to determine who is responsible for the costs and the stalling.

- **Cooled ULD**
  When the ULDs are cooled, the flowers will be cooled during the transportation between freight forwarder and airplane. Furthermore, when it is possible to have a ULD loaded from the grower to the auction, the flowers will be cooled during the whole supply chain. Also, the degree hours are easier to track. The cooled ULD can be regulated to a certain temperature.

This way there will be no temperature changes, so only the time needs to be measured. It will be difficult to have a ULD that can be used during the complete supply chain. Also, it will be expensive to charge and purchase single ULDs that regulate temperature.

- **One ULD fits all transport modes.**
As an addition on the previous alternative, it will be beneficial to have one ULD that fits all different transport modes. This way it will be easier to switch between transport modes and it will decrease the amount of times the boxes are touched, since the complete ULD is moved from grower to dock services. Also, it will make adjustments to the ULD more beneficial, as it can be used during the complete transportation process. On the other hand, a ULD is manufactured to be efficient for a specific transport mode. It will be difficult to have one type of ULD which is efficient for all different transport modes.

- **Controlled atmosphere (in a container)**
According to Rikken and Hulst (2013), a controlled atmosphere in the container results in a longer vase life. The systems accurately regulate the quantities of oxygen and carbon dioxide in containers using membrane technology. This creates an optimal condition in the containers, but only if the products in the container all need the same circumstances. If there are different products in one container and not all desire the same conditions, the controlled atmosphere will not work. Furthermore, the costs are high to implement this advanced technology. Also, not all transport modes use containers to ship the products. This makes it not feasible for all transport modes to implement.

- **Modified atmosphere packing.**
Unlike the controlled atmosphere, a modified atmosphere packing can be used in all transport modes. It is the same technique only on smaller scale (Rikken & Hulst, 2013). This makes it possible to regulate the conditions per box, which creates perfect environment for each product. Furthermore, this box will be re-usable to transport roses in. The downside of this, the boxes have to be transported back to Kenya to re-use. This will bring extra costs and emission for transport. Besides, there should be high deposit costs on the boxes, because the buyers need to bring the boxes back if a closed system is used until the roses reach the buyer. Otherwise the boxes are unpacked at the unpackers and need to be returned from there. But this will be more difficult for direct sale where the boxes are not going via the unpackers. Last, the same holds as for the controlled atmosphere in a container, the new technology is expensive. And for the modified atmosphere packing it will even more expensive, because the technology needs to be installed for all boxes instead of a container.

- **No sleeves on roses.**
After unpacking the roses, a plastic sleeve is placed on the roses as a protection for damaging and for an advertisement print. Without a sleeve the roses will be protected less and the growers are not able to print an advertisement on the roses anymore. Furthermore, the sleeves protect the buyers against the thorns of the roses. Without a sleeve there will be no protection against the thorns. On the bright side, there is less plastic used in the process. This will have a positive influence on the waste stream and less plastic needs to be produced. Also, less weight

needs to be transported to the buyer. Which has the most impact on bought roses abroad, where the roses are transported by air again. Last there will be one handling less, saving time and reducing the number of times the flowers are touched.

- **Smaller sleeves on the roses.**
  Another alternative could be to use smaller sleeves instead of no sleeves at all. This way the most fragile parts of the roses are protected. This way there is still less plastic used as for the current situation which results in less weight to be transported. However, it is still less protection than the current situation and the possibility to advertise is less.

- **Smaller boxes for direct sale.**
  For direct sale, the boxes can directly be transported to the buyer after the custom and phytosanitairy checks, if a complete box is bought by the buyer. When the buyer did not order a complete box, the box needs to be unpacked and put in a package to transport the roses. This can be a fust, if the buyer wants the roses on water, or a smaller box. If the roses are put in a smaller box before transport from Kenya, the unpacking step can be skipped. The roses can directly be transported to the buyer, which saves time, handling moments and waste. Furthermore, it can save money for the buyer, since the roses will not be unpacked in a different transport packaging. On the other hand, it will be less efficient to transport the roses. The rose-package ratio is worse with smaller boxes. Which makes it more expensive per rose, since the weight per rose is higher and the amount of carton per rose is higher. Also, it will be less efficient to load the boxes if different box sizes are used. This can be prevented if the boxes are in scale with the general boxes. For example, if a smaller box is exactly two times smaller, this will not give any difficulties with loading the airplane. This is already done by some growers in Kenya, which indicates it is a feasible alternative to implement. What must be considered is the amount of buyers that want the roses delivered in a box. If most of the buyers want their roses in a fust, this alternative will not be beneficial.

- **Folding/re-usable packaging.**
  With a high quality folding box, the box can be used multiple times. This decreases the amount of material used in the supply chain, since less boxes have to be produced. Furthermore, with a re-usable box it will be easier to generalize the boxes in the supply chain. It can be utilized as the standard box in the supply chain with a new design and an implementation strategy. Yet, due to the improved quality of the reused boxes, it will be more expensive than the present boxes. When production costs are too high, it can be challenging to implement. Reusable packaging use has the additional drawback of requiring shipping of the boxes back to Kenya. The boxes must be imported which will be challenging since all boxes must be transported back to the growers. This brings transportation costs and time. Furthermore, the inventory of boxes must be high, since it must be compensated that the outgoing stream of boxes will be larger than the incoming stream. Besides, the weight of the packaging will be higher which also causes an increase in costs.

- **Smart plastic construction.**
  The construction of plastic has influence on how easy it is to recycle. According to Balch (2019)

a smart construction with a similar construction can be produced which is easier to recycle. However, this is still in the developing phase, which makes it uncertain if the characteristics match the current plastics. Research has to be done on what characteristic are necessary and if the smart plastic can meet this constraints. Furthermore, the productions of smart plastic will be more expensive than the current plastic.

- **Nanotech packaging.**
  An other type of packaging which is still in the developing phase is nanotech plastic. Procurious HQ (2021) is talking about a colour changing package for food, which changes from colour when the food is starting to rot. This can also be used for the flowers to know when they start to rot. It changes colour when the temperature is changing, which makes it easier to check if the roses are on the correct temperature. Furthermore, it can indicate types of bacteria. So when the packages stay closed, the customer can be secured of a high quality rose in the package. This saves time with checking all roses. The downside is, it is not in use yet, and there are many uncertainties if it is feasible to implement.

- **Bio plastics.**
  Bioplastics have a similar feel to plastic but are made from biomass sources that are replenishable and easily accessible, like milk, wheat, and beef protein. Iverson (2022) claims that the boiling method used to create the package skin reduces air pollution. Most critically, the burden brought on by increased greenhouse gas emissions is reduced by the absence of synthetic plastics. Furthermore, waste materials can be used for a biological plastic. The downside is that not all bio plastics are biodegradable.

- **Soy ink.**
  To increase the recyclability of plastic, the ink used for advertisement on the sleeves can be replaced by soy ink. According to Iverson (2022) inks made from soy and vegetables don't release dangerous organic chemicals that could harm both the environment and people. Furthermore, it will be cheaper to use soy ink than normal ink. But, the use of soy ink is not yet in use. This makes it uncertain what the quality will be under different conditions.

- **Edible packaging.**
  In the food industry they started with edible packaging (Iverson, 2022). When the packaging is edible, there will be no waste stream. It is a complete biodegradable packaging which ends with the human body. For roses it will be more difficult to implement. First of all, to make the boxes edible, makes the amount of edible packaging enormous. This will not be eaten during the process, so there must be a different stream for the edible boxes to transport them to places where they can be eaten. Furthermore, the roses can bring bacteria which can make the boxes unhealthy to eat. Last, a minimum quality is demanded. The packaging should hold during the complete transportation from Kenya to the buyer. With edible packaging the quality of the packaging is not secured. On the other hand, the edible packaging could also be used for the sleeves on the roses. This way when roses are bought by a consumer, they also have something to eat. Again it has to be secured that the packaging will not be unhealthy due to the conditions the roses have to be in and the possible bacteria.

- **Use of IoT at packaging.**
  Internet of Things in packaging is a promising innovation for the future. However, it is in the developing phase which makes the possibilities uncertain. Also, it is a technology which can be difficult to implement throughout the whole system. Advantages of IoT are the promising possibilities for the future. With the help of IoT the temperature can be tracked and moderated and combined with other packaging innovations, the conditions in the packaging can be completely optimised.

In table 6.4 all alternatives are listed with the pros and cons per alternative. This gives an overview which can be used to make a new possible design in chapter 6.5.

Table 6.4: Packaging alternatives with pros and cons

Packaging	PRO	CON
Palletising	The boxes are touched less Less handling moments if a complete pallet is moved Possibility to make a ULD of a pallet for all transport modes	The pallets must fit on all ULDs of different transport modes The boxes must have an efficient fit on the pallet Forklift truck handling is required Pallets are needed in Kenya
Tunnel between cold stores	Less degree hours (less exposure to heat)	Limited space available Must be cooled in a peak moment Possible high purchase costs The ownership of these tunnels must be determined
Cooled ULD	Flowers are always cooled Easier to track and regulate temperature	Universal ULD needed Possible high purchase costs
One ULD fits all transport modes	Easy switch between transport modes The boxes are touched less	Difference in efficiency per transport mode
Controlled atmosphere (in containers)	Vase life will be higher Optimal condition for roses	Advanced technology Not available on all transport modes Expensive With multiple products the optimal conditions can differ
Modified atmosphere packing	Perfect condition for each type of product in the package Transport on box level will be under good conditions The boxes will be re-usable	Expensive Advanced technology Boxes must be transported to Kenya after using them Deposit costs must be extremely high
No sleeves on roses	Less plastic used One handling less Less weight	Roses are less protected against damage No protection against thorns No possibility to advertise on the sleeves
Smaller sleeve on the roses	Less plastic Less weight	Less protection (against thorns) Possibility of advertisement on the sleeve is less
Smaller boxes for direct sale	These boxes can be transported immediately to the buyer	Less efficient when different box sizes are used Smaller boxes is less efficient regarding material usage
Folding/re-usable box	Less material used Possibility to generalize all boxes	Boxes must be transported back to Kenya Manufacturing costs are higher for re-usable boxes Weight will be larger for more high quality boxes Large inventory necessary
Smart plastic construction	Easier to recycle	More expensive Uncertain if it has the same characteristics
Nanotech packaging	Saves time Provides security to customers Can indicate temperature changes Can indicate bacteria	Lots of uncertainties Still in the development phase
Bio plastics	Much possible raw materials Can use materials which are waste Less emission during production	Not all bio plastics are biodegradable
Soy ink	Easier to recycle No harmful organic compounds Cheaper	Lots of uncertainties
Edible packaging	Minimize waste	Less quality Roses can bring bacteria and are not always clean
Use of IoT at packaging.	Track and moderate temperature Much possibilities might be possible in the future	Challenging to implement Lots of uncertainties

6.4 Remaining supply chain modifications

Apart from the design alternatives discussed in the previous sections, there are possible remaining modifications in the supply chain to improve sustainability. Most of these possible changes have influence on the whole supply chain or on the product flow in the supply chain. Advice given in this section are to improve an overall scenario which will be formed in chapter 6.5. Here a combination will be made from the design alternatives in the previous section and the remaining modifications discussed in this section.

The possible modifications are:

- **More cost sharing for innovations.**
  This could give more possibilities for innovations. As discussed in section 3.4, the new design of the packages had not been implemented. The costs are for the growers to make changes in their packaging. However, the advantages of having different packaging are important for the whole supply chain. So it could be beneficial for the whole supply chain to invest in new packaging or other innovations which have impact on the whole supply chain. Furthermore, it can improve the cooperation between actors and speed up the innovations because of peer pressure. On the other hand, all stakeholders must agree when implementing an innovation, which could lead to discussions and delay.

- **More direct flow.**
  As stated in chapter 4 there are two types of flow. One of them is the direct flow, in which the roses are not sent via the auction. This will decrease the handling moments during the whole order picking process. The roses will directly go to the buyers box where the buyer collect them. It depends on the buyer if the roses are put on water or not. If the roses are not put on water the boxes will directly go from dock services to the buyers box. In this case there will be even less handling moments used since the unpacking process is skipped. Furthermore, less water is used. Also, there will be fewer destroyed roses. If the roses are not sold via the auction they will be destroyed, but this will not be possible if the roses are already sold before transport. So it will be beneficial to stimulate direct sale. A possibility to stimulate this is offering discounts for buying the roses directly. This results in a decrease in income, but it can be profitable if it is compared to the possible amount of roses which are destroyed. Buyers could be informed about the advantages of a direct purchase(higher quality roses and better for the environment).

- **'Aftuin' auction/Hub in Kenya.**
  To reduce the travel distance, a possible solution could be to place a hub in Kenya, or to change the process in 'Aftuin' auction (which means an auction directly from the growers). The products will go directly from Kenya, to the airport or harbor which is closest to the destination. However, with the general auction, when a customer buys a product, it will be in his collection box within three hours. If a hub or auction takes place in Kenya, it will be delivered in a larger time span. If it is chosen to use sea transport, it will be a time span of several weeks, which is not feasible for an auction. So, with this new method, there will be less flexibility on the chosen transport mode. Furthermore, there will be fewer quality checks during the process, since the flowers are directly shipped to the final destination. The quality loss of the transport

is not considered, so all stakeholders should have faith that the products are delivered in the desired quality. On the other hand, there will be fewer handling moments during the process, which results in higher quality. And all products that are transported are sold, which means a decrease in fewer kilometers corsses for unsold and destroyed products.

- **Distribution hub in Europe.**
  With a hub in the south of Europe the travel time from Kenya could be decreased. If the destination of the roses is known, the optimal hub could be selected to travel to. This could decrease the overall travel time and fewer kilometers have to be covered, which results in less emission and costs. However, this could be a difficult process. The travel time and expenses could be significantly greater than allowed if the incorrect hub is selected. Furthermore, if it is not a direct sale, it must be predicted which hub will be optimal. This will also be error prone.

- **Collect the CO_2 emission**
  As stated in RTL Nieuws (2022) it is possible to collect CO_2 emission while driving a car. This is a research of the technical university in Eindhoven. If it will be possible to collect the emission during all the transport this could lead to less emission in the environment. The emission of RTL Nieuws (2022) is used to partly power the car. This is most profitable when the car is powered by completely green energy, so the emission by driving is zero. Otherwise it will not be possible to produce less CO_2 than is collected. It would be interesting if the collected emission can be saved and used for other purposes as well. In the dutch greenhouses CO_2 is added to improve the growth of the vegetation (Lubbersen, 2018). If this could be the emission which is collected during transport in the supply chain, this could lead to a decrease in emission in the environment while at the same time less emission is produced for the greenhouses. A disadvantage is the difficulty to implement this modification. Since it is a new technology it is not sure how well this will work and if it will be possible for all transport or only for smaller cars as used in the research in Eindhoven.

- **Better information sharing.**
  Since there are many actors involved in this supply chain, it is important to optimize the communication. Many mistakes and wastes can be prevented by better information sharing. Within the process there is some lack in communication which leads to products being delayed and products standing outside cold stores waiting to be processed or not able to fit in the cold stores. By better information sharing it will be easier to prepare the estimated time of arrival. With these preparations it could be prevented that the cold stores are out of space. Besides, the planning can be optimized to make sure there is no shipping waiting to be processed which decreases time waste and time outside cold stores. On the other hand, not all stakeholders want to share all information. Some information is confidential, which makes it difficult to share all information.

- **Use boxes for further stages in the supply chain.**
  After the roses are unpacked the boxes are put in a carton press. So the boxes are used only once. Most of the boxes however, are still in good condition. These boxes can be re-used, but it will not be beneficial to send these boxes back to Kenya and use them again for the same route.

A possible solution could be to use the boxes elsewhere in the supply chain. Not all sold flowers are transported on water. Some of the flowers must be transported to other countries by air or by truck, or a buyer prefers to have the flowers in boxes again. In those cases new boxes are used to transport the flowers. Re-using the boxes from arrival will cause a reduction in material usages and it will decrease the amount of waste produced in the complete supply chain. Disadvantage is the time it will take during the unpacking process. It should be considered whether a box can be re-used or not. Furthermore, the roses should be unpacked more carefully. At the moment the boxes can be cut or torn open, but to re-use the boxes they have to be opened in such a way they van be closed again later in the process. Another disadvantage is that boxes are universal per product. So not all different types of flowers will fit in all kind of boxes. This does not have to be a problem when the arrived boxes are re-used for the same product type during the auction.

- **(Recycled) waste stream to Kenya.**
  To increase the amount of recycled products and decrease the amount of raw material, it could be a solution to transport the waste to Kenya. This can be transported as it is already recycled, or when it needs to be recycled in Kenya. For this process, the waste needs to be transported to Kenya, which will be extra transport of products and weight. This costs money and is extra emission for the transport, so it will be more beneficial to recycle the waste and use it for other purposes in the Netherlands.

- **Track and Trace of the temperature plus analyzing.**
  By track and tracing the temperature during the whole process, the hot-spots in temperature can be mapped. Furthermore, there will be more information about the degree hours and thus the vase life. This could help inform buyers to ensure the quality of the flowers. Furthermore, it will give information on differences in using different transport modes. By tracking the temperature the best transport mode can be selected based on quality. At the moment the temperature is measured within the boxes of the roses, however this has many flaws. The equipment is not always working for all transport modes. For example the data on the equipment used now must be collected within 30 days. The whole process in total for sea transport takes longer than 30 days, so not all data can be measured. New data loggers must be purchased to make sure all data can be measured and collected.

- **Closed cooling cycle.**
  As said in chapter 3.5 the quality of the roses will be better for a closed cool cycle compared to a process where the temperature changes more. So when the process has a completely closed cool cycle this will be best for the quality of the roses. This means the roses are continuously cooled for the whole process, from when they are cut to when they are sold. This results in fewer handling moments, since the roses will be in the same cooled container most of the time. Also, according to expert 6, when the roses are cooled all the time, the chance of diseases will be less. On the other hand, there are some difficulties for this process. First of all, the change in transport mode will be more difficult. Either the container with the roses must be cooled by itself and must fit in or on all transport modes in the supply chain, or the switch in transport mode must be done under cooled circumstances, so the handling moments must

be done in cold stores. Furthermore, the cooled containers are mostly powered by the vehicle. With a switch in vehicle there is a moment where the container is not powered. This should be prevented to make the cycle completely closed and on the right temperature for the whole process. Next there are fewer moments to check the roses on quality. If the roses are in a completely closed chain until the roses are bought, there will be no check for lower quality roses. This means the trust in the quality must be higher to buy the roses without having the quality checked. With better equipment for cooling and temperature measuring this can be realised.

- **Dry transport during the auction and to the buyer.**
  During the auction the roses are put on water and transported on water in fusts. If the roses are kept in the boxes they arrive in, the roses do not need to be unpacked. This is one handling less which is a profit for the quality, and an elimination of a time consuming part of the process. This saves money and time. Furthermore, there are no/fewer fusts needed which includes less water needed. Furthermore, there is less material needed. The sleeves used to protect the roses and put advertisement on are not needed when the roses stay in the boxes. Also, the cardboard box does not have to be replaced when the roses need to be transported again to a buyer abroad. The same box can be used to transport the roses. On the down side, some of the boxes arrive in bad conditions. This must be prevented by improving the quality of the boxes. Furthermore, the same problem occurs for dry transport as for a closed cool cycle. There is a quality check less. So there must be more confidence in the quality of the roses. Last, the minimum order is one complete box when buying roses. So either the boxes must be made smaller to make the minimum order smaller. But this decreases the efficiency in use of packaging and transport. Or the minimum order will be much higher than the current minimum order, which can cause a reduction in price and income.

- **Complete order to the same freight forwarder in Kenya.**
  Currently as stated in chapter 4 a grower transports his products to different freight forwarders at the airport. The truck needs to open and close the cabin every time to unload a part of the boxes at a specific freight forwarder and then close them again to bring the next part to another freight forwarder. Every time the truck opens the doors the boxes are exposed to the heat outside. If all the products are sent to the same freight forwarder, all boxes are unloaded at the same point and can be directly put in cold stores after unloading. This brings down the amount of degree hours. However, for direct sale it is dependent on the incoterms who will be responsible for choosing the freight forwarder. If all products of one grower must be delivered at the same freight forwarder there will be less flexibility in choosing a freight forwarder.

- **ULDs to air side during nighttime.**
  The boxes are transported to the air side by freight forwarders on a ULD. In this instance, the ULD is put into a cooled airplane. Although, this is usually done in the warm daylight hours, the roses are currently exposed to the heat and not being cooled, which raises the degree hours. Also, if the airplane has a delay the roses are not brought back to the cold stores but are waiting outside, which is more exposure to the heat. So either the roses should be cooled during transport or the roses should be transported by night when it is colder outside. But in

order for this to be profitable, the flowers must be loaded into the plane as soon as they reach the air side. This means that the schedule needs to change and that the planes should fly at night.

