THE DEVELOPMENT OF A METHOD TO ASSESS THE FUTURE-PROOFNESS OF DUTCH INLAND PORTS

Master Thesis Report

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The development of a method to assess the future-proofness of Dutch inland ports

by

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Preface

This thesis provides a method to assess the future-proofness of Dutch inland ports until 2050. This master thesis is carried out as part of my master in Hydraulic Engineering (specialisation Ports and Waterways) at the Faculty of Civil Engineering at the Delft University of Technology.

This graduation project was initiated by myself and further developed with help from the engineering firm Movares. I would like to thank Movares for this opportunity to give me the opportunity to create a method to assess the future-proofness of inland ports under their guidance. Special thanks go to my daily supervisor at Movares, Martijn van den Elzen, who supported me throughout this thesis with his expertise and offered me full flexibility to adapt the graduation topic throughout the project. His valuable contacts within and outside the company offered me opportunities to get in touch with other people who were involved in inland ports. I would also like to extend my gratitude to the other colleagues at Movares Water, who have been supportive to me and offered a pleasant working environment.

I would also like to thank my daily supervisor at the TU Delft, Cornelis van Dorsser. He guided me throughout the project by offering a lot of ideas, tips and feedback. His expertise was used to improve the content of this research and to write a scientific report. Furthermore, I would like to extend my gratitude to Robert Hekkenberg, for this expert knowledge and valuable input. Lastly, I want to thank committee chairman Prof. Tiedo Vellinga for his sharp analyses, essential tips and feedback.

Milan Dekker
Delft, November 2018

Summary

The inland ports play an important role in the Dutch transport system. Like all other (transport) sectors, the inland ports will undergo changes as a result of the societal changes in demand for services and goods. In addition, the hydraulic conditions on the inland waterways may change. These changes are likely to affect the current inland ports, which may result in a positive or negative impact (creating an opportunity or threat respectively). The inland port has to adapt to these developments in order to reduce the threats and to increase the opportunities, but this may require adaptations to the current infrastructure or services. These infrastructural adaptations require a large investment, which takes mostly about 30 years before these costs are recouped. It is therefore preferred to know the opportunities and threats beforehand, so that the inland port can already adapt to these projected changes ahead of time. This research focused on the development of a method to assess the future-proofness of a Dutch inland port in the period up to 2050.

The first step of this research was focused on defining the future-proofness of an inland port. An investigation into literature on the definition of future-proofness resulted in a general definition of the future-proofness: *The performance of an object, which has enough flexibility in order to remain useful and successful in the future*. Subsequently, this definition was translated to a future-proof inland port with help from the determination of the primary functions of the inland port. This resulted in the next definition: *A future-proof inland port remains useful and successful in the transfer of goods, the storage of goods and facilitating industrial processes for the production of goods in the future and is flexible enough in port services and infrastructure to deal with potential changes*.

In order to determine the future-proofness of the inland ports, a number of current Dutch inland ports were analysed. In the first place, it was required to analyse the three main functions of the inland ports (the transfer, storage and (industrial) production of goods). Furthermore, it was also investigated which port activities carry out these main functions of the inland ports. In the end, thirteen different port activities have been identified, which cover all three main port functions. These thirteen activities are important because the relation between the capacity and demand for these port activities determine the degree of usefulness and successfulness of the inland port. Finally, a set of port indicators has been defined in order to determine the port characteristics of the inland port (in relation to port activities).

Before a method could be set up to assess the future-proofness of inland ports, more information had to be obtained about uncertainties in long-term developments and the related methods to deal with these uncertainties. It was found that the long-term developments with relevance to the inland ports can be identified with methods from the forward looking discipline of 'Foresights', because the level of uncertainties seems to be equal to level 3 uncertainties according to the four classification levels of Walker et al. (2003). For this research, it has been chosen to use the new method for dealing with level 3 uncertainties: trend-based narratives (Van Dorsser, Taneja, & Vellinga, 2018). These trend-based narratives reflect the identified threats and opportunities for the different port activities for the specific inland ports.

The obtained knowledge about future-proofness, the port activities and the uncertainties in long-term developments were used to set-up a method to assess the future-proofness of the inland port, which exists of four different parts (see Figure 1):

- Part 1: Determination of the current inland port's strengths and weaknesses (port characteristics)
- Part 2: Determination of the port specific opportunities and threats (impacts)
- Part 3: Determination of the flexibility of the specific inland port
- Part 4: Assessment of the future-proofness of the specific inland port

In the first part of the research, the current information about the inland port is used to determine the port characteristics of the inland port. These port characteristics can be defined by identifying the present port activities in the current inland port and by using the selected port indicators. Subsequently, this information shows the strengths and weaknesses of the inland port. The more strengths the inland port has, the more likely that it remains attractive for port activities. It is therefore also more likely that this inland port can be considered as future-proof.

The projected impacts on the different port activities for the specific inland port are determined in part 2 of the method. Before this impact can be determined, it was first required to identify the plausible long-term developments with a relevance to inland ports. It was found that many of the current developments were driven by the globalisation process, while many of the future developments are expected to be driven by the increased awareness about sustainability. Subsequently, the relevant long-term developments were bundled in order to determine the impact on the various port activities in general. Port characteristics were included in order to determine the projected impact of the developments on the port activities for a specific inland port. The combination of identified relevant long-term developments and port characteristics has led to the generation of trend-based narratives, which reflects the projected opportunities and threats for a specific inland port. In order to determine the impacts of these narratives on the total inland port, the projected impacts can be calculated in relation to the total port area, total quay length and bulk throughput volumes. The smaller the projected negative impacts, the more likely that the inland port can be considered as future-proof.

The flexibility of the inland ports is determined in the third part of the method. The flexibility represents the degree in which the inland port can adapt to the future demand for port activities. The flexibility of inland ports cannot be measured directly, because it depends on various external factors (e.g. decisions from port authorities, municipalities or other institutes, which may change over time). Therefore two different aspects of the inland port are analysed: the potential reduction of negative impacts by replacing them with new port activities and the potential to increase the capacities of port activities (by converting the opportunities into new port activities at new terminal areas). The higher the potential to reduce its negative impacts and the bigger the possibility to increase the capacity of (new) activities, the more flexible the inland port.

The fourth and final part of the method assesses the future-proofness of the inland port. In this part, the results of the previous parts are used as an input and combined to determine the future-proofness of the inland port. The anticipated degree of usefulness, successfulness and flexibility of the inland port until 2050 are covered by three questions. The combination of answers on these three question ultimately determines the degree of future-proofness of the selected inland port.

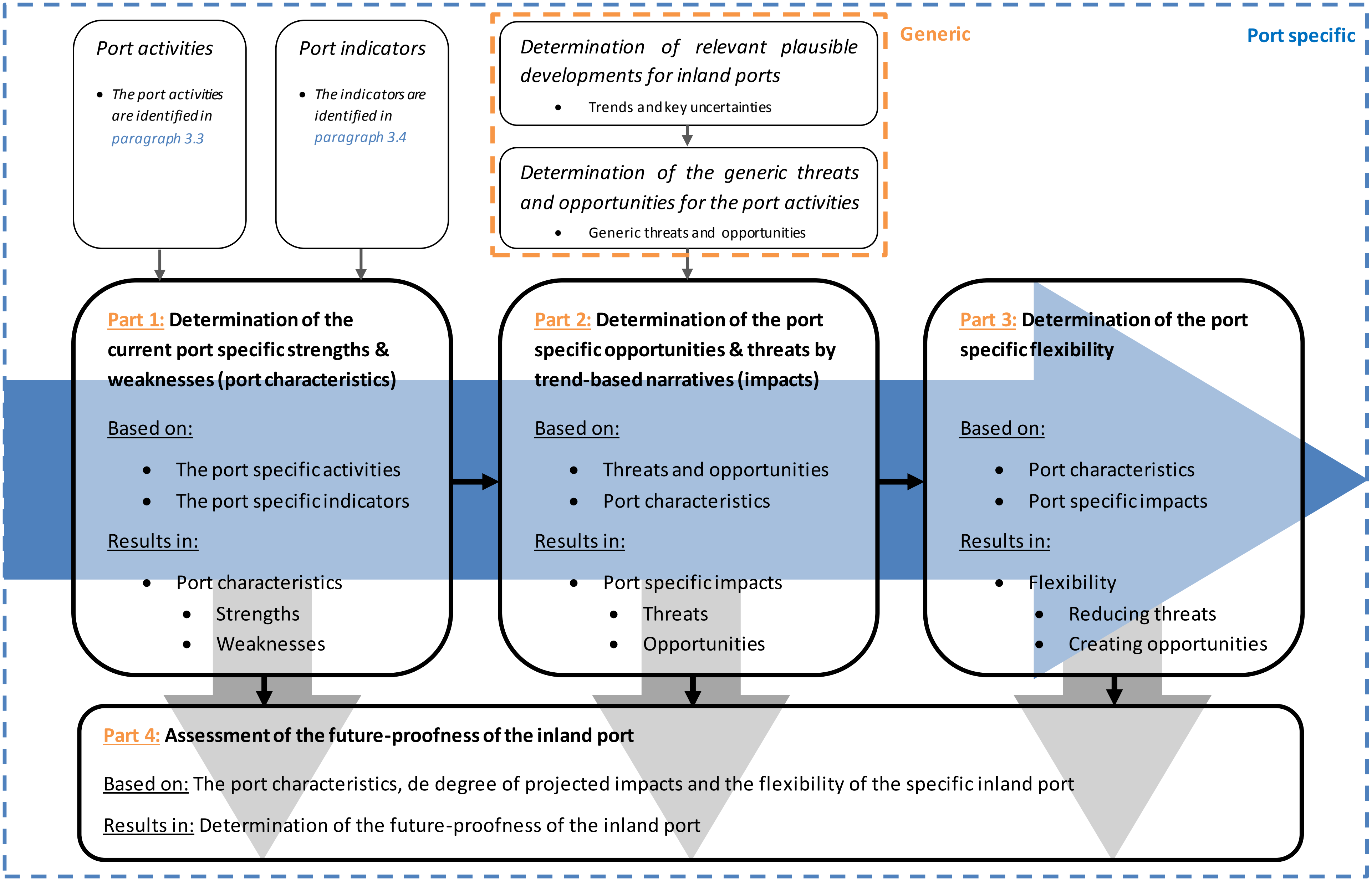


Figure 1: Schematisation of the total method to determine the future-proofness of an inland port

The applicability of this method was demonstrated through case studies, in which the future-proofness of three existing inland ports is assessed. The selection of these three case study ports was based on the available information about the inland port and the requirement that the composition of the current port activities within these inland ports differs. This resulted in the selection of the inland port of Bergen op Zoom, Oosterhout and Wageningen. The following results are identified for these inland ports:

The inland port of Bergen op Zoom is determined to be future-proof. The largest risk for this inland port is the anticipated negative impact of the declining demand for the production of plastics and transfer and storage activities for oil products. This first mentioned port activity is the dominant activity in this inland port and this will affect the inland port in a very negative way. On the other hand, the demand for many port activities are expected to increase and thus likely to remain useful and successful in the inland port of Bergen op Zoom. It is expected that the port activities with opportunities can compensate for the anticipated threats. In addition, the terminal infrastructure of the threatened port activities matches the required port infrastructure of some of the 'new' port activities. The flexibility of the inland port of Bergen op Zoom seems therefore sufficient. This combination of port characteristics, impacts and flexibility ultimately determines this inland port as future-proof.

The inland port of Oosterhout is also considered to be future-proof. The main reason for this future-proofness is the relatively small share of anticipated threatened port activities in relation to the total inland port. The negative impacts (caused by the steel processing activities) are considered to be relatively small. In addition, it is expected that the demand for many of the current port activities increases until 2050, which may lead to many opportunities for the inland port of Oosterhout. It is anticipated that these opportunities can compensate for the threats. The biggest challenge for the inland port of Oosterhout is the flexibility of the inland port, because the potential new port activities do not require the same terminal infrastructure as the threatened port activities. It is therefore required to invest a lot in the threatened terminal in order to adapt the infrastructure to the new port activity, which is not attractive for the new companies. Despite this lack of flexibility, the port is still regarded as future-proof due to the small negative and large positive impacts.

The combination of good port characteristics, impacts and flexibility determines that the inland port of Wageningen hardly faces any challenges in order to remain useful and successful in the future, which makes this inland port very future-proof. The inland port has one port activity, for which the demand is projected to decrease until 2050 (transfer and storage of oil products). This port activity is relatively unimportant for the inland port of Wageningen, which is therefore leading to a relatively small threat. In addition, the demand for the other inland port activities are anticipated to increase and therefore likely to compensate for the negative impacts. Furthermore, the threatened terminal matches the infrastructure of the port activities with opportunities, which is likely to attract port activities to the threatened terminals. This good flexibility was also strengthened by the relatively large availability of free areas, which can be used for future port activities. Overall, the inland port is expected to be very future-proof.

Table of contents

Terminology for inland ports

Effectiveness	The effectiveness is the extent to which the inland port is successful in producing a desired result or addressing a certain demand for the port function.
Efficiency	The efficiency is the extent to which a port function is conducted with minimum wasted effort or expense.
Future-proofness	A future-proof inland port is useful and successful for the execution of the main port functions in the future and is flexible enough in port services and infrastructure to deal with potential changes in these conditions.
Performance	The performance is the degree in which the inland port is able to perform its main functions effectively and efficiently, which can be assessed by the parameters.
Port activities	The port activities are representing those activities that are required for the main port functions of the inland port.
Port functions	The port functions are the functions, which represent the main purposes for the existence of the port.
Port indicators	The port indicators define the port characteristics, which present the strengths and weaknesses of the inland port.
Successfulness	When something is successful, it means that it has achieved the desired result. The inland port's successfulness is the degree in which the inland port is able to sustain effective operations (on the long-term) in an efficient manner as long as the inland port remains useful.
Usefulness	When something is useful, it means that it can help you to do or obtain something. For inland ports, the usefulness is the degree in which the inland port still fulfils its main functions and meets the required demands.

List of figures

List of tables

1. Introduction

This research has focused on the assessment of the future-proofness of inland ports. The more future-proof the inland port, the more likely that the demand remains high and that no investments are required for the adaptation of the inland port. For the inland port authorities, it is preferred to know the degree in which the inland port is future-proof as changes in the inland port infrastructure require a lot of investment and time.

This chapter serves as an introduction for this research. The first paragraph provides an insight into the background of the research and the problem statement. The second paragraph describes the main research question and research objective. Paragraph 1.3 presents the limitation of this research, while the research method is presented in paragraph 1.4. This is followed by the description of the scientific relevance of the research. This chapter is concluded in section 1.6 by presenting a reading guide, in which the structure of this report has been elaborated.

1.1 Background (problem definition)

Inland ports play an important role in the Dutch transport system. Due to the favourable location, a relatively large number of goods are transported in the Netherlands by inland waterway transport. The delta of the Rhine, Meuse, Scheldt and Ems can be found in the Netherlands, which means that there are more opportunities for using the natural waterways for the transport of goods compared to other European countries. In addition, many channels have been dug, resulting in an extensive waterway network, which promotes the possibilities and quality of inland navigation (Dutch Inland navigation Information Agency (BVB), 2017; Rijkswaterstaat, 2018). This can be seen in the percentages of transport by water in relation to the total goods transport. In the European Union (EU) this is equal to 6.2% (in tonne-kilometres), whereas in the Netherlands this is 44.2% (Eurostat, 2017). The many waterways and the relatively large transport volumes have ensured that the Netherlands has relatively many inland ports with large transhipment volumes. Figure 2 (on the next page) shows the location of the inland waterways and a few large (inland) ports in the Netherlands.

Like all other sectors, the inland shipping sector will undergo changes in the coming decades as a result of societal changes in the demand for services and goods. These may affect the port activities, whereupon the port infrastructure is subsequently adjusted. In addition, the hydraulic conditions will most likely change under the influence of climate change. Due to the changes in inland navigation as well as inland ports, both opportunities and threats will appear to the inland ports. In this research, the main focus is on the determination of a method to assess the future-proofness of the inland ports, which addresses these potential impacts for the current inland port activities. The development of a method for identifying the future-proofness of the inland ports can be considered as an added value for the port authorities in order to take advantage of these opportunities and to avoid the threats.

Figure 2: Dutch inland waterway network and the main (inland) ports; (Bureau Voorlichting Binnenvaart (BVB), 2017)

The results of this research can be used by Movares to check whether the inland ports are future-proof against developments in the inland shipping sector. If it turns out that the future-proofness of the inland port is not optimal yet, Movares can set-up a plan to improve the future-proofness of the specific inland port, which may be based on the opportunities that resulted from the method. As an engineering and consultancy firm in the area of infrastructure, public transport, mobility, energy, urban development and water, Movares can play a leading role in these improvements and in this way support the various inland ports to become a future-proof inland port. In addition, this research may increase the knowledge of the firm about the potential developments that may affect the inland ports and inland waterway transport in general, which could also be used for other projects related to inland shipping.

1.2 Research questions and research objectives

This section presents the research objective with the corresponding research questions.

Main question

The main objective of this research is to develop a method for the assessment of the future-proofness of inland ports in the Netherlands. The following main research question (MRQ) has been drawn up for this research:

MRQ: What method can be provided to assess the future-proofness of an inland port in the Netherlands until 2050 with regard to the current port activities?

By answering this main research question, the objective of the research has been met. However, the main question cannot be answered directly, because there is no method developed for the assessment of the future-proofness of inland ports yet. Three research sub questions (RSQ) have been defined in order to use a structured approach in gaining more insight into the future-proofness of inland ports. These are presented below.

RSQ 1: What is a future-proof inland port?

RSQ 2: What main port activities take place in the Dutch inland ports?

RSQ 3: What method can be provided to assess the future-proofness of inland ports?

The answer to research sub question 1 provides insight into the definitions for future-proofness. An analysis of these different definitions is then required to determine which definition is most suitable for the goals of this research. Establishing the definition for future-proofness is important in order to provide clarity in what is assessed within this research. Subsequently, it can be determined what future-proofness means for inland ports.

The answer of the second research sub question gives an insight in the different port activities in the inland port area. It is required to understand which inland port activities are present in the current Dutch inland ports, when assessing the future-proofness of the inland port activities. The future demand for these port activities in combination with the ports strengths and weaknesses is assumed to be representing the future-proofness of the inland port.

The answer of the third research sub question gives an insight in the proposed method to assess the future-proofness of the inland ports. Before the method can be set up, information from sub question 1 and 2 has to be obtained. After answering this third sub question, it is possible to answer the main question.

In addition to the determination of the method to assess the future-proofness of the inland ports, it is proposed to test the usefulness of this method by assessing the future-proofness for a limited number of inland ports (the case studies). This additional research objective is set up to present the functioning of the developed method. The next sub question has been set up for this additional research objective.

RSQ 4: What is the future-proofness of the three case study inland ports?

1.3 Research scope and limitations

This graduation research is aimed at presenting a method to determine the future-proofness of inland ports in the Netherlands. When this method is fully developed, the method may be used to assess the future-proofness of a limited number of inland ports (case studies). The choice to select only a small number of inland ports makes it possible to carry out an intensive approach to analyse these case study ports. In this way, it is showed that the framework works for various inland ports. In addition, it is not always easy to obtain this data. By limiting the number of inland ports, a more intensive and focused approach to obtaining data is possible by port visits and discussions with the relevant port managers. In the absence of good quantitative data, it is decided to switch to a qualitative approach, in which the available information serves as supportive data for the qualitative assessment.

Different types of inland ports can be found in the Netherlands. Examples include cargo handling ports, ports for overnight stays, passenger ports, service ports and emergency services ports. These inland ports have been built for different purposes with a port infrastructure adapted to these purposes. Due to these different port activities and port infrastructure, it is not possible to compare these different types of inland ports. For this graduation research it was decided to focus on the cargo handling ports. In these cargo handling ports, many different port activities takes place, which makes these inland ports the most interesting ports for this research.

The future-proofness of cargo handling ports can be examined from different perspectives. Possible perspectives are the point of view of the port activities, port infrastructure, shipping, economy, employment or management. This graduation research is limited to examining the future-proofness of inland ports with regard to port activities.

An analysis of the potential future developments plays an important role in a study into future-proofness. Only the developments that influence the demand for port activities and the associated port infrastructure are included in this analysis. In the analysis of the possible future conditions, the uncertainties play an important role in the projections. In order to understand these projections, it is required to determine how these uncertainties are included in this research. As the uncertainty becomes larger as the timeframe is extended, it is decided to set the timeframe on the period until 2050. In this way still some insight in the future conditions can be obtained. In addition, a period of 30 years is equivalent to the period in which the port authorities want to recoup their investments (also for constructions with a lifetime of 50 years).

1.4 Research method

In this section it is explained per sub question which steps have been taken to answer the research sub questions. This also includes explaining how the required information was obtained and which methods were used for this.

SQ 1: What is a future-proof inland port?

The first part of the research is focused on the concept of future-proofness. To test the future-proofness of the inland ports, a good definition of the future-proofness of inland ports is required.

The analysis of the definitions for future-proofness in general gives the first overall insight about this term. Various sources from the literature will be consulted for this analysis, including reports and books, which will be mainly obtained by means of the TU Delft library, the TU Delft repositories and public documents and sources via the internet. These sources are also used to define the future-proof inland port.

SQ 2: What main port activities take place in the Dutch inland ports?

The next step in the research concerns the establishment of port activities, which are the actions to fulfil the main functions of the inland ports. The demand for these port activities are the aspects on which the inland ports future-proofness will be tested, which makes it relevant to determine which activities are present in the inland ports. To determine these port activities, information is obtained by literature on inland ports, inland port visits, and interviews with port authorities and information from Google Maps. This literature concerns topics about the current function(s) of inland ports and about the activities of a well-functioning inland port. In addition, it is required to determine the port indicators, which present the strengths and weaknesses of the inland port activities. These are important for the determination of the port characteristics of the various inland ports.

SQ 3: What method can be provided to assess the future-proofness of inland ports?

The method to assess the future-proofness of an inland port cannot yet be determined. In order to establish a framework, the information from sub questions 1 and 2 is required. It is therefore decided to present the method for this third sub question after answering these first two sub questions.

At this point of the research, it emerges that additional insights in the understanding of the relationship between developments and uncertainties are still required. Different methodologies to deal with uncertainties in long-term developments have to be examined and eventually a method has to be selected. Furthermore, the relevant developments themselves have to be identified, which will be used for the determination of the trend-based narratives. These will be used to project the impacts of these developments on the port activities in the inland port. Ultimately, the obtained knowledge about a future-proof inland port, the port activities and the uncertainties in long-term trends is used to determine the method to assess the future-proofness.

SQ 4: What is the future-proofness of the case studies?

First, the case studies will be selected in order to answer the final sub question. The proposed method will then be used to assess the future-proofness of these case study ports. In the end, it can be concluded whether the method can be used to determine the future-proofness of the inland ports.

1.5 Scientific contribution

Substantial research has been carried out for sea ports in the Netherlands. Most of this research involves the port of Rotterdam, one of the main economic drivers in the Netherlands. The possible future developments and the possible consequences of these developments for the Port of Rotterdam (PoR) are regularly examined, for example in Havenvisie 2030 (Havenbedrijf Rotterdam, 2011). With the help of these studies, various frameworks have been developed at the Delft University of Technology to determine possible future developments and how to deal with uncertainties (Taneja, 2013; Van Dorsser, Taneja, & Vellinga, 2018).

For inland ports, less is known about the potential impacts of long-term developments, future-proofness and the possible measures to improve them. This is partly due to the limited availability of data on inland ports. Current available literature on the future of ports focuses in particular on improving the future-proofness of a specific seaport rather than a general approach for ports. In addition, some research can be found about the potential futures of inland waterways (Van Dorsser, Very Long Term Development of the Dutch Inland Waterway Transport System, 2015; Rijksoverheid, 2018; Wageningen UR, 2008), but this is not directly related to the inland ports itself. Moreover, it has not been determined what the future-proofness of inland ports is and how it can be determined. With the help of this graduation research, an attempt has been made to define the future-proofness of inland ports and to establish a general method for determining the future-proofness of the inland ports. The scientific contribution in this research mainly concerns the development of this method.

In addition to the theoretical contribution, the research also has a practical contribution. After all, the research was carried out from the wishes of the engineering and consultancy firm Movares, which is aimed at gaining an insight into the possible developments in the inland navigation sector and the inland ports. By understanding the possible long-term developments, it is possible for them to respond to these developments in the inland port and to improve their services for their clients.

1.6 Report outline

The report is divided into 7 chapters. In this first chapter, the subject of this research was introduced on the basis of background information and the associated problem definition and objective. Subsequently, the main research question was set up and elaborated with research sub questions. Finally, the scope, the research method and the scientific contribution of this graduation project have been worked out.

The definition of future-proofness in general has been defined in the second chapter. This has been followed by the translation of the general definition of future-proofness into the definition of the future-proofness of the specific case of inland ports.

The third chapter is focused on the identification of the main activities of the inland ports, which are related to the main functions. These main activities are considered to be the most important aspects to be assessed for the future-proofness of inland ports. In addition, the indicators for the determination of the strengths and weaknesses of the inland ports are presented.

The fourth chapter focuses on the development of a method to determine the future-proofness of inland ports. The information obtained from the previous chapters was used and new sub questions were drawn up, as more information was required. This mainly focuses on the uncertainties in the analyses of long-term developments. The different methods for determining future conditions are compared, with the degree of uncertainty being highlighted. The most suitable method for analysing the long-term developments and the associated uncertainties has been selected. This chapter concludes with the set-up of the general framework for the assessment or future-proofness for inland ports, in which a guideline has been set up to determine the future-proofness of inland ports.

The fifth chapter is focused on determining the potential trends, uncertainties and impact of these potential trends. These potential trends are first derived from the general trends and are required to be relevant for the inland ports. Furthermore, it is required to assess the generic impacts of these individual scenarios on the individual inland port activities. Then the overall generic impact on the various inland port activities can be calculated, resulting in port activities containing opportunities or threats.

Chapter 6 is used for the actual assessment of the future-proofness of three existing inland ports (the case studies). In the first place, three inland ports have to be selected as the case studies. For this assessment of the future-proofness of the case studies, the method from chapter 4 will be used. When the results about the future-proofness are known, it can be used in order to compare the results of the case study. Using this comparison, it is possible to identify common patterns about the future-proofness of inland ports.

Chapter 7 completes the research with the conclusions and recommendations. The most important part of this chapter is the answer to the main question. Furthermore, recommendations were made for the use of this research and for any further investigation into the future-proofness of inland ports.

Finally, additional information about the research can be found in the appendices.

Figure 3 shows schematically how the report is structured.

Chapter 1: Introduction
- Introduction of background and the problem definition and objective
- Set up of main question and the sub questions
- Explaining research method, scope and scientific contribution

Chapter 2: Defining future-proofness
- Determination of the definition of future-proofness in general
- Determination of the definition of a future-proof inland port

Final product: Insight in the definition of future-proofness for inland ports (answering SQ 1)

Chapter 3: Inland port activities
- Determination the main port functions in the inland port
- Determination of the main activities in the Dutch inland ports
- Determination of port indicators (possibly representing the strengths and weaknesses of the inland port)

Final product: Insights in the main functions, activities and indicators of the inland port (answering SQ 2)

Chapter 4: Method for assessment of future-proof inland ports
- Identification of methods to deal with uncertainties in long-term developments
- Selection of the most suitable method for the assessment of future-proofness of inland ports

End product: Framework for the assessment of future-proofness of inland ports (answering SQ 3)

Chapter 5: Trends, uncertainties and generic impact
- Analyse the uncertainties in long-term developments
- Presentation of the potential trends and key uncertainties up to 2050, relevant to the activities in the inland ports
- Determination of the plausible trends and uncertainties with relevance to the inland port activities
- Determination of the generic impacts of each plausible trend on each main port activity

End product: Generic impact of the plausible trends on the inland port main activities

Chapter 6: Future-proofness assessment for three case studies
- Selection of the case studies
- Determination of the strengths and weaknesses of the specific inland port (port characteristics)
- Determination of the opportunities and weaknesses of the specific inland port (impact)
- Determination of the flexibility of the specific inland port
- Assessment of the future-proofness of the inland port
- Comparison of the future-proofness of the different case studies

End product: Insight in the future-proofness of the case studies

Chapter 7: Conclusion and recommendations
- Answering the main question
- Drafting recommendations for the use of the research
- Drafting recommendations for further research into future-proofness

Figure 3: Report outline

2. Defining a future-proof inland port

2.1 Introduction

The second chapter addresses the first research sub question: “What is a future-proof inland port?”. In order to define a future-proof inland port, it is required to understand the concept of future-proofness in general. A literature study has been carried out to define this general future-proofness. Subsequently, this definition will be used as an input for the definition of a future-proof inland port, for which the main functions of the inland port has to be analysed. This will result in a clear definition of a future-proof inland port, which will be the basis of the method to assess this future-proofness.

The process to define future-proofness in general is presented in 2.2. Paragraph 2.3 is used to define the future-proof inland port. Paragraph 2.4 summarises the chapter, providing an overview of the content and answering the research sub question.

2.2 Definition for future-proofness in general

This first paragraph provides insight in the definition of future-proofness in general. Several sources with varying definitions for future-proofness have been consulted in order to identify the core elements of this concept. The final definition for future-proofness will be determined at the end of this paragraph.

The term future-proof is commonly found in engineering, electronics, communications and management strategies. Through an investigation of multiple sources, several definitions for future-proofness (or future-proofing) have been found. Some typical examples are presented below.

1. “Future-proof software, computer equipment, etc. is designed so that it can still be used in the future, even when technology changes.” (Cambridge Dictionary, 2018).
2. “Future-proof means that a product is unlikely to become obsolete.” (Oxford Dictionaries, 2018).
3. “If something is future-proof, it will continue to be useful or successful in the future if the situation changes.” (Collins Dictionary, 2018).
4. “Future-proof describes a product, service or technological system that will not need to be significantly updated as technology advances.” (Technopedia, 2018).
5. “Future-proofing is the process of anticipating the future and developing methods of minimizing the negative effects while taking advantage of the positive effects of shocks and stresses due to future events.” (Rich, 2018).
6. “A future-proof company has the ability to respond quickly to new circumstances.” (Van Rijt & Van den Ende, 2016 (only in Dutch)).
7. “A future-proof board is strong, flexible and resilient, so that it is prepared for what they cannot know.” (Gemeenten van de toekomst, 2017 (only in Dutch)).

From the definitions from the box above, a pattern has been identified. This pattern in the definition for future-proofness is deducted as a performance state of an object, in which two additional requirements should be met.

Before these requirements will be presented, the definition of the performance of an object will be explained. Performance is equal to the degree in which the main functions of the object can be executed effectively and efficiently. This again includes complex terms, which also needs some more explanation:

- Functions are the mode of actions or activities by which the object fulfils is purpose.
- Effectiveness is the extent to which the object reaches the desired result according to the demand.
- Efficiency is the extent to which the object can conduct its main function with a minimum effort or expense.

These two requirements for an object in order to become future-proof are as follows:

1. It continues to be useful and successful in the future (derived from definition 1, 2, 3, 5, 6 and 7). The definitions of useful and successful will be explained as follows:
    a. *Useful* means that it can help you to do or obtain something (Cambridge Dictionary, 2018).
    b. *Successful* means that something has achieved the desired results or became popular (Cambridge Dictionary, 2018).
2. It is flexible enough for changing future conditions (derived from definition 1, 4 and 6).

It can be concluded that the more future-proof an object is, the less vulnerable the performance is against future changes. The definition of future-proof in general can therefore be determined as follows:

Future-proofness is the performance of an object, which has enough flexibility in order to remain useful and successful in the future.

2.3 Definition for a future-proof inland port

The previous paragraph has provided insights in the definition of future-proof in general. In this report the future-proofness of the inland ports will be investigated. From this point of view it is required to determine the definition of a future-proof inland port, for which it is required to identify the main function of the inland ports. The definition of a future-proof inland port is presented in this paragraph.

First, information is gathered about the main function of the inland ports. Therefore a literature study has been carried out, in which the inland ports (and the inland waterway transport system) are investigated. It was found that inland waterway transport (IWT) is in place for a long time. Far back in history, the IWT was mainly focused on the transport of passengers. Later, the transport of freight became also important. The development of road and rail transport has led to a decline of passenger transport by the inland waterways. Nevertheless, the IWT remained an important transport modality for the transport of goods (alongside the road and rail transport). This can be mainly attributed to the presence of production and consumption areas around the inland ports, which has served as the starting or end-locations for the transport of freight over the waterways. In addition, the inland ports became hubs for the transport network due to the connection with the other transport modes at the inland ports (Rijkswaterstaat: Dienst Verkeer en Scheepvaart, 2010).

Three main functions are identified for the current inland ports (Ligteringen & Velsink, 2012; Rodrigue, Debrie, Fremont, & Gouvernal, 2010), which are presented below. The identified main functions are those who represent the main purposes for which the inland port is used. These main functions are performed by the various inland port activities, of which the efficiency and effectiveness of these activities presents the usefulness and successfulness of the inland port. As already addressed in chapter 1, it should be taken into account that it was chosen to reduce the scope of the research to the inland ports with transhipment activities.

1. The first main function for the inland port is the transfer of goods. The inland port can be identified as a hub in the transport network at which different transport flows meet. At the inland port, the goods can be unloaded from a transportation vehicle and be loaded on another transportation vehicle. This transport could take place in two different ways: within the same transport modality (e.g. ship to ship) or towards another transport mode (e.g. ship to truck).
2. The second main function of the inland port is the storage of goods. Between the unloading and subsequent loading of the goods, the goods have to be stored within the inland port. In addition, some industrial companies are located at the inland port. These companies import the raw materials in big volumes for economic reasons. These volumes cannot be used at once, which results in the fact that these raw materials have to be stored at the inland port area. The produced goods mostly have to be stored some time at the inland port as they are also transported by large volumes for economic reasons.
3. The third main function of the inland port is to facilitate industrial processes to produce cargo in the port area. This industrial activity processes raw materials (or semi-finished products) into finished products, which can both be transported by inland waterway transport. The purpose of these activities is adding value to the product, which can then be sold for a higher price.

It is considered that the identified main functions of the inland ports (the transfer of goods to or within transport modalities, the storage of goods and the facilitating of industrial processes) remain constant over time. However, the demands for the inland port will change over time. Inland ports must evolve in order to remain useful and successful in these changing conditions. The port can be considered as useful when the inland port still fulfils its primary functions in the future by providing the services and infrastructure for the main functions. In this case, the inland port still fulfils the demand. The inland port can be considered as successful when the inland port activity is able to sustain an effective operation on the long-term in an efficient manner. The minimum goal for a successful port is to sustain, as long as the port remains useful. For the inland ports, the effectiveness can be defined as the state at which the inland port is able to address a certain demand, while the efficiency is the extent at which the activities can be conducted with a minimum wasted effort.

The analysis of the function of the inland ports and the previously determined definition for being future-proof has led to the following definition for the future-proof inland port.

A future-proof inland port remains useful and successful in the transfer of goods, the storage of goods and the industrial production of goods in the future and is flexible enough in port services and infrastructure to deal with potential changes.

2.4 Conclusion

This chapter addresses the sub question regarding the future-proofness: "What is a future-proof inland port?". The sub question is answered in this paragraph, which also gives an overview of the results.

In the first place, a literature study about future-proofness has been executed to obtain information about future-proofness in general. During this literature review, several sources have been consulted. A similar pattern has been identified from these different definitions, which describe the concept of the future-proofness in general. This pattern contains two conditions that an object has to meet in the future in order to become future-proof. These are as follows:

- It remains useful and successful
- It is flexible enough when the future conditions change

It can be concluded that the more future-proof an object is, the less vulnerable the performance is to future changes. The definition of future-proof in general can therefore be determined as follows:

Future-proofness is the performance of an object, which has enough flexibility in order to remain useful and successful in the future.

The second part of the chapter included the determination of the definition of a future-proof inland port.

In order to understand the future-proofness of the inland port, it was required to know the main functions of the inland port. These main functions of the inland port have been determined with the help of a literature study on inland ports. It was concluded that the main functions are the transfer of goods, the storage of goods and the industrial production of goods.

It was also considered that this main function remains the same over time, but that the needs will change. Therefore the inland ports must evolve to remain useful and successful. The port can only be considered as useful when the inland port still fulfils its primary functions in the future by providing the requested services and infrastructure. It remains successful when the inland port is able to sustain effective on the long-term in an efficient manner (as long as it remains useful). For the inland ports, a high effectiveness can be reached when the inland port is able to address the demand, while high efficiency is reached when the activities are conducted with a minimum wasted effort.

It has led to the following definition of a future-proof inland port.

A future-proof inland port remains useful and successful in the transfer of goods, the storage of goods and the industrial production of cargo in the future and is flexible enough in port services and infrastructure to deal with potential changes.

3. Inland port activities

3.1 Introduction

This chapter addresses the second research sub question: "What main port activities take place in the Dutch inland ports?". These port activities have to be defined in order to identify the port characteristics of the inland port. Before the port activities can be defined, more information has to be obtained about the main functions, because the port activities are performing these main functions. Subsequently the port activities can be defined. Furthermore, the port indicators have to be defined. These can be used to define the inland port's strengths and weaknesses in relation to the port activities.

Paragraph 3.2 presents the main port functions with some additional explanation in relation to the future-proofness. Paragraph 3.3 is focused on the selection of the port activities representing the performance of the port functions in the inland ports. Subsequently, paragraph 3.4 is used to determine port indicators. Paragraph 3.5 serves as the summary of this chapter, providing an overview of the content and answering the sub question.

3.2 Main port functions

The inland port area is an area with a few main functions, for which different types of infrastructure and services are required. It is therefore important to understand the main functions of the inland ports. As already shortly described in the previous chapter, three main functions have been identified for the inland ports (Ligteringen & Velsink, 2012; Rodrigue, Debrie, Fremont, & Gouvernal, 2010): the transfer of goods, the storage of goods and the (industrial) production of goods. The relation between these three main port functions and the future-proofness is described in this paragraph.

Transfer of goods

The transfer of goods is the most important function of the inland port. The goods are brought to the inland port by one of the three transport modalities (road, rail or inland waterway transport) and are unloaded at the inland port terminals. From the inland port, they can be further transported to another location with one of the three previously mentioned transport modalities (unless they are used for production in the inland port). For inland ports it is common that the transfer of goods is related to the inland waterway transport. Therefore the transfer of goods takes mainly place at the quays along the inland port basin.

The inland port can be considered future-proof when the port is still useful and successful for the transfer of goods within the projected developments. In order to remain useful, it is required that the inland port offers the facilities and services, which can be used to meet the demands for transfer activities. For example, the port dimensions need to be sufficient for the inland vessels and the number of berths needs to be sufficient to unload sufficient inland vessels simultaneously. In order to remain a successful inland port, it is required that the inland port sustains effective and efficient in the transfer of goods in the long term (for example by adapting the quay operations to the specific type of cargo transferred at the quay).

Storage of goods

The second main function of the inland port is the storage of goods. This storage is important as the arriving goods cannot always be further transported immediately. Moreover, many port companies use their port area to stock their goods until these goods are requested. The storage of goods mainly takes place at the terminals next to the port basins.

The inland port can be considered useful when the storage function in the inland ports meets the demand. It is then required that the inland port provides the services and infrastructure, such as a sufficient storage area. In order to become a successful inland port, it is required that the inland port sustains effective and efficient in the storage of goods in the long term (for example by adapting the storage method to the type of cargo stored at the quay). When the inland port is both useful and successful for the storage of goods in the future, it can be considered future-proof for the storage function.

Industrial production of goods

The third and last considered main function is to facilitate industrial processes to produce products in the port area. This industrial activity processes raw materials (or semi-finished products) into finished products. This process results in an added value for the products as finished products can be sold for a higher price. The industrial production processes (using IWT) are mainly located next to the port basins.

The inland port can be considered as useful for the industrial processes, when the industrial functions can be performed. In order to be useful, the inland port should be providing the facilities for the industrial production activities in order to meet the demands. A successful inland port for the industrial production of goods remains effective and efficient in the production of goods in the future conditions. For example, this efficient production can be achieved when the area of the production companies is adapted to the specific type of goods at the company. When the inland port can still be considered as both useful and successful for the industrial production in the future, then it can be selected as future-proof for the industrial production activities.

3.3 Selection of main activities in the inland ports

In the previous paragraph, the main port functions have been determined. These port functions are performed by port activities. The performance of these port activities can be used for the assessment of the future-proofness of the inland ports. It is therefore required to select these main port activities, which is the main goal of this paragraph. For the identification of these main activities in the inland ports, a literature study has been carried out in order to get more insight in the various main activities in the inland port. In addition, the use of Google Earth resulted in increased knowledge about the port activities in the inland ports. Finally, there have been a few meetings with port authorities, in which the inland ports were visited (see Table 1). This led to additional insights in the most important inland port activities with a relation to the inland waterway transport.

Port	Contact	Function	Date
Alphen aan de Rijn	Ivo Hilhorst	Terminal manager Alpherium	February 23rd
Cuijk	Vieky Brands Paul Kersten	Company contact officer Policy advisor economics	March 1st
Oosterhout	Hanneke Klerks Arie Rietveld	Policy advisor urban development Director of the container terminal	February 26th
Oss	Jan van den Berg	Port manager	February 28th
Rotterdam	Victor Schoenmakers	Director corporate strategy	June 13th
Utrecht	Frank van Kleef Taco Jansonius	Port manager Logistic coordinator	February 21st
Venlo	Jan Mulders	Policy advisor economics	March 19th
Wageningen	Ton Kok	Port manager	March 1st
Zwijndrecht	Bert van Hemert	Advisor / Account manager ports	February 27th

Table 1: List of port visits

Thirteen main inland port activities have been identified with help from the obtained insights. These selected main inland port activities are presented in Table 2 on the next page. These activities are divided in three groups of activities, each category being related to one of the main functions of the inland port. Therefore a group of transfer activities, storage activities and industrial activities has been generated. It can be seen that four activities have been identified for the transfer of goods. The storage of goods is also performed by four different main activities, while five different activities have been identified for the industrial activities. The different activities are explained on the next page.

Main inland port functions	Nr	Main inland port activities
Transfer of goods	1	Container transfer
	2	Dry bulk transfer
	3	Liquid bulk transfer
	4	Transfer of the remaining types of goods
Storage of goods	5	Storage of containers
	6	Storage of dry bulk
	7	Storage of liquid bulk
	8	Storage of remaining types of goods
(Industrial) production activities	9	Agro-bulk production
	10	Construction materials production
	11	Energy production
	12	Recycling activities
	13	Remaining industrial production processes

Table 2: Main activities of the inland port according to the main functions

Main activities related to transfer of goods

The transfer activities in the inland port are mainly located at the quays between the port basins and the terminals. At these locations, the cargo is transferred between one transport mode (e.g. inland vessel) and another transport mode (e.g. truck), another transportation vehicle within the same transport mode (e.g. other inland vessel) or to the terminal area for storage. The execution of the activities concerning the transfer of goods is heavily dependent on the cargo types, which resulted in the following transfer activities: transfer of containers, transfer of dry bulk, transfer of liquid bulk and the transfer of the remaining goods (e.g. break-bulk, neo-bulk).

Container transfer

The container transfer is the activity at the quay of a container terminal. The inland vessels are bringing the containers to the inland port, at which it is unloaded by gantry cranes or other quay cranes. From there it is transported to the storage areas by forklift trucks, reach stackers, chassis, straddle carrier or by special transport systems (e.g. Multi Trailer System (MTS), Automated Guided Vehicle (AGV)). In some cases it can be directly loaded on another transportation vehicle. The other way around, containers are brought from the storage area to the quay, from which these containers are loaded on the inland vessels. (Ligteringen & Velsink, 2012, pp. 130-135)

Dry bulk transfer

The transfer of dry bulk cargo (e.g. ores, coals, chemicals and agro-products) is slightly different from the container transfer. The biggest difference between the container and dry bulk transfers can be found in the (un)loading process. For dry bulk cargo, the unloading process can be executed with help from grabs, pneumatic systems, vertical conveyors, bucket elevators, slurry systems and self-discharging vessels. A conveyor belt system is then mostly used to transport the cargo towards the storage areas. The loading of the inland vessels is mostly executed as a continuous process in which the dry bulk is transported by a conveyor belt system from the stockpiles towards the holds of the ship. Sometimes a telescopic or spiral chute is used to reduce the drop height and fall velocities (Ligteringen & Velsink, 2012, pp. 202-216).

Liquid bulk transfer

The liquid bulk (e.g. crude oil, refined products, liquefied gas, chemicals) is mainly (un)loaded by pipelines, which are able to pump the liquid bulk volumes out of the inland vessels into other inland vessels, storage tanks in the terminal or tanks on other transportation vehicles. The other way around, the liquid bulk is also pumped into the inland vessels with help from pipelines. Due to the additional safety restrictions, these terminals are mainly located at sheltered locations at which waves and wind do not have a significant influence on the inland vessels (Ligteringen & Velsink, 2012, pp. 173-191).

Transfer of remaining types of goods

Other types of goods can be also transferred from the inland vessels to the quays. The transport of these goods mainly takes place at general cargo terminals at which different goods can be (un)loaded. These goods are in most cases (un)loaded by (mobile) quay cranes or ship derricks, for which a lot of labour is needed to hook up and unhook the cargo. Break-bulk (many pieces of various dimensions and weights), neo-bulk (many pieces of mostly uniform size and sometimes uniform weight), bagged goods and special bulk cargo are examples of this type of goods (Ligteringen & Velsink, 2012, p. 154).

Main activities related to storage of goods

The storage activities are related to the area at which the cargo can be stored when it is not immediately needed. Storage of cargo is mostly located in the terminal areas, which are located next to the inland port basins. The main activities concerning the storage of goods are related to the way the storage is stored. This can be different for various cargo types. In addition, the transport between the transport modes and the storage area is also part of the storage activities, which is mainly executed by special storage equipment. When it is stored at a certain location, no activities are required until the cargo can be transported to another location. The following storage activities have been identified: storage of containers, storage of dry bulk, storage of liquid bulk and storage of other goods.

Storage of containers

The storage of containers takes place on the surface of the terminal areas. These containers can be stored by stacking them for several layers. The transport between quay and storage area is executed by the quay crane, special storage cranes (e.g. rubber tired gantry (RTG), Rail Mounted Gantry (RMG) or Automated Stacking Crane (ASC)), reach stackers or trucks (Ligteringen & Velsink, 2012, pp. 135-136).

Storage of dry bulk

The dry bulk storage can be performed in different ways. Most of the dry bulk is stored on stockpiles, which can be outdoors or indoors. The transport of dry bulk from the quay to the storage area is mostly executed by a high conveyor belt system, while it is transported from the stockpiles with help from discharge gates and a tunnel conveyor or a scraper/reclaimer. In special occasions, bulldozers and trucks are used for this transport. The quality of agro-bulk products is dependent on the conditions in which they are stored, therefore these products are mostly stored in refrigerated storage areas or in silos (Ligteringen & Velsink, 2012, pp. 216-217).

Storage of liquid bulk

A large part of the liquid bulk can be distinguished as hazardous cargo. Therefore the storage of this type of cargo requires a lot of special attention. The liquid bulk is stored in tanks in the port area. The transport of liquid bulk between the quay and the tanks takes place by pipelines. The bulk is then pumped out of the inland vessel to the tanks and vice versa. From these storage areas it can be further transported to the required locations (Ligteringen & Velsink, 2012, p. 191).

Storage of remaining types of goods

The storage of other goods is an activity which largely depends on the type of cargo, which has to be stored. Some of this bulk has complex dimensions and most of the time only small volumes are transported (special bulk and neo-bulk). The storage system has to be adapted to the type of stored goods due to this complexity, which mostly results in storage in the transit shed, open storage or in warehouses. The transport between transfer area and storage area is mostly executed by forklift trucks or a combination of a tractor with a trailer. Within the storage area, forklift trucks and mobile cranes are used frequently. From these storage areas these products can be further transported to the hinterland, when needed (Ligteringen & Velsink, 2012, pp. 154-159).