- **Combined truck service in Kenya.**
  Figure 4.3 of chapter 4 shows the growers located on different places in Kenya. This includes the smaller growers which do not have enough products to fill a complete truck. With a combined truck service these smaller growers can use one truck to transport both their products. This can also be done with larger growers who for example have multiple trucks, but the last truck is not completely filled. This way most of the trucks will be filled and fewer trucks are needed in total. This saves costs for the growers and helps by emitting less. Furthermore, fewer trucks at freight forwarders can make the logistics easier. To make this work, it will be important that the growers work together which can cause problems. Furthermore, this could counteract the previous discussed modification, complete order to the same freight forwarder, since different growers have a contract with different freight forwarders, which means, more freight forwarders per truck.

- **Improvement of Kenyan road infrastructure.**
  The last modification is an improvement of the Kenyan infrastructure. With a better infrastructure, there will be less waste in time since the trucks can drive faster. Furthermore, it could lead to shorter travel distance for some of the growers. However, it takes much money and time to realise this modification.

- **Machine learning and AI.**
  With the help of machine learning and AI, a prediction model can be made regarding the sales of the roses. With this prediction model the efficiency can be optimised (Procurious HQ, 2021). For example, when the roses are sold from Kenya and the final destination is known, the roses do not have to come to the Netherlands, before they are transported to the buyer. This results in a reduction in operational costs since the travel distances are lower and more efficient. This can be challenging for the peak/unpredictable moments. It will be a scenario based system, which costs a lot of time to have the data implemented for high precision in the prediction. Besides the system will be expensive to implement.

- **Automated inventory management with robotics.**
  As we begin to look toward the future, we anticipate that automation will be crucial in guaranteeing sustainability because it offers a precise and effective substitute for human operators (Procurious HQ, 2021). It can save time during the process which results in fewer degree hours and faster delivery. On the other hand, a box can be stuck in the system when the paperwork is not consistent. All growers must have the same etiquette on the box for the robotics to understand the destination of the box. Mistakes in consistency can lead to lost products, products outside a cold store and long delivery times. Furthermore, it would be expensive to implement a complete automatic inventory management.

- **Unpacking and sleeve after auction.**
  Before the roses are going on the auction the roses are unpacked. This is a moment to check the quality and if the quality is not high enough, the roses are destroyed. When the roses are unpacked after the auction, this moment of checking the roses is lost. The customers must trust that the roses are of enough quality when they buy them. This can cause problems that must be compensated by a better information flow regarding the handling moments and degree hours to make sure the roses are transported under the right conditions and with careful handling moments. Otherwise it would be difficult to ask for more trust while the quality checks are fewer. Furthermore, the time the roses arrive at the customers box for pick up will be longer when the customer wants the roses unpacked. However, there will be a choice to purchase the complete box which does not result in extra time after buying the roses. The roses can arrive in the same time as when the roses are unpacked before the auction or even faster, when the customer demands the roses to be packed in a carton box for transportation. This makes it easier for transport after buying the roses and makes it cheaper when the roses are not transported on water the trucks can be loaded more efficiently and with less weight. This also reduces emission when the weight in the truck is less. Furthermore, it reduces the amount of materials used as the roses are transported in the same box as they arrive in.

- **Educate customers on sustainability.**
  Educating costumers makes them aware of the possibilities regarding sustainability. When the costumers are interested, the costs can be shared for innovations. This speeds up the process, and improves the business case of the innovations. On the other hand flowers are a luxury product and this makes it not sustainable to buy them. Educating people on the footprint a flower has can backfire and can cause a decrease in sales. Furthermore, educating costumers is expensive which will not be earned back in money. So it is an investment to make for the environmental sustainability.

- **Switch in pipeline infrastructure to hydrogen.**
  When the pipeline infrastructure is switched to transport hydrogen, the transition to hydrogen powered vehicles will be stimulated. This can cause a transition to an environmental friendly transport system. However, all transport modes must be driven by the same fuel which currently is not the case. Also, it will be an expensive and time consuming project with uncertainties whether it will work.

- **Electric roads.**
  Trucks have been equipped with pantographs, roof-mounted pick-ups that can draw power from overhead wires, a 130-year-old technology initially employed with trams. The truck just needs to drive underneath the wires and lift the pantograph, much like a train does, in order to connect while it is moving. Then, with zero carbon emissions, it is powered by electricity (Williams, 2017). Since there is a general route from arrival of the flowers in Europe to RFH, this could be an electric road. The trucks are always powered for this route and if they are uncoupled the electric battery will be used to drive a different route. This makes the traveling radius larger and stimulates the use of electric trucks. The implementation of this electric road will be expensive and a time consuming project, but it is an existing technology which makes it

feasible to implement.

- **Battery swapping.**
  To overcome one of the largest obstacles regarding driving an electric vehicle, charging time, battery swapping can be a solution (Williams, 2017). If it is as efficient and easy as filling a truck with patrol, the popularity of electric vehicles could increase. With battery swapping the truck arrives at a charging point where a full battery is inserted and the empty battery is taken out. It is a fast recharging system which stimulates driving electric. However, it is an expensive procedure. Much batteries are needed to meet the demand. Furthermore, developing these batteries is not environmental friendly which makes it questionable if it makes it better to drive electrical at all.

- **Truck platooning.**
  When many trucks are driving in a country, truck platooning can be a solution. With this method, all trucks autonomously follow each other in a platoon. The first truck is driving and the rest follows. This could spare much emission since the trucks drive closer to each other than normally, which is efficient driving. This also causes the truck to have a larger travel radius because of the efficiency. Furthermore, when this system is implemented it stimulates the electric truck, since it would be beneficial to be a part of a platoon. Also, there will be less congestion on the roads since all trucks are driving in the same lane. This truck lane does not hinder the other cars and can drive by traffic jams. This can only work if the complete country introduces truck platooning. The infrastructure must be adjusted for these types of trucks and all trucks must be able to drive autonomously. To implement it on a smaller scale, the trucks must have the exact same schedule to drive in a platoon. Last, it is still not allowed by the governance to drive completely autonomous due to safety and ethical reasons.

- **Solar roads.**
  To generate energy with solar panels, it is possible to implement the solar on the road (Williams, 2017). 90 % of the time the roads are not occupied by traffic, and in this time period the solar panels can generate electricity. The world has many roads, so there will be enough space to generate a lot of energy. The solar panels can be implemented in existing roads which makes it relatively easy to install. On the other hand, it will be an expensive process which can easily be damaged by heavy vehicles. Furthermore, the dust on roads can disturb the panels from generating energy. Also there are lots of uncertainties on the roads, like what the maximum weight will be and how efficient they will be due to dust and traffic on the panels.

- **Generate energy during transport.**
  When energy is generated on the vehicle during the transportation, the generated energy can directly be used by the vehicle. Like the hydrogen boat discussed in the previous section of transport modes, there can be a truck or airplane with solar panels on it or wind energy could be used on a boat to power the motors. This way the energy will be green and there will be no emission during generating energy. Also the vehicle will be powered with renewable energy which results in fewer emissions. However, this is a new technology which should be implemented on the existing transport modes. This can be difficult and unreliable at some

time. That is why there is a dependable supply needed in order to make the transport modes reliable.

In table 6.5 all modifications are listed with the pros and cons per modification. This gives an overview which can be used to make a new possible design in chapter 6.5.

Table 6.5: Remaining supply chain modifications with pros and cons

Remaining supply chain modifications	PRO	CON
More cost sharing for innovations	More possibilities for innovations More cooperation of different parties (peer pressure)	All stakeholders should agree
More direct flow	Fewer handling moments Fewer destroyed roses	
'Aftuin' auction/Hub in Kenya	Less handling moments Fewer kilometers traveled No kilometers traveled for destroyed/unsold products	Fewer possibilities for quality checks Much time between auction and delivery More trust required from all stakeholders Long time delivery modes are not feasible
Distribution hub in Europe	Fewer kilometers traveled Less travel time possible for other countries in Europe	Predictions must be made for best hub Sensitive for mistakes in hub choice
Collect the CO_2	Less emission in environment Possible to implement CO_2 where needed	New technologies necessary
Better information sharing	Less waste in time Better planning in capacity cold stores Fewer moments out of the cold stores	Some information is confidential
Use boxes for further stages in the supply chain	Less production/material needed Less waste	Not all products fit in all boxes Time consuming
(Recycled) waste stream to Kenya	Less production/material needed More recycled boxes	Extra transport/weight to Kenya
Track and trace of the temperature plus analyzing	More information about the degree hours More information about temperature hot-spots	Measurement equipment should be purchased
Closed cooling cycle	Fewer degree hours Fewer handling moments of the boxes Fewer diseases for the flowers	Fewer possibilities for quality checks More trust required from all stakeholders Difficult with change of transport mode
Dry transport during the auction and to the buyer	Elimination of one part in the supply chain No fusts needed Less material needed (no sleeves) Roses are touched less	Fewer possibilities for quality checks More trust required from all stakeholders Minimum order of one box The quality of the boxes must be improved
Complete order to the same freight forwarder in Kenya	Fewer degree hours	Less flexibility in choosing a freight forwarder
ULDs to air side during nighttime	Fewer degree hours	The airfreight planning must be changed
Combined truck services in Kenya	Trucks are mostly filled Fewer trucks needed Fewer trucks at freight forwarders	Growers should work together More freight forwarders for one truck
Improvement of Kenyan road infrastructure	Less waste in time	Large costs and time to realise
Machine learning and AI	Reduce operational costs Optimisation in efficiency	Expensive system Time consuming to implement Scenario based, so can be difficult with peaks
Automated inventory management with robotics	More efficient Saves time	Expensive system Paperwork on boxes must be consistent
Unpacking and sleeve after auction	Easy continuation of transport Saves plastic if sleeves are not necessary	Fewer possibilities for quality checks More trust required from all stakeholders Longer delivery time after auction

External supply chain modifications	PRO	CON
Educate customers on sustainability	Create awareness Possible extra money for innovations by customers	Expensive without profit Might backfire regarding decrease in sales
Switch in pipeline infrastructure to hydrogen	Creates infrastructure for sustainable fuel Stimulates using sustainable alternatives	Expensive Time consuming All transport modes must be able to switch
Electric roads	Stimulate the use of electric trucks Larger possible transport distance Existing technology	Expensive Time consuming to implement
Battery swapping	Stimulate the use of electric trucks Fast recharge of an electric truck	Expensive Much batteries needed
Truck platooning	Less emission Less congestion Stimulate the use of electric trucks Efficient driving	All trucks must have the same schedule Must be implemented in the complete country The trucks must be autonomous Not allowed by governance
Solar roads	Can be stuck down to existing roads Possibility to generate much energy	Dust can disturb generating possibilities Many heavy vehicles can damage the panels Expensive Lots of uncertainties
Generate energy during transport	Generated energy can be used directly Less alternatives of energy generating needed Less emission	New technology Dependable supply needed Current transport modes must be adjusted

6.5 Design alternative combinations

With the discussed alternatives, combinations are made to form 5 different designs. The designs have different focus points to improve the current supply chain. The method used to form the designs is as follows:

1. A specific goal is defined for the design. What should be the main focus to improve the current supply chain.
2. Is there a large logistic difference to be made for the new design? With large changes, not all alternatives will be applicable.
3. What transport modes fit the design with the required goals?
4. What packaging methods meet the demand and will be feasible with the chosen transport modes? Not all packaging can be transported with all different transport modes.
5. What remaining modification can be implemented to further improve the design?

By following this method it was concluded that some of the remaining supply chain modifications fit all 5 designs. So these will be implemented regardless of the design:

- More cost sharing for innovations.
- More direct flow.
- Track and trace of the temperature plus analyzing.
- Educate costumers on sustainability.

These modifications do not have any direct impact on the logistics of the supply chain, but are methods to improve the sustainability and the possibilities to make innovative sustainable changes in the supply chain.

To calculate the Vase life of the roses for the new designs, the same formula has been used as for the current situation in chapter 4.2. $StartingDegreehours - (FarmTemperature * FarmTime) - (TruckingTemperature * TravelTime) - (FFTemperature * FFTime) - (AirlineTemperature * AirlineTime) - (ConsigneeTemperature * ConsigneeTime) - (UnpackingTemperature * UnpackingTime) - (AuctionTemperature * AuctionTime)/(20 * 24)$ There are changes in transport modes for the new designs which bring some small modification to this formula. For example when the transport mode is not a truck but a train, the Trucking Temperature and Trucking Time will be replaced by Train Temperature and Train Time.

Forming design 1: Low Emission Update

Step 1 and 2, a specific goal for design 1, is the focus on reducing emissions in combination with quick fixes and small adjustments to the current supply chain (a low emission update). Hence a sustainable update of the current supply chain. The emissions are mostly dependent on the transport modes (step 3). For choosing an alternative for the transport modes, lower emissions than the current situation while keeping the logistics mostly the same, are preferred over simply opting for the lowest emissions without taking current logistics into account. For the transportation of the roses from the grower to the airport, a truck on bio diesel is chosen. Since there is not enough charging infrastructure in Kenya, it will not be a quick fix to implement an electric truck. To keep the process logistics the same, the other possible transport modes discussed in chapter 6 also do not qualify as a correct fit. For the transportation from Kenya to Europe, again there is chosen for a bio fuel with the same transport mode. This will be an airplane on bio kerosene which results in less emission while keeping the logistics the same. Last, to transport the roses to RFH, an electric truck is chosen. In Europe, and specifically in the Netherlands, there is a great charging infrastructure present. This makes it possible to implement an electric truck without having to apply many modifications. The infrastructure can be improved by more and quicker charging stations, but this will be a subject for a later stadium.

After choosing the transport modes the fourth step will be executed, choosing the packaging alternatives. For the packaging, again the alternatives must be relatively easy to implement and if possible decrease the emission. Since none of the packaging alternatives influence the emission, the requirement is to choose alternatives which are easy to implement. Therefore, two alternatives are chosen; smaller sleeves on the roses and smart plastic constructions.

Finally, step 5 of the method is executed, choosing the remaining modifications. The first modification reduces the emission by transporting the flowers in Kenya with a combined truck service. The roses of several (smaller) growers will combine their products in the same truck. This results in fewer trucks driving, so less emission. Furthermore, two modifications which do not influence the amount of emission; better information sharing and the use of boxes for a further stage in the supply chain are added to improve the sustainability. These are relatively easy to implement which makes them a good fit for this design.

The complete design is given in table 6.6.

This design is implemented in a swimlane diagram (figure 6.1) which can be found underneath. For the direct flow a different swimlane diagram has been made which can be found in appendix E figure E.1. The set-up of this swimlane is the same as for the current supply chain. The rectangles

Table 6.6: Low Emission Update with the alternatives per subject

Transport mode	**Packaging**	**Remaining alternatives**
Truck on bio diesel	Smaller sleeves on the roses	Better information sharing
Airplane on bio kerosene	Smart plastic construction	Use boxes for further stages in the supply chain
Electric truck		Combined truck service in Kenya

are the same steps as for the current supply chain, while the ovals are the modifications or additions. The changes compared to the current supply chain are mostly found in the transport modes. The transportation to the freight forwarder in Kenya, which is also done with a combined truck service, is now executed with bio fueled trucks. The airline ships the ULDs on an airplane which is powered by bio kerosene. And the ULDs are transported to dock services with an electric truck. Furthermore, the unpacking procedure is almost the same, but the roses will come with smaller sleeves on the auction. The other 3 alternatives cannot be seen in this swimlane. All plastic used should be smart constructed plastic, which is easier to recycle. But this is not a physical flow change and therefore not visible in the swimlane. The same goes for the information sharing, which will influence the waiting times, but this is not visualised in the swimlane. Last, the usage of the boxes in a further stage of the supply chain is also not completely visible in the swimlane. Partly this procedure is done when the roses are unpacked. The boxes need to be checked, Whether the quality is is still high enough to re-use them in a further stage. The implementation of the re-usable boxes is only relevant when the buyers want their products in boxes instead of in a fust. Then the last part of the swimlane will change, since the roses need to be packed in the previously used boxes instead of transported in a fust to the rented buyer box.

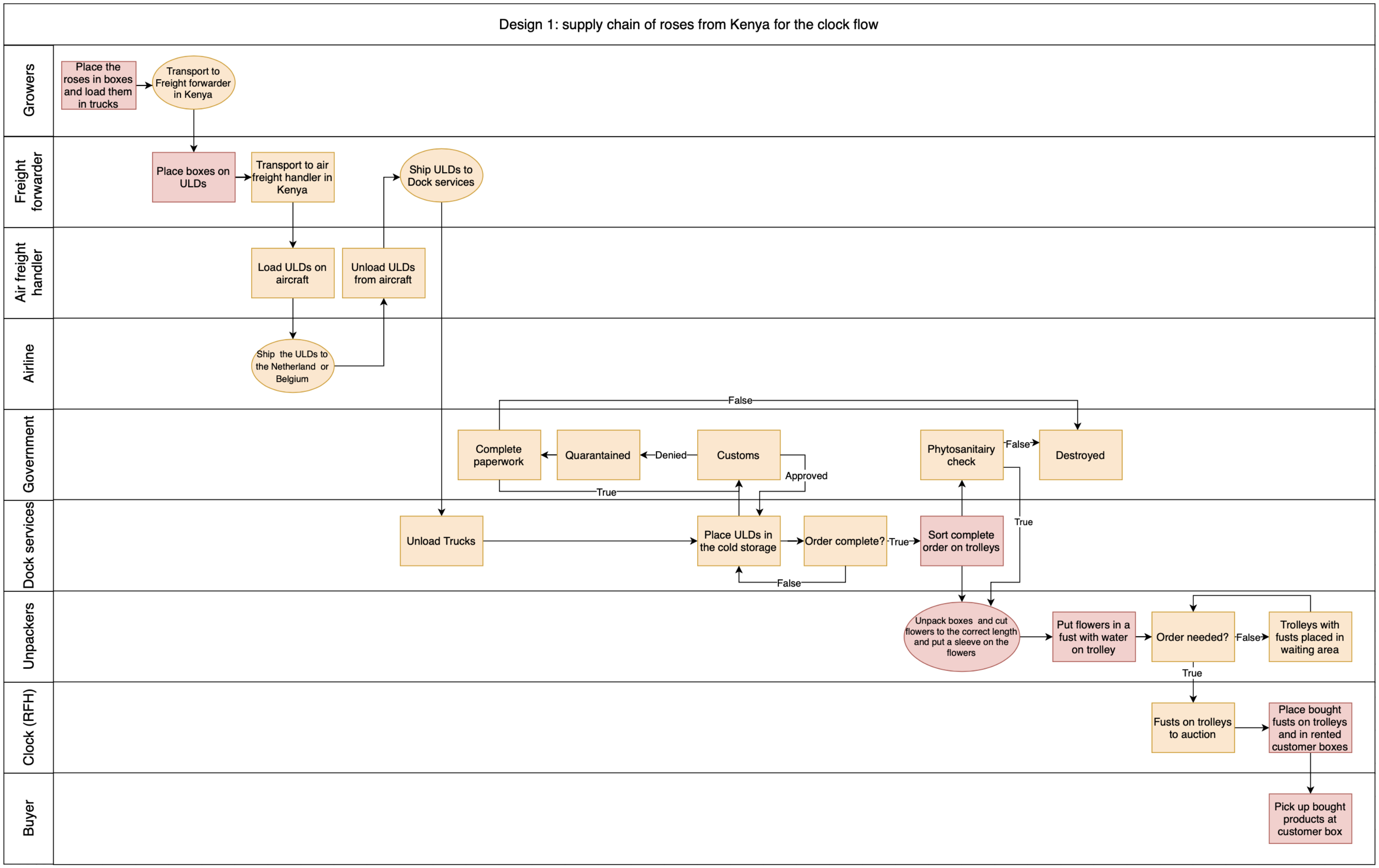

Figure 6.1: Swimlane diagram of the clock flow of the Low Emission Update

Scoring the alternatives of the Low Emission Update

The alternatives of the Low Emission Update are rated. For the transport mode the emission is given by kg CO_2 equivalents per ton kilometer. Key figures are used to have an average value to compare to the current situation. Since the amount of roses per transportation does not differ for the current situation and the Low Emission Update, these values can directly be compared to each other. For the current situation the key figures are found with a tool from Milieu centraal, Stimular, Connekt, and Rijksoverheid (2022). The emissions are WTW (Well-to-wheel) which means it includes the powering of the vehicle to move as well as the powering of the tools inside the vehicle. This tool was also used for the electric truck. For the bio fuels the following resources are used: Stimular (2021) and Maï (2021). What should be taken into account are different types of generating bio fuels and the different types of generating energy. The origin of the bio fuel strongly influences the environmental impact. There are three generations in bio fuel. First generation bio fuels are extracted from agricultural crops such as rapeseed and soy. They compete directly with food production. These bio fuels are partly responsible for the rising food prices. These negative effects are so great that, for example, the CO2 gains are completely canceled out as a result of extra land use in the tropics. These first-generation bio fuels should therefore be phased out. Second generation bio fuels are extracted from (vegetable and animal) waste streams such as manure, frying fat, tomato stems and wood chips. They do not compete with food production and are more environmentally friendly. The CO_2 gain of these bio fuels can be as high as 89%. Third generation bio fuels are made from algae, but are not yet commercially available. So for this design it is assumed that second generation bio fuel is used. Furthermore, the 89% is an theoretical number which possibly can be reached. There is no guarantee that this will be achieved by implementing bio fuel. According to Maï (2021) the use of bio kerosene can result in 50% to 90% reduction in emission. That is why an average of 70% is chosen as the key figure to compare the emissions. Last, for the electric truck the emission is 0. It is assumed that the energy to power the truck is green, so with the help of wind turbines or solar panels. Otherwise the emission would be 0.523 kg CO2-eq/kWh.