Main activities related to industrial production

Many activities concerning the industrial production of goods are also facilitated at locations along the port basins. For this research, only the production companies with inland waterway transport-related activities are taken into account. This means that for the production of the goods, the inland raw materials can be supplied and/or the finished products can be transported out of the inland port by inland waterway transport. These industrial processes are originally located at the inland port areas because of the proximity of various transport modes (mostly IWT and road transport, sometimes rail network). These industrial processes are largely focused on high-quality and location-bound industrial processes. The following five main categories of industrial activities have been identified in the inland ports: the production of agro-bulk, construction materials production, energy production, the recycling processes and the remaining industrial production activities.

Agro-bulk production

Along the inland ports, a lot of agro-bulk producers have been detected. The fact that big amounts of inland ports can be transported by inland vessels to the hinterlands, makes it attractive to use the areas around the inland port for the processing of these agricultural products. The production of agro-bulk products can therefore be considered as a main inland port activity.

Construction material production (e.g. cement, concrete or asphalt)

The location of most of the inland ports is close to the residential areas, which makes it an interesting location for several production plants. These location-bound industrial activities for the production of construction materials are therefore located in the inland port areas. In addition, the raw materials can be supplied by the inland waterway transport, which is preferred because of the required large volumes for this production.

Energy production
The energy production activities can also be found in many inland ports. This current energy production includes in general the production with fossil fuels. The main types of fossil fuels are coal, petroleum and natural gas. The heat from the burning fuels can be directly used for heating or it can be converted to mechanical energy. Other methods to produce energy can be the use of biomass, sustainable energy and nuclear processes, although the nuclear energy production activities cannot be found in the considered Dutch inland ports. The raw materials for the energy production can be supplied with help from the inland waterway transport to the industrial complex and the energy is further distributed toward the surroundings for the energy use.

Recycling activities
The location of the inland port areas is also preferred for the recycling activities. These recycling activities include the demolishment of the scrap, which can be collected in large volumes by inland vessels or trucks. After the recycling process, the new material is transported to the preferred location in the hinterland.

Other industrial production
Besides the four activities mentioned above, it is possible that the inland port includes other types of activities related to added value production. Examples of other industrial activities, which have been found in the inland ports, include the production of chemical products, the production of biofuels and the production of paper.

3.4 Indicators for determination of strengths and weaknesses of inland ports

The future-proofness of the inland ports is not only dependent on the (future) performance of the port activities. In addition, this impact also depends on the strengths and weaknesses of the specific inland ports. For the assessment of the future-proofness it is therefore required to determine the strengths and weaknesses of the various inland ports according to the current port characteristics. In this paragraph, it is identified which port indicators can be used to define these strengths and weaknesses. These port indicators are defined during the interviews with port authorities and with help of some researches about inland port performances, which uses port indicators (Roll & Hayuth, 1993; Tongzon, 1995; Wiegmans, Witte, & Spit, 2015). The most important identified port indicators are presented below.

Accessibility

The accessibility of the inland port defines the degree in which the inland port can be reached for the different transport modes. The better the accessibility, the more likely the inland port will be used for the transport of cargo and thus the more likely that the inland port will be used for the selected port activities. Some examples to assess the accessibility of the inland port are the distance to the main waterway, the availability of a railway connection in the port area, the distance to the nearest motorway access and the quality of the hinterland connections.

Capacities of the various inland port activities

The usefulness of the inland port is mainly assessed by the fact whether the inland port has sufficient capacities to fulfil the demand of the port activities. Ideally, the capacity is exactly equal to the demand for the port activity. However, when the demand becomes higher than the capacity, the inland port cannot facilitate sufficient port activities. The three different port functions have resulted in three different types of port capacities: transfer capacities, storage capacities and production capacities. The capacities are all dependent on many different factors. Some examples are the areas for the various inland port activities, the utilisation of the storage area, the (un)loading handling rate of the quay equipment, the number of terminal equipment and the dwell time of the cargo.

Dependency on companies with port activities

The dependency on companies with port activities also reflects the port characteristics of the inland port. In general, the more companies the inland ports has, the more port activities in the inland port. When an inland port only has a few companies with port activities within its port area, this inland port can be assumed to be very vulnerable to the decisions of these companies. Therefore, a large amount of companies with port activities in the inland port is assumed to be a strength.

Dependency on type of port activities

The dependency of the inland port on the different port activities also tells something about the port characteristics of the inland ports. When the inland port is dedicated to a lot of different port activities, then the overall inland port is not expected to be very vulnerable to changes in the demand of one specific port activity. However, when the inland port is only performing a limited number of port activities, it would be very vulnerable to a change in the demand of that activity. It is therefore preferred that the inland port has a broad range of inland port activities, which can be assessed by the identification of the various port activities in the inland port.

Dimensions of port basins

The dimensions of the port basin (and the related access channel and main waterway) are decisive for the maximum permitted vessel sizes in the inland port. In some cases, the maximum dimensions of the inland vessels can even be more restricted due to the presence of a ship gate or lock at the entrance of the inland port. The dimensions of the inland vessels are mainly restricted because of the limited depth and width of the inland port basins. The length of the inland vessels is mainly restricted by the bends in the port basins and the dimension of the turning circle. Finally, the height of the inland vessels is dependent on the free height, which is mostly dependent on the height of constructions (e.g. bridges). In general, when larger ships are allowed to berth in the port, it is more likely that the port will be used for the port operations because of the higher transport capacities of the larger inland vessels.

Hinterland size

The size of the hinterland is also an important factor for the inland ports. The bigger the hinterland, the bigger the number of companies that could potentially use the inland port for their inland port activities. In addition, the hinterland is also the area, where the majority of the potential personnel lives. It is therefore preferred that the hinterland area includes enough residential areas. This hinterland size is dependent on various factors. Some examples are the location towards other inland ports, the density of hinterland connections and the natural boundaries of the surroundings of the inland port.

Operational time by extreme hydraulic conditions

The operational time of the inland ports is the time in which the inland port is available for the inland port activities. The higher the operational time, the higher the capacity of the inland port activities can be and thus the more likely that the inland port is useful and successful. For this port indicator, the extreme hydraulic conditions are taken into account to determine the operational time. During extreme conditions, the capacity of the inland vessels may be limited (or the inland vessels may be permitted to sail on the inland waterways. The presence of storm barriers or locks makes it possible to perform the port activities, although extreme hydraulic conditions may occur at the main waterway. When the inland port is not protected sufficiently, the inland port may not be able to perform its main activities during these extreme conditions. This would reduce its operational time.

Operational time by municipal permits

The operational time is also dependent on permits, which differs for the different inland ports. For some inland ports, it is only allowed to perform the port activities during weekdays, while other are also allowed to perform its port activities during the night and in the weekends. Overall, the less restrictions in the operational time of the port activities, the more likely that the inland port is useful and successful.

Potential area for future port activities

Many companies without port activities can be found next to the port basins in the various inland ports, which restricts the number of companies which can make use of the IWT. In theory, these companies could be replaced to a location further away from the port basin, leaving space for companies with port activities. The total area around the port basins (both free areas and areas with companies without port activities) represents the potential area which can be used for port activities in the future. The bigger this area, the higher the potential capacity for port activities in the inland port.

3.5 Conclusion

The sub question for this chapter was set up to obtain more knowledge about the inland ports. Moreover, it was chosen to select the main inland port activities, which was reflected in the research sub question: "What main port activities take place in the Dutch inland ports?". The sub question is answered in this paragraph, which gives an overview of this chapter's content.

During the first phase, more knowledge has been obtained about the main port functions of the inland in order to be able to assess the future-proofness of the inland ports. The three main functions were the transfer of goods, storage of goods and the industrial production of goods. In addition, the relation between these main functions and the future-proofness was described.

The second part of this chapter was focused on the determination of the main activities of the inland ports. In Table 3, the identified main functions are presented in the left column. The right column presents the main inland port activities, which are identified with help from literature study, visits to inland ports and interviews with port authorities. These thirteen different port activities are all related to transfer activities, storage activities or (industrial) production activities. These activities will be included in the method to assess the future-proofness of the inland port

Main inland port functions	Nr	Main inland port activities
Transfer of goods	1	Container transfer
	2	Dry bulk transfer
	3	Liquid bulk transfer
	4	Transfer of the remaining types of goods
Storage of goods	5	Storage of containers
	6	Storage of dry bulk
	7	Storage of liquid bulk
	8	Storage of remaining types of goods
(Industrial) production activities	9	Agro-bulk production
	10	Construction materials production
	11	Energy production
	12	Recycling activities
	13	Remaining industrial production processes

Table 3: Main activities of the inland port according to the main functions

The last paragraph determines the port indicators. These indicators can be used to identify the strengths and weaknesses of the inland port. This information is then used to determine the current port characteristics of the inland port. These are: accessibility, capacities of the various inland port activities, dependency on companies with port activities, dependency on type of port activities, dimensions of port basins, hinterland size, operational time by extreme hydraulic conditions, operational time by municipal permits and potential area for future port activities.

4. Method for the assessment of future-proof inland ports

4.1 Introduction

This fourth chapter is focused on the set-up of the method to assess the future-proofness of the inland ports, which is the main objective of this research. This chapter will be used to answer the third sub question: "What method can be provided to assess the future-proofness of inland ports?". Despite the obtained insights about the definition of a future-proof inland port (see chapter 2) and the determination of the current inland port activities (see chapter 3), it is not yet possible to answer the third sub question. More knowledge about the method to deal with uncertainties in the long-term developments is required. Three questions have been set up to get more insight in this subject. These questions support the third sub question and are called the sub sub-questions (SSQ). These three sub sub-questions are:

SSQ 1: What type of uncertainties can be found in long-term developments?
SSQ 2: Which methods can be used to deal with uncertainties in long-term developments?
SSQ 3: Which method is considered to be most suitable for the assessment of future-proof inland ports?

After answering these three sub sub questions it is possible to set-up the method to assess the future-proofness of inland ports. This framework to assess the future-proofness uses the obtained information from the previous chapters and paragraphs in order to answer the research sub question of this chapter. The main research question of this research is thereby also answered. This method can be used to determine whether the case studies are future-proof in the remainder of this study.

The three sub sub-question will be answered in paragraph 4.2, which gives an insight in the various future disciplines to deal with uncertainties in long-term trends. Paragraph 4.3 presents a research, which introduces a new method to deal with these uncertainties: the trend-based narratives. This method will be used to assess the future-proofness of an inland port, which is presented in paragraph 4.4. Paragraph 4.5 serves as the concluding paragraph, in which the main results are presented.

4.2 Methods to deal with uncertainties in long-term developments

For the assessment of the future-proofness of inland ports, it is required to take the long-term developments into account, because these developments determine the potential future demand for the various port activities. These long-term developments concerns trends and uncertainties. The uncertainties can be defined as limited or inadequate information, which can be generated by a natural variability within a system (aleatory uncertainty) or by a lack of knowledge (epistemic uncertainty) (Walker, Marchau, & Kwakkel, 2013). In order to project the potential future demands for the various port activities, it is required to understand the different future-looking disciplines, which can be used to deal with the different types of uncertainties in long-term developments. A suited method (to deal with uncertainties) can then be selected to be integrated in the assessment of the future-proofness of inland ports.

Overview of different future-looking disciplines and the related levels of uncertainties

A recent research has been performed to link the futures research and the most suitable approaches for making a long-term policy decision, given a certain level of uncertainty (Van Dorsser et al. (2018)). In order to understand this link, it is first required to obtain more insights in the different types of uncertainties before the link becomes clear. The information about these different types of uncertainties is described in this section.

Levels of uncertainties

Walker et al. (2003) defined different levels of uncertainties, which were based on the different levels of knowledge. The identified levels of knowledge cover the total spectrum, ranging from the ideal situation of complete understanding to the least preferred situation of total ignorance. These two situations relate to the two extreme levels of uncertainty (complete certainty and total ignorance).
The situation with complete certainty is the extreme situation, where everything is precisely known. This would be the ideal situation for the long-term developments as it is exactly known how the future will look like. However, this situation of compete certainty of long-term developments is not attainable in practice. Therefore this level of uncertainty acts as a limiting characteristic at one end of the spectrum. The extreme situation with total ignorance of the long-term developments acts as the limiting characteristic for uncertainties on the other end of the spectrum. In this situation, nothing is known and there is no idea how the future may look like.

Walker et al. (2003) identified four intermediate levels of uncertainties:

- Level 1 uncertainty
- Level 2 uncertainty
- Level 3 uncertainty
- Level 4 uncertainty

The level 1 uncertainty represents the situation at which it is admitted that the uncertainty can be described adequately by means of a point estimate and its sensitivity. The level 1 uncertainty is therefore mostly treated through a sensitivity analysis of the related model parameters, for which the impacts of the fluctuations of the model parameters on the outcomes can be assessed.

For level 2 uncertainty, slightly less is known than for level 1 uncertainty. This level of uncertainty can be described adequately in statistical terms. The situations with a level 2 uncertainty are captured by a probabilistic forecast (trend-based + expert judgement) with a confidence interval.

For a level 3 uncertainty, no probabilities can be defined anymore. In case of the level 3 uncertainties, one is able to generate multiple futures without knowing the probabilities (e.g. storyline scenarios). These futures describe what potentially could happen and are aimed to present an overview of the potential future conditions, based on the current knowledge.

The level 4 uncertainty represents the deepest level of uncertainty. In this case, it is only known that it is not known. This uncertainty is based on the current and future knowledge. This last requirement presents the knowledge that can only be achieved when a future event has happened, which cannot be projected beforehand. These extreme events are called 'Black Swans' (Taleb, 2007). The inclusion of these extreme events distinguishes the level 4 uncertainties from the level 3 uncertainties.

Link between forward-looking disciplines and the level of uncertainties

According to the research by Van Dorsser et al. (2018) three things were required in order to link the futures field and the way of dealing with uncertainty in policymaking: a clear description of the various types of futures (see Figure 4 (Voros, 2017)); a clear link between the various forward-looking disciplines in the futures field and the types of future they address; a clear link between the type of future and the related level of uncertainties from Walker et al. (2003).

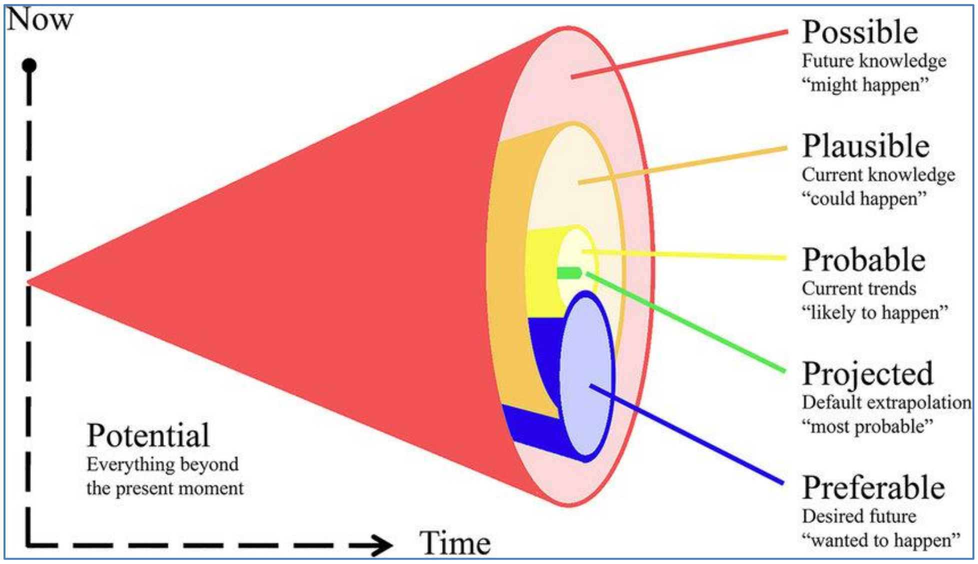


Figure 4: Futures cone (Voros, 2017)

These three links are described in the mentioned research (Van Dorsser et al., 2018) and a conceptual model has been proposed in order to improve the link between the futures and the policymaking. This model is called the Futures Research Pyramid, which is presented in Figure 5. This figure shows the relationship between the type of futures, the type of forward-looking disciplines in the futures field and the level of uncertainties. In general, the higher the place in the hierarchy, the higher the level of uncertainty. The four different layers are described in the text below Figure 5.

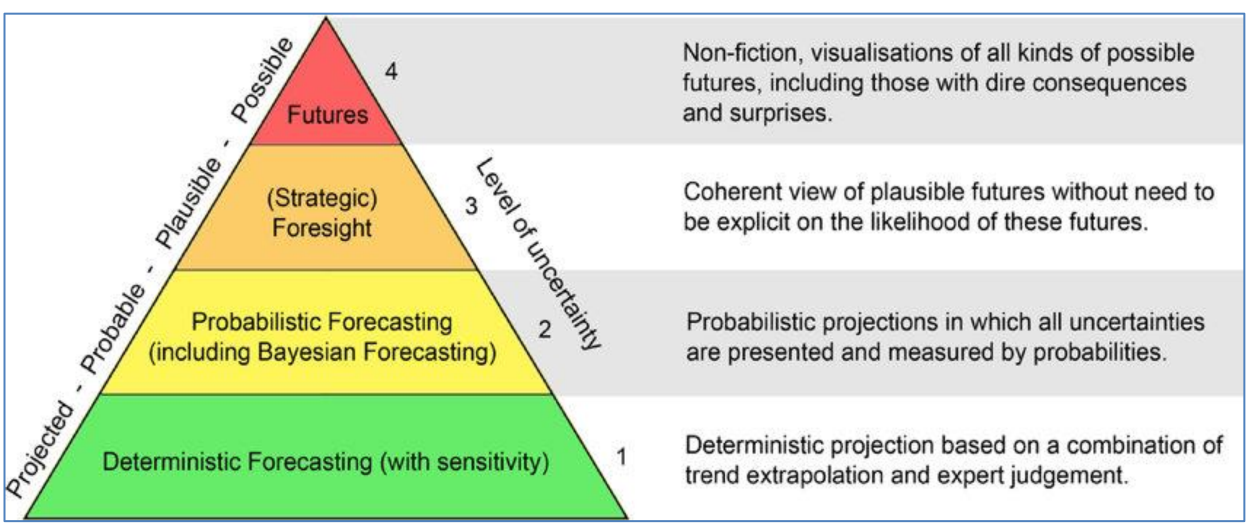


Figure 5: Futures Research Pyramid (Van Dorsser, Walker, Taneja, & Marchau, 2018, p. 82)

The first (bottom) layer of the pyramid is the 'Deterministic Forecasting (with sensitivity)'. This layer is linked to projected futures and level 1 uncertainties. The projected futures are the default future. The level 1 uncertainty is a situation which can be described by a point estimate and its sensitivity. The methods from this first layer aim to provide a single forecast of the future state of the trend, which is based on the extrapolation of the current trend and expert judgement. In the end, these methods are used to provide the single most probable estimate with a high level of certainty. They are mainly considered for a short period of time, but this depends on the timescale of the trend.

The second layer of the pyramid represents the 'Probabilistic Forecasting'. This layer is linked to the probable futures and the level 2 uncertainty. Probable futures are the futures that are likely to happen, based on the current trends. The level 2 uncertainty represents the situation for which it is possible to describe alternatives and their probabilities. The methods in the second layer aim to provide an overview of possible outcomes, for which the variation of the main parameters is known. These methods (e.g. scenarios based on the output of a probabilistic forecast) can be both used for short-term and long-term projections, but the larger the time horizon, the less detail can be taken into account.

The third layer of the Future Research Pyramid is the '(Strategic) Foresight', which is linked to plausible futures and level 3 uncertainties. The plausible futures are those futures which could happen based on our current knowledge about the trends. The level 3 uncertainty represents the situation in which one is able to generate multiple alternatives without any probabilities. The methods in the third layer aim to develop an overview of the plausible futures without explicitly knowing the likelihood of these futures (e.g. storyline scenarios). The extreme futures are not included in this layer.

The top layer represents the 'Futures'. This layer is linked to both the possible futures and the uncertainties of level 4. The possible futures presents all futures that can happen, based on both current and future knowledge. The level 4 uncertainties includes the deepest level of uncertainties. The methods in the top layer also aim to develop an systematic overview of the possible futures without explicitly knowing the probabilities (e.g. storyline scenarios). Unlike the third layer, the methods in this layer also include the extreme scenarios with dire consequences: the wildcard scenarios.

Approaches to deal with uncertainties in long-term developments related to (inland) ports

Several researches that deal with these uncertainties in long-term developments have been published, related to (inland) ports or the inland waterway transport. However, only a few researches have been published to present an actual approach (framework) to deal with these uncertainties in long-term developments. In this section, two relevant approaches are presented, which were set up in the dissertation of Van Dorsser (2015) and Taneja (2013) at the Delft University of Technology.

Very long term development of the Dutch Inland Waterway Transport System

The dissertation of Van Dorsser (2015) was aimed at developing a method for taking the long-term developments of the Dutch IWT system into account into the evaluation of the infrastructure development strategies with a long-term impact. The research shows an approach which integrates the uncertainties in the long-term perspectives of the Dutch IWT system.

There are sufficient methods to deal with the uncertainties in long-term developments (see Table 5-2 in this research (Van Dorsser, 2015, p. 130)), which has been structured into four different categories. These categories are based on the different levels of uncertainties by Walker et al. (2003). It was concluded that the length of the time that can be anticipated at a certain level of uncertainty depends on the amount of detail required for the description of the issue under consideration. Therefore it was suggested to start considering the problem at the highest possible level of aggregation and to zoom in to obtain a more detailed view. In the end, the selected layer of methods presents the way uncertainties must be taken into account.

It is observed that the proposed approach is focused on the identification and quantification of both long-term trends and uncertainties. It is aimed at the visualisations and estimations of these potential future conditions. This relates particularly to the uncertainties of level 2 and level 3 in the classification of Walker et al. (2003).

The Flexible Port

According to the dissertation of Taneja (2013) the potential future perspectives cannot be projected adequately due to the wide range of uncertainties. The deepest uncertainties are present during the port planning, at which the uncertainty has to be determined for the design of constructions. Currently, a conventional design process is followed for most of projects, resulting in inflexible solutions for (inland) port constructions and infrastructure. In order to prepare the ports for different future situations (due to uncertainties in the developments), flexible constructions and infrastructure can be introduced. This resulted in the fact that this dissertation was aimed at finding a suitable uncertainty handling approach, which introduces flexibility in the port planning.

This resulted in the set-up of Adapted Port Planning (APP) framework. This framework is set up for the port planner in order to include uncertainty and flexibility considerations in the traditional port planning. In the first step of this framework, the objectives and criteria have to be specified. This is followed by the generation of plausible alternatives with relation to the objectives. In the following steps, the uncertainties in the alternatives must be identified. It should be assessed whether this can result in an opportunity or in a vulnerability. In the following step of APP, the flexibility and robustness of the alternatives must be increased. Subsequently, the alternatives have to be evaluated, which results in the selection of a single alternative. As a concluding step, a monitoring plan must be created in order to track whether the object still fulfils the criteria of the objective. When this is no longer the case (because of a different future than expected), a contingency plan provides how to deal with this vulnerability, which has been set up beforehand.

The framework of the Adaptive Port Planning is focused on the following aspects of uncertainties: identification of the uncertainties, prepare for the uncertainties, adapt to the uncertainties, manage the uncertainties and profit from the uncertainties. From these focus points, it can be concluded that this approach is focused on the adaptability, for which the identification of uncertainties is executed without focussing on the visualisations and estimations of the potential future conditions. This relates particularly to the uncertainties of level 3 and level 4 in the classification of Walker et al. (2003).

Determination of a suitable forward-looking discipline for dealing with uncertainties

This paragraph presented different approaches to deal with uncertainties in long-term developments. These approaches are in line with the link between the forward-looking disciplines and the different levels of uncertainties. According to this link, it is proposed to select the forward-looking discipline by considering the level of uncertainty of the long-term developments with relevance to inland ports.

The methods from the fourth layer (Futures) can be used when the future is completely uncertain. This means that there are no indicators in which direction the future developments will unfold. The main reason for the inability of estimating the outcomes lays in the fact that the possible outcomes are based on future knowledge (knowledge which is gained after a new event has happened). The other reason lays in the level of detail of selected aspects, because more detailed the aspects will result in larger uncertainties of the long-term developments. For the inland ports, it is expected that the direction of the trends can still be projected. It is therefore not completely uncertain what the future will look like. Therefore the methods, related to the level 4 uncertainties, are not used for the assessment of the future-proofness of the inland port.

The next step is to determine whether a method from the third layer (Fore sight) can be used. The proposed method for looking ahead in this layer is the generation of a range of storyline , which reflects the plausible developments. The methods of this layer are recommended as long as it is possible to identify all the plausible futures without any likelihoods. For most of the transport and port related aspects it is possible to identify these plausible futures. For these long-term developments it is therefore possible to use the level 3 uncertainty methods for the assessment of the future-proofness.

For the use of level 2 uncertainties (Probabilistic Forecasting), it is necessary to assign likelihoods to the alternative futures. To achieve this, probabilistic forecasts or scenarios have to be generated for the visualisation of the future. For these projections it is required to include all known uncertainties explicitly into account. The forecasts do provide a central median estimate and a bandwidth for the level of uncertainty. However, the probabilistic projections are based on the presumption that all relevant uncertainties are known and that an estimate of the uncertainty level can be provided. This estimate of the overall uncertainty can only be provided when the level of detail is high enough to identify all relevant uncertainties. This is not the case for the future-proofness assessment of inland ports, because not all relevant uncertainties can be identified due to the small level of detail of the uncertainties. This means that the methods from the second layer cannot be used for the projection of the future.

For this research, it is proposed to use the methods from the third layer of the Future Pyramid (see Figure 5). A new method to deal with the level 3 uncertainties will be used for this assessment: trend-based narratives (Van Dorsser et al., 2018). These trend-based narratives are selected as a suitable method because it outlines the plausible developments. In the next paragraph, this newly-developed method to deal with plausible developments (with level 3 uncertainties) will be explained.

4.3 Port metatrends (Van Dorsser, Taneja, & Vellinga, 2018)

The previous paragraph presented the determination of the forward-looking discipline to identify the future projections: methods from the third layer of Futures Research Pyramid (Van Dorsser et al., 2018). The newly-developed method of trend-based narratives is selected to deal with the plausible developments, which includes both opportunities and threats for inland port activities.

Hardly any researches with trend-based narratives and relevance to (inland) ports have been published, because this method is introduced recently. The main research is Port Metatrends (Van Dorsser, Taneja, & Vellinga, 2018), which includes a scientific framework to get insight in the long-term trends, uncertainties and implications for ports. This framework was originally generated for the Port of Rotterdam (PoR) to prepare (and anticipate) for long-term trends, but can also be used as a guideline for other (inland) ports. The trend-based narratives can be regarded as a subset of incremental storyline scenarios that only deal with the plausible developments. The method to set up these trend-based narratives is as follows:

1. Carry out a trend-analysis using the three layered meta-framework.
2. Develop trend-based narratives, which describe the potential future implications of a plausible and significant development with help from the previous step.

The method to develop the trend-based narratives scenarios is further explained in this paragraph, because this will be used to determine the impacts of the long-term trends on the various port activities.

Conceptual three layered meta-framework for analysing long-term trends

For the trend-analysis, the method of Van Dorsser et al. (2018) uses the three layered meta-framework (see Figure 6). In order to improve the ability to anticipate on the long-term developments, it is recommended to look at different kinds of long-term trends. The trends that take longer than 100 years can be filtered out as it can be considered as relatively stable until 2050. Another important step is to study the 50 years lasting economic (Kondratieff)-waves and find out how these primary drivers can relate to these megatrends. Finally all other megatrends with a duration of ten to thirty years should be examined. This results in the creation of an integrated meta-framework, which supports the knowledge gained at the various layers and improves the understanding of trends with the different levels of inertia.

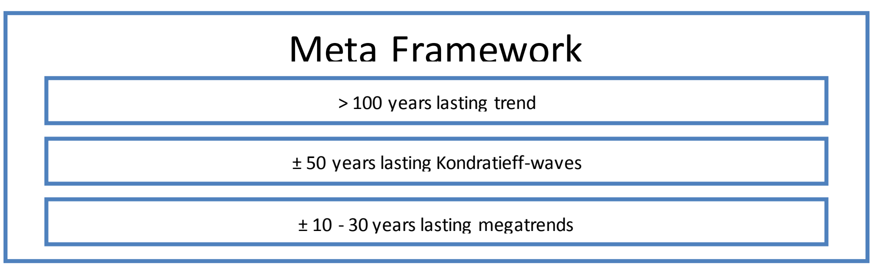


Figure 6: Conceptual meta-framework for analysing trends (Port Metatrends, 2018, p. 29)

10-30 year megatrends

Megatrends are the trends, representing the global developments with a duration between ten and thirty years. The determination of megatrends takes place by defining the number of relevant categories. This categorisation is based on the STEEEP-method, which stands for the following categories of megatrends: Societal, Technological, Economic, Environmental, Energy and (geo)Political.

50 year Kondratieff-waves

Kondratieff-waves have a duration of about 50 years. These are based on an analysis of long-term trends, which follow a transition path that is subject to cyclical movements around an important trend. The Kondratieff-waves can be related to the major economic, social and technological drivers of the world economy and global society. These waves are closely related to the distribution of the new technologies and the new infrastructural network. This results in the fact that it is useful to do research to the Kondratieff-wave in order to identify future trends and to address the speed of these trends.

>100 year lasting trends

Century-long trends are the trends which unfold over a period for at least one century. These developments can be expected to remain relatively stable over the next few decades. Therefore it is useful to filter these trends out.

Integrate all three layers into a broader meta-framework

All the knowledge gained from the various long-term trends, can be used into the broader meta-framework. This framework shows that the three different layers of the meta framework are related to each other. Century-long trends signal issues that trigger the direction of the next Kondratieff-wave, while the Kondratieff-waves give an indication of the timing and inertia of the megatrends (with the corresponding drivers). On the other hand, megatrends jointly confirm the direction of the socio-, techno- and economic drivers of the present and next Kondratieff-waves. Kondratieff waves signal that century-long trends may reach the 'maturity' stage of their s-curve. This integrated meta-framework is presented in Figure 7.

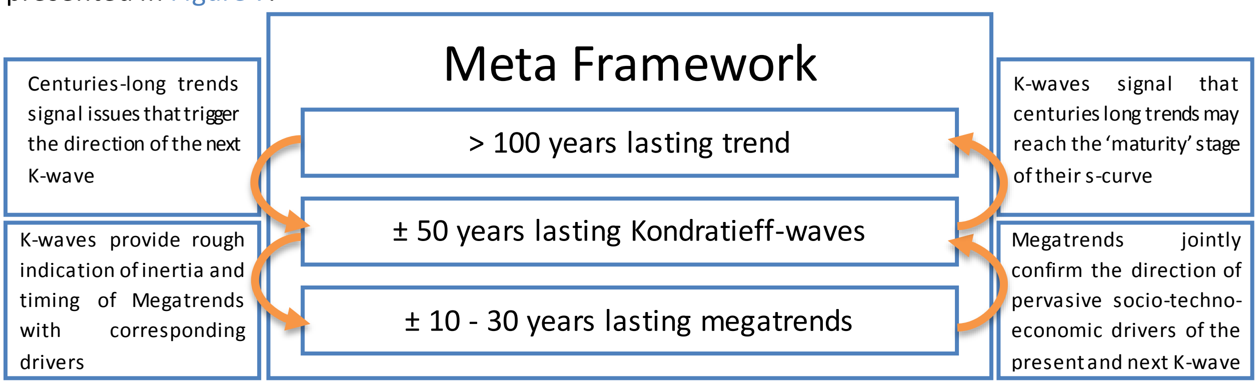


Figure 7: The integrated meta-framework for analysing trends (Van Dorsser, Taneja, & Vellinga, 2018, p. 39)

From the identified trends, insight in the pervasive drivers of the Kondratieff-wave and their corresponding levels of inertia can be established. The identification of these drivers can be seen as essential for understanding the direction of future trends, as this is very useful for obtaining the indication of the period when emerging technologies can become dominant. During the downswing period of the present Kondratieff-wave the drivers of the following Kondratieff-wave can be identified. The pervasive drivers can be corroborated by a range of well-known megatrends and by the emerging technologies, which inertia will align to the inertia of the Kondratieff-wave.
These pervasive drivers of the previous and next Kondratieff-wave can then be used to determine the trend-based narratives, which reflect the plausible developments affecting the port activities. This method will therefore be used to determine the plausible developments for the inland port activities, which ultimately defines the impacts on the activities in the inland port.

4.4 Method to assess the future-proofness of an inland port

With the obtained insights in the previous chapters and paragraphs, it is possible to set up a method to assess the future-proofness of the inland ports. This paragraph is used to determine this method and explains the various required steps to assess the future-proofness of an inland port. These steps are:

1. Determination of the port specific strengths and weaknesses (port characteristics)
2. Determination of the port specific opportunities and threats (impacts)
3. Determination of the port specific flexibility
4. Assessment of the future-proofness of the specific inland port

Part 1: Determination of the strengths and weaknesses (port characteristics)

The next three steps have to be taken to determine the strengths and weaknesses of a specific inland port:

- Determination of port activities in a specific inland port
- Determination of port characteristics in a specific inland port
- Determination of port specific strengths and weaknesses

In this first part, the strengths and weaknesses of the current inland port will be identified, because the current inland port serves as a baseline measurement for the assessment. For the current inland port situation, it is known what kind of port activities are present and the port characteristics can be defined. This identification of the port activities is based on the identified port activities as categorised in paragraph 3.4. Furthermore, the port indicators (as defined in paragraph 3.5) are used to define the port characteristics, which presents the strengths and weaknesses of the present port activities in the inland port. When the inland port contains a lot of weaknesses (e.g. very dependent on one specific inland port activity), it may be very vulnerable to potential (negative) changes in the demand for the various port activities until 2050, which may not be good for the inland port's future-proofness. However, the future-proofness of the inland port is not only dependent on the current port characteristics, because it does not take the projected future impact on the port activities and the flexibility into account. This projected impact is therefore determined in part 2.

Part 2: Determination of the port specific opportunities and threats (impacts)

The next steps have to be taken to determine the opportunities and threats for the port activities in a specific inland port:

- Identification of plausible future developments for inland ports in general
- Identification of generic opportunities and threats
- Identification of opportunities & threats for specific activities (based on trend-based narratives)
- Identification of the impacts in relation to the total inland port

The second part of the approach aims at the identification of the port specific opportunities and threats, which is defined by the projected changes in demand for the port activities. The inland port activities with a decreasing demand are considered as a threat, while inland port activities with a projected increase in demand are considered to be an opportunity. Before these port specific opportunities and threats can be determined, several other steps have to be taken.

In the first place, the plausible future developments have to be identified. The three-layered system is used to identify the plausible drivers of the long-term global trends, as described in Port Metatrends (Van Dorsser, Taneja, & Vellinga, 2018). When these main drivers are known, it is possible to identify the plausible future developments with a relevance to inland ports in general. The identified plausible future developments are then combined in order to present the generic opportunities and threats on the inland port activities.

Furthermore, these identified long-term developments are translated into port specific trend-based narratives, in which the generic port impacts are adapted to the impacts of one specific inland port activity. These port specific trend-based narratives are determined with help from the results of the first part of this approach (the inland port strengths and weaknesses), which are used to assess whether it is likely that the inland port activities are anticipated to be threatened or whether it is projected to create an opportunity for the specific inland port.

Defining the type of impacts of the trend-based narratives on the port activities

The impacts of the various port specific trend-based narratives can be different in magnitude for different port activities, therefore making it useful to determine what kind of impacts can be expected. The following categories have been distinguished for the different degrees of impacts:

- Minimal impact : Hardly any impact on (transfer / storage / production) volumes of port activity
    - It is projected that the impact of these trend-based narratives is so small that hardly any changes in the demand for the affected port activity are projected. The transferred, stored or produced volumes for the inland port activity are therefore expected to remain approximately the same as in the current situation. In addition, the type of commodities, activities, equipment and infrastructural dimensions remain the same as in the current situation.
- Marginal impact : Impact on (transfer / storage / production) volumes of affected port activity
    - It is projected that the impact of these narratives has an effect on the demand for the affected port activity. However, this impact will be limited to the transferred, stored or produced volumes, which are expected to increase or decrease (depending on a positive or negative impact respectively). The type of commodities, activities, equipment and infrastructural dimensions are not expected to differ from the current situation.
- Major impact : Impact on volumes, commodities, activities, equipment and infrastructure of port activity
    - It is projected that the impact of this narratives has a large effect on the affected port activity. In this case, the impacts will not be limited to the transfer, storage and production volumes, but the overall business model is affected. This changing business model may deal with changing types of commodities, activities, equipment and infrastructural dimensions.

This degree of impact can then be combined with the type of impact (positive and negative) to define the projected impact of the port specific trend-based narratives on each inland port activity. The following impacts can then be distinguished for the inland port activities:

- Major opportunity = Positive impact & Major impact
- Marginal opportunity = Positive impact & Marginal impact
- Minimal opportunity = Positive impact & Minimal impact
- Minimal threat = Negative impact & Minimal impact
- Marginal threat = Negative impact & Marginal impact
- Major threat = Negative impact & Major impact

Impact in relation to the total inland port

Although the number of port activities with threats and opportunities and the type of impact provides an first impression of the impacts of the trend-based narratives on the individual port activities in the future, it does not present a good impression of the impacts on the total inland port. The composition of the various port activities within the inland port is therefore included in the approach to determine the impact of these plausible future developments on the total inland port. When there is little information known about the inland port activities and port characteristics, this impact can be identified by using the following aspects:

- Terminal area
    - The terminal area defines the surfaces in the inland port, which are used for the various inland port activities. This information can be combined with the projected impacts for the various port activities to identify the share of the threatened activities in relation to the total inland port area. The higher this share, the less likely that the inland port can be considered as future-proof.
- Quay length
    - The quay length defines the length along the basin, at which it is possible to perform the transfer activities. The projected demand for these transfer activities is already identified in the previous step, making it possible to combine these results. The share of threatened quays (the quays at which the demand is projected to decrease) to the total quay length gives an insight in the impact of the future developments on the inland port. The higher the share of threatened quay length to the total quay length, the less likely that the inland port can be considered as future-proof.
- Cargo throughput
    - The cargo throughput is considered as third aspect to give an insight in the impacts of the trend-based narratives on the total inland port. The higher the share of inland port activities with opportunities to the total cargo throughput, the more likely the inland port can be considered as future-proof. When the inland port mainly transfers cargo types, which are likely to decrease in demand, the inland port may face problems with its future-proofness.

When it is found that the inland port contains a lot of activities with opportunities in relation to the total port area, total quay length and total cargo throughput, it is likely that the inland port may be more future-proof than an inland port with activities, which are predominantly projected to be threatened. However, the future-proofness of the inland port is not only dependent on the impacts, but also on the earlier determined port characteristics and the flexibility, which will be determined in part 3.

Part 3: Determination of the port specific flexibility

The next steps have to be taken to determine the flexibility of a specific inland port:

- Determination of the potential to reduce negative impact by replacing the threatened port activities by new port activities
- Determination of the potential areas to expand the number of facilities for (new) port activities
- Determination of the port specific flexibility

The flexibility of the inland port represents the degree in which the inland port can adapt to the future demand for port activities. In this case, flexibility is mainly about whether a new port activity can be performed on the existing infrastructure of the threatened port activities, so that this threatened terminal can be used again in a useful and successful way. In addition, the amount of sufficient space for new port activities is also included in the determination of flexibility, because this represents the degree in which the inland port may convert its opportunities into new port activities. These determination of the port specific flexibility is based on these two different aspects. The method to determine the results of this third part of the assessment is described in this paragraph.

Analysis of the current port infrastructure of the threatened port activities for new port activities

The current infrastructure of the projected threatened port activities has to be analysed in order to determine whether this infrastructure can be used for new port activities. This analysis has to be executed for all individual terminals with anticipated threatened port activities. For all these terminals, it is required to determine whether other inland port activities can use the current port infrastructure. When the demand for these other port activities is expected to increase, it is possible that these port activities may replace the threatened port activities. The inland port remains therefore useful and successful in performing the port activities. When there are no port activities to replace the threatened activities, the inland port becomes less useful and successful. When there is more than one threatened port terminal, the results of the flexibility of the various terminals has to be combined in order to define the overall flexibility with regard to the current port infrastructure.

Analysis of the potential to expand the capacities of the port activities

The capacities of the port activities can be increased in two different ways: increasing the internal capacity at the terminal (e.g. by improving the equipment, terminal configuration) and by increasing the total area for port activities. These two possibilities to increase the capacity are described below.

Increasing the internal capacities

The internal capacities of the inland port terminals are not known, which makes it impossible to calculate whether inland port terminals can increase their internal capacity. However, the following aspects (related to the terminal capacity) can be analysed to determine qualitatively whether the internal capacity can be improved:

- Quay equipment
  - The equipment at the quay defines the handling rate at which the cargo can be transferred. When this equipment can handle high numbers of cargo within a time period, the capacity will be also high. This high capacities can be mainly achieved when the quay equipment is dedicated to the type of commodities.

- Terminal equipment
    - Terminal equipment defines the handling rate of the cargo at the inland terminal itself. The higher this capacity, the more cargo can be stored and transferred within a time period. The internal capacity can be increased by improving this equipment for the various port activities (e.g. by using the reach stackers in container terminals).

Increasing the terminal area

When the potential increase in terminal capacity is not projected to be sufficient for the increased demand, it may be required to expand the terminal area. The more area without inland port activities along the port basin, the more potential for expanding the port area (and therefore the capacity for the port activity). This area could also attract new port activities and/or companies to the inland port, which is beneficial for the future-proofness of the inland port. The next three aspects are considered to define whether the area for port activities can be increased:

- Free area in the inland port
    - The free area in the inland port represents the area along the port basin, which can be used for future port activities. The larger this free area in the port area, the less likely that the port terminals will be restricted to a maximum port capacity, because the inland port may increase its terminal capacity. When there is little free area available, it becomes harder to take advantage of the increasing demand for certain port activities, making it less future-proof.
- Areas along the port basin without port activities
    - The areas along the port basin without port activities serve as a potential area, which can be used in the future to increase the total capacity for the port activities. In contrast to the free areas, this area cannot be used immediately for the inland port activities, because it is already used by a company without port activities. This company has to be relocated to another location before it can be used for port activities, which is a very intensive process. This type of area can therefore not directly be considered as potential future terminal area, while it may become potential port area in the future.
- Free terminal area due to expansion of the current port basin
    - In the most extreme case, it can be decided to increase the total port area by constructing a new port basin (or by expanding the current port basin). In this case, the total terminal area will be increased and the port activities with a projected increase in demand are not restricted to the current terminal area. Unfortunately, most inland ports cannot expand its port basin due to the high construction costs and the presence of residential areas and other buildings around the inland port. For this research, it is not taken into account that the inland port may expand its port basin, because this changes the port characteristics of the current inland port significantly.

When the flexibility of the inland port is determined, the future-proofness of the inland port can be assessed. The results of port characteristics, impact and the flexibility will be combined in part 4 of this method.

Part 4: Assessment of the future-proofness of the specific inland port

The final step is the assessment the future-proofness for a specific inland port, which includes the next steps:

- SWOT-analysis to present the strengths, weaknesses, opportunities and threats
- Determination of the results of the combination of port characteristics, impact and flexibility
- Determination of the overall future-proofness of the inland port

In this part, a first insight in the future-proofness of the various port activities has been presented by a SWOT-analysis. The combination of strengths, weaknesses, opportunities, threats presents this first insight in the future-proofness.

SWOT-analysis

A SWOT-analysis is a framework to evaluate an entity's competitive position by identifying its strengths, weaknesses, opportunities and threats (Wikipedia, 2018). This framework could be used to assess what the entity (e.g. business, location, industry or product) can and cannot do, which is based on both internal and external factors. It is important that the result of the SWOT-analysis presents a realistic and clear result.

The following elements have to be included in the SWOT-analysis and are described as follows:

1. *Strengths*: Describes what an entity excels at and separates it from the competition
2. *Weaknesses*: Describes what an entity prevents from performing at its optimum level
3. *Opportunities*: Describes favourable external factors which can provide a competitive advantage
4. *Threats*: Describes the external factors which can provide a competitive disadvantage

The SWOT-analysis is used to clearly present the strengths, weaknesses, opportunities and threats of the specific inland port, which have been determined in the previous steps. The combination of the number of opportunities (and strengths) in relation to the threats (and weaknesses) gives a first impression of the future-proofness of the inland port.

Assessment of future-proofness

The SWOT-analysis gives a first impression of the future-proofness of the inland port in relation to the number of port activities, but it does not take the relative importance of the various port activities for the specific inland port into account. In order to determine the future-proofness of the inland port, it has to be assessed whether it is expected that the inland port remains useful and successful in the future by using the results of the first three parts of this method. In this way, the assessment refers to the definition of a future-proof inland port from chapter 2. This combination of port characteristics, impact and flexibility is used to determine the overall inland port's future-proofness.

In order to become useful, the inland port capacity has to meet the future demand for the primary functions of the inland ports. This can only be achieved when there are sufficient port activities to use the port area and infrastructure in a useful way. The inland port remains successful as long as the inland port activities remain effective and efficient on the long-term, so that the port activity can continue to exist in the inland port area (on condition that it remains useful). In addition, the flexibility is taken into account in order to determine whether the inland port may reduce the threats and is able to convert the opportunities in new port activities.

Three questions have been generated for the final assessment of the future-proofness of the inland ports. The combination of the answers on these questions determines whether the inland port can be considered as future-proof, because they sum up the results of the previous parts of the method. These questions are:

1. Is it projected that the inland port activities in the inland port are hardly threatened?
2. Are there sufficient opportunities to compensate for the anticipated threats?
3. Does the existing infrastructure match the infrastructure needed for these identified opportunities?

Table 4 shows the different combinations of answers on the three questions, which can be specified for all inland ports and can be used as a general guideline to determine the future-proofness of inland ports. This table presents a 'plus-sign' when the question can be answered positively. When the question is answered negatively, the 'minus-sign' is presented. The last column presents the overall degree of future-proofness, while a description of these type of inland ports is also presented.