Table 6.7: Score transport mode of the Low Emission Update

Transport mode	Current situation	Transportation mode	Low Emission Update	Difference
Truck on diesel	0.212 kg CO2-eq/tonkilometer	Truck on biodiesel	0.023 kg CO2-eq/tonkilometer	-89%
Airplane on kerosene	0.55 kg CO2-eq/tonkilometer	Airplane on bio kerosene	0.165 kg CO2-eq/tonkilometer	-70%
Truck on diesel	0.212 kg CO2-eq/tonkilometer	Electric truck	0 kg CO2-eq/tonkilometer	-100%

For packaging and the remaining modifications, the rating is done on a qualitative matter instead of quantitative. A distinction is made between a positive influence (+), a negative influence (-), a positive as well as a negative influence (+-) and no influence (0). The alternatives are rated on 4 different subjects; the emissions, the costs, the quality and the materials usage. These are in line with the definition formed of sustainability in chapter 5.3. In table 6.8 the scoring of the packaging alternatives is given and in table 6.9 the scoring of the remaining modifications is presented. These scores are given with the help of the list of pros and cons of chapter 6 and the gained knowledge during this design research. To see if the alternatives match the goal of the design, the scores can be checked. For example, smaller sleeves would not have been chosen for this design if the goal was to improve the quality, since it has a negative impact on the quality.

Table 6.8: Score packaging alternatives of the Low Emission Update

	Smaller sleeves on the roses	**Smart plastic construction**
Emission	0	0
Costs	+	-
Quality	-	0
Material usage	+	+

Table 6.9: Score remaining modifications of the Low Emission Update

	Better information sharing	**Use boxes for further stages in the supply chain**	**Combined truck services in Kenya**
Emission	0	0	+
Costs	+	+	+
Quality	+	-	-
Material usage	0	+	0

Vase life for the Low Emission Update

For the Low Emission update there are not many differences regarding the degree hours compared to the current design. There are two modifications which have influence on the degree hours. First, better information sharing has a positive influence on the degree hours. The degree hours will not be decreased, but better information sharing makes sure the degree hours will not unnecessarily increase. The second modification that has influence on the degree hours is the combined truck service. It has a negative impact in two ways. First of all, a truck drives by different growers, which means the travel time will be larger. Second, the truck needs to open more times to load the roses at different growers. An estimate must be made on how much longer it takes and how many times the truck must be opened. Assuming that most of the growers are able to fill a complete truck, the truck service will only be used for around one third of the growers. On average it will be half an hour longer and a truck must be opened an extra time per trip. So the average time and temperature will be higher for one third of the trucking trips. This results in $2/3 * 40.57 = 27.05$ degree hours which stay the same (see table **??** for the current degree hours of the trucking). An average temperature around eight degree is used and it takes around five hours, so for one third of the cases it will be half an hour longer and one degree warmer for opening the truck which results in $5.5 * 9 = 49.5$. This must be multiplied by one third and be added to the two thirds that stay the same $1/3 * 49.5 + 27.05 = 43.55$. On estimate it will increase the degree hours with three, which will be negligible looking at the total amount of degree hours of 5674.34 degree hours. Also, the handling moments are the same, so it can be concluded that the vase life will be the same for the current design and for the Low Emission Update.

Implementation plan for the Low Emission Update

The Low Emission Update does not have complex alternatives which makes it relatively easy to implement. The transport modes in Kenya do need to have bio fuel. The vehicles do not have to change only the fuel needs to be available in Kenya. If it is difficult to acquire bio fuel around the country, it will be necessary to have a specific point (like the airport) where it will be made available. The trucks have to make sure they always leave the airport with a full tank. For the airplane it will be the same. The airplane itself does not have to be changed, but the fuel must be available. Since the airplane is flying to Europe and back, it might be easier to acquire the bio kerosene in Europe. Last the electric truck must replace the diesel truck and an electric truck must be purchased. The purchase costs are around 250k to 300k euros which is around 3 times more expensive than a diesel truck (Nijenhuis, 2021). However, it will probably be subsidised to purchase an electric truck in the coming years. Furthermore, the costs for using an electric truck will be much lower, considering the taxes which need to be payed for a diesel truck and the fuel costs of diesel are much higher than for charging an electric truck. Including the charging infrastructure, the costs for an electric truck will be around €34.000/year where the costs for the diesel truck will be around €49.000/year according to Nijenhuis (2021). So over the years, it will be beneficial to purchase an electric truck.

Regarding the packaging there must be an agreement with the growers and the manufacturers of the sleeves. These must be made of smart plastic which is currently in a development phase. If a simple solution is found in the coming years to make the plastic composition more sustainable, this will be an easy fix. Furthermore, the smaller sleeves on the roses will also be a simple fix. If the growers agree that the advertisement will be less, but at the same time the costs will be reduced this can be fixed in a short time period. From now on the new sleeves can be used after the old sleeves are out of stock.

For the information sharing it must be considered what information can be shared and what is confidential. This must be discussed with all direct stakeholders in the supply chain. The most important information which needs to be shared for this design is the expected time of arrival and the changes in arrival time due to congestion. Furthermore, in order to make the combined truck service efficient, the transportation times must be matched. So for the truck service a time schedule must be made. This can be implemented in two ways. Either it can be a truck of one grower which will drive by other growers to pick up their products. Or the products are combined in a distribution center where the trucks of all producers arrive. The first option will be easier to implement, but this will only work if the information between growers will be shared and rules (like the incoterms) are drawn up to prevent discussion between the growers. The last modification will be to use boxes for further stages in the supply chain. In order for this to work, the unpackers need to be more careful when they unpack the roses. The boxes must be checked whether the quality is good enough to re-use. These boxes must be transported to the end of the supply chain where the roses are packed to transport to a buyer. The most difficult part in order for this modification to be efficient is the check up of the boxes on quality. A box must only be re-used when it is certain that the quality is good enough. This should not take too much time to prevent congestion. This will cost money and increase the degree hours of the roses.

Forming design 2: CCC Design

For design 2 the focus is on improving the quality of the roses. It will be important to keep the cool chain closed and to minimize the handling moments where the roses or the boxes are touched (Closed Cooling Cycle design). Therefore, the transport modes are chosen in such a way that the roses can keep in the same transport packaging during the transportation to RFH. The roses are put in a controlled atmosphere container at the growers where the roses are transported by truck to the train station. This first mile transport is needed, since it will not be possible to have a train station at all growers. However, there have to be enough train stations close to the growers to minimize the first mile transport. The container of the truck is loaded on the train, so the roses do not have to leave the container. The train rails pass all the different cities where the growers are located and continues to transport the roses to the harbor. Here the containers of different growers are unloaded from the train on to the boat. Since the containers can cool themselves and keep control of the conditions, the transition of transport mode is not harming the roses. When arriving in Europe, the containers are loaded on an electric truck which will transport the container to dock services. This will be a standard route which is an electric road, so the trucks will always have enough power to ship the containers to dock services without losing time for charging the trucks.

For the whole transportation a controlled atmosphere container is used to keep the conditions optimal. This container is ULD that will fit on all transport modes of this design. The container is moved from transport mode to transport mode. Furthermore, to minimize the amount of times the roses are touched for loading and unloading the container, the roses are stacked on a pallet. This way the pallet can be moved instead of the boxes. In order to protect the roses even more, the boxes will be re-usable boxes of high quality. It should be kept in mind that after using the boxes too much, the quality will decrease. When this happens these boxes must be recycled and new boxes must be taken to transport the roses. Last, a smart plastic construction is used to decrease the material usage and increase the recyclability.

Step 5, the remaining supply chain modification are partly discussed during the transport modes. First of all, a closed cooling cycle is necessary to minimize the degree hours and the keep the quality high. The electric roads are used for the electric trucks since it will be a standardized trip from harbor to RFH without having trucks which need to be charged during the transportation of roses. Furthermore, with better information sharing, it can be avoided that roses are waiting outside a cold store for to long. Finally, the dry transportation during the auction in combination with unpacking and sleeving the roses after the auction minimizes the amount the roses are touched directly. The unpacking is only done when the buyer wants it, so unnecessary handling moments will be excluded.

The complete combination of alternatives is given in table 6.10

Table 6.10: CCC Design with the alternatives per subject

Transport mode	**Packaging**	**Remaining alternatives**
Train	Palletising	Better information sharing
Boat	One ULD fits all transport modes	Closed cooling cycle
Electric truck	Controlled atmosphere (in container)	Dry transport during the auction and to the buyer
	Folding/re-usable box	Unpacking and sleeve after auction
	Smart plastic construction	Electric roads

This design has been implemented in a swimlane diagram (figure 6.2) which can be found underneath. For the direct flow a different swimlane diagram has been made which can be found in appendix E figure E.2. The set-up of this swimlane is the same as for the current supply chain. The rectangles are the same steps as for the current supply chain, while the ovals are the modifications or additions. Furthermore, the stakeholders which perform the tasks are slightly different. Since the roses are not going by air but by boat, the air freight handler is replaced by shipping coordinators and the airline by shipping organisations. As can be seen, the complete procedure of shipping the roses from Kenya to RFH is different. This is logical since the transport modes are different which need different proceedings to have a smooth process. Furthermore, the unpackers are performing their tasks later in the process, since the unpacking and sleeving is postponed to the end of the supply chain.

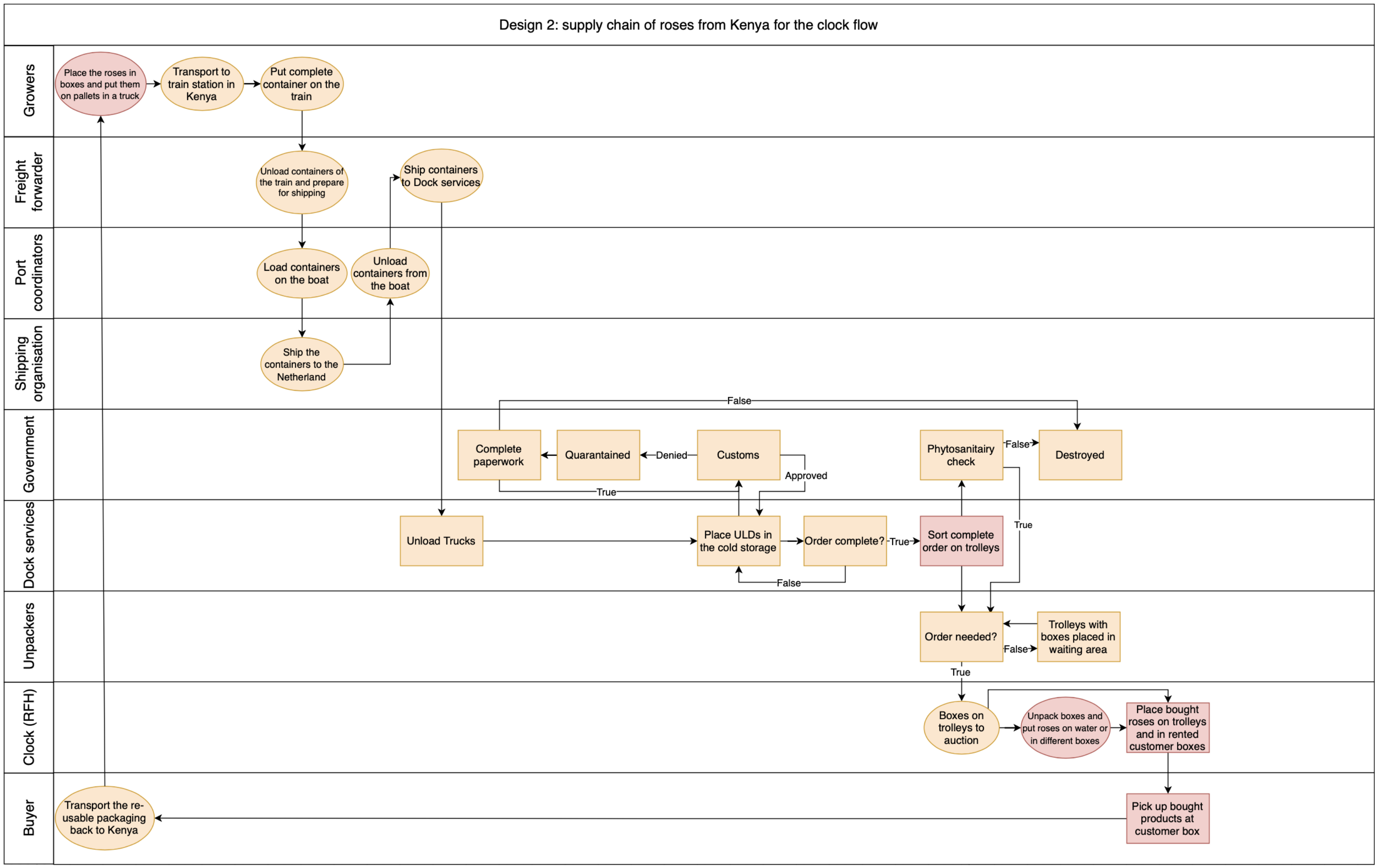

Figure 6.2: Swimlane diagram of the clock flow of the CCC Design

Scoring the alternatives of the CCC Design

For the CCC Design the same procedure is used as for the Low Emission Update regarding the scores per design alternative. The key values are used from the same tool as the current design (Milieu centraal et al., 2022). However, the difference can not be calculated in the same way as for the Low Emission Update. The differences of the Low Emission Update are based on the same weight and the same distance. For the electric truck this will be correct, but for the boat and the train this will be different. First, the train can transport a maximum of 41 containers per trip. So the weight is 41 times larger but it can compensate for 41 trucks. Assuming that the same amount of roses is transported by train as in the current situation by truck, the weight will be the same. Only the train will go from Kitale to Mombasa which is around 900 km, and the trucks come from different places around Kenya, which differ from 40 to 400 km to the airport in Nairobi. Since the train will not go directly, but stops at different locations for different growers, the choice is made to make the distance by train 1000 km. With that the emission for the train is $1000 * 0.027 = 27kgCO_2eq/ton$. For the trucks an average distance of $(400 + 40)/2 = 220km$ is taken. So the emission for the truck will be $220 * 0.212 = 46.64kgCO_2eq/ton$. For a boat the capacity will also be larger as for an airplane. But again it is considered that the same amount of flowers need to be shipped. The distance for the boat is 13186.24 kilometers from Mombasa to Rotterdam. So the emission will be $13186.24 * 0.012 = 158.23kgCO_2 - eq/ton$. For an airplane the distance is 6662 km from Nairobi to Amsterdam, which results in $6662 * 0.55 = 3664.1kgCO_2 - eq/ton$.

Table 6.11: Score transport mode of the CCC Design

Transport mode	Current situation	Transportation mode	the CCC Design	Difference
Truck on diesel	0.212 kg CO2-eq/tonkilometer	Train	0.027 kg CO2-eq/tonkilometer	-42%
Airplane on kerosene	0.55 kg CO2-eq/tonkilometer	Boat	0.012 kg CO2-eq/tonkilometer	-96%
Truck on diesel	0.212 kg CO2-eq/tonkilometer	Electric truck	0 kg CO2-eq/tonkilometer	-100%

As in the Low Emission update the packaging and remaining modifications are scored on a qualitative matter. These either improve the quality of the roses, or do not have influence on the quality but improves one of the other parts of sustainability.

Table 6.12: Score packaging alternatives of the CCC Design

	Palletising	One ULD fits all transport modes	Controlled atmosphere (in containers)
Emission	0	0	0
Costs	-	-	-
Quality	+	+	+
Material usage	-	0	0
	Folding/re-usable box	**Smart plastic construction**	
Emission	0	0	
Costs	+-	-	
Quality	+	0	
Material usage	+	+	

Table 6.13: Score remaining modifications of the CCC Design

	Better information sharing	Closed cooling cycle	Dry transport during the auction and to the buyer
Emission	0	0	0
Costs	+	0	+
Quality	+	+	+
Material usage	0	+	+
	Unpacking and sleeve after auction	**Electric roads**	
Emission	0	+	
Costs	+	-	
Quality	0	0	
Material usage	+	0	

Vase life for the CCC Design

For the second design the degree hours are completely different. Throughout the complete transportation of the roses from Kenya to RFH the roses are in the same controlled atmosphere container. This ensures that the roses are cooled during the complete trip. The roses are kept on a temperature of 2 degrees. The degree hours on the farm are the same as for the current situation, so 55.5 degree hours. However, the preparations might be more time consuming since the roses are entering a container for the coming 30 days. Therefore an addition of 10 degree hours is done. So the trucks enter the containers with a decrease in degree hours of 65.5 hours. Trucking to the train and from the train to the harbor is done on 1 degree Celsius (the same temperature as the containers have now when shipping the roses by boat), for around 12 hours (1000 km), which results in 12 degree hours. When the containers arrive at the harbor they are loaded on a boat and shipped to Europe. It takes around 30 days before the roses arrive at RFH (including the trip from harbor to RFH), so $30 * 24 * 1 = 770$. After arriving at dock services the roses are not going through the unpackers, but stay in cold stores. Therefore the degree hours for this process are less. The auction itself is the same process as the current situation, so this makes the degree hours the same ($5 * 4 = 20$ degree hours). The roses are only unpacked if the buyer wants it, this adds 40 degree hours to the product (the same as the current situation). In total the degree hours are $6240 - 65.5 - 12 - 770 - 20 = 5372.5$ which results in a vase life of around 11.2 days. Besides, the handling moments are decreased from seven to five times, which results in less damage by touching the boxes and roses and fewer risks of lower quality. Furthermore, the cold chain is closed for almost the complete process, which makes congestion less problematic. There will be no exposure to high temperatures during the process.

Implementation plan for the CCC Design

The most challenging part of implementing the transport modes of the CCC Design is the train in Kenya. Most of the railway is already in place, but it will be more efficient when the train stations are close to the growers. Therefore, the rails must be adjusted to decrease the travel time to the train stations by truck. Furthermore, the trains must be adjusted to power the controlled atmosphere containers. On the boat the containers must be powered, or the containers must have a battery which has enough capacity to power the container for the complete trip. Shipping the products by boat is cheaper than by airplane. The costs for one container on a boat is 715 euros times 20 pallets is €14300. For an airplane the costs are 3$/kg. One pallet holds 24 boxes of 14kg per box on average. In order to ship the same amount of flowers (one container) the costs will be $20 * 24 * 14 * 3 = 20160$. So the usage costs of a boat are smaller than for an airplane. Last the electric truck must be implemented instead of the diesel truck. Since there will be an electric road, there is no need for extra charging infrastructure. However, the implementation costs are, just like the Low Emission Update, 3 times higher than a diesel truck.

For palletising it will be necessary to have trucks on the farms which can handle the pallets. This includes employees who can work with a truck. When they are not already available at the farm, the trucks must be purchased and a truck driver has to be hired. This will cause extra costs for the growers. In order to make a controlled atmosphere container (which costs between $1500 and $1750) efficient, it has to fit on all transport modes. On the boat it must be able to stack just like the other containers, which makes it the same dimensions and therefore also possible for transport with a cargo train. The truck also needs the capability of driving a container with general dimensions. The smart plastic construction will be the same as for the previous design and must be an easy fix when this plastic is developed. Last the re-usable boxes have a logistic challenge. The boxes must be transported back to Kenya to re-use. A container can be loaded with these boxes and shipped back to Kenya. However, it must be discussed with all actors in the supply chain that this increases the costs. These costs should be divided between all stakeholders. Thereafter these boxes have to be transported back from the harbor to all growers and they should be divided over the growers. Next, there must be a large inventory with these boxes. The travel time for the boxes back to the growers is large. Enough boxes are needed to compensate for the time period the boxes are on the way back to Kenya.

Better information sharing is discussed in the Low Emission Update and for this design the same implementation plan holds. The closed cooling cycle will automatically be implemented when the roses stay in the same container for the whole transportation cycle. But, it will be necessary to unload the containers inside a cold store. The cold store openings need to be adjusted to make sure the container fits the opening and the roses can directly be loaded in the cold store. Currently the unpackers are directly located after dock services. This will not be efficient when the unpacking process takes place after the auction. The boxes stay closed during the auction and are sorted in the same way as the current situation. But after the auction the boxes are brought to the unpackers (if necessary) or directly to the customers box. This difference must be taken into account in the sorting system of RFH. Last the electric road between the harbor and the RFH locations needs to be purchased and built. The costs for this project will be high and electric trucks must be adjusted with a charging system to make use of the electric road. This will be a time consuming modification. If the trucks are bought in an earlier stage of the transition to a new design, it should be considered how the trucks are adjusted to use the electric roads with the overhead charging system.