<table>
<tr><th>Scores</th><th>Question 1</th><th>Question 2</th><th>Question 3</th><th>Total</th></tr>
<tr><td rowspan="2">Very future-proof</td><td>+</td><td>+</td><td>+</td><td>Very future-proof</td></tr>
<tr><td colspan="4">The inland ports with a positive scores for the three questions are expected to be very future-proof. These types of inland ports are not expected to be heavily threatened, while the port activities with opportunities are expected to compensate the limited threatened port activities. Furthermore, the existing infrastructure in the inland port matches the infrastructure required to perform the new port activities, which makes it easy to attract these port activities to this type of inland ports.</td></tr>
<tr><td rowspan="6">Future-proof</td><td>+</td><td>+</td><td>-</td><td>Future-proof</td></tr>
<tr><td colspan="4">This type of inland ports are not projected to be substantially threatened. Furthermore, there are sufficient opportunities to compensate the threatened port activities. It is therefore likely that the inland port will remain useful and successful for the inland port activities. However, the existing infrastructure is not likely to match the required infrastructure for the 'new' port activities. This infrastructure should therefore be adapted to these new requirements, which shows that the inland port is not flexible enough. Overall, these type of inland ports are determined to be future-proof, because it is likely that the port remains useful and successful.</td></tr>
<tr><td>+</td><td>-</td><td>+</td><td>Future-proof</td></tr>
<tr><td colspan="4">This third type of inland ports is also considered to be future-proof. The main reason for this classification lays in the fact that the inland port activities are not expected to be threatened substantially. Furthermore, the port activities with opportunities are expected to require the same infrastructure as the projected threatened port activities, which makes the inland port flexible for the different port activities. The little inland port activities, which are projected to be threatened, are not expected to be fully compensated by the port activities with opportunities. Overall, the inland port can still be considered as future-proof.</td></tr>
<tr><td>-</td><td>+</td><td>+</td><td>Future-proof</td></tr>
<tr><td colspan="4">The future-proofness of these type of inland ports is also considered to be future-proof, despite the fact that it these inland ports are considered to be heavily threatened according to the trend-based narratives. The main reason of this good future-proofness lays in the fact that these threatened port activities can be compensated by new port activities (opportunities). In addition, the port infrastructure is considered to be equal to the required infrastructure for the new port activities, which makes this type of inland ports very flexible.</td></tr>
</table>

Challenges	+	-	-	**Challenges**
	The inland ports in this category faces some challenges in order to become future-proof, despite the fact that the inland port is not expected to be threatened heavily by the future trends. However, it is not expected that the threatened port activities can be compensated by the new port activities (the opportunities), which reduces the usefulness and successfulness of this type of inland ports. Furthermore, the current port infrastructure does not match the infrastructure of the new port activities. It is therefore not considered that the inland port is flexible enough to attract these new port activities.			
	-	+	-	**Challenges**
	This sixth type of inland ports are also considered to face challenges in order to become future-proof. The main challenges are generated by the fact that it is projected that the inland port activities will be heavily threatened according to the trend-based narratives. On the other hand, there are sufficient opportunities to compensate for these threatened port activities. Unfortunately, the current inland port infrastructure does not match the required infrastructure for the opportunities, therefore not likely to attract these activities with opportunities to the inland port area.			
	-	-	+	**Challenges**
	This type of inland ports is expected to face challenges in order to become future-proof. In the first place, it is anticipated that a substantial part of the port activities is threatened, which is not beneficial for the successfulness of the inland port. Furthermore, the port activities with opportunities are not expected to compensate for the threatened port activities, which also reduces the usefulness of the inland port. On the other hand, the flexibility of the inland port is expected to be sufficient, because the current inland port infrastructure is matching the required infrastructure for the new port activities, which may compensate some of the threatened port activities.			
Significant challenges	-	-	-	**Significant challenges**
	The last type of inland ports are projected to face significant challenges in order to become future-proof. For these specific ports, all three questions are answered negatively. This corresponds to an inland port with port activities, which are projected to be threatened substantially. Furthermore, the activities with opportunities are not able to compensate for the threatened port activities, which reduces the usefulness and successfulness of the inland port. Moreover, these inland ports are not flexible enough, because the current infrastructure is not equal to the required infrastructure for the new port activities.			

Table 4: Overview of the general guideline to determine the future-proofness of an inland port

Overall approach to assess the future-proofness of an inland port

Figure 8 presents the overall approach, which is proposed to determine the future-proofness of a specific inland port. The three boxes in the middle represent the first three parts of the approach, which have been presented in the previous paragraph. The input for these different steps is presented in the boxes above the three parts. The final part of the method (the assessment of the future-proofness for the inland ports) is presented in the box in the bottom, where the results of the first three parts are used as input.

Required steps to be taken

Before this approach is followed for the case studies, it is chosen to determine the generic impacts of the trends on the inland port activities (orange box in Figure 8) beforehand, because these generic impacts are the same for the same port activity within every inland port. These generic impacts outline the generic threats and opportunities of the identified plausible developments for the various port activities. This information can then be used as input for the determination of the port specific trend-based narratives (and their related impacts on the inland port activities) for the case study ports, which is part 2 of the overall approach.

The determination of the generic impacts of the long-term developments is therefore presented in the next chapter (chapter 5). Chapter 6 presents the determination of the future-proofness of the case study inland ports, which follows the presented method and uses the results from chapter 5 as input for the second part of this approach.

Qualitative assessment

In first instance, it was tried to present a quantitative method to assess the future-proofness of the inland ports, because the quantitative data can then directly be used to determine the port characteristics, impacts and flexibility. Various attempts have been made to obtain this quantitative information about the port activities and the characteristics of the specific inland ports. The following actions have been taken:

- Contact with the Dutch inland port association (Nederlandse Vereniging van Binnenhavens (NVB))
- Information from Statistics Netherlands (Centraal Bureau Statistiek (CBS)) and Eurostat
- Contact with several port authorities (e.g. Arnhem, Bergen op Zoom, Drachten, Moerdijk, Zwolle)
- Inland port visits and interviews with port authorities (Alpen aan de Rijn, Cuijk, Oosterhout, Oss, Rotterdam, Utrecht, Venlo, Wageningen, Zwijndrecht)
- An extensive literature study to obtain data about inland ports

It was found that many of the required information about inland ports was not known by these port authorities, because it was not monitored. In addition, the known port information is too generic to assess the future-proofness of the various port activities in the inland port. When it became clear that this detailed port information could not be obtained, it was decided to provide a qualitative approach. This means that the method becomes less accurate, but in this way it is still possible to determine the future developments and to present a first insight in the future-proofness of inland ports. Moreover, the obtained information can still be used as supportive information to the quantitative assessment.

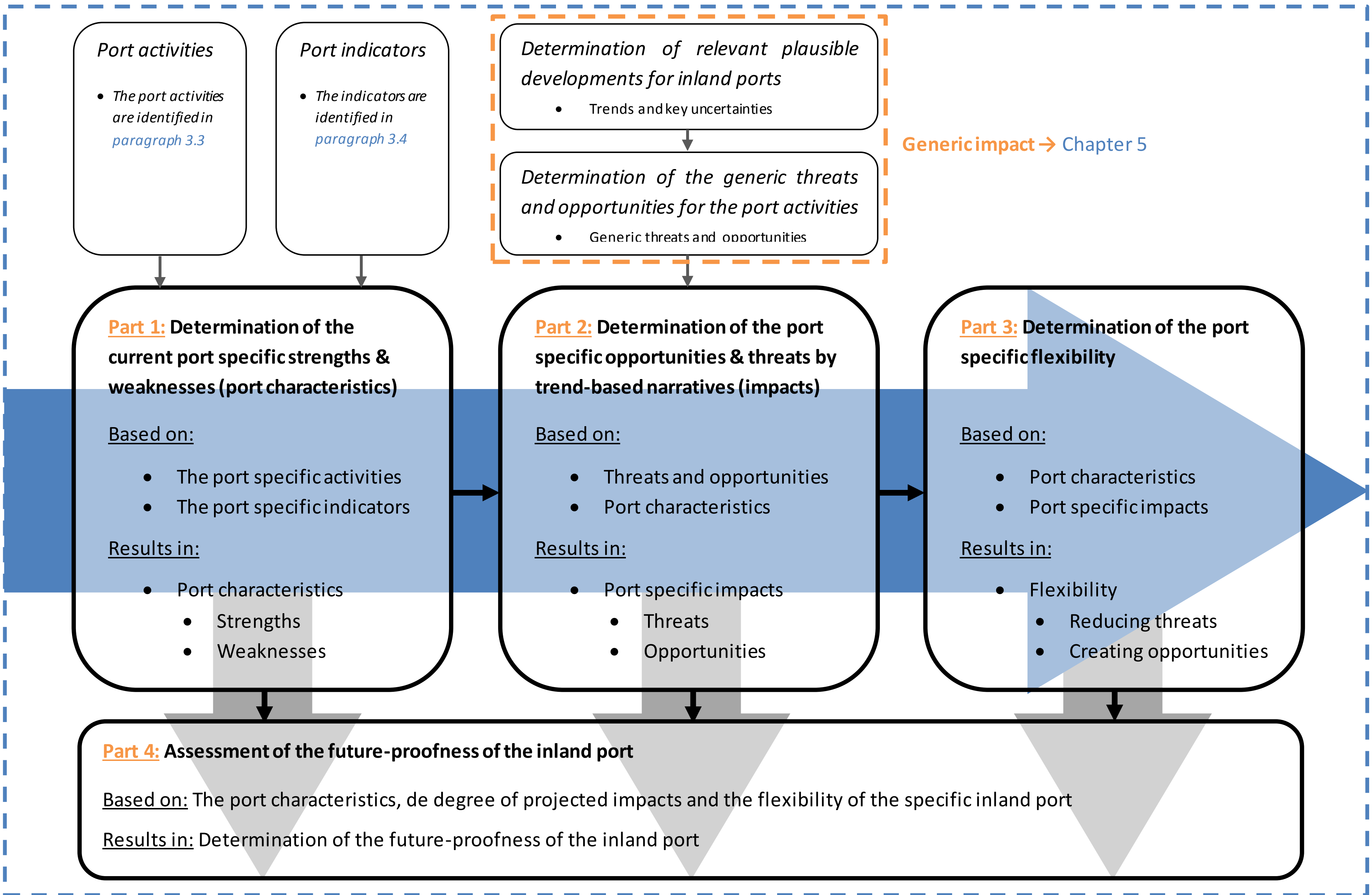


Figure 8: Schematisation of the total method to determine the future-proofness of an inland port

4.5 Conclusion

This chapter answers the third sub question of this research: "What method can be provided to assess the future-proofness of inland ports?". Before the method could be provided, it was required to obtain more insights in the uncertainties in the long-term developments and the related methods to deal with these uncertainties. The following sub sub questions have been set up.

SSQ 1: What type of uncertainties can be found in long-term developments?

SSQ 2: Which methods can be used to deal with uncertainties in long-term developments?

SSQ 3: Which method is considered to be most suitable for the assessment of future-proof inland ports?

The first two sub sub questions are answered by a literature study about forward-looking disciplines and different type of uncertainties in long-term developments. The type of uncertainties were categorised by the research of Walker et al. (2003), resulting in four different uncertainty levels (ranging from absolute certainty to absolute uncertainty). The link between the forward-looking disciplines and the different levels of uncertainties is described in the research of Van Dorsser et al. (2018), resulting in four different categories of forward-looking disciplines: Deterministic Forecasting, Probabilistic Forecasting, Foresights and Futures.

The method to select the forward-looking discipline is based on the approach of Van Dorsser et al. (2015), who suggested to start considering the problem from an overall point of view and to stepwise zoom in to obtain a more detailed view. It was found that the methods from the third layer of the Futures Pyramid (Van Dorsser, Walker, Taneja, & Marchau, 2018) were best suited to deal with the uncertainties in the long-term developments, because the level of uncertainties for the relevant developments was equal to the level 3 uncertainties. The methods from this third layer use a range of plausible trend-based narratives that reflects the identified threats and opportunities for the inland ports. These trend-based narratives are developed by combining the relevant trends and uncertainties with the strengths and weaknesses of the concerned inland port. Each assessment is there fore specific to a certain inland port.

After obtaining insights about the uncertainties, it is possible to answer the main sub question of this chapter. The overall method to assess the future-proofness of the inland ports has been presented in Figure 8. This method exists of four different parts:

- Part 1: Determination of the current inland port's strengths and weaknesses (port characteristics)
- Part 2: Determination of the port specific opportunities and threats (impacts)
- Part 3: Determination of the flexibility of the specific inland port
- Part 4: Assessment of the future-proofness of the specific inland port

Chapter 5 is used to identify trends and uncertainties with relevance for the inland port activities. This identification will be performed in a similar manner as in the research of Port Metatrends (Van Dorsser, Taneja, & Vellinga, 2018). The identified relevant developments are used to determine a generic impact for the various port activities. This information is also used for the set-up of the trend-based narratives.

Chapter 6 presents the assessment of the future-proofness of the three case study ports, which follows the proposed method from this chapter. By comparing the results of the three case study ports, common patterns may be found, which can be used to determine the future-proofness of other ports.

5. Trends, uncertainties and generic impact

5.1 Introduction

The fifth chapter aims at identifying the expected future trends and key uncertainties and their expected generic impacts on the inland port activities. The potential trends and key uncertainties are required to give an insight in the potential changes in societal demand and/or natural conditions. With help from these identified trends and key uncertainties, a generic reflection of the threats and opportunities can be presented for the different port activities. These can then be used to determine the port specific trend-based narratives, which presents the expectation (and plausible deviations) for the future demand of the port activity in a specific inland port. This last step will be performed for the case study ports, which is presented in chapter 6.

Paragraph 5.2 identifies the main drivers of the current and future long-term developments for the inland port. These main drivers are used to present the plausible and relevant trends and key uncertainties for inland ports and the inland waterway transport, which are presented in paragraph 5.3. Paragraph 5.4 presents the generic reflection of the threats and opportunities per port activity, which consists of one general overview of the future made up of trends and possible deviations. An overview of these generic threats and opportunities is presented in paragraph 5.5. Finally, the chapter has been concluded by presenting a short overview of the chapter in paragraph 5.6.

5.2 Identification of the main drivers of the relevant long-term developments

In the previous chapter it is determined that the long-term developments for the inland ports and the inland waterway system can be identified with help from trend-based narratives. With help from these trend-based narratives it is proposed to identify the plausible future outcomes. This research uses a similar approach to determine the trend-based narratives as in Port Metatrends (Van Dorsser, Taneja, & Vellinga, 2018), which method is already presented in paragraph 4.3.

Trend-analysis using the three-layered meta-framework

The three-layered meta-framework was set up to obtain insight in long-term developments for the Port of Rotterdam, but the framework can also be used as a guideline for the long-term developments for inland ports. First, it is required to identify the long-term developments for the three different layers within the meta-framework (megatrends, Kondratieff-waves and century-long trends). It is then necessary to integrate these trends into the three-layer meta-framework. By means of this framework it can then be determined which drivers are most important for the current and future developments. The main results are presented in this section and can be used to identify the relevant long-term developments and the relevant port specific trend-based narratives for inland ports.

Identify the trends for the three different layers within the meta-framework

10-30 year megatrends

Megatrends are the trends, representing the global developments with a duration between ten and thirty years. These can result in societal, technological, economic, environmental, energy and (geo)political changes in the world. The identified megatrends are presented in the research of Van Dorsser et al. (2018, pp. 47-76), which can also be used for this research.

50 year Kondratieff-waves

Kondratieff-waves (K-waves) have a duration of about 50 years. These long-term developments follow a transition path that is subject to cyclical movements around an important trend, which are closely related to the distribution of the new technologies and the new infrastructural network. More information can be found in the research of Port Metatrends (Van Dorsser, Taneja, & Vellinga, 2018, pp. 77-108). The results of the analysis on the K-waves are presented in Table 5, showing that both the 5th and 6th K-wave are projected to affect the inland ports up to 2050. The emerging technologies of the present K-wave are also likely to be the dominating technologies in the next K-wave.

Kondratieff Timeframe	**1st wave 1782-1845**	**2nd wave 1845-1892**	**3rd wave 1892-1948**	**4rd wave 1948-1992**	**5th wave 1992-2036**	**6th wave 2036-2085**	**7th wave 2085-2130**
Dominating technologies of indicated cycle	Water power, Sails, Turnpikes, Iron casting, Textiles	Coal, Iron, Steam power, Mechanical equipment, **Canals**	**Railways**, Steam ships, Steel, Heavy industry, Dyestuff, Telegraph	Electric power, Oil, **Cars**, TV, Radio, Durables, Petrochemicals, Welding, Pipelines	**Global transport, systems,** Mobile phone, Social media, Internet, Materials science, Biotechnology	**Probable:** Recycling, Cradle to cradle, Renewable energy, Smart integrated systems, ***Intermodality***	**Possible:** New social standards, redistribution of wealth, ***3D-printing with recyclable materials,*** local bio-based manufacturing
Emerging technologies of the next cycle	Mechanical equipment, Coal, Stationary power, **Canals**	Steel, City gas, Indigo, **Railways**, Telegraph	Electricity, **Cars**, Trucks, Roads, Petrochemicals, Radio, Phone, Oil	**Bulk Carriers, Containers, Container vessels,** Space flight, **Aircraft,** Computers, Electronic data interchange, Telecommunication	Recycling, Cradle to cradle, Renewable energy, Smart grids, Integrated systems, Smart customised solutions, ***Intermodality***	**Plausible:** Bio-based materials, Local production, Self-sustainability, Decoupling of economic output, wealth and transport, ***3D-printer***	**Hopeful:** Human well-being, Recovery of ecosystems
Principal drivers	Manufacturing	Industrial production	Standardisation	Ford-Taylorism	Globalisation	Sustainability	Quality of life

Table 5: Kondratieff-waves and their primary transport drivers (Van Dorsser, Taneja, & Vellinga, 2018, p. 91)

>100 year lasting trends

Century-long trends are the trends which unfold over a period for at least one century. These developments are expected to remain relatively stable over the next few decades. In the Port Metatrends research (Van Dorsser, Taneja, & Vellinga, 2018, pp. 109-233), nine century-long trends have been identified. These nine are shown below. More detailed information about these trends and their impact on ports is presented in this research (Van Dorsser, Taneja, & Vellinga, 2018, pp. 256-261).

1. Secularisation and individualisation
2. Nature of activities and social power
3. Population and urbanisation
4. Energy and raw material use
5. Technological progress and economic output
6. Connectivity and information exchange
7. Climate change and environmental degradation
8. Transport costs and globalisation
9. Shifts in political world order

Determination of the main drivers of the current and future long-term developments

The research by Van Dorsser et al. (Port Metatrends, 2018, pp. 234-253) gives an overview of the identified integrated meta-framework for identifying future developments significant for the Port of Rotterdam. From the trends, identified during these previous steps, insight in the pervasive drivers of the Kondratieff-wave and their corresponding levels of inertia has been established. The identification of these drivers is considered to be essential for understanding the direction of future trends, because this is very useful for obtaining the indication of the period when emerging technologies can become dominant. During the downswing period of the previous Kondratieff-wave the drivers of the following Kondratieff-wave can be identified. Currently, we are in the downswing period of the fifth Kondratieff-wave, which is mainly driven by globalisation and ICT.

The drivers of the sixth Kondratieff-wave are expected to be sustainability and the increasing connectivity, which can be derived from the identified century-long trends. The pervasive drivers can be corroborated by a range of well-known megatrends and by the emerging technologies, which inertia will align to the inertia of the Kondratieff-wave. During the coming ten to twenty years many research will be done in the new drivers for sustainability and the increasing connectivity, while these innovations will be implemented very limited in the society during these first few years. From about 2030/2040, the implementation of these innovations is projected to scale-up. From this point of view, the developments with relation to these main drivers are likely to emerge within the timeframe of this thesis research.

Main drivers of the current and future long-term developments for inland ports

It is expected that the main drivers of the trends for inland waterways and inland ports are similar to the main drivers of the Port of Rotterdam (PoR), because the identified trends are not selected for the Port of Rotterdam only. The identified trends can be seen as general worldwide trends and can be applied to all different aspects influenced by the trends. For this reason it is useful to use this approach for the identification of the main relevant trends for the inland port activities. Before these trends will be identified, the main drivers will be explained in more detail.

Globalisation

The process of globalisation is the trend of increasing interaction between people or companies on a worldwide scale resulting in a larger economic, financial, trade and communications integration (BusinessDictionary, 2018). The globalisation slowly started in the 19th century by the introduction of the telegraph and the steamship. Advances in transportation and communication technology have resulted in a continuation of the interaction since then. However, the globalisation increased significantly from the 90s of the 20st century as a result of big advancements in transportation methods (e.g. jet engines, container ships) and communication technology (e.g. internet, mobile phones). These developments have resulted in a dramatic decline of the transport costs (Oosterhaven & Rietveld, 2003). The process is therefore considered as the main driver of the current Kondratieff-wave. It is expected that the globalisation continues, although it is expected to slow down and potentially result in reverse globalisation.

Sustainability

Currently, a growing awareness about climate change can be detected in the society. The Paris climate agreement (United Nations, 2015) can be seen as a worldwide recognition of the risks of climate change and the human contribution to this process. Many researches have concluded that the climate change has resulted in a change of natural conditions in the world, which should be reduced as much as possible. Besides the climate change, there is also a growing awareness about sustainability. It has become clear that the natural resources are limited and that more sustainable solutions need to be generated to counter this. The process of increased awareness about sustainability is therefore considered as the main driver of the next Kondratieff-wave.

Increasing connectivity and information exchange

Another driver of the long-term developments can be attributed to the increasing connectivity. The increasing connectivity may ultimately lead to the situation in which all physical devices are connected within one network: the Internet of Things (IoT). The Internet of Things is the network of physical devices embedded with electronics, software, sensors and connectivity, which enables these objects to exchange data. This exchange of data for the inland waterway transport system can take place in different ways: within inland ports, between inland vessels and inland ports, mutually between inland ports or mutually between inland vessels. This data exchange may create opportunities for more direct integration of the physical world into computer-based systems and can be seen as an advancement of the ICT systems. In the end, this is likely to result in efficiency improvements and reduced human intervention.

In contrast to the globalisation and sustainability trend, the trend about increasing connectivity and information exchange is not a driver of one specific Kondratieff-wave, but it joins the main drivers of multiple Kondratieff-waves. The increased connectivity is a trend that has been observed for a period longer than 100 years and continues independently without the dynamics of the Kondratieff waves. The increasing connectivity is seen as a very important century-long trend for the inland ports. Therefore the developments within this century-long trend will be also discussed.

5.3 Relevant general long-term developments and relevant trends

The relevant drivers of the long-term developments regarding the climate change and the changing demand for goods and services for ports are described by the research of Van Dorsser et al. (Port Metatrends, 2018) in the previous paragraph. From this research it was concluded that the globalisation was the main driver of the current developments, while the coming developments are likely to be driven by sustainability and the increasing connectivity. With help from the main drivers, it is possible to determine the various relevant long-term developments for inland port activities. These main trends and key uncertainties are identified with help of a literature study and a meeting with Mr. Schoenmakers (Director Corporate Strategy of Port of Rotterdam) (2018).

Trend 1: Relocation of low-value industrial processes

One of the most clear results of the globalisation process in the inland ports can be identified as the relocation of industrial processes and services to new economies (European Parliament, 2016), which is in most cases related to the low-value and labour-intensive industries (see Figure 9). Most of these industries are relocated due to lower labour costs in developing countries and low transportation costs (Keaty, 2003).

Apart from the relocation of some industries from the inland port, the globalisation has also led to a changed transport chain. In the past, the transport of freight took mainly place over a ‘short’ distance between the production and consumer area. Due to the production of several products in these developing countries, the products had to be transported for larger distances from the production areas (e.g. in Asia) to the consumer area (e.g. the Netherlands). This resulted in a rapid increase in inter-continental transport volumes, which also resulted in a rapid growth of the throughput in sea ports. The cargo is unloaded at the sea ports and from there it is transported to the hinterland by road, rail, pipeline or inland waterway transport. Therefore, the Dutch inland waterways also serve as a hinterland connection for seaports within the Hamburg-Le Havre range (HLH-range). These hinterland connections have grown in transport volumes and became more important over time (Port of Rotterdam, 2016). The transport volumes are therefore considered to increase, because it is expected that this trend will continue.

The relocation of low-value industrial processes could lower the demand for low-value industrial activities in the port area. The inland ports with many industrial activities are therefore considered to be negatively affected by this first trend. It is also anticipated that the demand for transport and storage activities of dry bulk may decrease, because the raw materials will be already processed in the developing countries.