Forming design 3: Futuristic Supply Chain

The goal of design 3 is to have an out of the box design to stimulate the sector and RFH let go of the present situation, but think further in the future which innovations could be possible (Futuristic Supply Chain). This is created with mostly the same structure of the supply chain to make it easier to compare to the current situation. Therefore, three transport modes have been chosen. For the transportation from grower to the airport a zeppelin has been chosen. A zeppelin is an old fashion transport mode, but research has been done on new types of zeppelins which can transport cargo.

Since it has currently not been done but has many potentials, it is a perfect fit for this design. For the transport from Kenya to Europe, an electric plane has been chosen. Many vehicles are moving towards electric power. The same goes for the airplane. Lots of research has currently been done on how to have enough power to fly a plane with more weight than only the batteries. If the capacity improves it will be a perfect solution for the transport of fresh products. Last the transport from Europe to RFH will be done by using the hyperloop. It is a transport mode in the developing phase, which has many potentials.

For the packaging there are also some innovative alternatives that can improve the sustainability of the supply chain. First, modified atmosphere packaging. This is an innovation which is already possible to use. Furthermore, this can be expanded with nanotech plastic for the packaging to see if the roses are losing quality without opening the boxes. For the sleeves, bio plastics can be used with the advertisement printed with soy ink. This makes it a bio degradable sleeve. The boxes will all be transported on an ULD which fits all transport modes to make the transition efficient without touching the boxes more.

With the help of the modified atmosphere packaging, a closed cooling cycle can be created. The roses are held on the right conditions on box level. The roses stay in these boxes during the auction and are unpacked and sleeved afterwards to go to the buyers. The inventory management at dock service will be an automatic system which uses robots to sort the boxes on the trolleys for the auction. Last during the transportation energy is generated which will be used to power the vehicles. This way the vehicles will be self powered with green energy. This can be done by solar panels on the vehicles.

The combination of the discussed alternatives is listed in table 6.14.

Table 6.14: Futuristic Supply Chain with the alternatives per subject

Transport mode	**Packaging**	**Remaining alternatives**
Zeppelin	One ULD fits all transport modes	Closed cooling cycle
Electric airplane	Modified atmosphere packaging	Dry transport during the auction and to the buyer
Hyperloop	Nanotech plastic	Automated inventory management with robotics
	Bioplastics	Unpacking and sleeve after auction
	Soy ink	Generate energy during transport

As discussed the process of the supply chain is mostly the same as the current situation. In figure 6.3 the clock flow of the Futuristic Supply Chain is presented. The main differences are the transport modes. Where for the zeppelin first mile transport is needed to bring the roses to the zeppelin. Furthermore, at dock services the procedures are automated and the unpackers are shifted to the end of the supply chain just like in the CCC Design. The direct flow swimlane diagram can be seen in appendix E figure E.3.

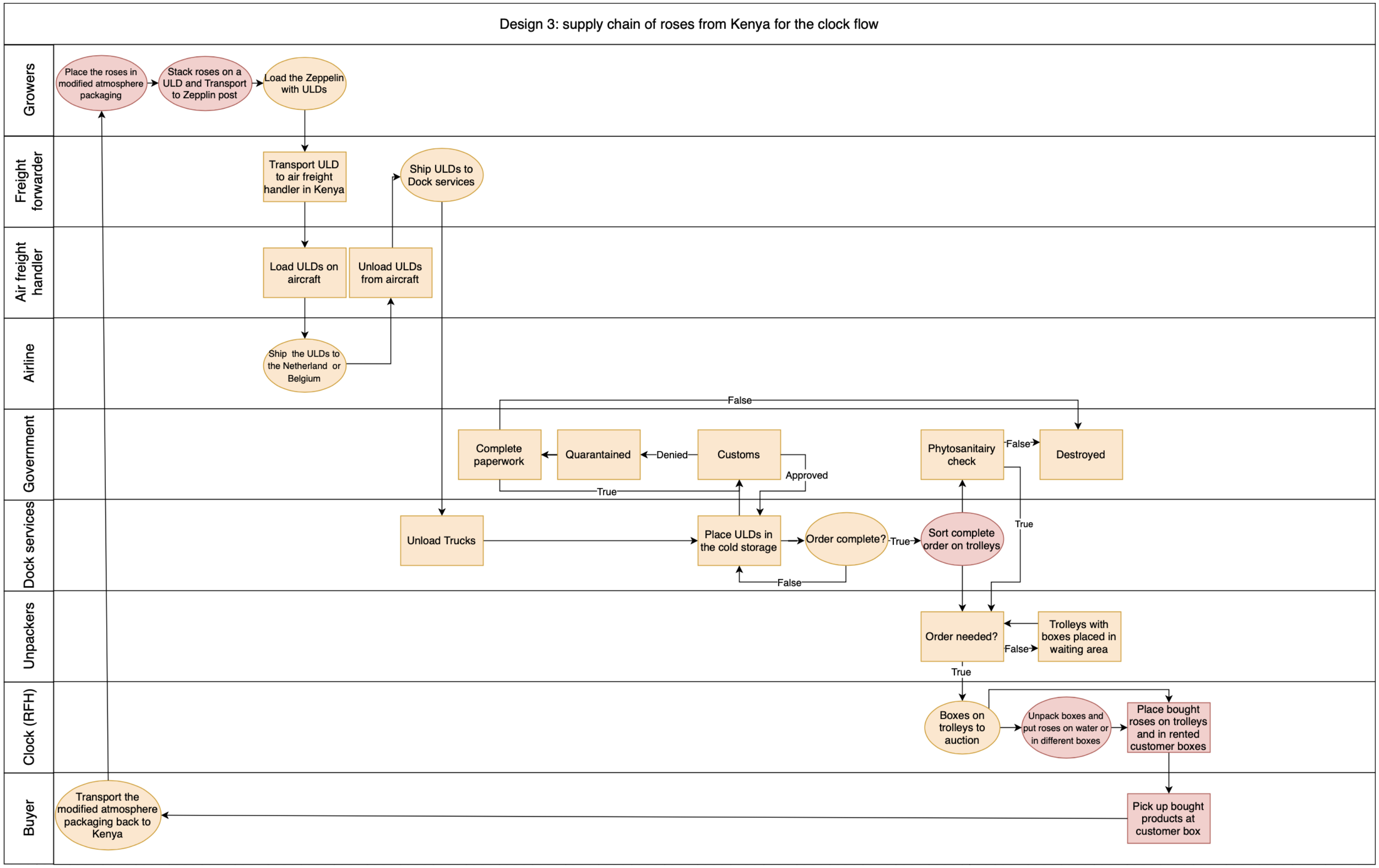

Figure 6.3: Swimlane diagram of the clock flow of the Futuristic Supply Chain

Scoring the alternatives of the Futuristic Supply Chain

Since all new transport modes of the Futuristic Supply Chain are electrically driven and it is assumed that this energy is green, they all create zero emission. Therefore the emission is 100 percent less for all transport modes.

Table 6.15: Score transport mode of the Futuristic Supply Chain

Transport mode	Current situation	Transportation mode	the Futuristic Supply Chain	Difference
Truck on diesel	0.212 kg CO2-eq/tonkilometer	Zeppelin	0 kg CO2-eq/tonkilometer	-100%
Airplane on kerosene	0.55 kg CO2-eq/tonkilometer	Electrical airplane	0 kg CO2-eq/tonkilometer	-100%
Truck on diesel	0.212 kg CO2-eq/tonkilometer	Hyperloop	0 kg CO2-eq/tonkilometer	-100%

The packaging and remaining modifications are scored qualitatively. However, these scores are not used to fit the goal. The goal was to create an out of the box design, therefore the innovative choices were made with a logical connection between the alternatives. But the scores can be used in a later stadium when the design is rated as a complete design.

Table 6.16: Score packaging alternatives of the Futuristic Supply Chain

	One ULD fits all transport modes	Modified atmosphere packing	Nanotech plastic
Emission	0	0	0
Costs	-	-	-
Quality	+	+	0
Material usage	0	+	+
	Bioplastics	**Soy ink**	
Emission	0	0	
Costs	-	-	
Quality	0	0	
Material usage	+	+	

Table 6.17: Score remaining modifications of the Futuristic Supply Chain

	Closed cooling cycle	Dry transport during the auction and to the buyer	Automated inventory management with robotics
Emission	0	0	0
Costs	0	+	+-
Quality	+	+	0
Material usage	+	+	+
	Unpacking and sleeve after auction	**Generate energy during transport**	
Emission	0	+	
Costs	+	-	
Quality	0	0	
Material usage	+	0	

Vase life for the Futuristic Supply Chain

For the Futuristic Supply Chain the same preparation process is necessary as for the current and first design. Therefore, the first part will be the same with 55.5 degree hours. The roses are packed in modified atmosphere packaging which makes sure the temperature stays at an average temperature of five degree (the same as was aimed for in the research of Voort et al. (2016)). Since the speed of the transport modes of the Futuristic Supply Chain are not known, an estimation is made. For the zeppelin, taking into account take-off and landing, the same time is used as for a truck. This is five hours on average. Furthermore, for the flying process, the same time is chosen as for a regular airplane, which is around 18 hours. Then the roses are transported with the hyperloop. Assuming this to be a fast transport mode, the roses will be at RFH in around one hour. This results in $(5 + 18 + 1) * 5 = 120$ degree hours. The rest of the supply chain will be the same as for the current design, except for the part that the roses are not unpacked before the auction, and when not necessary, not unpacked at all. This gives a decrease of 40 degree hours in respect to the current situation on this part. As a result the total amount of degree hours for the Futuristic Supply Chain is $6240 - 55.5 - 120 - 20 = 6044.5$. This is a vase life of 12.5 days. Also the handling moments are decreased from seven to five, which makes the risk on damaged roses less.

Implementation plan for the Futuristic Supply Chain

The implementation plan of the third design will be more challenging. There are many unknowns about the alternatives which makes it difficult to have a specific plan. For the transport modes it will be discussed what the important parts are for realizing the modifications. First, for the zeppelin a take-off and landing place must be realized. The take-off has to be situated close to the growers and the landing should be at the airport. It will be difficult to have a landing zone at the airport, due to safety issues with the other air traffic. The possibility should be investigated, otherwise the landing place has to be further away from the airport and a truck arranges the last mile delivery. This will be the freight forwarder which needs to collect the products. For an electric plane the most challenging part is the capacity. This is the reason why the electric plane is currently not in use. According to Shell (2022) it will be possible to transport people in a couple of years, but to transport cargo is more challenging. Probably the implementation of an electric plane in the coming 10 years might be optimistic. For the hyperloop much research is currently done. The two main bottle necks are costs and safety. Due to safety issues it might not be possible to transport humans, but this can be an opportunity for cargo. The safety regulation is different since the transport itself will not be threatening for people. The question is, if it will harm the roses. Besides, the costs will still be extremely high. Stil and van Zoelen (2018) state that it will cost 20 million euro to implement five kilometers of hyperloop.

Since all transport modes are new, the ULDs must be adjusted for the transport modes. This gives an opportunity to make one ULD that fits all transport modes. On these ULDs the modified packaging must fit efficiently. The costs for these packaging will be high and even higher when they are adjusted with nanotech plastic. The composition of this plastic must be able to handle the modifications of the atmosphere in the packaging. A difficult process would be to bring the packaging back to Kenya to re-use. Since the transport mode is the airplane, it will be expensive to ship the empty packaging back. A solution could be to transport the packaging back by sea freight. Next, all the other plastics must be bio plastic with the advertisement drawn in soy ink. The bio plastic must be developed to withstand water and in such a way that it will be possible to print the advertisements on it.

If the roses stay in the modified atmosphere packaging, the roses will be cooled during the whole system. They will only be unpacked after the auction to put the bio plastic sleeves on the roses. The packaging must consist of clear labeling for the automated inventory management at dock services. The boxes will automatically be sorted and placed on trolleys to go to the auction. Last, all the transport modes must have solar panels on the top of the vehicle. This way the energy can be generated during the transportation and the vehicles can be powered directly.

Forming design 4: Extra Hub in Europe

The goal for design 4 is to minimize the emissions, but this time by minimizing the travel distances. And when the travel distance is minimized the degree hours will be less when the cooling cycle stays the same, which results in higher quality roses. By placing an extra distribution hub in the south or south east of Europe the distances between Kenya and the distribution are shorter (the Extra Hub in Europe). Furthermore, when a prediction model is used, the distance to buyer and the distribution hub can be minimized. For example, when it is predicted that the buyer is located in the west of Europe, the roses will shipped to RFH in the Netherlands and if the buyer is expected to be in the east of Europe the roses must be shipped to the new hub. The transport modes used are a train in Kenya to transport the roses from all growers to the harbor, just like in the CCC Design. From the harbor the roses are either shipped to the new hub or to the Netherlands (or close to the Netherlands) by a cargo vessel. From here the roses are transported by train to the distribution hub. Since the average distance from Kenya to the hub will be shorter, the boat will be the preferred choice. The travel time is one of the largest disadvantages of the boat, but this will be less when the hub is closer. Besides, the emissions produced by train and boat are less than for truck and airplane, which is in line with the goal of this design.

For the packaging, there is much overlap between the Extra Hub in Europe and the CCC Design. Since the process is mostly the same regarding the transport modes, it seems logical to use the controlled atmosphere containers for all transport modes to have one ULD that fits all transport modes and keep the cooling cycle closed as much as possible. Furthermore, the roses are stacked on pallets to minimize the handling moment with loading and unloading the containers. Also, just like the CCC Design, smaller sleeves on the roses are used and re-usable boxes to minimize material usage. The packaging alternative which is not overlapping with the CCC Design is the smaller box for direct sale. Since the goal is to minimize travel distances, the smaller boxes stimulate the direct sale. For direct sale the travel distance will be less since the roses do not have to go by a RFH hub.

An extra distribution hub in Europe is the first remaining alternative which is necessary for this design. This design is based on an extra hub which is used with prediction models formed by machine learning and AI. In order to improve the prediction model the information shared must be correct and precise. This data must be collected and analyzed. If this system does not work with a high degree of certainty the travel distances will be higher instead of lower and the efficiency is low. Furthermore, as discussed, with the use of a container which is moved as one ULD for all transport modes, the cooling cycle can be closed. The transport during the auction will be dry to minimize the handling moments and the unpacking is only done when necessary, at the end of the auction.

Table 6.18 shows the combination of the discussed alternatives.

Figure 6.4 shows the swimlane of the fourth design. It is much like the swimlane of the CCC Design. The differences are, the roses are not always shipped to the west of Europe, but it depends on what hub is used. Furthermore, in Europe the train is used to transport the roses from harbor to dock services. Since a truck is necessary to bridge the last mile from train station to RFH there is an extra handling

Table 6.18: The Extra Hub in Europe with the alternatives per subject

Transport mode	Packaging	Remaining alternatives
Train	Palletising	Distribution hub in Europe
Boat	One ULD fits all transport modes	Better information sharing
Train	Controlled atmosphere (in containers)	Closed cooling cycle
	Smaller sleeve on the roses	Dry transport during the auction and to the buyer
	Smaller boxes for direct sale	Machine learning and AI
	Folding/re-usable box	Unpacking and sleeve after auction

where the train is unloaded and the truck is loaded. It will not be realistic to have a train station in dock services so the train can be unloaded directly at dock services. Therefore, this extra step will be necessary. For the direct flow shown in figure E.4 of appendix E the smaller boxes for direct sale differ from the CCC Design. The rest of the alternatives are either the same as the CCC Design, or are not visualized in the swimlane diagram since these are not physical changes.

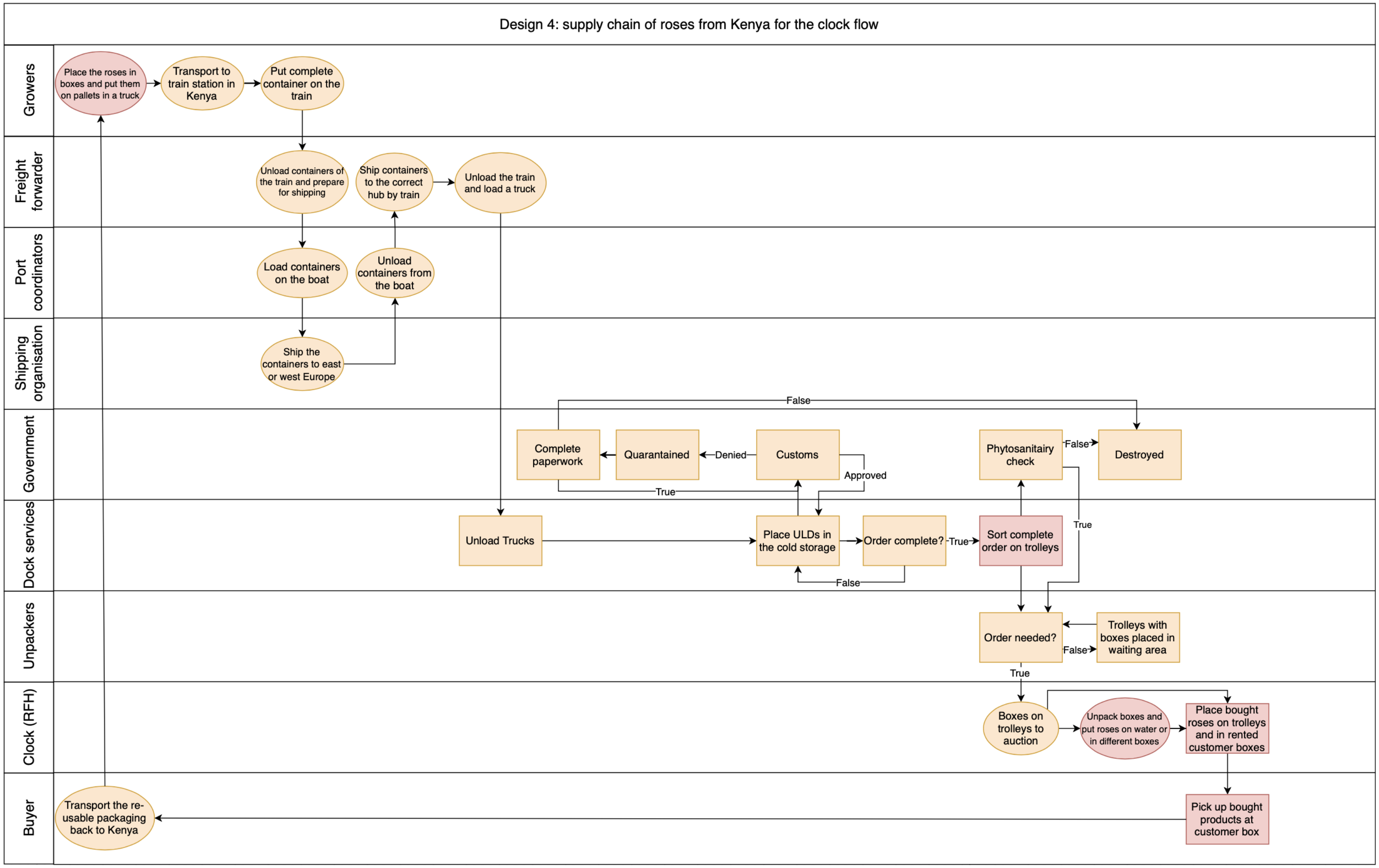

Figure 6.4: Swimlane diagram of the clock flow of the Extra Hub in Europe

Scoring the alternatives of the Extra Hub in Europe

For the transport modes the scores are given the same way as for the CCC Design. The only difference is the electric truck is replaced by a train. The calculation of the train has already been done, so this will be the same. Table 6.19 shows the values per transport mode.

Table 6.19: Score transport mode of the Extra Hub in Europe

Transport mode	Current situation	Transportation mode	the Extra Hub in Europe	Difference
Truck on diesel	0.212 kg CO2-eq/tonkilometer	Train	0.027 kg CO2-eq/tonkilometer	-42%
Airplane on kerosene	0.55 kg CO2-eq/tonkilometer	Boat	0.012 kg CO2-eq/tonkilometer	-96%
Truck on diesel	0.212 kg CO2-eq/tonkilometer	Train	0.027 kg CO2-eq/tonkilometer	-42%

The qualitative scores from table 6.20 and table 6.21 are used to choose the alternative matching this design. What strikes is the +- score of the smaller boxes for direct sale by the emission. The goal is to reduce emission by reducing travel distance. However, the smaller boxes are less efficient and therefore have more emission per rose. On the other hand, when there is more direct sale, the travel distance will be less as discussed before, the roses do not need to go via the RFH locations, which results in less distance traveled. Since the combination of shorter travel distance and less emission is chosen, this alternative meets the demands of this design. The rest of the alternatives all have a positive influence on the emission or do not have an influence on the emission, but positive influences on one of the other subjects. These alternatives are chosen to improve the supply chain in all possible matters regarding sustainability.

Table 6.20: Score packaging alternatives of the Extra Hub in Europe

	Palletising	Cooled ULD	Controlled atmosphere (in containers)
Emission	0	0	0
Costs	-	-	-
Quality	+	+	+
Material usage	-	0	0
	Smaller sleeve on the roses	**Smaller boxes for direct sale**	**Folding/re-usable box**
Emission	0	+-	0
Costs	+	-	+-
Quality	-	0	+
Material usage	+	+-	+

Table 6.21: Score remaining modifications of the Extra Hub in Europe

	Distribution hub in Europe	Better information sharing	Closed cooling cycle
Emission	+	0	0
Costs	+-	+	0
Quality	+	+	+
Material usage	0	0	+
	Dry transport during the auction and to the buyer	**Machine learning and AI**	**Unpacking and sleeve after auction**
Emission	0	+	0
Costs	+	+-	+
Quality	+	+	0
Material usage	+	0	+

Vase life for the Extra Hub in Europe

Determining the vase life of the Extra Hub in Europe is much like the vase life of the CCC Design. However, the largest difference is the travel time for the boat. When the hub in the east of Europe is used, the travel time will be about half of the travel time as for traveling to the west of Europe. Since it has not been determined what the exact location is, it is assumed that the travel time will be exactly half of the travel time. Furthermore, it is assumed that one third of the roses is going to the hub in the east of Europe and the rest will go to the hub in the Netherlands. This is because most of the roses are bought in eastern Europe according to the numbers of RFH. For the first part there will be no differences compared to the CCC Design, so this stays 65.5 degree hours. Also, the shipment by trains stays the same, which resulted in 24 degree hours. The boat trip is for two thirds the same and for one third it will be different. So $770 * 2/3 = 513.3$ degree hours. For the other part it will be $15 * 24 * 1 = 360$, $360 * 1/3 = 120$ and $120 + 513.3 = 633.3$. So the total amount of degree hours for the shipment to the correct hub will be 1200 hour to arrive at dock services. The rest of the process will be the same as for the CCC Design. So the vase life of the roses for the Extra Hub in Europe is $6240 - 65.5 - 633.3 - 20 = 5521.2 = 11.5$ days. Also, the handling times is decreased from seven to five which is the same as for the CCC Design.

Implementation plan for the Extra Hub in Europe

The implementation of the transport modes is equivalent to the CCC Design. The only difference is the train used in Europe. The train can reach the harbor, so a railway has to be laid down from harbor to the RFH hub. This will cost a lot of money, besides there is much likely a railway from the harbor to different places that already exists. This railway can be used with the addition of a truck for last mile transport. For the extra hub in eastern Europe, it would be a demand to have the hub located near the railway station, so the containers can directly go to this hub. Building the hub costs money which will be an investment. This can be earned back over the years by the reduction of the transportation costs. Machine learning will be necessary to predict the destination of the roses. Data must be collected on the location of the buyers. This way a prediction model can be made over the years on the most efficient destination for the roses. It will be necessary to have a good information system to optimize this prediction model. Last in order to stimulate the increase in direct sale, different box sizes will be available for direct sale. The boxes must be in scale with the general boxes. This makes it still possible to efficiently stack the boxes. The growers must purchase different box sizes from the box supplier.

The rest of the alternatives are already discussed in the other designs. The implementation of these alternatives does not differ. So the main difference with the other designs will be building the extra hub. If RFH keeps growing, it will be necessary to have more space. So it will be possible to invest in extra room on different locations instead of a centralized point in the Netherlands. However, the unpackers and dock services need to cooperate with the newly developed hub. The workload will be divided over the hubs, which can result in less work for the unpackers and dock services in the Netherlands. Part of the unpackers and dock services must relocate to the new hub.

Forming design 5: Kenyan Auction

The last design is focusing on a decrease in waste of energy and emission by reducing the amount of unnecessary transportation. By implementing a hub in Kenya and 'aftuin' auction the roses will be purchased when they are in Kenya (the Kenyan Auction). This ensures that all roses that are transported are going to a buyer. No roses will be destroyed due to not selling them. Furthermore, the roses are distributed from Kenya, so unnecessary transport can be prevented if the destination is somewhere close to Kenya. This saves time (quality) and money with a decrease in unsold products. Since the auction is in Kenya there are only two transport modes in this design. The roses are shipped from grower to airport by a bio diesel truck. Form here the roses are transported by an airplane on bio kerosene to the country of the buyer. The buyer needs to pick the roses at a pick up location at the airport of arrival after. The transportation to the country of destination must be a fast transport mode, so the buyer does not get the products much later than one day after purchasing it.

The roses are put in modified atmosphere packaging without sleeves. This reduces the waste, since no plastic is used and the boxes will be re-used. Since all transport will be directly from Kenya there must be different sizes of boxes to make it possible for a buyer to purchase one box at the time.

The first remaining modification is an 'aftuin' auction to minimize waste and increase efficiency. To make sure the buyers can pick the roses up at the demanded time and in order to keep the efficiency high, there must be great information sharing during the whole process. The ULDs with flowers must be transported on the air side in Kenya by nighttime to minimize the degree hours by standing outside. Even when the boxes of the roses are cooled, it will be a waste of energy when the controlled atmosphere needs to cool a box which is standing in the sun. During the auction the roses are moved in the boxes and are not put on water. Most of the roses must be transported by an airplane later on, so they all need to be packed in boxes for the transportation and it will be a waste of material to pack and unpack the roses in between. Furthermore, the handling moments will be decreased. Last to minimize the amount of trucks driving in Kenya with not a full loading, there will be a combined truck service to transport the roses to the airport. This will prevent transport of half filled trucks.

The alternatives which form the Kenyan Auction are given in table 6.22.

Table 6.22: The Kenyan Auction with the alternatives per subject

Transport mode	**Packaging**	**Remaining alternatives**
Truck on bio diesel	One ULD fits all transport modes	'Aftuin' auction/Hub in Kenya
Airplane on bio kerosene	Modified atmosphere packaging	Better information sharing
	No sleeves on roses	Dry transport during the auction and to the buyer
	Smaller boxes for direct sale	ULDs to airside during nighttime
		Combined truck services in Kenya

The swimlane shown in figure 6.5 is different than the other designs. First of all there are not two different flows, since all the products go from the growers in Kenya directly to the country of destination of the buyer. The flow for the direct flow is the same as for the clock flow, except for not going through the clock. The auction takes place in Kenya and after the roses have been bought they are transported to the airport to travel to the destination. Here the roses are checked, as is done at dock services, with a customs check and phytosanitairy check. When the roses have passed the checks, they are transported to a pick up location at the airport. Here the buyer can pick up the roses as he wishes.

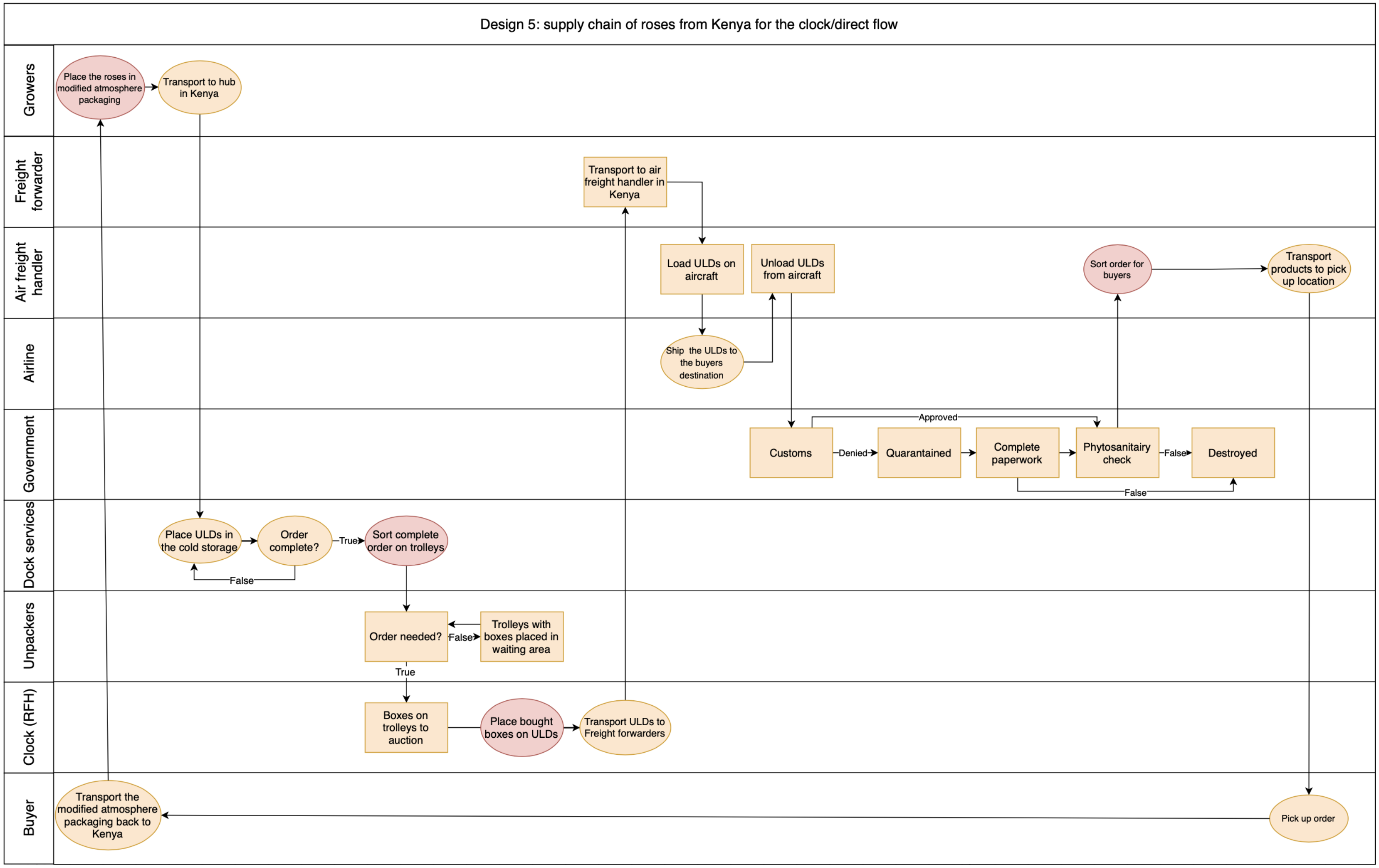

Figure 6.5: Swimlane diagram of the clock flow of the Kenyan Auction

Scoring the alternatives of the Kenyan Auction

The scoring of a bio diesel truck and a bio kerosene airplane have already been done in the Low Emission Update. Again it is assumed that the same amount of roses are transported and therefore the weight will be the same. Table 6.23 shows the figures for the improvement in emissions. Since the last transport is skipped for this design it is a 100% decrease in emission.

Table 6.23: Score transport mode of the Kenyan Auction

Transport mode	**Current situation**	**Transportation mode**	**the Kenyan Auction**	**Difference**
Truck on diesel	0.212 kg CO2-eq/tonkilometer	Truck on biodiesel	0.023 kg CO2-eq/tonkilometer	-89%
Airplane on kerosene	0.55 kg CO2-eq/tonkilometer	Airplane on bio kerosene	0.165 kg CO2-eq/tonkilometer	-70%
Truck on diesel	0.212 kg CO2-eq/tonkilometer	-	0	-100%

The packaging alternatives and remaining modifications are chosen in such a way to minimize waste. Therefore material usage was a key factor for the choices in packaging. In table 6.24 it can be seen that all alternatives have a positive influence on the material usage. Only smaller boxes for direct sale have a score of +-. However, the minis is based on single use boxes. Respectively with smaller boxes there is more material than roses. So more material used per rose which have to be recycled. But with the modified atmosphere boxes, the boxes will be re-used and therefore, there will be less waste. Still there is some more material used to make this boxes, but it will be depended on how often these boxes are used whether this will beneficial or not. Since these boxes are of high quality to make it possible to make them modify the atmosphere, the boxes will probably be used for a long period, so the amount of material used to make a smaller box will be worth it. Besides, when all roses are transported directly from Kenya to the buyer, there must be a solution for buyers who want to purchase a smaller amount of roses. The remaining modifications are all focusing on not having unnecessary losses on all parts. With better information sharing, there will be no waste in time for picking up and delivering the roses. Also the roses will directly be transported to cold stores at arrival. The dry transport during the auctions makes sure the roses will not be unpacked and packed for no reason. The transportation of ULDs during the night makes sure the cooled boxes are not exposed to heat which must be compensated with the cooling system. And last the combined truck service makes sure that trucks are fully loaded and unnecessary trucks can stay at the grower.

Table 6.24: Score packaging alternatives of the Kenyan Auction

	Modified atmosphere packing	**No sleeves on roses**	**Smaller boxes for direct sale**
Emission	0	0	+-
Costs	-	+	-
Quality	+	-	0
Material usage	+	+	+-

Vase life for the Kenyan Auction

For the vase life of the Kenyan Auction some different estimations must be made. First of all, the auction takes place in Kenya. A new hub must be built, so it is assumed it has enough cooling capacity. The process on the farm stays the same, so the degree hours for this part will be 55.5. The roses are

Table 6.25: Score remaining modifications of the Kenyan Auction

	'Aftuin' auction/Hub in Kenya	Better information sharing	Dry transport during the auction and to the buyer
Emission	+	+	+
Costs	+-	+	+-
Quality	+	-	+
Material usage	+	0	0
	ULDs to airside during nighttime	**Combined truck services in Kenya**	
Emission	0	+	
Costs	-	+	
Quality	+	-	
Material usage	0	0	

packed in modified atmosphere packaging, so for the rest of the process the temperature will be five degree Celsius. The transportation to the hub will be done by truck which is assumed to be the same travel time as for the current situation. This means the new hub is located near the airport. On average this is eight hours, so $7.5 * 5 = 37.5$ degree hours. Subsequently the auction takes place for around five hours in which the roses are kept in the packaging. From here the freight forwarding process and airline handling will take the same time as for the current situation. However, because of the modified atmosphere packaging this is all done on a temperature of five degree Celsius. This takes around 18 hours, so $18 * 5 = 90$ degree hours. When the roses arrive at the airport they will be kept for the custom check and phytosanitary check, after which they are picked up by the buyer. All the checks will probably take about one hour (if the information is correct and no problems occur). This will result in five degree hours. In total this will be $55.5 + 37.5 + 90 + 5 = 188$ degree hours. The vase life will be 12.6 days ($6240 - 188 = 6052$ hours). Combined with only four handling moments which results in low risks for damaging the flowers.

Implementation plan for the Kenyan Auction

For the transport modes the implementation is only dependent on the availability of the bio fuel. Just like the Low Emission Update, it will be important to have a supplier for the bio diesel and bio kerosene in Kenya. Most of the packaging alternatives have also been discussed in previous designs, but the omission of the sleeves has only been done in this design. Since all sold products will go by airplane to the country of destination, the roses will not be put on water and the roses will not be unpacked. So the sleeves will not be added, which results in no advertisements on the roses. This should be discussed with the growers. It will save money, but there will be a lack in advertisement. Since all sales can be seen as a direct flow, the differences in box sizes will be necessary to keep the smaller buyer satisfied. Just like the Extra Hub in Europe, those boxes must be in scale to keep the stacking efficient. However, this will be more expensive, since the amount of packaging per rose will be more. The modified atmosphere packaging is expensive for a general box, but will be even more expensive for different box sizes.

The most logistically challenging part will be the 'aftuin' auction. The buyers must be aware of the possible longer transport time. Currently when a product has been purchased on the clock it will be in the customers box within two hours. This will not be possible, so this must be a shift in the mindset of the buyers. The roses will be delivered a day after the roses have been sold. Furthermore, the unpackers are working in Kenya instead of the Netherlands. This could be a problem for the unpackers which can cause problems for this design. In Kenya the air transport must be rearranged, since the destinations for the roses will differ. Either there will be more flights necessary to different locations, or the roses are not shipped to the final destination and are transferred to the final destination. This will not be ideal, since it can cause an increase in degree hours and a decrease in quality. If the air transport is rearranged, the roses must travel during night time, which will decrease the exposure to the heat during the day time. Even if they are in modified atmosphere packaging, it will be more efficient if the outside temperature is lower.

The rest of the alternatives do not differ from the other designs. The implementation will be the same for this design.

6.6 Conclusion

This chapter contains the third and fourth design activities. As stated in chapter 2, the list with design alternatives has been formed within the analyses and the developing ideas phase. Literature research on possible alternatives has been done together with the analyses of other companies working on sustainability. The alternatives are divided in three categories. First the transport modes which has direct impact on the emission. Alternatives are found for the transportation from grower to the airport/harbor, for the transport from Kenya to Europe and last for the shipment to RFH. For each alternative a list with pros and cons is discussed. Next alternatives are found for the packaging. The impact of changing packaging can be seen in material usage and the quality of the roses. Again, the possibilities are explained along with benefits and drawbacks. The last list consists of remaining supply chain modifications. Most of these do not directly affect one of the criteria used to measure sustainability discussed in chapter 5.4. The alternatives of the three categories can be combined to form a new design in the creating solutions phase of the methodology. Five designs are formed with these alternatives. With a focus point per design, the alternatives fit for the designs are implemented. First the transport modes, followed by the packaging and remaining modifications. The alternatives have been scored to ensure the alternatives meet the demand of the design and the vase life per design is calculated. Last an implementation plan per design has been written, which clarifies the difficulties of implementing a new design.

Chapter 7

Evaluation of the new designs

To evaluate the formed designs a multi-criteria analyses is done. This results in a score for the designs, which makes it possible to compare the designs on sustainability (design activity 5). The scores are plotted in a Pareto front, to visualise what the trade-offs are. These trade-offs are discussed and elaborated. Also, interviews are held to evaluate the feasibility to implement the designs. With different stakeholders it is discussed what designs will be feasible to implement and what the bottlenecks are for implementing the formed designs.

7.1 Multi-criteria analyses

A multi criteria analyses has been done for the five formed designs. As a reference, the current supply chain is taken as a completely neutral design called design 0. The scores for this design will mostly be 0 to make it possible to compare. However, this will not always be realistic, since some of the scores should be higher or lower than average for the current design. In chapter 5.4 it has been explained how to give a value to sustainability. These measurement methods are partly used for the requirements. The requirements are all qualitatively scored. For the requirements which can be scored quantitatively a scale will be made to transmit the quantitative to qualitative score. For the qualitative measurements there will be a scale of five levels. The lowest score is a double minus (- -) and the best score is double plus (++), the other ratings are a single minus(-), a single plus (+) and a zero for a neutral score (0). This system has been chosen, because this makes it easier to compare the results with a neutral scenario. Partly, the scores are based on qualitative research. Therefore the scale is kept on these five levels. Assumptions are made which will cause difficulties in smaller differences in scores. For example, the difference between a 7 and a 8 on a scale is difficult to determine for a qualitative measurement.

For the multi criteria analyses, the weigh factors should be determined with the level of importance in mind. This will be done by giving the constraints a weighing factor of two while the objectives have a weight of one. The requirements have been rated per main requirement (discussed in chapter 5.5) after which they have been put together in a Pareto front to compare and analyse the possible trade-offs.

The constraints have a higher weight factor, but the scores for the constraints must not be below zero to improve the current design. Constraints with a score below zero, will lead to infeasible solutions. For the objectives, trade-offs have to be made to create the highest total score possible. In fact the constraints are binary. The score constraint is met or not. But the constraints in the MCA are still scored with the same method as the objectives. The score method as described above, can also be used on most of the constraints. The + and - will indicate the level of improvement within the constraint.

FC 1. The design has to be more environmentally sustainable than the current supply chain.

Figure 7.1 shows the first MCA. The requirements of chapter 5.5 are listed in the top row. But there are some requirements left out. As discussed in chapter 5.5, some of the requirements have been based on the process in forming the designs or have been carried out in a different way. These requirements can not be rated in the multi criteria analyses. These are:

- 'Possible environmental friendly design changes must be provided.' which has been done in chapter 6 of this thesis for all designs.
- 'The process must provide insight in what design changes have the most impact on the environmental sustainability.', this has not specifically been done, but this will be discussed in the conclusion of this chapter.
- 'Green energy must be used.' For the alternatives which are powered with electricity it is assumed that green energy is used. However, there are designs which do not include these kind of changes. The power supply of the cold stores are not discussed in this research, but these can all be powered by green energy.
- 'The process should provide insight in the level of environmental sustainability in comparison with other similar supply chains.' This has not been done in this research, but is something which will be discussed in the recommendations (chapter 8).

The other requirements are all rated below. It is expected that the third design will score best for this part, because these out of the box ideas are optimal for improving the environmental sustainability. Furthermore, it is expected that the overall scores will be high, because all designs had a focus on improving the environmental sustainability. The scores lower than the current design are marked in red and the scores higher are marked in green.