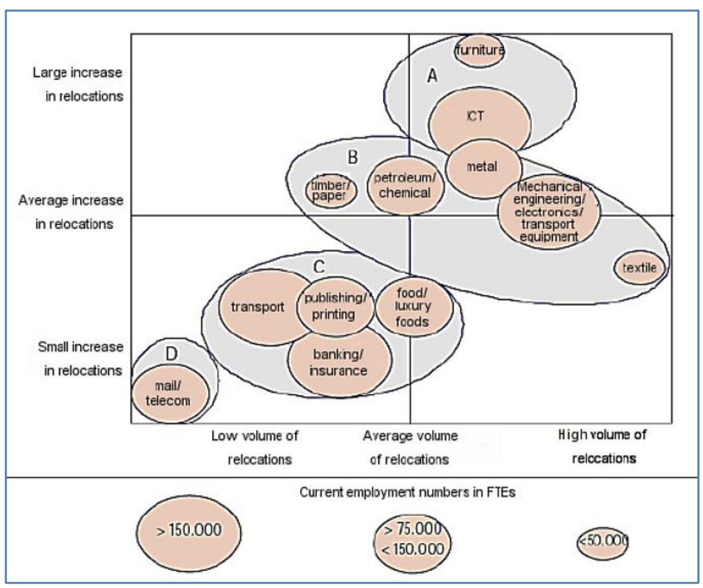
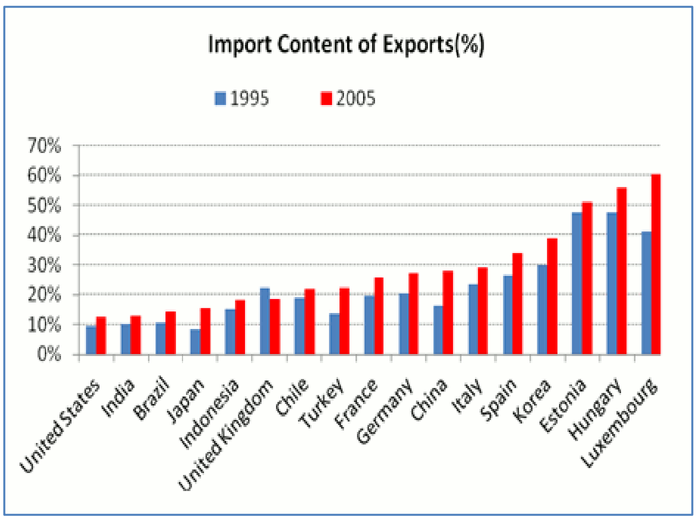


Figure 9: Classification of industries relocated to areas outside the EU (European Parliament, 2016, p. 14)

Trend 2: Specialisation of the remaining industries

The second identified trend is also related to the relocation of the low-value industrial processes to the countries with low wages. Due to the lack of knowledge in these developing countries, some high-quality industrial processes have not been relocated to these countries and thus remained in the developed countries (and thus in the Dutch inland ports). For this reason, it is found that the industrial companies in the inland port areas are focussing into specific high-quality processes, in which they are competitive due to knowledge, size, location, diversity and quality. It is expected that the remained industrial companies will focus even more at specialised processes due to the increasing knowledge in the developing countries (Aiginger, 2000; Statistics Netherlands (CBS), 2018). The specialisation process of the Dutch industries is likely to change the type of supply from raw materials to (semi-)finished products as the basic products will be produced in the developing countries.

Figure 10 presents a graph, which presents the increase in share of imported cargo, which is processed and then exported again. This underlines the trend that the volumes of intermediate goods increases in developed countries such as the Netherlands. This implies that the high-quality industrial processes may remain in the developed countries, because this requires the highest level of knowledge. It is therefore likely that these high-quality industrial processes remain in the inland port area.



It is anticipated that the specialisation of the remaining industries will result in an even bigger increase in demand for transport and storage activities for semi-finished products, while the demand for raw materials is likely to decrease. Overall, the inland ports with a lot of specialised industrial processes are projected to be positively affected by this trend.

Figure 10: Imported content of exports (%) (Dadush & Ali, 2018)

Trend 3: Replacement of small inland vessels for larger inland vessels

Another identified trend is the continuation of the scaling of the inland vessels. According to the report of the Central Commission for the Navigation of the Rhine (CCNR), the dimensions of the inland vessels increases (see Figure 11). The trend to increase the dimensions of the inland vessels is mainly based on lower transport cost per unit. However, this increase dimensions of inland vessel is limited, because for many of the inland waterways it is not possible to expand its dimensions. Therefore the increase in inland vessels dimensions takes mainly place by replacing the smaller inland vessels for the inland vessels with the maximum allowed dimensions for the inland waterways.

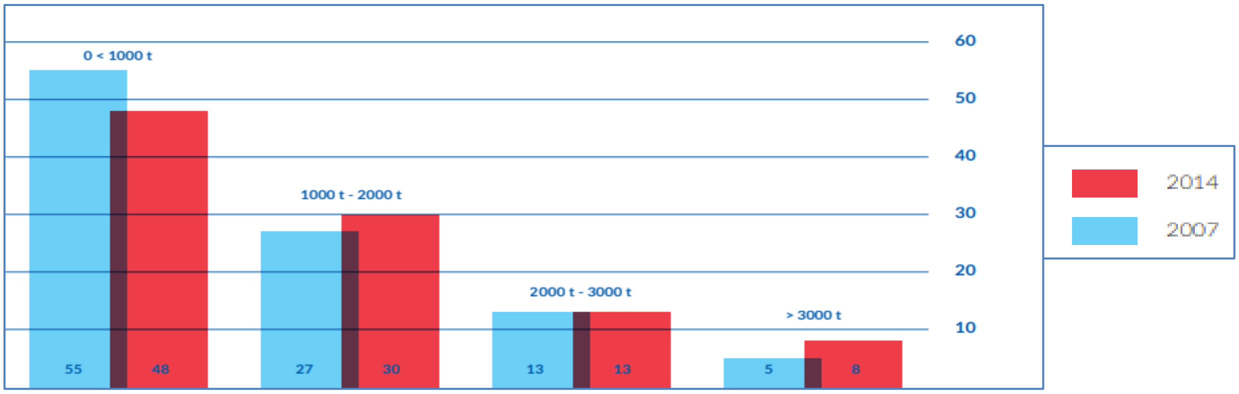
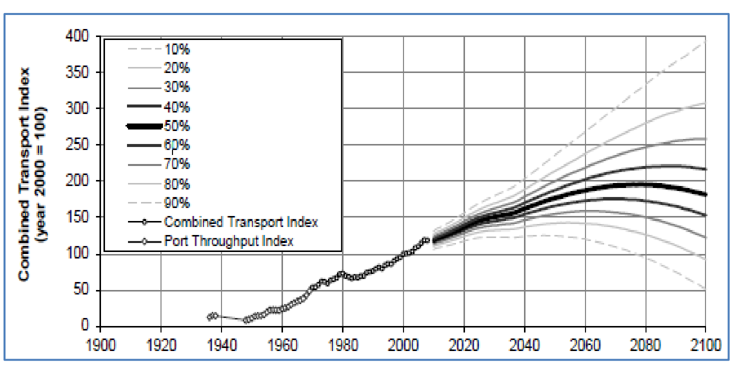


Figure 11: Shares of individual classes in the dry goods fleet in Western Europe (CCNR: Central Commission for the Navigation of the Rhine, 2016, p. 50)

The change to larger inland vessels is likely to change the individual inland ports, because the client is likely to base the optimal dimensions of the inland vessel on the available infrastructure. It is therefore likely that small inland vessels and the related infrastructure along the small inland waterways will disappear over time. The inland ports along these small waterways are therefore considered to be negatively affected by this third trend, while the ports along the large waterways may be positively impacted.

Trend 4: Gradual stagnation of the growth in product demand

An increasing demand for products in general can be seen in the society for a long time. Currently, much of our products are produced in developing countries, which has resulted in a growing transport volume between developing countries and seaports in the developed countries (e.g. the Port of Rotterdam). It is likely that this trend will continue until 2050, although it is also likely that this increase will slow down due to various causes (e.g. aging population, declining consumption in the hinterland, decreasing hinterland productivity). The growing demand requires larger transport volumes to be transported to the hinterland from the seaport, for which the inland shipping also takes care of the expected increased transport volumes.



It is possible that the demand already stagnates before 2050, which is presented in Figure 12. It presents the probabilistic projection for the development of the transport demand, which may already decrease after 2030.

Figure 12: Probabilistic projection for development of Overall Transport Demand (Van Dorsser, Very Long Term Development of the Dutch Inland

The projection of an increasing demand for transport activities is likely to increase the demand for all the transport activities in the inland port, although this growth may reduce after 2030. Especially the inland ports with container activities are expected to benefit from this trend, as this commodity is projected to increase substantially until 2050. The inland ports, in which the current throughput volumes are approaching the capacity are required to increase its capacity in order to fulfil the demand.

Trend 5: Energy transition to reduce emissions

Many researchers have found out that the enhanced greenhouse effect is caused by human activities. The biggest contribution is the extreme increase in greenhouse gas emissions (NASA, 2018), for which the transport sector is contributing for almost 14% of the total greenhouse gasses (see Figure 13). The increased awareness about sustainability has led to stricter legislations for the emission of these greenhouse gasses in an effort to reduce the effects of climate change. This mandatory reduction of greenhouse gasses leads to a decrease in fossil fuel use, which is the main contributor to the increased greenhouse effect. Therefore a transition can be seen from the use of energy generated by fossil fuels to sustainable sources.

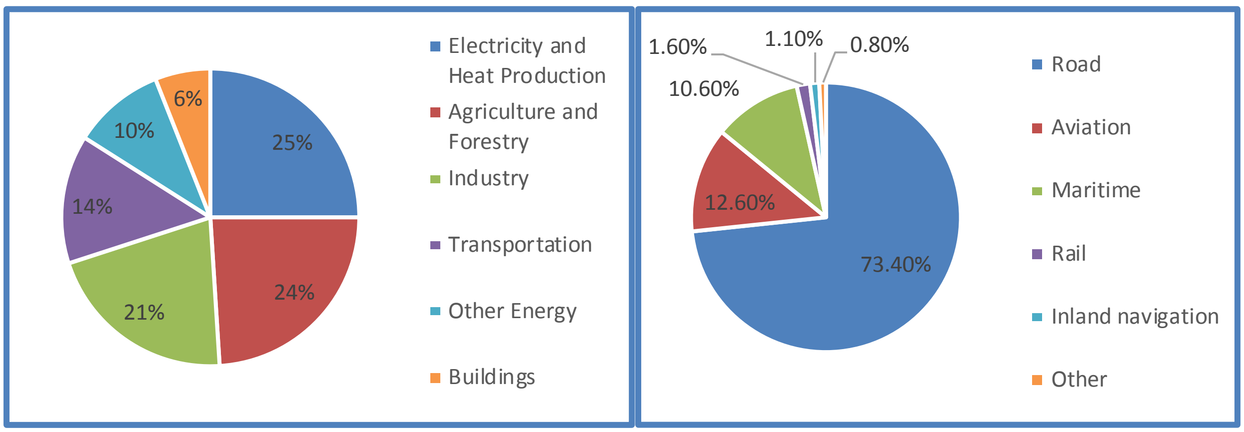


Figure 13: Carbon emissions share by sector (IPCC, 2014) & Energy demand share by transport mode (European Commission)

A major consequence of the energy transition is expected for the energy producers, which are sometimes located in the inland ports (e.g. inland port of Utrecht). Conventional energy producers are likely to leave the inland port areas and are likely to be replaced by sustainable energy producers in order to provide sufficient (sustainable) energy (see Figure 14). For inland port equipment, emissions can be reduced by using electrified port equipment (for quay equipment, storage equipment and transport equipment) (Port of Rotterdam, 2014; Johanson, 2010), which is cleaner than using fossil fuels. This reduced demand for energy production may lead to a decrease in fossil fuel throughput in the inland ports, although the total throughput loss may be reduced by the introduction of sustainable fuels (for which a lower demand is expected than for fossil fuels due to electrification).

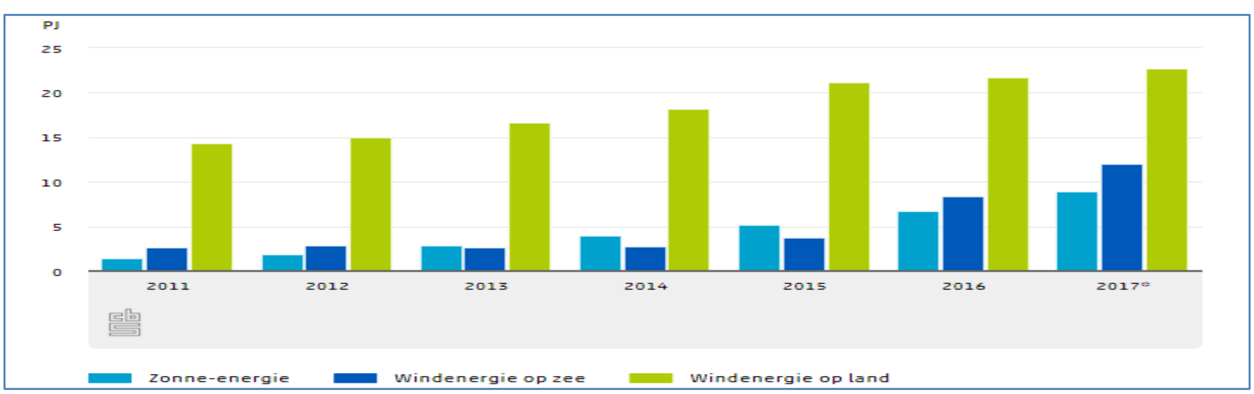


Figure 14: Energy use in the Netherlands for solar energy, wind energy on sea and wind energy on land (CBS, 2018)

In the past, the transport over inland waterways was the most environmental friendly transport mode for some of the greenhouse gasses, but the road transport has been improved significantly. In order to improve the inland vessels performance, it is required that inland vessels themselves also have to invest in innovations to replace fossil fuels for new fuels (e.g. LNG, Hydrogen, synthetic fuels) or electrification of the fleet, for which facilities have to be constructed in the inland port area (Port of Rotterdam, 2017). Unfortunately, there are still technological challenges in order to reduce the GHG-emissions of the inland vessels. In addition, the inland waterway transport industry is rather conservative branch, in which only the ship owners are responsible for the costs to modernise the inland vessels, while the shippers do not have to invest. As long as no agreement has been made between the vessel owners and shippers about these high costs for the owners, it is not likely that the inland vessels will be modernised. This could result in a reduction of market share of IWT in the modal split, when no measures are taken. However, last April a declaration was signed by the inland shipping sector to reflect the commitment to fasten the greening process of the inland vessel sector (Government of the Netherlands, 2018).

The inland waterway transport may lose market share due to the slow transition to sustainable and clean transport alternatives for inland vessels. This has an effect on the demand for all port activities, because it may be reduced. Moreover, the ports with conventional energy producers are likely to be affected even more by this fifth trend, because these activities may disappear from the inland port area.

Trend 6: Transition to sustainable and recycled resources

The growing awareness about sustainability is also resulting in a trend in which the non-sustainable resources are replaced by sustainable or recycles materials. It has become clear that the natural resources are limited and therefore a decrease can be expected in the total volumes of non-sustainable resources. An example is the expected decrease in oil products and raw materials in the future. This decrease is caused by scarce of raw materials, depletion of the extraction areas and other sustainability reasons. It seems that the peak oil production and the peak coal production took place in 2015 and it is expected that peak gas production is reached around 2030 (Peak oil barrel, 2014). This reduction of non-sustainable resources will have significant effects on the port activities in the inland ports, as most of the industrial processes still use the non-sustainable resources. Ultimately, these non-sustainable resources for new products may be replaced by sustainable materials (for which the sources cannot be depleted). Some examples of these sustainable materials are vegetable oils or biological chemicals.

Finally, the awareness about recycling has been growing in the society. The fact that not all resources can be used limitless without depletion already resulted in the trend to limit the amount of waste. The easiest way to limit this amount of waste is to recycle as much materials as possible. The recycling volume is already growing every year (Afvalfonds, 2016). More and more materials can be reused and in the future the number of reusable materials seems to become even larger. The inland port seems to be a good location for the recycling activities as the waste and scrap can be easily brought to the inland port by means of the various transport modes. The outcomes of these recycling activities may be directly used in the production areas in the inland port, but can also be transported outside the inland port, resulting in bigger transport flows between the inland ports.

The inland ports with recycling activities are therefore likely to be positively affected by this sixth trend. On the other hand, the ports with activities dealing with non-sustainable raw materials (e.g. oils, coals) are projected to be negatively affected by this trend.

Trend 7: Increasing number of construction activities

It is expected that the housing shortage in the Netherlands will reach its absolute peak in 2018 with a shortage of more than 200,000 houses (Capital Value, 2017). This shortage of houses has been growing significantly over the last decades as a result of the financial crisis (in which hardly any new houses were built), a growing population, an aging population and the trend to smaller households. Now that the economy is steady and growing again, it was expected that this shortage would be reduced quickly. Unfortunately, the construction companies do not have the capacities to reduce this shortage, resulting in an even increasing shortage of houses. In the short term, it is expected that many permits will be granted for the construction of new houses, so that after 2018 the shortage will slowly decline (see Figure 15), which will increase the volumes of construction-related materials.

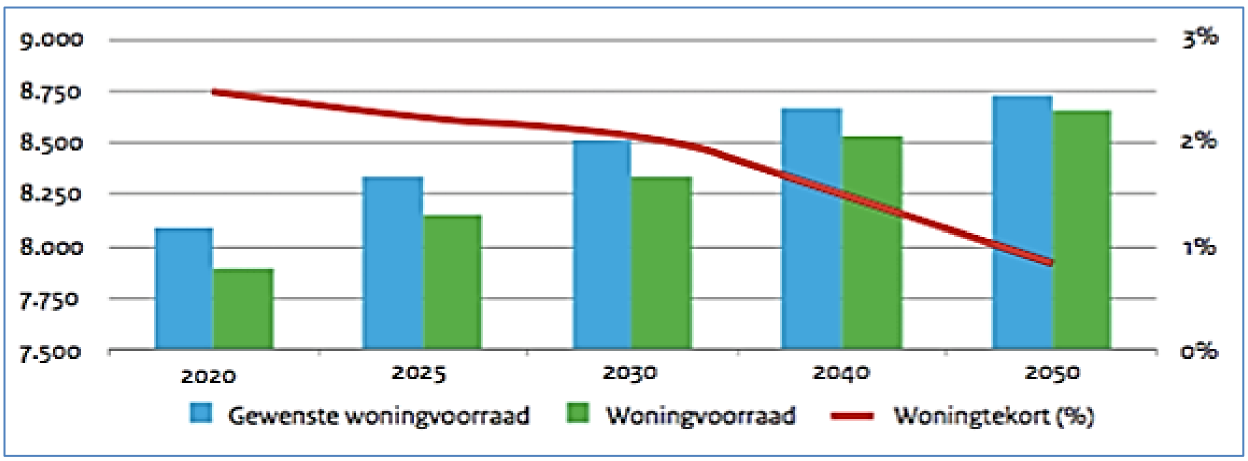


Figure 15: Shortage of houses in the Netherlands (red line) (Das Kapital, 2016)

The construction of these houses requires a lot of construction materials, such as concrete and steel. Volumes of sand and gravel are required for the new constructions (e.g. for the building foundation and for producing concrete). The inland waterway system plays an important role in the transport of sand and gravel, because the inland vessels can transport large volumes at once. Due to the increased demand for construction activities (and thus construction materials), this transport for these activities is likely to increase until 2050. The ports with sand/gravel terminals, concrete plants and asphalt plants are therefore expected to be positively impacted by this trend.

Trend 8: Increasing demand for food and feeder from the Netherlands

The trend for an increasing demand for food and feeder from the Netherlands has two main causes: an increase in domestic demand for local food and feeder (Fresh Plaza, 2014) and an increase in foreign demand for food and feeder from the Netherlands (Government of the Netherlands, 2017).
The local and sustainable production of these food (supplements), such as cereals, starch and animal feeds, fits within the trend in the Netherlands that we want more locally produced and biological goods, explaining the first trend.

The reason for the increased foreign demand lies in the fact that the Dutch food (supplements) and feeder are known for the very high quality. Due to various scandals at foreign agro-bulk terminals, this is a reason for many countries to choose to import the Dutch agro-bulk products. In addition, the increasing food shortage in the world results in an increase of the demand for reliable food from the Netherlands. The increasing demand for Dutch food (supplements) is therefore likely to result in a higher agro-bulk production, which is mainly transported by dry bulk or liquid bulk inland vessels. The throughput volumes of these two commodities is therefore likely to increase, which is beneficial for the ports with these port activities in their inland port area.

Trend 9: Climate change and the related change in hydraulic conditions

The increased volume of greenhouse gasses resulted in a strengthened greenhouse effect, which also resulted in global warming. Global warming is a worldwide problem and changes the overall climate system on the planet. The first signs of global warming have already be identified in the Netherlands (KNMI, 2015). The weather patterns have been changing, resulting in more extreme weather situations. More periods with extreme rainfall and extreme drought are identified and this is likely to occur even more frequently in the future. In addition, the increasing temperature results in a decrease in ice surface and expanding of water volumes. This results in a rising sea water level (NASA, 2018; KNMI, 2015), which also influences the water levels at the inland waterways. It can already be seen that the frequency of these extreme conditions increases (see Figure 16), while in the future it is expected that these extreme water levels will appear even more frequently. This has consequences as it could result in reduced transport capacity on the inland waterways, because of the limited air draft (during high waters) or because of the limited draught (during low waters). In extreme cases, this may also result in a shipping ban, in which no inland waterway transport activities are allowed. Therefore the total amount of transport on the inland waterways and the transfer capacity in the inland ports may be reduced.

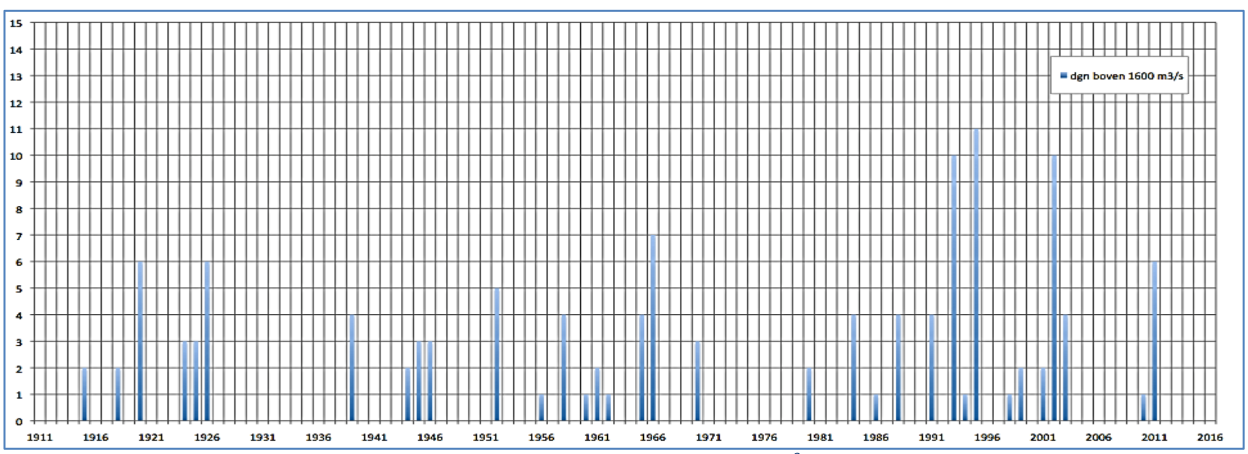


Figure 16: Number of days of an extreme discharge in the Meuse (above 1600 m^3/s) (1911-2016) (Waterpeil.nl, 2016)

The increasing frequency of the extreme hydraulic conditions may affect the inland ports, which are not projected by a lock or a flood protection. These ports will therefore suffer the same hydraulic conditions as on the inland waterway, which could lead to a decreasing operational time of the inland port. The inland port may therefore become less attractive for the inland port activities.

Trend 10: Development of big data sharing

As already described, data sharing could take place in three different ways: between inland vessels, between inland vessel and inland ports and between the inland vessels and constructions. In the end, it is expected that data sharing will increase the safety of the inland port, optimise the nautical traffic (see Figure 17) and reduce the turn-around times of the inland vessels.

When inland vessels are equipped with sensors, it is possible to present the other inland vessels real-time information about various data (e.g. position, water depth (SMASH!, 2018)). The second category of data sharing includes the data sharing between inland vessels and the inland ports. The inland vessels can then give information about the inland vessel to the inland port (e.g. amount of cargo, location or vessel dimensions), while the inland port could give information about the inland port (e.g. availability of quay/jetty or hydraulic conditions) (Port of Rotterdam, 2016; Van Hengstum, 2018). Finally, information can be exchanged between inland vessels and constructions, which could include information about, for example, the passage of a ship lock or bridge (e.g. Blauwe Golf Verbindend (2018)). In this way, the inland waterway transport can potentially be optimised with relation to waiting times.