The first requirement has low scores. Design 1, 3 and 5 will not influence the use of pesticides since they all use the airplane to reach Europe and therefore have the same process as the current situation. Design 2 and 4 make use of the boat where the roses are dipped in a dipping solution to decrease the chance of bugs. This is also sometimes done for air transport. This remedy is not harmful, but it will increase the use of pesticides. Therefore the second and forth design scored a minus for this part. The second and third requirement are scored by looking at the packaging alternatives. The scores are the same in both cases. All designs have a positive influence on the recyclability of the materials and the amount of raw materials used. The third and fifth have a ++ score, since the materials are all re-used materials, and all the materials are either bio degradable or re-usable. The efficiency in energy usage is the same for the first design as for the current design. None of the alternatives used to form the

Low Emission Update have influence on the energy usage. For the other designs the alternatives have a positive impact on the energy usage. With a modified atmosphere packaging and controlled atmosphere in containers the roses are kept in specific conditions. This is an energy efficient process, since these boxes and containers are kept closed. This way it will not cost extra energy to keep the same conditions. For the modified atmosphere packaging it will be slightly less efficient, since these boxes will be exposed to heat from the air outside and the people touching the boxes. Therefore, the scores for design 2 and 4 are ++ and for design 3 and 5 are +. For the CO2 equivalents a scale is taken. When the total decrease of equivalents by transport is more than 50%, it will be scored with a +. When the decrease is from 75% to 100%, it will be scored with ++. Last the last requirement is hard to score. None of the designs are necessarily a closed circular system, but the designs 2 to 5 make it possible to have a completely closed circular system with the use of packaging which is re-used. However, the third and fifth design have more difficulties by transporting the packaging back by plane. This is an expensive process where probably a boat will be necessary to transport the packages back. This will be more difficult than for design 2 and 4. Therefore the second and forth design are scored with ++ and design 3 and 5 are scored with +. Design 1 is scored with a 0. This is the same as for the current design. Without having re-usable packaging, the supply chain will not be circular.

	The design changes should not have negative impact on the use of pesticides.	The design should have recyclable or re-usable packaging as much as possible.	The design should have as little raw materials as possible.	The efficiency in energy usage should be increased.	There has to be less CO_2 equivalents than the current supply chain.	The supply chain should be a closed circular system.	**Total:**
Weight:	*1*	*1*	*1*	*1*	*2*	*1*	**7**
Design 0: Current supply chain	0	0	0	0	0	0	**0**
Design 1: Low Emission Upgrade	0	+	+	0	++	0	**6**
Design 2: CCC Design	-	+	+	++	++	++	**9**
Design 3: Futuristic Supply Chain	0	++	++	+	++	+	**10**
Design 4: Extra Hub in Europe	-	+	+	++	+	++	**8**
Design 5: Kenyan Auction	0	++	++	+	++	+	**10**

Figure 7.1: MCA of the requirements from FC1.

FC 2. The design must be feasible to implement.

The second main requirement with the corresponding constraints and objectives has been listed in figure 7.2. Again the five designs are scored according to the same system. These scores are all about the feasibility to implement the designs. It is expected that the third design, which is futuristic with out-of-the-box ideas, will score low on this part and the first design, with small modifications to decrease the emissions, will score high on this part. Because the current design is already implemented it would be strange to keep the scores of this design to zero. Therefore, some of the scores for the current design are changed to ++. The scores for economical feasibility are kept on 0. For the implementation costs, the costs will be zero and the new designs can possibly cost money and the usage costs can either be increased or decreased when keeping the current score at 0. For the impact on society the current design is also kept to 0. Not changing the design will not have impact on the social part.

Physically all designs are feasible to implement, but for design 3 and 5 much is asked from the land use in Kenya. This can make it slightly more difficult than for the other designs. There will be a positive impact on society, because all designs will cause a decrease in pollution. Furthermore, the fifth design will cause an increase in employment in Kenya. With the auction in Kenya, there will be more employment. This is still positive, even in comparison to the decrease in work in the Netherlands. It will increase the welfare of Kenya, which has more impact than the decrease in work in the Netherlands. For the third requirement the scores are almost all negative. All designs cost money to implement. Design 1 costs relatively little money to implement, so this is scored with 0. Designs 2, 4 and 5 do cost money for either building a railway or an extra hub. These costs are relatively low in comparison with design 3. The research has been done on Kenya, but the designs should also be implemented in other countries. For design 1 and 5 this would not be a problem at all. For design 3 the technologies must be available at the other locations and spacing must be made for the zeppelin, but this is respectively not difficult over time. For the second and forth design there are more bottle necks. Not all countries are close to water to transport the products by sea freight. This can be dissolved by having longer transport periods for the trains, but this might not be efficient. Furthermore, there must be a railway available which is connected to the harbors. This can all be developed, but will be difficult and at high costs.

The following three requirements are technological feasibility, logistical feasibility and economical feasibility to use the design. Regarding the technological feasibility all designs, except design 3, score positive, since all alternatives do already exist. For design 3 there are many uncertainties whether it will be possible to implement these alternatives as discussed in chapter 6. Logistically the first design will have no difficulties at all and the second design will also be respectively easy. The third and forth can have some difficulties for the connection between the transport modes and the logistics behind the prediction model of design 4. The last design will have the most difficulties logistic wise. The auction needs to be replaced to Kenya, only for the roses. The roses will also come from different countries and all the other flowers need to have a auction for themselves as well. This is logistically challenging compared to a centralized auction. The usage costs of design 1 are higher than the current design. Therefore, the score will be a -. For design 2 to 4 the usage costs will be much lower, which results in a score of ++. Design 5 will have higher costs for the bio fuels, but will have less travel time and travel moments, which makes it cheaper. Therefore the score is a +.

	The design has to be physically feasible in the coming 10 years.	The design should not have negative impact on the society.	The design should be economically feasible to implement.	It should be possible to implement the design in other horticultural areas.	The design should be technologically feasible to implement in the coming 10 years.	The design must be logistically feasible in the coming 10 years.	The design should be economically feasible to use.	Total:
Weight:	2	1	1	1	1	2	1	9
Design 0: Current supply chain	++	0	0	++	++	++	0	12
Design 1: Low Emission Upgrade	++	+	0	++	++	++	-	12
Design 2: CCC Design	++	+	-	-	++	+	++	9
Design 3: Futuristic Supply Chain	+	+	--	+	--	0	++	2
Design 4: Extra Hub in Europe	++	+	-	-	++	0	++	7
Design 5: Kenyan Auction	+	++	-	++	++	-	+	6

Figure 7.2: MCA of the requirements from FC2.

FO 1. The quality of the roses should be as high as possible.

Since design 1 does not differ that much from design 0, it is expected that this design will differ much in score in respect to the current situation. Furthermore, design 5 is expected to score high because of the increased efficiency in travel time to the buyer and the reduction in handling moments. Last it is expected that the CCC design has high scores, since this is one of the focus points of this design.

The first constraint is met by all five designs, this results in a score of ++ for all of them, which is the same as for the current situation. On the other hand, not all designs improved the degree hours and some of them decreased the amount of degree hours and the vase life. This can be seen in the scores for the second and third requirement. The differences between those two requirements are taking into account the handling moments, which results in design 2 and 4 scoring higher for the second requirement than for the third. It is expected that the decrease in handling moments will increase the vase life, even when the degree hours have slightly decreased. For the last requirement the number of actions has decreased for all designs except for design one. This results in a + for designs 2 to 5 and a 0 for design 1 which has the same handling moments as the current design.

	High quality roses with a minimum vase life of 7 days must be delivered.	The vase life should be increased to a minimum of 10 days.	The amount of degree hours should be as small as possible.	The number of actions should be as small as possible.	Total:
Weight:	2	1	1	1	5
Design 0: Current supply chain	++	0	0	0	4
Design 1: Low Emission Upgrade	++	0	0	0	4
Design 2: CCC Design	++	+	0	+	6
Design 3: Futuristic Supply Chain	++	+	+	+	7
Design 4: Extra Hub in Europe	++	+	0	+	6
Design 5: Kenyan Auction	++	+	+	+	7

Figure 7.3: MCA of the requirements from FO1.

7.2 Pareto front of the designs

For RFH it will be interesting to see the trade-offs between the designs. It is discussed with expert 3, that it will not be interesting to have a semi positive score on all aspects, but it is more interesting to have a score that is much better than the others. In figure 7.4 and 7.5 the designs are plotted in a Pareto front. First the environmental sustainability is plotted against the implementation feasibility. Second, the quality is plotted against the implementation feasibility. On the x-axis, low scores mean low feasibility to implement and on the y-axis the low scores mean either low quality or low environmental sustainability. In order to make it more clear the graphs have been split, instead of having one three dimensional graph with the quality, feasibility to implement and the environmental sustainability.

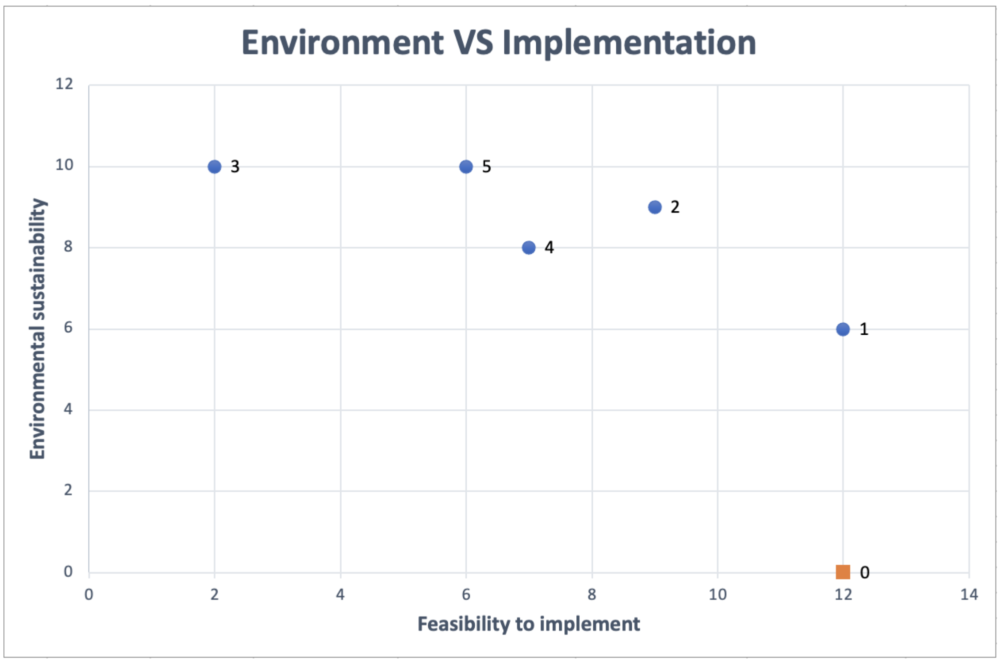

Figure 7.4: Pareto front of the environmental sustainability VS the feasibility to implement.

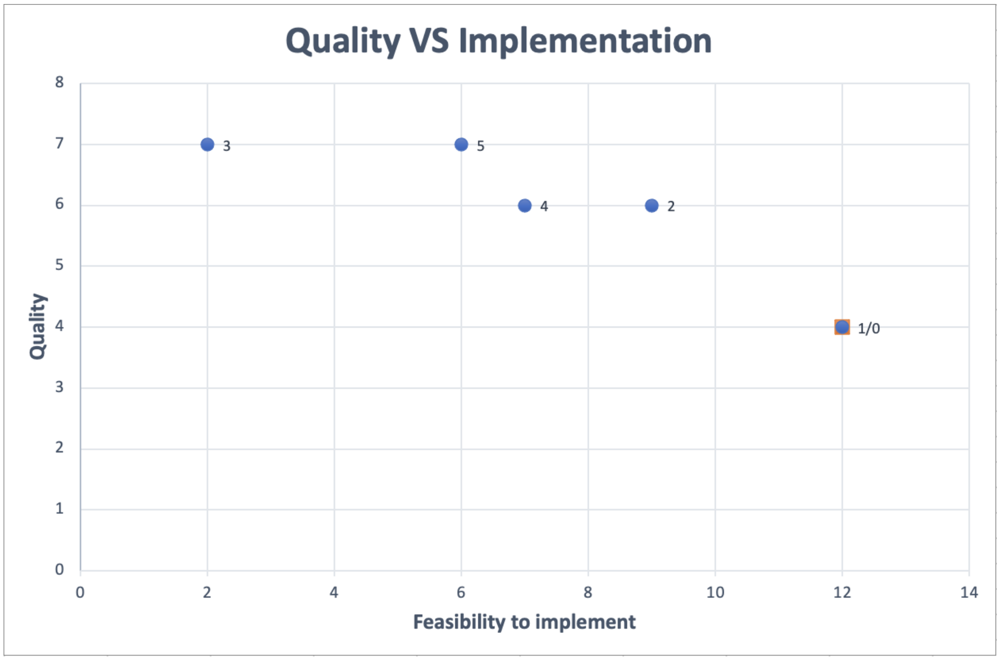

Figure 7.5: Pareto front of the quality VS the feasibility to implement.

7.3 Discussion on scoring the designs

According to the Pareto front, design 3 and 5 have the highest scores on both quality and environmental sustainability. However, the feasibility to implement are the lowest scores. Choosing between the futuristic supply chain and the Kenyan auction, based on the scores in the Pareto front, the Kenyan auction will be the favorite. The quality and the environmental sustainability score the same while the implementation feasibility of design 5 is higher. However, looking at figure 7.2, design 5 is the only design with a negative score on a constraint for the implementation feasibility. This means that design 5 cannot be implemented in the coming 10 years, only if this negative point can be resolved. The main bottle neck is the logistic feasibility. As discussed this is due to changing the auction to Kenya, while the other flowers are still sold from the auction in the Netherlands. Furthermore, there are more countries which sell roses on the clock. This means that either Kenya should get a monopoly on selling roses, or the auction of the roses from Kenya must be linked to the auction of the other flowers in the Netherlands. Getting a monopoly for selling roses will not be realistic. In order to make this design feasible, the auction must be linked. There has to be a function on the clock, which indicates a choice on the location the flowers are coming from. This makes it possible for the buyers to see the origin of the roses together with the time period for arriving. The other problem is the amount of flights from Kenya to the rest of the world. An increase in flights is necessary to reach all destinations of the buyers. It will not be appealing to buy roses from Kenya when the roses need to be collected in a country located further away. On the other hand, the transportation to other countries is also regulated from the Netherlands, but it still might be challenging to arrange this service all over the world.

Looking at the quality and environmental sustainability the futuristic design will be most interesting when the Kenyan auction will not be feasible. However, the score for the implementation feasibility is much lower than all the other designs. Since most of the alternatives are new, there is much uncertainty if future technologies will make the design feasible. However, design 3 must be considered in the future. All alternatives are making the supply chain more sustainable. The implementation costs of most alternatives are high, but the usage costs are low. It would be beneficial to invest in such alternatives when they are possible in the future. The alternatives can be merged with all other designs by either adding them to the design or replacing the alternative with the same functions.

Looking at the design that is most feasible to implement, the Low Emission Update scores best in the Pareto front. The alternatives are not challenging to implement in the coming 10 years which makes it a relatively easy design to implement. Furthermore, the quality of the roses stays the same compared to the current design and the environmental sustainability increases. However, if the fourth main requirement, 'The design should be future proof after implementation', is taken into account, this design will not be suited. The costs for airfreight is increasing, which will make it too expensive to transport the roses by air. But, for an in-between solution for a more environmental friendly supply chain the Low Emission Update can be sufficient.

The CCC design, was expected to have the highest score on quality. However, the score is lower than the third and fifth design. This is mostly because the degree hours are quantified with average temperatures. For the CCC design the roses are kept on the same temperature during the complete process. This will improve the quality, but it is not taken into account for the degree hours calculations. For the environmental sustainability, the score is also slightly lower than the third and fifth design. However, the implementation feasibility is higher. This is a trade-off for the designs. It should be decided by RFH what the most important aspect is, and what the risks are for choosing a specific design. The CCC design has the highest average score, but it has not the best score in any of the subjects.

Like the CCC design, the Extra Hub in Europe does not have a top score on any of the subjects. Besides, the scores for implementation and sustainability are lower than the CCC design. The quality score is the same. Looking at the Pareto front, this design will never be chosen, since the CCC design will always be more sufficient. But, the placement of the hub can be optimized by collecting data and improving the prediction model before building the hub. This can result in fewer degree hours, higher quality roses and fewer costs. Most of the scores of design 4 will improve when the prediction model will be perfect. However, in order for design 4 to be relevant at all, this will also be the largest bottleneck.

7.4 Stakeholder and expert opinion

To validate the five designs formed in chapter 6.5 interviews have been held with different stakeholders and experts. Stakeholders were asked what their opinion is on the new designs, if they think the designs are feasible to implement and what adjustments could be made to the designs. Who the experts are and what their expertise is can be found in appendix A.

Before the interviews started, the designs were explained with their main goal. Furthermore, the design alternatives of all designs were given to see if there are any misunderstandings on the alternatives. When all alternatives were clear and the designs including the method of forming the designs were understood, the interview started. First the question 'What are the first thoughts on the newly developed designs?' was asked where after the discussion started on the different designs. The following discussion are based on the questions:

- Is there a focus point/design missing in the list of new designs?
- Are there any alternatives which will not succeed in any way?
- Which design is most likely to be implemented?
- Which design will not be feasible to implement and why?
- Which design do you prefer to be implemented?
- What additions would you make to one of the design?

These questions were used as a tool during the interviews to keep the discussion going. The designs resulted in the following findings.

Design 1 and 2 are close to the current situation, only the second design is in the development phase. However, according to expert 9, the transition to bio fuels and electric trucks is not easy. It would be difficult to have enough bio resources to provide all transport and the capacity on the electrical network can be a bottle neck to provide a large scale transition to electrical trucks. In order to be a quick fix, the truck service in Kenya should reduce the emissions in Kenya instead of the use of bio fuels. And it has to be ensured that the electrical network capacity is sufficient in the Netherlands. For the second design, the electric roads do not fit this design. This is a more futuristic alternative, which makes it a better fit with the third design. The third design is not likely to be feasible in the near future, but it would be great if these alternatives could be implemented. The fourth and fifth design were investigated in a pillar several years ago. Design 4 would be logical and theoretically a profitable design. However, according to expert 5, the Dutch are too dominant and therefore the roses will pass the Netherlands before going to the hubs located elsewhere in Europe. Expert 7, expects design 4 to be an addition on the second design. When the second design is implemented without any flaws, the fourth design could be an improvement for the future. Design 5 does have logistical difficulties. The large amount of small shipments will not have a beneficial business case. It will not be efficient, and many more transport possibilities are necessary to send the roses to the rest of the world from Kenya. All in all the designs consist of most of the possibilities with different focus points. The most difficult will be the implementation of the designs. Except for design 3, there are no new alternatives. But still the designs are not used yet. This is mostly because of the business case which will not be profitable, or no actors are willing to pay for the innovations (expert 8).

The design which is most preferred by the experts is design 2. Parts of this design are currently researched within RFH. The boat is already proven to be a successful alternative for the airplane, which makes this design more feasible. All experts agreed on the necessary transition to low/zero emission vehicles to be used in the future. So the transition to electric trucks seems to be undeniable. However, for the coming years design 2 needs to be combined with design 1 or the current design (expert 2). It will not be feasible to implement this design directly. A transition time is necessary to arrange the logistics regarding the shipments which will take much longer than the shipments via air transport. In the future it would be great if design 2 can be combined with design 3 and/or design 4. This will have a positive impact on the sustainability.

7.5 Conclusion

In this chapter the five formed designs are scored on sustainability (design activity 5). The designs have different focus points and it was expected that this would lead to different scores in a MCA. However, the resulting scores are close. It can be concluded that all designs have strong points and all designs have some flaws. None of the designs has the best scores on all topics. Trade-offs need to be made by RFH. What will be the most important part to improve and what are the corresponding risks. The chosen design could be improved by adding alternatives of the other designs. However, this could cause a decrease in score for other parts. The only design which is more difficult to improve is design 3. This design scores badly on feasibility to implement. This is due to the use of new technologies, which bring uncertainties in implementation possibilities. However, in theory these new technologies will improve the supply chain regarding sustainability in every way. Therefore, these alternatives can be added to the other designs, when the technologies improve over the years and the feasibility increases. According to the experts the second design (CCC design) is most promising. Low emission vehicles are the future and it will be undeniable that these need to be used. However, the most important bottle neck for implementing a new design is the business case. For most of the actors, this is the most important part of the process. If the new design is not profitable, the design will not be implemented.

Chapter 8

Discussion, Conclusion and Recommendation

The chapter starts with a discussion where the results of the new design are discussed and where the validation of the experts is considered. How they are carried out and what conclusions may be drawn from the outcomes. Second the conclusion, where the main objective is discussed together with the design activities. This chapter ends with the recommendations for further research and for RFH.

8.1 Discussion

The discussion will mainly focus on chapter 5.5 to chapter 7.4, since these mainly contain the results and the solutions. The requirements formed in chapter 5.5, are validated with two experts within RFH. This list could be further improved and expanded when more stakeholders are asked for their opinion. Furthermore, the research has changed during the process, which resulted in some irrelevant objectives. The list of requirements could have been specified more when a more quantitative study was done.

The list with conceptual design alternatives practically complete according to the different stakeholders and experts which are interviewed. However, several alternatives have been tried to be implemented before without success. The bottlenecks per design alternative are listed in chapter 6. Still these alternatives are implemented in some of the designs, since there are more and more actors motivated to change the supply chain to be more environmental friendly. An alternative which not worked several years ago, might be an acceptable solution for the future.

The five formed designs for this thesis are all improvements on the current supply chain, each with their own specifics. Looking at the first design, it will be relatively easy to implement. The degree hours will not change and the logistics stay the same. The most difficult parts to implement are the bio fuels in Kenya and the combined truck service. In order to implement these alternatives, the information sharing in Kenya must be optimized and the resources must be made available. The growers need to cooperate with these changes. They will be responsible to streamline the truck service and make sure the bio diesel is used. Also, the airport will play an important role for the bio kerosene in the airplane. This design has the lowest score on improving the environmental sustainability. This is mainly because the alternatives consists of quick fixes, which results in the least impact. In order to improve this score, the bio fuels have to be made of 100% biodegradable resources, which is currently not existing. However, research is being conducted to create it. Furthermore, the material usage could be improved by less raw materials and more re-usable parts in the supply chain. The Low Emission Update is considered to be an okay improvement of the current design, but it will not be future proof. It will be interesting for the near future, but it should be considered whether investing in it is worthwhile.

The second design is considered to be most promising by experts and the author. The design is future proof, since sea transport and train transport can both be adjusted to be more sustainable with green powering. Overall it is a consistent design. The design is clearly more environmental friendly than the current design with possibility to improve even more. The implementation will be relatively simple according to the scores in the Pareto front. The down side regarding the implementation lies in the fact that it will not be simple to implement this design in other countries. Not all countries have a rail network and not every country is located at sea. On the other hand, rail transportation will not be difficult to implement as it is a well known transport mode in most of the countries. Furthermore, it will be possible to transport the products to a country which is located near the sea, to use a boat. This can bring some logistical difficulties with different rail types and importation rules, but it will not be impossible. The Kenyan government (or the government of other countries) will be responsible for developing the railway. It should be researched if the currently available railway can be improved and used for the roses, or if a completely new railway would be necessary. This will influence the implementation costs which needs to be considered by RFH. The investment for the rest of the stakeholders depends on the use of the the railway. If it is used by both public trains and the train for the roses, the government should be responsible for the investment. But, when the railway will only be used by cargo for the roses, all actors need to be involved in the payment for the railway. Also, the transportation of the re-usable boxes, back to Kenya need to be funded by all actors. Next the growers need to invest in trucks and truck drivers to transport the pallets.

Third the futuristic design. This is considered to be an interesting design according to the interviewed experts. The whole sector is innovating, so these could be solutions for the future. It has a great score on environmental sustainability and quality, but the possibility to implement as a down side. For the future this will be questionable, if and how it will be possible to implement the alternatives of this design. Either way, this design brings lots of theoretical improvements for all designs. The implementation of the zeppelin will have influence on the transportation for the growers. They need to ship the roses to the zeppelin, instead of the airport. Also the freight forwarder needs to collect the roses from the zeppelin to the airport, since the zeppelin will not be able to land at the airport. Furthermore, the automated inventory management will change the working environment for dock services. The workload will be less which is a positive result.

Design 4 is the least popular design according to most experts and the Pareto front. The Extra Hub in Europe does not have a high score on any of the requirements. This makes it less interesting for RFH to make a switch in the supply chain. Although the idea has already been researched, it was unsuccessful in that instance. The dutch floriculture was to dominant to have hubs on different locations in Europe. The stakeholders in the Netherlands have much power and are currently not positive about a switch in hub locations. However, also this design has much potential. When the prices keep increasing, this could lead to cost savings. The travel times by boat will be much lower. Furthermore, if the floriculture grows, RFH must be expanded. This could be done by implementing more distribution hubs, which makes it interesting to look for the opportunities this design offers. On the other hand, when the floriculture declines, it should be considered if it will be financially feasible and beneficial to implement new hubs. The most important part will be to convince the Dutch actors. This could either be done by a better business case and an optimal prediction model, or by an external push for more environmental sustainability.

The last design brings much opportunities, but has one major bottleneck. The logistics for design 5 are difficult to implement with the small orders for different destinations. This is confirmed in the interviews. For this design to work there must be a cheaper way to transport small shipments to different destinations. This appears not to be feasible in the coming years, but might be promising for the future. If this problem could be fixed, this design could have the best scores overall. However, the last mile transport is not considered in any of the designs. The distances for pick-up can be larger than for the other designs, which makes the buyer an important part in measuring the sustainability. Since the transportation only reaches a hub at the airport, the buyer should pick the roses up by using an environmental friendly transport mode in order to not harm the environment. Besides, if the buyers are located at specific areas and the locations are not spread around the world, the feasibility to implement this design will improve. However, this cannot be ensured with a dynamic market place. Much is dependent on the airport for the Kenyan auction. The flight planning needs to be adjusted, which can be difficult.

RFH can use this research as an inspiration for future developments for the supply chain of roses. The new designs with the corresponding Pareto fronts will help to start a discussion with the stakeholders. This should change the mindset of the actors on keeping the current situation as it is. In order to improve the sustainability, much changes can be made. This thesis shows different ways to do so. RFH cannot change the complete supply chain on its own. Collaboration between the actors is needed to innovate and to finance the future developments. This thesis will not be enough to convince all actors that changing the supply chain is necessary, but it will help to give insight in the possibilities for the future. Together with a cost benefit analyses this thesis should provide sufficient information on the changes that should be made and how to implement these changes.

8.2 Conclusion

This design thesis is conducted to achieve the main objective 'A new design for the supply chain of roses from East-Africa which is more sustainable'. To fulfill the objective several steps are conducted. First the current situation of the supply chain is analyzed in the first design activity. This is executed in the analyzing phase. Research was done on the basic perspectives in the floricultural sector. With this knowledge, discussion within RFH resulted in a schematic overview of the current supply chain. It can be divided in two physical flows (clock flow and direct flow). The schematic flow was elaborated in a detailed swimlane with a calculation of the vase life of the roses. It was concluded that many stakeholders are involved in the supply chain, which play a large role in possible adjustments in the supply chain. Next, in order to compose the requirements, a clear definition of sustainability had to be defined. The goal of improving overall sustainability is achieved by reducing negative impact on the environmental part, while at the same time making sure it will be profitable to sustain business and not harm the social aspects. Combined with more literature and the definition for sustainability at RFH it resulted in the specific definition used in this thesis. 'Sustainability is a mixture between not harming social parts, not making too expensive changes, but most of all being environmentally sustainable by reducing emission, using green/less energy and making re-usable/recyclable transport packaging with less raw materials'. The sustainability is scored on five KPIs: Emission, Materials, Quality, Economical sustainability and Social sustainability. Not all KPIs have the same level of importance which is clarified in the requirements.

With the KPIs for sustainability in mind, four main requirements are formed in the developing ideas phase. The requirements are:

- The design has to be more environmentally sustainable than the current supply chain.
- The design must be feasible to implement.
- The quality of the roses should be as high as possible.
- The design should be future proof after implementation.

These requirements can be seen as the topics for a longer list with objectives and constraints per requirement. After validation of this list, the requirements can be implemented in the MCA in a later stadium of this thesis. This list is the result of the design activity 'List the design requirements for the new design of the supply chain'.

Research is done on possible design alternatives in the analyzing phase (design activity 3). This contains a research on other companies involved in becoming more sustainable, as well as out of the box ideas on sustainability. Combined with the authors knowledge this resulted in a list with concept design alternatives formed in the developing ideas phase. The concept alternatives are divided in three parts. First the transportation modes, second the packaging and third the remaining modifications. With these lists combinations could be made to form new designs in the creating the solution phase of the methodology.

In the next design activity, 'Combine the design alternatives to develop new possible designs' the combinations are made. This resulted in five designs with all a different point of view for improvement. Each of these designs is discussed in depth. A swimlane diagram is made per design to see the differences with the current supply chain followed by a qualitative scoring for all design alternatives to make sure the alternatives fit the goal of the design. A calculation is made on the expected vase life per design which resulted in some differences, but none of these differences were severe. Last, an implementation plan is written were it was concluded that the Low Emission Update was relatively simple to implement, since the alternatives do not need large adjustments. For the Futuristic Supply Chain the implementation would be most difficult. The adjustments will be tremendous compared to the current supply chain. This is all considered in the MCA to score the designs on feasibility to implement.

This is the next design activity where the level of sustainability is scored. With the MCA two Pareto fronts are plotted. One where the environmental sustainability is plotted against the feasibility to implement and second the quality against the feasibility to implement. It will be a trade-off on the demand to choose a design. RFH needs to decide what would be the most important part and has to choose the corresponding design. The designs can be further improved by combination of the designs or adjustments to the alternatives. However, the impact of the alternatives mostly influence more than one part in the MCA. Therefore, a small advantage on one of the categories can lead to a large disadvantage on another subject. These trade-offs are affected by the goal per design. In order to make one best design, the trade-offs should be judged objectively.

The evaluation with the experts resulted in some new insights. Most of the alternatives are theoretically possible and will result in an improvement of the supply chain. However, the main reaction was that in practice, it will be difficult to implement. The CCC design is most likely to be implemented, since this is currently in development within the floricultural sector. Sea freight is a promising solution for the high air freight prices. The largest bottleneck for the implementation is the business case for the designs. According to the experts, money still is the most important part for most of the stakeholders, so as long as the business case is not beneficial the alternatives will most likely not be implemented. Unless there will be an external push by a high powered stakeholder like the government.

To conclude, this design thesis resulted in five designs with different improvement points. It would be a trade-off on the different KPIs to select a design. RFH needs to decide what criteria will be valued as most important and what should be the impact of a new design. In order for a new design to be implemented the business case should either be profitable, or an external push must force the supply chain to make changes. This could either be from the government/European Union, or the consumers.

8.3 Recommendation

In order to improve the supply chain and implement alternatives, it is necessary that the basis of the supply chain is optimized. According to the interviews and some discussions held throughout the process, it came to mind that the current supply chain has much flaws. These flaws mostly exist in the area of information sharing, different interests for stakeholders and the willingness to innovate. It is an old sector with lots of experience throughout the supply chain. This experience can be used to improve the possible alternatives and innovations. This could be achieved when the more experienced parties collaborate with parties that have more interest in innovation. When collaboration is improved, the information flow will improve as well and the situation could arise where the different actors in the supply chain all pursue one shared goal of improvement.

To make the research that has been done in this thesis more useful for the sector, the scope can be expanded. Currently the scope does not include the work that is executed at the growers. This could be a research on its own. The land use and generating the resources to improve the growth can be optimized regarding sustainability. It would be interesting to include the complete process at the grower. Next the transportation after the clock would be interesting to consider. When the currently considered part of the supply chain is environmental friendly, but the roses are transported by high emission transport modes to the buyers, the complete process will still be harmful to the environment. This could be prevented by expanding the offer of transport to the buyer, for example with the help of Floriway the transportation department of RFH for the national shipments. Floriway can invest in zero emission vehicles. Combined with an increase in using Floriway, this could lead to a large improvement on sustainability. Also, Floriway could be expanded to international shipments.

The alternatives discussed in this thesis all are scored with pros and cons. However, these are based on the expected impact of the alternatives. It would be helpful to test the alternatives before implementing them. This results in prior knowledge on the bottlenecks and improvement points for new alternatives. Another way to verify the impact of the alternatives is planning more interviews with experts. Nine specialists were consulted for information and input on this thesis. The number of experts should be increased, and the differences in expertise of the actors should be divided. More specialists from a variety of fields arrive at various potential outcomes of the options. This could give more insight in the implementation possibilities and the overall impact of implementing a new design. Furthermore, more experts could be involved in the scores of the alternatives and designs. This would give more value to the qualitative research.

To increase the value of this research even more, the qualitative studies can be quantified. In order for this to be possible, different studies must be done on the packaging and the remaining modifications. This is a time consuming process where not all values are readily available. However, with research on key figures this can be simplified. The data should be collected as much as possible to make the quantitative scores reliable and precise. If all data is collected it would be interesting to add a business case study. This would improve the willingness of different actors to cooperate. Also, the quantified studies need to be validated. The vase life is estimated after a calculation on the degree hours in combination with the handling moments. However, the exact impact of the handling moments is unknown.

To have a more quantified study, RFH is currently working on the hortifootprint discussed earlier in this thesis. This tool can calculate the overall footprint of one rose coming from Kenya to the Netherlands. It has to be considered what the final destination of this rose is to create a complete view on the situation. This tool could help educate actors and consumers on sustainability. When the information is spread on the current footprint and the possible improvements with their impact, it would stimulate to innovate and make the supply chain more sustainable by reducing the negative impact on the environment while at the same time make sure it would be profitable to sustain business and not harm the social aspects.

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Appendix A

List of Experts

- Expert 1:
  At the moment I live as an expat in Kenya and have the function Commerce/ Key Account Manager Africa. I'm responsible for the supply from East Africa to our marketplace in Europe. I focus on maintaining the flows and new opportunities regarding demand and supply.
  Before I worked as Key Account Manager International in Holland and now work for about 6,5 years for RFH.

- Expert 2:
  I have been serving in the role of Commercial Manager in the Global Sourcing unit, leading a team that supports buyers in direct sourcing of cut flowers from our Members based across Africa. This process involves designing solutions for ensuring the flowers are delivered to the buyers, including logistics, documentation, quality control, as well as financial solutions.
  I have been in the flowers industry for more than 18 years, of which 14 have been in the commercial and export side of business (4 of these years at RoyalFloraHolland). I studied Business Management (majors in Marketing) at the University plus I have also a college Diploma in Human Resources Management.

- Expert 3:
  As teamlead Supply Chain Networks & Solutions am I responsible for the development of an (inter)national network which connects growers with their buyers. The transportation, but also designing and setting up new logistical services which are necessary to accommodate a supply chain from grower to buyer are the responsibility of the team.
  In October 2019 I started as an international supply chain expert with Royal FloraHolland. Previously I worked at a logistic service provider and a large retailer for clothing. I studied Transport, Infrastructure & Logistics at the TU Delft.

- Expert 4:
  As International Key Account manager am I responsible for the Agents/Unpackers and Key Accounts (Growers) in Kenya and Ethiopia. I am also responsible for selling services and helping

the Growers/Agents to succeed with these services (also the logistical services).
At the moment I am working for Royal FloraHolland for 5 years. I started at Royal FloraHolland in the position of Product Manager Rose. After 3 years I changed position to the position I have now, International Key Account Manager.

- Expert 5:
  Since 2018 I work as Logistic Expert for the department of Public Affairs at Royal FloraHolland. In this role I'm responsible for advocacy, for building a network of public and private of logistic stakeholders and connecting Royal FloraHolland to logistic innovations with a public character. In my previous role at Royal FloraHolland I was responsible as a program manager of various supply chain development programs.

- Expert 6:
  I am working for 27 years at RFH. Currently as program manager Phyto Affairs, Sustainability and Quality development am I responsible for programs (preventive and curative) on plant pests and diseases, Sustainable projects and Quality Development Projects.
  Phyto in relation to imports, exports restrictions and findings/outbreaks of Quarantine Plant pests and diseases, also in relation to sea freight and air transport. Reduction of carbon footprint and sustaining longevity and sustainability in the supply chain (for example from wet to dry flower chain).
  Further on roles in certification of growers, reducing single use plastic product and transport packaging and product cooling in relation to plants and flowers on our premises. Knowledge partner of the total floricultural chain in combination with sustainability.

- Expert 7:
  Teamleider at Dockservice.

- Expert 8:
  Responsible and accountable for the department Flower Handling Services (FHS), part of Royal FloraHolland (RFH), I manage the logistical & commercial side of the international flower business. FHS handles yearly more than 200 million stems of flowers from different areas such as Kenya, Israel, Italy, Turkey and more, for delivery to clock and direct customers. Since 2005 I have been working for RFH in mainly the international and commercial side of the flower business. I have a logistical background, grew up in the flowers, and recently I obtained my masters degree for Digital Business at the University of Amsterdam.

- Expert 9:
  Manager logistics and business development. I'm responsible for the Logistics Strategy and Business Development team within Royal FloraHolland since March 2022. The team covers strategy, conceptual designs, and pilots in the area of logistics in our warehouses and the logistics network, both national and international. Previously I've worked in the supply chain of a large Dutch retailer for over 11 years after finishing my study Systems Engineering Policy and Management at Delft University.

Appendix B

Current supply chain direct flow

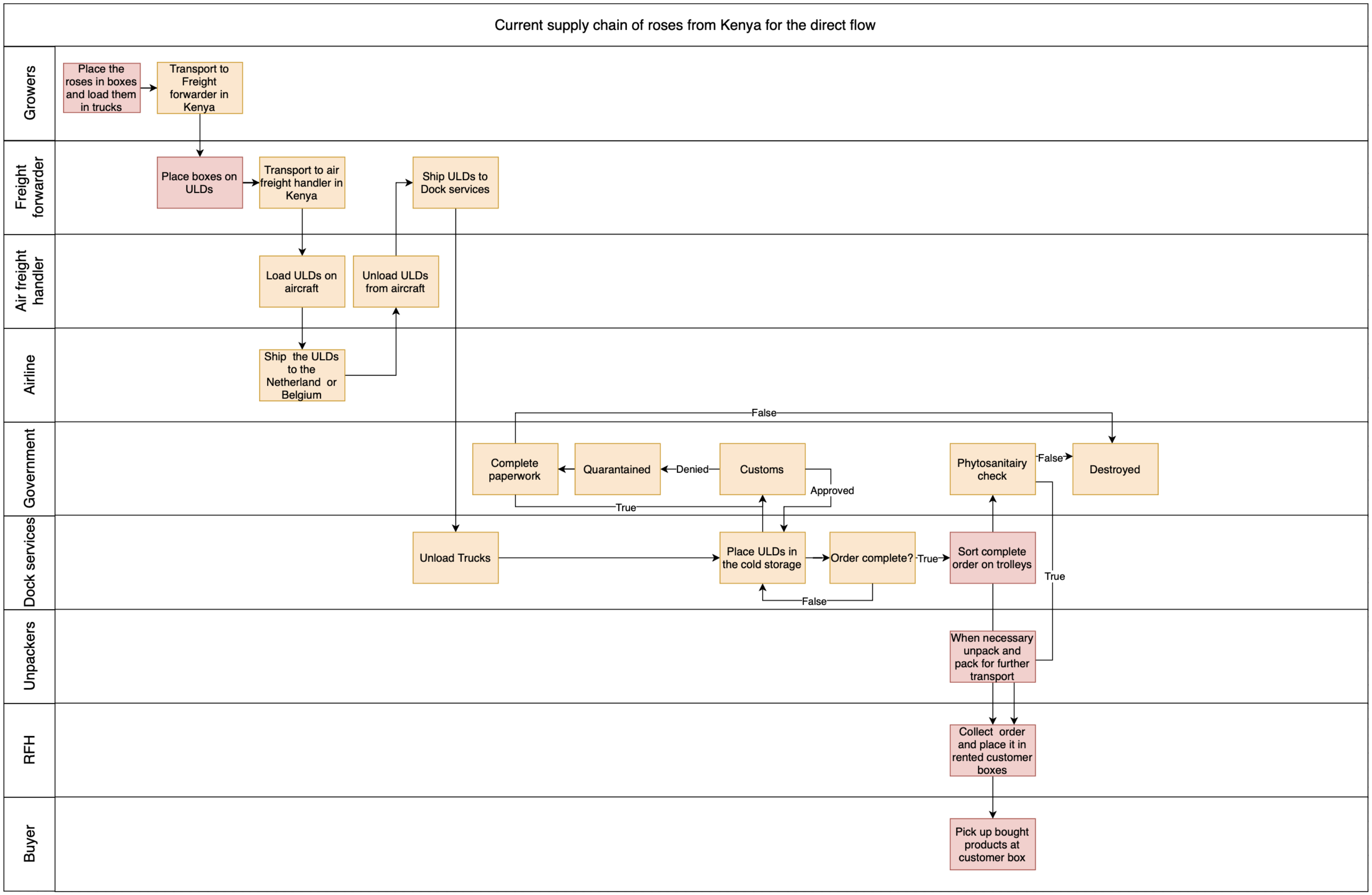

Figure B.1: Swimlane diagram of the current supply chain of roses for the direct sale

Appendix C

Customs

When a product is shipped from outside the European Union to the Netherlands, it must have customs clearance to enter the Netherlands. Most of the times this is done at the airport. However, for the horticultural sector this is different. It is possible to place a request on being an inspection location and one of these locations is Dock services in the RFH buildings. Furthermore, there are some freight forwarders which are also approved to have inspections. Moreover, there are some buyers which have an inspection location, but these are not taken into account for this explanation. In figure C.1 a detailed overview is given to explain the possibilities regarding the customs and inspections.

When the roses are sold in Kenya, there are two possible options. The roses can be sold via RFH or without RFH. Either way, the roses are shipped to an airport of the European Union or to an airport outside the European Union. At these airports, the first check is done with a x-ray scan. However, the roses do not yet have customs clearance, so it is still a Kenyan product. The roses can be transported in transit, which means they still need to be checked, but they can transport the Kenyan products in the Netherlands under strict agreements. If the roses are sold via RFH and the roses are transported via dock services, the phytosanitairy check is done at dock services. An employee of the KCB comes to dock services and does sample tests. If the products get green light, they will get a proof of deportation. If they have a red light, the shipment will be destructed. When the shipment is approved, the transportation continues to either the buyer or the auction.