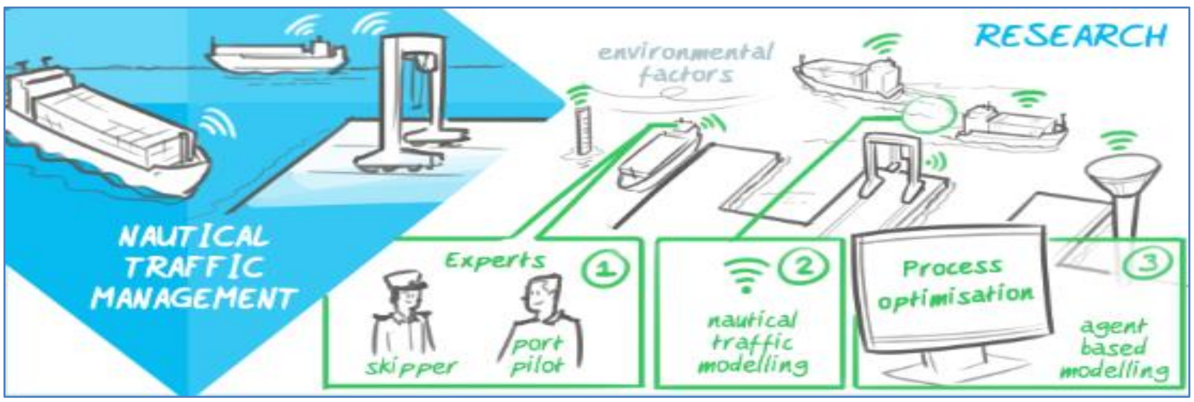


Figure 17: Concept of big data sharing (Smart Port, 2018)

Trend 11: Development of synchro-modality

It is expected that all cargo will be labelled with all kinds of data about the transport (e.g. destination, volumes, dimensions) in the future. In this way, the synchro-modality can be introduced in the transport chain. The synchro-modality represents the optimally flexible and sustainable allocation of cargo to different modes and routes in a network under the direction of a logistics service provider, so that the customer (e.g. shipper) is offered an integrated solution for its (inland) transport (Platform Synchromodaliteit, 2018). This means that the transport modes and routes are not decided beforehand, but that this transport mode and route will be selected on the most optimised solution (see Figure 18). For the synchro-modality it is needed to use extensive data exchange between port authorities, inland vessels and transport companies. It is preferred to include multiple transport modes in the inland port area. The transfer of cargo between the various transport modes can then be executed easily without losing a lot of time, especially when containers are used as they can be used for transport by rail, road and IWT (Port of Rotterdam, 2016). In addition, the transport companies get better insight in the transport chain and this knowledge can then be used to further optimise the flexible transport chain, where return flows and recycling becomes also more important (Port of Rotterdam, 2016).

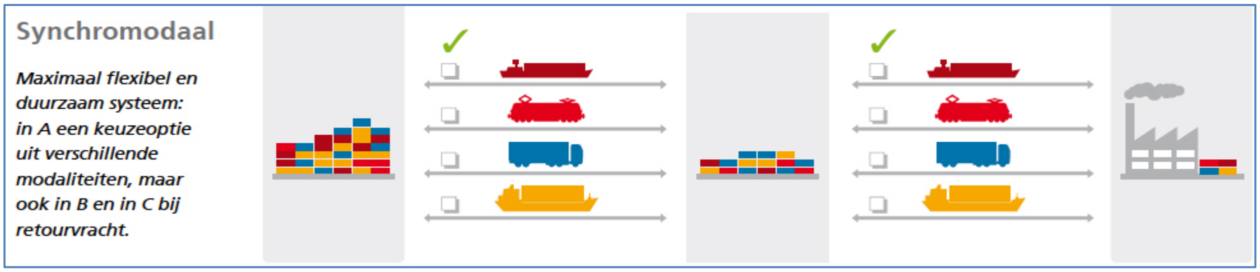


Figure 18: Concept of synchro-modality (Platform Synchromodaliteit, 2018)

Trend 12: Development of autonomous shipping

Another trend, related to the increasing connectivity, is the development of autonomous shipping. Autonomous shipping is the transport of cargo by inland vessels without any sailors on the vessel itself. For this type of inland shipping it is required to use sensors on the inland vessels and/or to optimise the data exchange between the inland vessels and other objects in order to know which actions the vessels should take to transport the cargo effectively and safely.

In the first phase, there will be still someone at the inland vessels to control if everything goes as supposed. In a later stage, the inland vessels will be controlled from a remote location. In case of major dangers, there is still room for intervention in the inland navigation vessel in this way. Eventually, it could lead to a situation with fully autonomous shipping, in which the inland vessels ship all by themselves. Due to the extended data exchange, the inland vessels could potentially ship without any sailors and will be safe enough to avoid accidents with other inland vessels and constructions. This could potentially result in a more efficient, safe and environmental friendly inland waterway transport (SMASH!, 2018; Van Dam, 2018).

Trend 13: Introduction of smart infrastructure and equipment

The thirteenth identified trend is the introduction of smart infrastructure and equipment. This means that the infrastructure and equipment can store all sorts of data with the help of sensors and can exchange this with the designated objects.

By including sensors into the infrastructure itself, many information about the state of the inland port can be obtained. By including the sensors in the quay infrastructure (Figure 19), it is possible to detect whether inland vessels are moored. When this is the case, information can be provided to other inland vessels that the specific quay/jetty is not available for port-related activities. The arriving inland vessels can then lower down its speed in order to safe fuels. In addition, innovative port infrastructure can also be used for the detection of infrastructure failure. By detecting potential failures in time, the constructions can be mostly repaired or reconstructed before failure. The downtime and the total costs of the inland port can then be reduced and the port performance will be increased (Smart Port, 2018).

In accordance with the port infrastructure, the port equipment could also be included in the Internet of Things. The quay equipment and storage equipment can be connected to the Internet of Things for the exchange of data about the freight between the inland vessel, quay equipment and storage equipment. In this way the employee, who controls the quay crane, knows which freight has to be (un)loaded from the inland vessels and the storage equipment will be ready in time to store the unloaded freight. It is expected that this process will ultimately be executed by autonomous processes with minimal human interference, resulting in an even higher efficiency and safety (Port of Rotterdam, 2016).

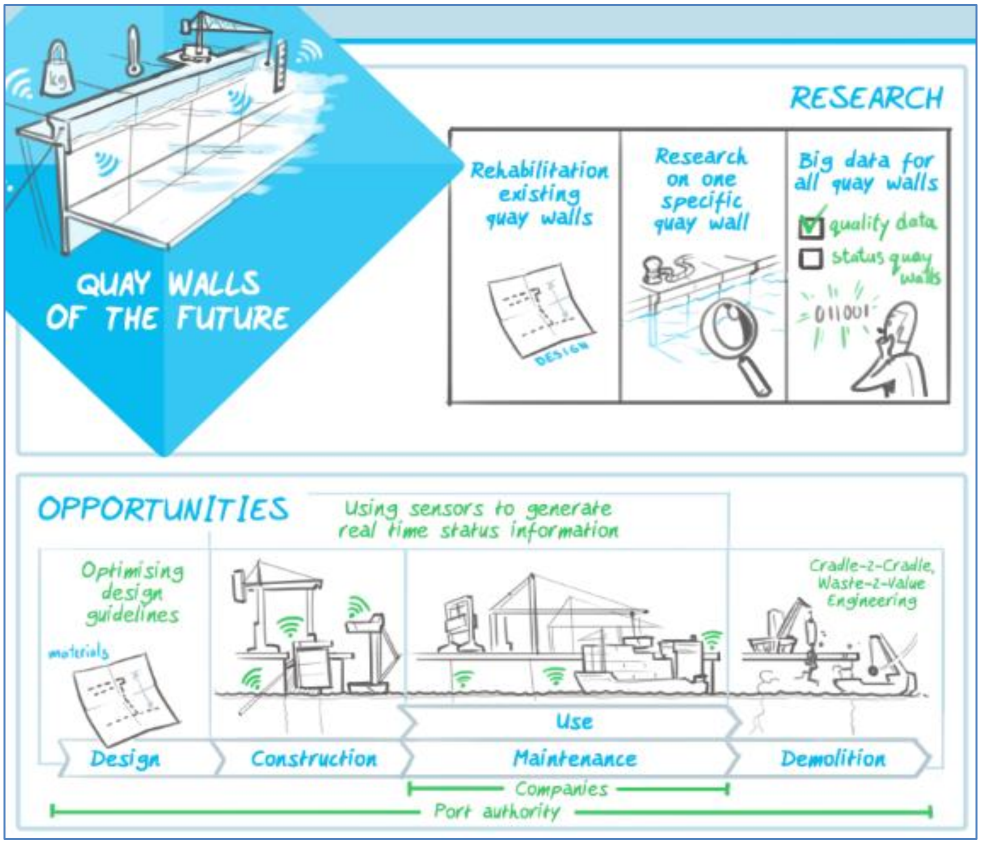


Figure 19: Concept of smart quay walls (Smart Port, 2018)

Trend 14: Introduction of 3D-printing

The last identified trend is the introduction of 3D-printing in the society. 3D-printing is the process to produce a good locally with help from a special printing device, which can build up the product layer by layer. This process could potentially shake up the total transport chain in the future, but the influence in the current condition is still minimal, because in many cases it is still a very costly and complicated process. Currently, it is mainly used for spare part replacement and in some cases already for ultra-postponement of production. The materials are also limited to plastics and pastes at the moment. However, the 3D-printing technology advances very fast, making it possible to use a growing number of materials. When the 3D-printing is fully developed, it is expected that the 3D-printing technology will result in avoiding transports, because (most of) the goods can then be produced locally by recycled materials. However, this last step is expected after 2050, which is not in the scope of this research. Before 2050 only small changes are expected in the transport flows (e.g. reduced material use and storage and an increase in bulk for 3D-ink.

Overview of identified plausible trends

With help from the previously mentioned general long-term developments, it was possible to identify the most relevant trends for the inland ports. The trends are only considered relevant when it is expected to change the (hydraulic) conditions of the inland port or when the societal demand for the inland port activities is expected to change in the time period until 2050.

The identified trends, which are considered to influence the inland port activities (in the future), have been presented in Table 6. These selected trends present the direction of the future conditions, but not the eventual result. Therefore these trends can be used for the determination of trend-based narratives, which method is selected from the third layer of the Futures Pyramid (Van Dorsser, Walker, Taneja, & Marchau, 2018, p. 11). First, the generic impact of these trends on the port activities are determined, which gives a first impression of the generic threats and opportunities on the port activities.

Nr.	Identified long-term future trends
1	Relocation of low-value industrial processes
2	Specialisation of the remaining industries
3	Replacement of small inland vessels for larger inland vessels
4	Gradual stagnation in the growth of product demand
5	Energy transition to reduce emissions
6	Transition to sustainable and recycled resources
7	Increasing number of construction activities
8	Increasing demand for food and feeder from NL
9	Climate change and the related change in hydraulic conditions
10	Development of big data sharing
11	Development of synchro-modality
12	Development of autonomous shipping
13	Development of smart port infrastructure and port equipment
14	Introduction of 3D-printing

Table 6: Identified relevant trends for inland ports

5.4 Generic reflection of threats and opportunities per port activity

The identified trends from the previous paragraph already give some information about the long-term developments with a relevance to the inland port activities, but they do not directly present the threats and opportunities for these inland port activities. It is therefore required to identify per inland port activity a generic overview of the potential threats or opportunities, based on the trends and the possible deviations. This generic impact does not present the actual impact on specific inland ports, because it is also dependent on the strengths and weaknesses of the inland port.

Container transfer and storage

The following trends are projected to have an impact on the container port activities in inland ports:

- Trend 1: Relocation of low-value industrial processes
- Trend 2: Specialisation of the remaining industries
- Trend 3: Replacement of small inland vessels for larger inland vessels
- Trend 4: Gradual stagnation in the growth of product demand
- Trend 9: Climate change and the related change in hydraulic conditions
- Trend 14: Introduction of 3D-printing

The main trend for the container transfer and storage activities projects an increase in demand until 2030, after which the growth is likely to stagnate, similar to the trend concerning the stagnation in product demand. It is therefore projected that the demand for container activities will increase until 2050, while the growth could possibly stagnate after 2030. Overall, this may create an opportunity for the container activities in the inland port.

The other trends could slightly influence this main trend. The relocation and specialisation of the port industries is likely to result in an increase of (intermediate) cargo transport and therefore result in an increase of container volumes. Furthermore, the replacement of smaller container vessels for larger container vessels may increase the container transport throughput on the inland waterway transport, because the transport costs per container may decrease. On the other hand, the climate change is projected to decrease the operational time of the inland port due to the more frequent extreme hydraulic conditions. Finally, the introduction of 3D-printing may reduce the transport volumes of products, because the 3D-printers are expected to produce locally.

Dry bulk transfer and storage

The following trends are expected to have an impact on the port activities with dry bulk:

- Trend 1: Relocation of low-value industrial processes
- Trend 2: Specialisation of the remaining industries
- Trend 4: Gradual stagnation in the growth of product demand
- Trend 6: Transition to sustainable and recycled resources
- Trend 7: Increasing number of construction activities
- Trend 8: Increasing demand for food and feeder from the Netherlands
- Trend 9: Climate change and the related changes in hydraulic conditions
- Trend 14: Introduction of 3D-printing

The main trend for the dry bulk transfer and storage activities differs for the different type of commodities. For the transfer and storage of coals and other non-sustainable resources, the demand is projected to decrease significantly. This decrease in transfer and storage volumes may be even that large that the inland port activity leaves from the port area. The port activity with these type of commodities is therefore considered to be threatened significantly. For the sand and gravel terminals, a different main trend has been identified. The demand for these port activities is expected to increase due to the projected increase in construction materials due to the shortage in housing and other constructions. Furthermore, the transfer of agro-bulk products may also likely to increase due to the increased demand for agro-bulk products. In general, the sand/gravel and agro-bulk transfer and storage activities are therefore projected to create opportunities for inland ports.

The other trends are expected to (slightly) influence the main trends for the various dry bulk commodities, resulting in plausible deviations from the projected main trend. The relocation and specialisation of the port industries may result in a decrease of dry bulk volumes, because more products will be already produced in developing countries. Furthermore, the reduced product demand may reduce the supply volumes for the remaining port industries. The climate change may also reduce the inland waterway transport due to the reduced operational time of the inland port due to the more frequent hydraulic conditions. On the other hand, the 3D-printing could result in a new type of dry bulk transport: '3D-ink'. This may slightly increase the demand for dry bulk transfer and storage activities.

Liquid bulk transfer and storage

The following six long-term trends are expected to have an impact on liquid bulk activities:

- Trend 1: Relocation of low-value industrial processes
- Trend 4: Gradual stagnation in the growth of product demand
- Trend 5: Energy transition to reduce emissions
- Trend 6: Transition to sustainable and recycled resources
- Trend 8: Increasing demand for food and feeder from the Netherlands
- Trend 9: Climate change and the related change in hydraulic conditions

The main trend for the liquid bulk transfer and storage activities differs between various forms of liquid bulk. For the oil products, the energy transition and the transition to sustainable resources are the two most important trends. It is therefore expected that the demand for these conventional liquid bulk products will drop significantly in the future, possibly resulting in the departure from the inland ports. Some sustainable liquid bulk products may possibly replace these oil products. For the chemical terminals, the relocation of low-value industrial processes is the most important long-term development. The basic chemical processes are expected to be relocated to the developing countries, therefore only remaining the high-quality chemical processes in the future inland port. In general, the liquid bulk transfer and storage activities are likely to be threatened in the inland port.

The gradual stagnation in product demand may reduce in a reduced demand for liquid bulk supply materials for the industrial processes. The climate change is also expected to reduce the inland waterway transport due to the reduced operational time of the inland port, because of the more frequent hydraulic conditions. On the other hand, the increasing demand for agro-bulk products could result in an increase of liquid bulk transfer and storage activities (e.g. vegetable oils). These last trends are expected to (slightly) affect the main trend for the two main liquid bulk commodities, resulting in plausible deviations from the projected main trend.

Transfer and storage of the remaining types of cargo

The following five long-term trends are expected to have an impact on activities related to the remaining commodities:

- Trend 1: Relocation of low-value industrial processes
- Trend 2: Specialisation of the remaining industries
- Trend 4: Gradual stagnation in the growth of product demand
- Trend 6: Transition to sustainable and recycled resources
- Trend 9: Climate change and the related change in hydraulic conditions

The terminals, which transfer and store the remaining types of cargo, are very diverse (e.g. break-bulk, neo-bulk, special products). It is therefore not possible to give an impression of the generic opportunities or threats of these types of terminals, because this depends on the specific product.

Agro-bulk production

The following trends are expected to have an impact on the agro-bulk production activities:

- Trend 2: Specialisation of the remaining industries
- Trend 4: Gradual stagnation in the growth of product demand
- Trend 8: Increasing demand for food and feeder from the Netherlands

The main trend for the agro-bulk production is the increasing demand for food and feeder from the Netherlands. This domestic and international increased demand for agricultural products is also likely to result in an increase of the agro-bulk volumes in the inland port, because the majority of the current agro-bulk is transported by inland waterway transport. These agro-bulk processing facilities are therefore frequently located at terminals along the port basin. From this location, the agro-bulk can be transferred to an inland vessel and eventually to the consumer. This activity may therefore create opportunities.

The other trends are expected to (slightly) influence the main trends for the various agro-bulk production activities, resulting in plausible deviations from the projected future demand. The specialisation of the remaining industries is likely to result in more high-quality agricultural cargo production in the inland ports, therefore potentially increasing the agro-bulk transport volumes. On the other hand, the domestic demand for agro-bulk products may stagnate after 2030, because of the stagnation of product demand due to the projected population decline. The demand for this port activity may slightly reduce for this reason.

Construction materials production

The next three trends are projected to have an impact on the production activities for construction materials:

- Trend 6: Transition to sustainable and recycled resources
- Trend 7: Increasing number of construction activities
- Trend 14: Introduction of 3D-printing

In general, the construction materials production is projected to create an opportunity for the inland port, because it is expected that the demand for concrete and other construction materials will increase in the future due to the projected increase in construction activities. The fact that these supply materials can be transported in big quantities by inland vessels makes it also likely that the terminals with producers of construction materials will remain in the inland port area.

Two minor trends for the future activities of construction materials have been identified. These trends may create small opportunities and threats for the specific port activity. The transition from non-sustainable raw materials into sustainable and recycled materials may increase the demand for the inland port activity, because the production of concrete already requires sustainable raw materials (although the production process itself is not very sustainable, but that improves as well). It is therefore likely that these construction materials will still be used for future constructions. The introduction of 3D-printing is likely to decrease the demand for construction materials and the related production activities for these materials. The 3D-printed materials may replace the current construction materials, therefore avoiding any transportation. This may create a threat for this specific port activity.

Energy production

The following trends are expected to influence the generic demand for energy production activities:

- Trend 5: Energy transition to reduce emissions
- Trend 6: Transition to sustainable and recycled resources

Both trends can be considered as main trends for the energy production activities. Both the transition from conventional energy production towards sustainable and clean energy and the transition to sustainable and recycled raw materials are changing the demand for the current energy production in the inland port. In general, it is expected that the conventional energy producers will leave the inland port (creating a threat). This threat may be (partly) countered by the introduction of renewable energy producers in the inland port area (and therefore creating opportunities).

Recycling processes

Two trends are projected to have an impact on the production activities for construction materials:

- Trend 4: Gradual stagnation in the growth of product demand
- Trend 6: Transition to sustainable and recycled resources

The main trend for the increasing demand for recycling processes is based on the continued demand for raw materials. The fact that the non-sustainable raw materials may be depleted in the future, has resulted in an increased awareness in the society about the requirement to recycle materials. This movement has ensured that a transition has started to use more recycled materials. In addition, the number of materials that can be recycled is also growing. It is therefore expected that the recycling activities provides opportunities for the inland port, because the scrap can be easily transported by inland vessels towards the recycling terminals in inland ports.

The gradual stagnation in product demand could reduce the need to use recycled materials, because the overall demand may decrease. It is therefore considered that this trend may reduce the created opportunities for recycled activities.

Remaining industrial production activities

The next five trends are expected to affect the other industrial production activities in the inland port:

- Trend 1: Relocation of low-value industrial processes
- Trend 2: Specialisation of the remaining industries
- Trend 4: Gradual stagnation in the growth of product demand Trend 6: Transition to sustainable and recycled resources
- Trend 14: Introduction of 3D-printing

The terminals with the production of other industrial processes are very diverse. Chemistry, processing steel products, production of paper and the production of plastics are some examples, which can be categorised as this port activity. The diversity in port activities makes it not possible to create a generic overview (containing generic opportunities and threats) for this port activity according to the identified trends. The generic impact can therefore only be determined when you know the production process in the inland port.

5.5 Generic impacts of the long-term trends on the port activities

This paragraph is used to present an overview of the generic impacts of the various long-term trends on the main port activities, as described in the previous paragraph. This generic impact presents whether the port activity is expected to be impacted positively or negatively by a trend. This generic impact can be used as a guideline in order to determine the trend-based narratives for the port activities in the specific inland ports, where the port strengths, weaknesses and other characteristics are also included.

Table 7 presents the main results from the previous paragraph. The plusses and minuses present the generic opportunities and threats. The green boxes with the plusses are expected to present a positive impact on the inland port activity, meaning that it is expected that the demand for these inland port activities increases. The red boxes with the minus represent the negative impact of the trend on the demand for the port activities. The yellow boxes with the question mark presents the situation, for which no generic impact can be determined, because it depends heavily on the specific type of goods for transfer, storage or production. The empty boxes present the situation in which the trend is not projected to affect the demand for the port activity. Finally, the boxes with a thick outline represent the expected dominant trend(s) for the port activity.

Port activity		Generic impact	Type of commodity or industrial process	Trend 1: Relocation of low-value industrial processes	2: Specialisation of remaining industries	3: Replacement of small vessels for larger vessels	4: Gradual stagnation in growth of product demand	5: Energy transition to reduce emissions	6: Transition to sustainable and recycled resources	7: Increasing demand for construction activities	8: Increasing demand for food and feeder from NL	9: Climate change & related change in hydraulic cond.	10: Development of big data sharing	11: Development of synchro-modality	12: Development of autonomous shipping	13: Development of smart port infrastructure & equipment	14: Introduction of 3D-printing
	1	Container transfer	Container	+	+	+	+					-					-
	2	Dry bulk transfer	Agro-bulk	-	-		-				+	-					
			Coals	-	-		-	-	-			-					
			Sand/gravel	-	-		-			+		-					
	3	Liquid bulk transfer	Oil products				-	-	-			-					-
	4	Transfer of remaining goods	*Various cargo*	?	?		?		?			?					
	5	Container storage	Container				+					-					
	6	Dry bulk storage	Agro-bulk	-	-		-				+	-					
			Coals	-	-		-	-	-			-					
			Sand/gravel	-	-		-			+		-					
	7	Liquid bulk storage	Oil products				-	-	-			-					-
	8	Storage of remaining goods	*Various cargo*	?	?		?		?			?					
	9	Agro-bulk production	Agro-bulk		+		-				+						
	10	Construction material prod.	Concrete / Asphalt						+	+							-
	11	Energy production	Conventional					-	-								
			Renewable					+	+								
	12	Recycling activities	Recycling				-		+								
	13	Remaining ind. production	*Various activities*	?	?		?		?								?

Table 7: Expected generic impacts of the trends on the port activities

In Table 7, it can be seen that not all identified trends are taken into account. The impacts of the introduction of the various technologies in the transport sector (trend 10 to 14) cannot be projected beforehand, because this is also dependent on other aspects of the inland port, such as port authority strategy. For these trends another framework has to be set up, but this is outside the scope of this research. For the remainder of this research, only trends 1 to 9 are therefore taken into account.

5.6 Conclusion

The fifth chapter was aimed at the determination of the relevant long-term trends and the generic impacts of the identified trends on the various inland port activities.

In the first part of this chapter, the main drivers of current and future trends had to be identified. A three-layered meta-framework was used for this identification, which was developed by Van Dorsser, Taneja & Vellinga (2018). This meta-framework describes the interaction between century-long trends, Kondratieff-waves and the megatrends. With help from this framework it was concluded that the current developments are mainly related to the globalisation, while the future developments are mainly driven by the increased awareness about the sustainability. In addition, the developments from the century-long trends about the increasing connectivity are also relevant for the future of the inland ports. With help from these 'main drivers', the most relevant trends for inland ports have been identified (see Table 8).