It is possible to transport the roses via RFH, but not via dock services, or to transport not via RFH at all. For these options, the checks cannot be done at dock services and it will be necessary to have a freight forwarder which has an inspection location. Since the freight forwarders are located on the airport, it is not necessary to transport the shipment in transit. The phytosanitairy checks are done the same and the transportation continues the same way. Only if the roses are not going via RFH in the first place, it can not be sold via the clock.

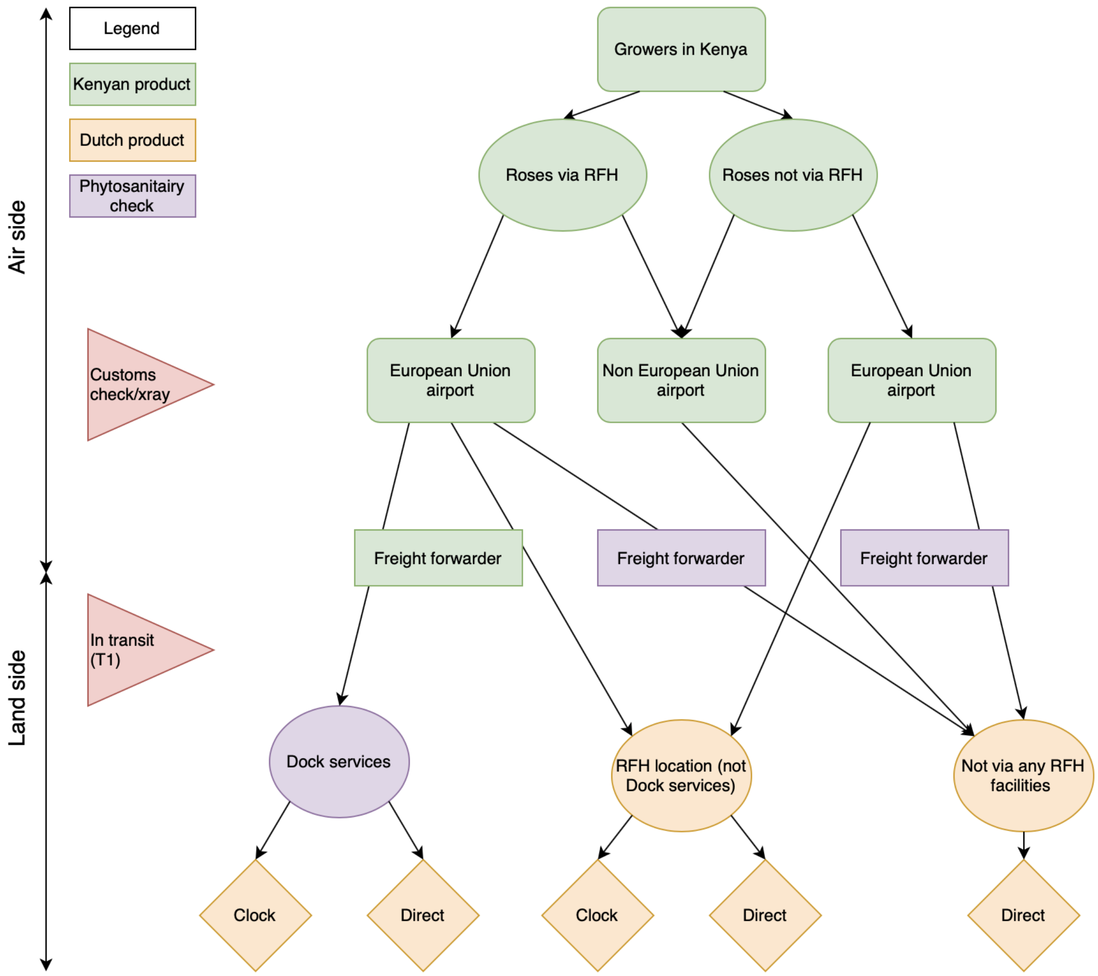

Figure C.1: Overview of the customs

Appendix D

Standard form of the stakeholder analyses

Figure D.1 shows the standard form of a stakeholder analyses. The graph is divided in 4 quadrants with a corresponding level of power and level of interest.

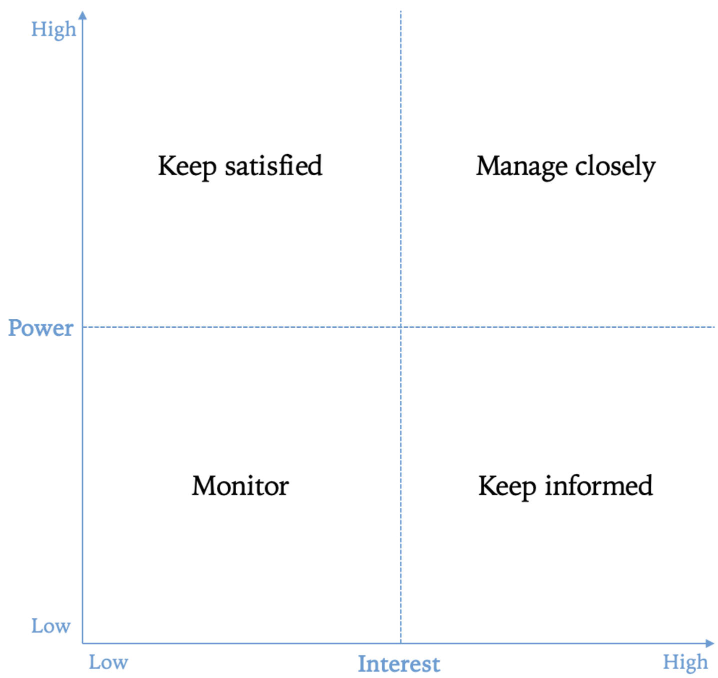

Figure D.1: The standard format of the stakeholder analyses

Appendix E

New designs direct flow

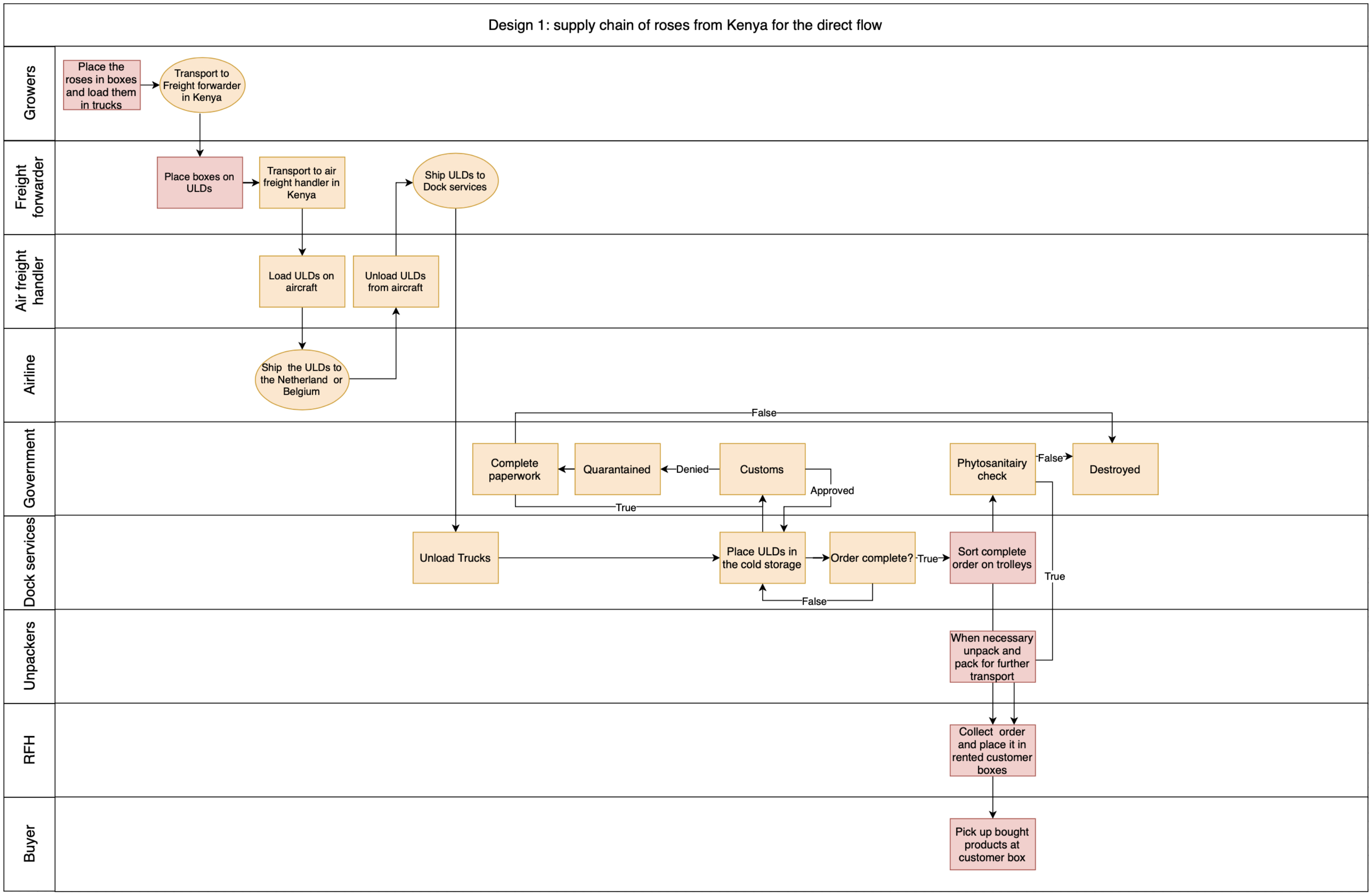

Figure E.1: Swimlane diagram of the direct flow of Design 1

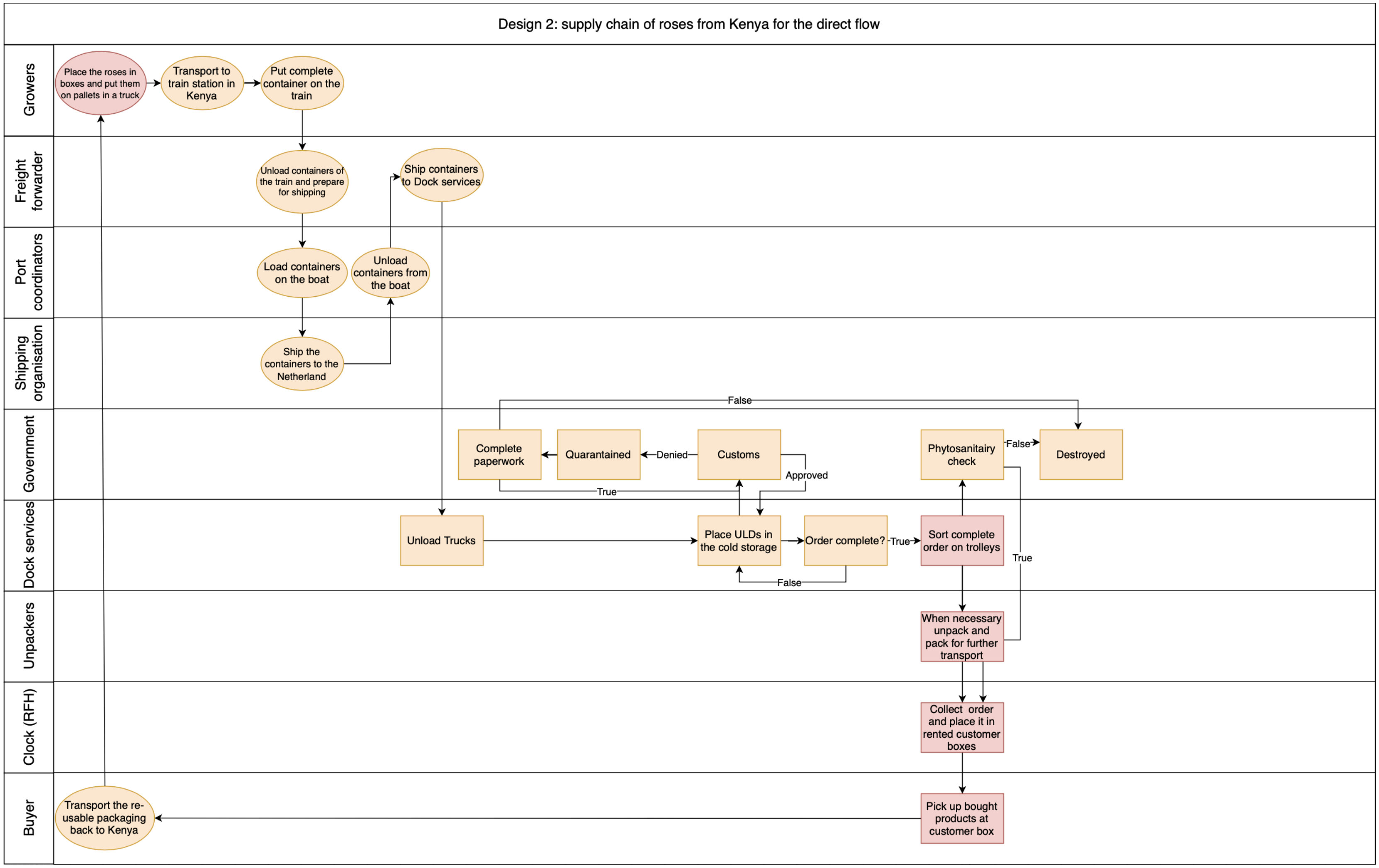

Figure E.2: Swimlane diagram of the direct flow of Design 2

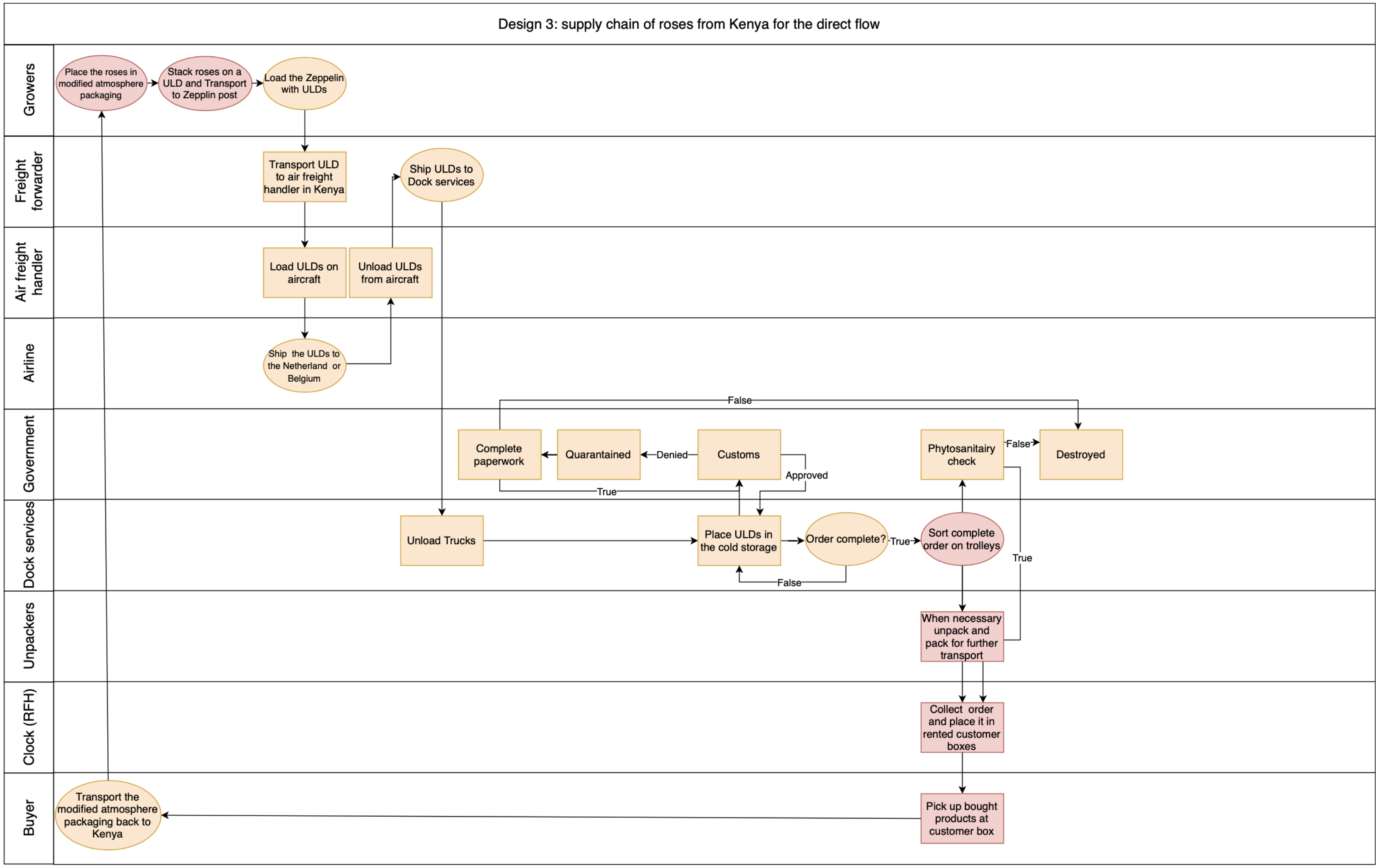

Figure E.3: Swimlane diagram of the driect flow of Design 3

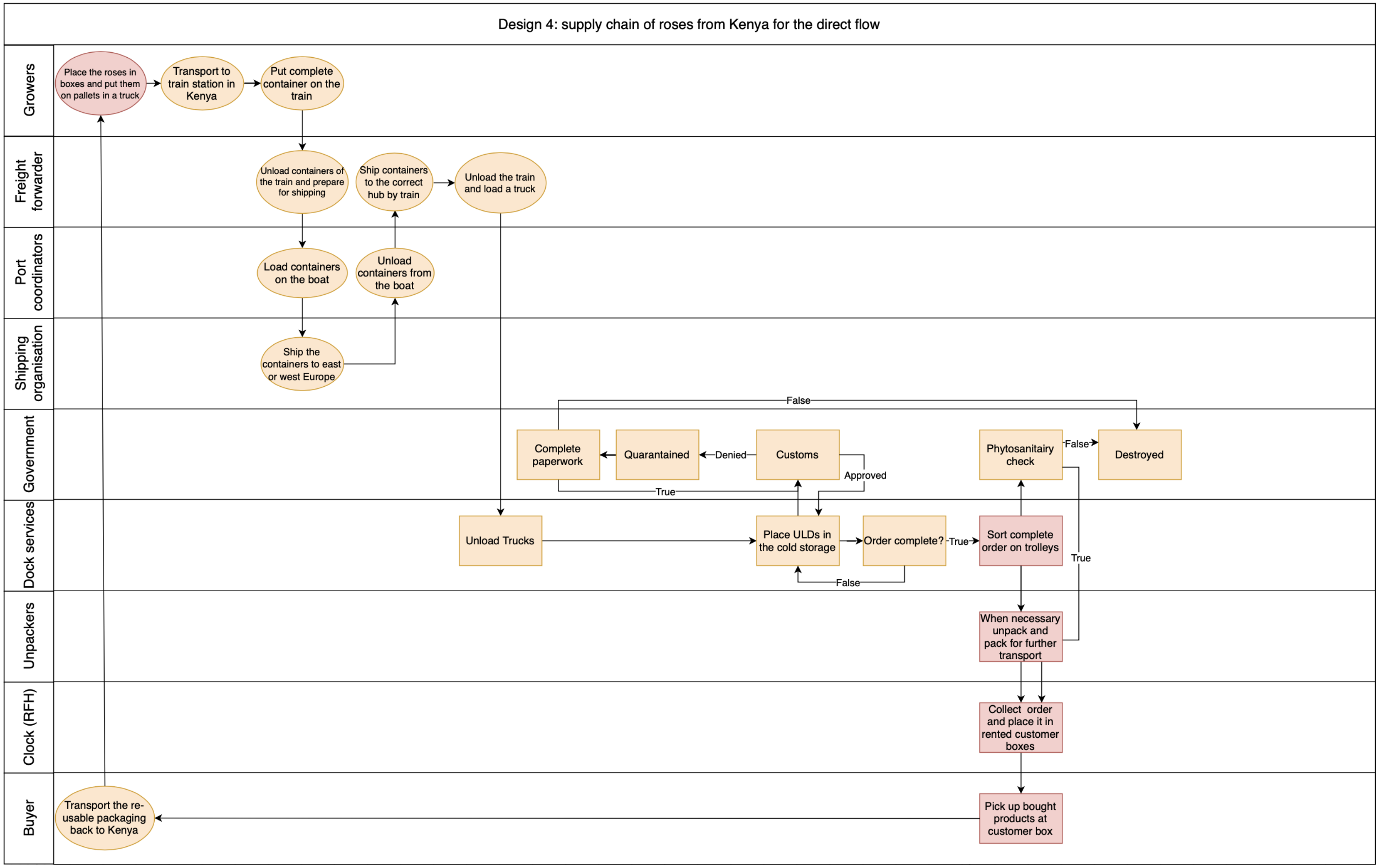

Figure E.4: Swimlane diagram of the direct flow of Design 4