Nr.	Identified long-term future trends
1	Relocation of low-value industrial processes
2	Specialisation of the remaining industries
3	Replacement of small inland vessels for larger inland vessels
4	Gradual stagnation in the growth of product demand
5	Energy transition to reduce emissions
6	Transition to sustainable and recycled resources
7	Increasing number of construction activities
8	Increasing demand for food and feeder from NL
9	Climate change and the related change in hydraulic conditions
10	Development of big data sharing
11	Development of synchro-modality
12	Development of autonomous shipping
13	Development of smart port infrastructure and port equipment
14	Introduction of 3D-printing

Table 8: Identified relevant trends for inland ports

These identified trends were then used to determine the generic opportunities and threats of these trends on the various inland port activities. In this step, the dominant trend(s) have been identified for the various port activities and it was assessed whether these generic projected impacts would be positive or negative, resulting in opportunities or threats respectively. An overview of these generic impacts of the trends on the port activities have been presented in Table 7. It was also concluded that the impacts of the introduction of various technologies in the transport sector (trend 10 to 14) cannot be projected, because these trends are also dependent on other aspects of the inland port, such as port authority strategy. For the remainder of this research, it was therefore decided that only trend 1 to 9 would be taken into account.

For the assessment of the future-proofness of an inland port, these generic impacts can then be used as input for the determination of trend-based narratives, which have to be set-up for all port activities in the inland port. This does not mean that the trend-based storylines will be equal to these generic impacts, because the trend-based narratives are also based on the port characteristics of inland ports.

6. Future-proofness assessment for three case studies

6.1 Introduction

The sixth chapter focuses on the actual assessment of the future-proofness of three existing inland ports (the case studies), answering the fourth sub question of this research: "What is the future-proofness of the three case study inland ports?". In this chapter, the selected method is used to determine the future-proofness of three existing inland ports. When the future-proofness of these existing inland ports is determined, a general pattern may be identified by comparing the results of these case study ports.

In paragraph 6.2, three inland ports are selected from the long list of Dutch inland ports. Paragraph 6.3 until 6.5 shows the assessment of the future-proofness of these three case studies, in which the proposed method from chapter 4 is followed. This means that the strengths and weaknesses of the specific inland port have to be defined in the first part. This is followed by the determination of the opportunities and threats by translating the general impacts (results of chapter 5) into port specific impacts. The third part of the approach contains the determination of the port specific flexibility, in which the adaptability of the inland port is identified. The fourth and final part defines whether the inland ports can be considered as future-proof. The comparison of the results of the three case studies is presented in paragraph 6.6, in which it is proposed to identify a general guideline to determine whether inland ports can be considered as future-proof. Paragraph 6.7 serves as an overview of the content and closes this chapter.

6.2 Selection of case studies

For this research it is proposed to select three existing inland ports as case studies in order to find out whether this method works properly for assessing the future-proofness. It is therefore required to select three inland ports with a different composition of port activities and characteristics. In this paragraph, the selection process is described.

According to the scope of this research, the first limitation is based on the fact that it should be an inland port with transfer activities for cargo. This requirement already significantly reduces the total number of potential inland ports for this research, but there are still around 400 inland ports left.
Out of these remaining 400 inland ports, around 300 inland ports can be described as a 'small inland sand and gravel port' (Binnenhavenmonitor 2015, 2016). This means that these small inland ports only serve as a transfer area for very small volumes of sand and gravel. These very small transport volumes and very low demand for port activities results in the decision to not take these inland ports in account.

As the group of potential inland ports is still large, it was chosen to select the three case study ports by limiting the list of remaining inland ports by two criteria:

1. the amount of available information about the inland port
2. the requirement that the composition of port activities differs between the selected inland ports.

The first selection criterion is based on the fact that the port characteristics of the specific inland ports have to be determined. Whenever some (qualitative or quantitative) information is available, it can be

used as supportive information for the determination of strengths and weaknesses of the inland ports. Furthermore, this information can be used for the determination of the port specific trend-based narratives.
The latter criterion deals with the validation of the method to assess the inland ports future-proofness. When the selected inland ports are having (almost) the same composition of port activities, it is likely that no differences will be seen in the results of this research. By selecting different kind of ports as the case studies, more differences can be identified within the results and therefore it is possible to identify some patterns.

These two criteria led to the selection of the following inland ports for the case study:

1. Bergen op Zoom
2. Oosterhout
3. Wageningen

The location of these inland ports is presented in Figure 20. In addition, an overview of these three inland port areas in relation to the port activities has been presented in appendix A.

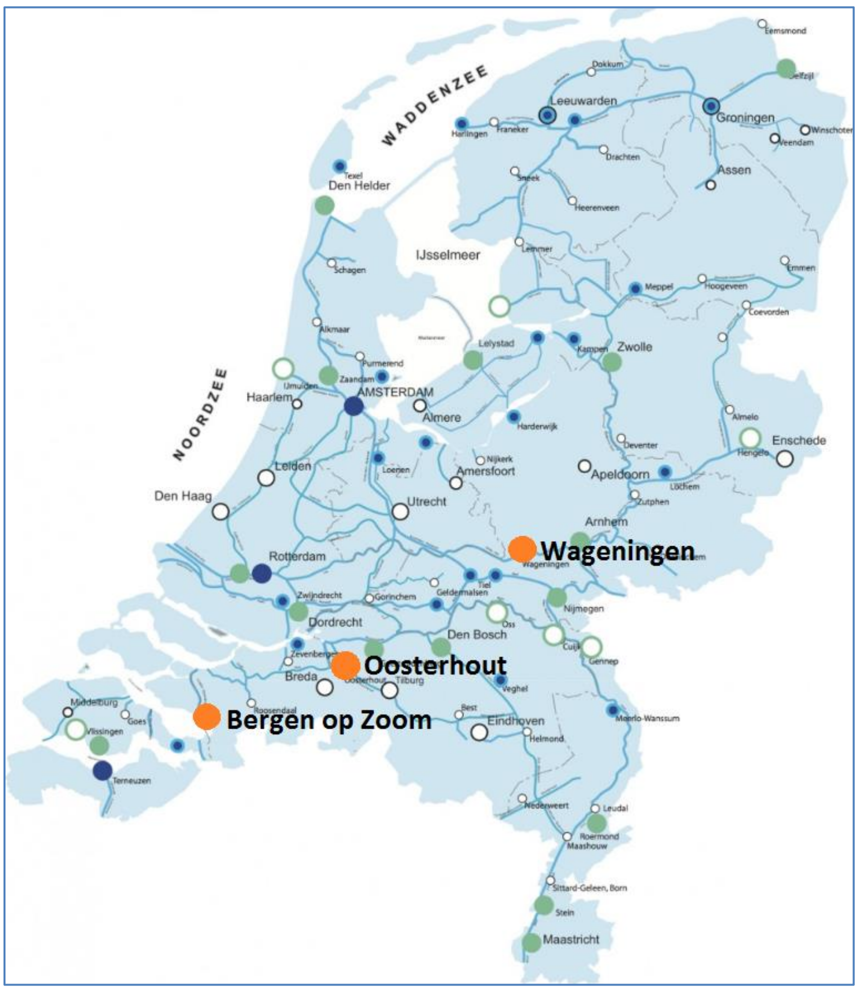


Figure 20: Location of the case study inland ports in the Netherlands (Bureau Voorlichting Binnenvaart (BVB), 2017)

6.3 Recap of the method for the assessment of the case study ports

This paragraph serves as a recap of the method, which will be used for the determination of the future-proofness of the three case study ports.

Part 1: Determination of the current inland ports strengths and weaknesses

The first part of the method is the qualitative determination of the port characteristics of the inland port. The information, obtained by Google Maps, port visits, meetings with the port master or literature is determines the performance of the inland port in relation to the port indicators: accessibility, capacities, dependencies, dimensions, hinterland size, operational times and potential area for future activities. In this way, the port's strengths and weaknesses can be identified for every inland port.

Part 2: Determination of the port specific opportunities and threats

The second part of the method is focused on the determination of the projected opportunities and threats for the inland ports. These different opportunities and threats are identified by determining the port specific trend-based narratives for the various port activities, resulting in port activities with opportunities and threats. Furthermore, the impact of these trend-based narratives over the total inland port are determined, because some port activities are more dominant in the inland port than other port activities. For these three case studies, this overall impact is determined by looking at the share of threatened port activities in relation to the total port area, the total quay length and the total bulk throughput. The higher the shares for threatened port activities in relation to the total inland port, the more likely that the port activities will leave the inland port. This makes the inland port less useful and successful (and thus less future-proof).

Part 3: Determination of the future-proofness of the inland ports

The third part of the method is used to determine the flexibility of the inland port. The flexibility of the inland port represents the degree in which the inland port can adapt to the future demand for port activities. This flexibility cannot be measured directly, but two different aspects are taken into account: the potential to adapt current threatened port terminals to the requirements of new activities and the potential to attract port activities to new port areas. The first aspect presents the possibility to adapt a threatened port terminal into a new port terminal with a reliable port activity. When the current port infrastructure of threatened port activities can be used for other port activities, the negative impacts may be compensated. The latter aspect presents the degree in which the inland port can convert its opportunities into new port activities in order to increase its successfulness. The higher the free area in the port area, the higher this flexibility of the inland port.

Part 4: Assessment of the future-proofness of the inland ports

The information from the first three parts of the method are combined in the assessment of the future-proofness. A SWOT-analysis is set up to clearly present these results. Furthermore, the usefulness, successfulness and flexibility of the inland port has to be defined. Three questions have been set up to determine whether the inland port can be assigned as future-proof. The combinations of answers on these three questions determine the degree of future-proofness of the inland port, for which Table 4 can be used. This table presents a general guideline for the determination of the future-proofness of the inland ports according to the combination of answers on the three questions. Ultimately, the future-proofness of the three case study ports can be compared to identify general patterns.

6.4 Future-proofness assessment of case study port 1 (Bergen op Zoom)

The assessment of the future-proofness of the inland port of Bergen op Zoom will be performed in this paragraph. This assessment follows the method, which is described in chapter 4 and in the previous paragraph. The first three parts of the described method are therefore performed separately. At the end of this paragraph, these results are combined in order to assess the future-proofness of the inland port (part 4 of the method). In this paragraph, only the main results of the assessment will be presented. More detailed descriptions for the port of Bergen op Zoom are presented in appendix B.

Part 1: Determination of the current inland ports strengths and weaknesses

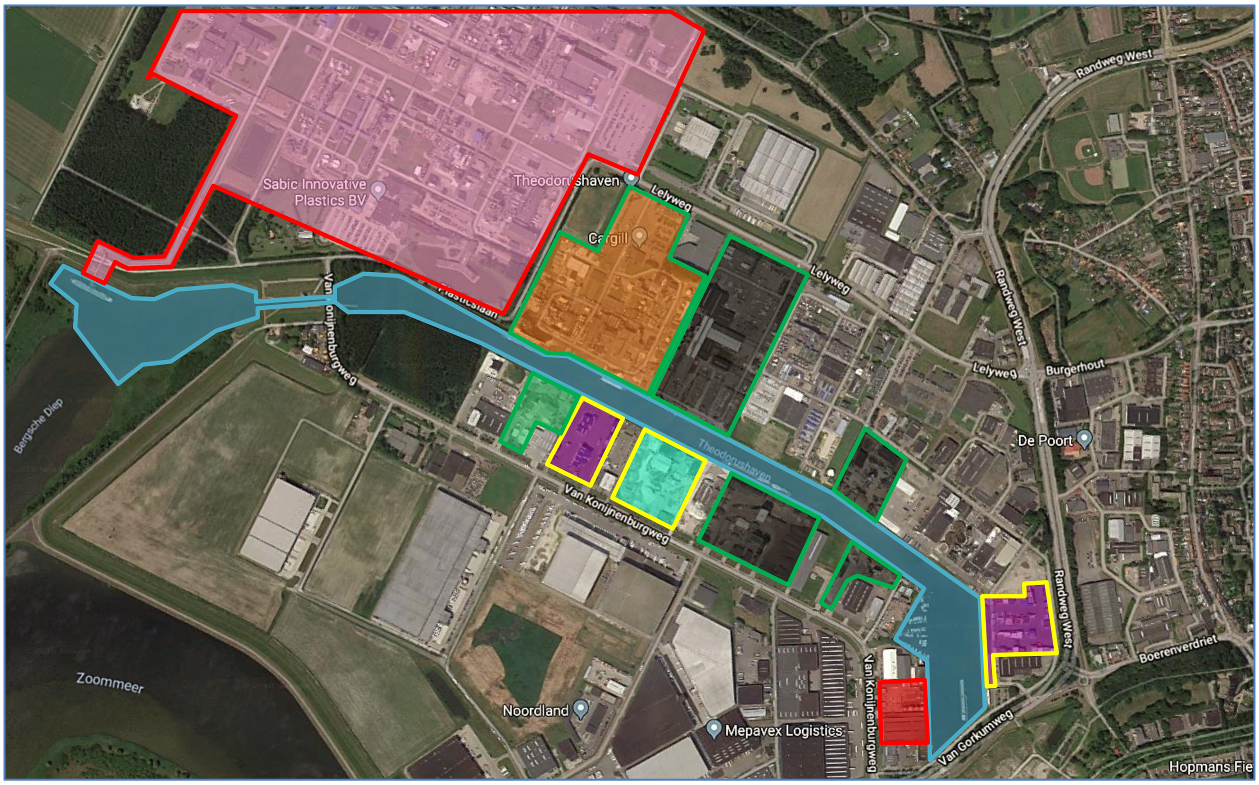


Figure 21: Overview of the port activities in the inland port of Bergen op Zoom (the colours represent different activities)

The inland port of Bergen op Zoom is a large inland port, operated by eleven different companies (see Figure 21 (appendix A explains the meaning of the different colours)). The industrial companies vary in the production of plastics, agro-bulk, recycling and construction materials (both concrete and asphalt). The inland port also contains some container, dry bulk and liquid bulk terminals, which makes the inland port very diverse. However, the throughput volumes of the agro-bulk and liquid bulk for the production of plastics are responsible for 50% and 25% of the total bulk throughput volumes respectively, which make the inland port very vulnerable for changes in demand for these two port activities. These two main port activities are operated by two different companies respectively: Cargill BV and SABIC Plastics BV. When one of these companies would leave the inland port, the inland port throughput will drop substantially, making the inland port very dependent on these companies. The other nine inland port companies have much smaller cargo throughputs and areas in the inland port, making the port less vulnerable for the departure of one of these other companies.

The inland port is accessible for inland vessels up to CEMT-class Va, which is equal to inland vessels with the following maximum dimensions (length x beam x draught): 110 m x 11.40 m x 3.50 m. The port configuration includes one port basin with a lock at the entrance. This lock is closed when the water level at the inland port is considered to be a risk for the water safety or for inland navigation. The inland port can therefore be considered safe for extreme hydraulic conditions on the inland waterway outside the port basin.

The good road accessibility, the large operational time and the large hinterland size are considered to be a strength for the inland port. Finally, there is some area left in the inland port for future port activities, but this mainly requires the relocation of existing companies without port activities. Because of this extensive relocation process of the companies, this inland port cannot easily expand the current activities or facilitate new activities.

Strengths	Weaknesses
CEMT-class Va	Bad rail accessibility
Good road & inland navigation accessibility	Little free area in the inland port
Large hinterland area	Low container transfer capacity
Large operational time	Many companies without port activ. along basin
Large throughput volumes and quay length	Very dependent on two activities & companies
Large number of port activities & companies	

Table 9: Overview of inland port strengths and weaknesses for Bergen op Zoom

Part 2: Determination of the port specific opportunities and threats

The second part of the method is used to determine the port specific impacts of the plausible future situation. In order to determine these impacts, trend-based narratives have been generated in order to identify these plausible future impacts of the various inland port activities in the inland port of Bergen op Zoom. These trend–based narratives for the inland port activity may include an opportunity or a threat (dependent on the type of impact). Finally, it can be assessed which share of the port activities in relation to the total inland port is projected to be under threat in 2050.

Table 10 presents an overview of the generated trend-based narratives for the different port activities, which includes the projected future outcome of the demand of the port activities. The last column presents this projected impact of these trend-based narratives for the inland port activities in Bergen op Zoom. Part 2 of appendix B describes the determination of these trend-based narratives for the port activities and includes the reasoning for the projected impact. These trend-based narratives are determined by combining trends and uncertainties (with relevance to a port activity) with the inland port characteristics and the identified strengths and weaknesses of the inland port. A trend-based narrative with a projected decrease in demand for the port activity will result in a negative impact (a threat), while a trend-based narrative with a projected increase in demand results in a positive impact (an opportunity). The degree of the impacts uses the categorisation, which was already described in paragraph 4.4 (minimal, marginal or major impact).

	Port activity	Trend-based narrative	Projected impact
1	Container transfer and storage	Opportunity to increase the container throughput	Marginal opportunity
2	Dry bulk transfer and storage	Opportunity to increase the sand/gravel throughput (dry bulk)	Marginal opportunity
3	Liquid bulk transfer and storage	Threat of decline in the transfer and storage throughput of oil products (liquid bulk)	Major threat
4	Transfer and storage of remaining cargo types	Opportunity to create a terminal for break-bulk, neo-bulk or special goods	Minimal opportunity
5	Agro-bulk production	Opportunity to increase the agro-bulk throughput and production	Marginal opportunity
6	Construction materials production	Opportunity to create a hub for the construction materials production	Minimal opportunity
7	Energy production	Opportunity to introduce renewable energy production in the inland port	Minimal opportunity
8	Recycling activities	Opportunity to create a recycling hub	Major opportunity
9	Plastics production	Threat of decline in the demand for plastics	Major threat

Table 10: Projected impacts of the trend-based narratives for the various port activities in the inland port of Bergen op Zoom

The inland port of Bergen op Zoom contains a lot of port activities, which are projected to create opportunities. The demand for only two of the present port activities is projected to decrease: the liquid bulk transfer and storage (oil products) and the production of plastics. The main reason for this decrease lays in the transition to produce more sustainable products and to use renewable energy sources (instead of fossil fuels). In addition, the anticipated stagnation in demand for products after 2030 may reduce the demand for these products even further.

On the other hand, seven activities are projected to create opportunities for the inland port of Bergen op Zoom. Six of these port activities are already present in the current inland port: container transfer and storage, sand/gravel transfer and storage (dry bulk), transfer of remaining cargo types, the production of agro-bulk, the production of construction materials and the recycling activities. The recycling activities are projected to have the largest positive impact on the inland port, because it is anticipated that the total volume of recycled materials will increase substantially. In addition, it is also expected that the number of materials to be recycled will increase, so that more types of materials can be recycled in the future. For the other port activities, no changes in cargo types are expected, therefore only resulting in minimal or marginal opportunities (depending on the expected increase in volumes). The energy production is the only port activity, which is not present in the inland port yet. In the future, the renewable energy production activity may be introduced, although no port infrastructure is present for this type of activity.

However, the number of port activities with positive and negative impacts on its own does not give a good representation of the actual projected impacts on the inland port. It is therefore required to take the port characteristics into account to obtain additional insights in these impacts for the inland port of Bergen op Zoom. The projected impacts can be presented in relation to the total inland port, for example by calculating the share of threatened port activities in relation to the total port area, quay length and bulk throughput volumes. Figure 22 presents the share of the impacts of the total inland port area, quay length and bulk throughput respectively. The green colours represent the port activities with opportunities, while the red colours represent the port activities with threats. The darker the red and green parts, the larger the projected impacts of the threats and opportunities respectively.

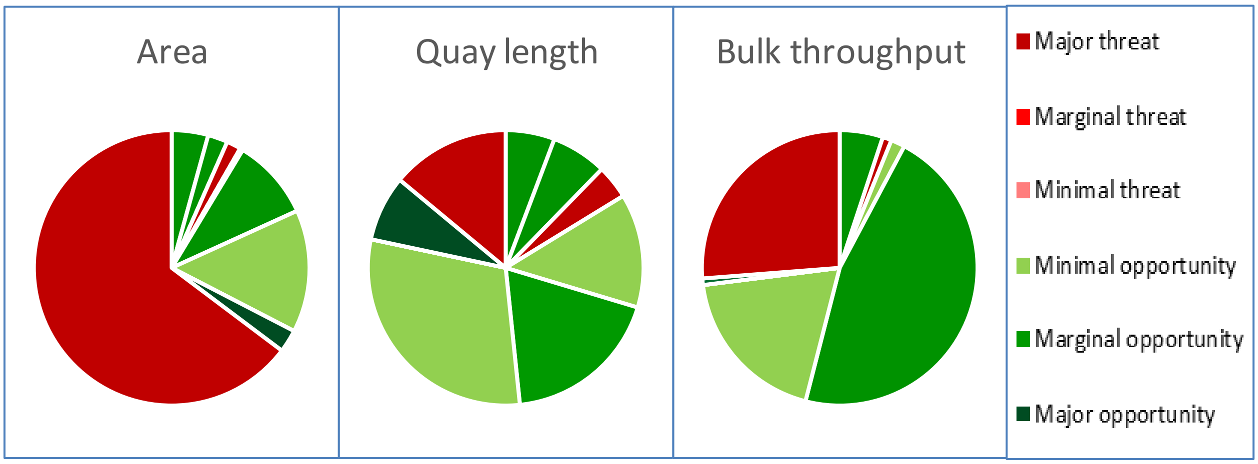


Figure 22: The share of port activities with opportunities (green) or threats (red) in the inland port of Bergen op Zoom with relation to the total port area, total quay length and total throughput volumes in the port

From the identification of the impacts of the trend-based narratives on the port activities, it could be concluded that the inland port of Bergen op Zoom was hardly affected by any threats. Figure 22 shows a different outcome as more than 65% of the total port area along the inland port basin is occupied by port activities, which may be heavily threatened in the period up to 2050. The share of the quay length of these threatened activities is relatively low (20%) compared to the share for the port area, because the large terminal for the production of plastics has only one berth. The share of throughput volumes of the threatened port activities is about 25% of the total bulk throughput, which is also relatively low compares to the share for the total area. In this case, the share is relatively low because of the relatively high throughput volumes of the agro-bulk terminal.

Overall, the share of threatened port activities is high in relation to the total port. The inland port of Bergen op Zoom requires measures to reduce these projected threats in order to become a future-proof inland port. The inland port also requires to retain port activities with positive future prospects in the inland port in order to become future-proof. Finally, it should also attract new port activities into the inland port area, therefore improving the usefulness and successfulness (and thus the future-proofness) of the inland port.

Part 3: Determination of the flexibility of the inland port of Bergen op Zoom

The third part of the method is used to determine the flexibility of the inland port. The flexibility of the inland port represents the degree in which the inland port can adapt to the future demand for port activities. This flexibility cannot be measured directly, but two different aspects will be analysed: the potential reduction of negative impacts by replacing them with new port activities and the potential to increase the capacities of port activities (by converting the opportunities into new port activities at new terminal areas). The higher the potential to reduce its negative impacts and the bigger the possibility to increase the capacity of (new) activities, the more flexible the inland port. In this section, the flexibility of the inland port of Bergen op Zoom is determined (see part 3 in appendix B for a detailed analysis).

Analysis of the current port infrastructure of the threatened port activities for new port activities

The current infrastructure of the projected threatened port activities has to be analysed in order to determine whether this infrastructure can be used for the new port activities. In this way, it can be determined whether the inland port could reduce its threats (and thus remain useful and successful in the future). The two terminals with threatened port activities will be treated separately.

SABIC Innovative Plastics B.V.

This dominant company in the inland port produces high-quality plastics, which is currently being manufactured with non-sustainable raw materials: oil products. This non-sustainable method of production of plastics will possibly disappear, as a result of which this port activity may no longer be successful. The infrastructure of this inland terminal (containing an extensive network of pipeline connections) is specified for production activities with liquid bulk products (both transfer and storage). Fortunately, several port activities (with an anticipated increase in demand) require a similar port infrastructure as the current plastics production company: the production of bio-based plastics, renewable energy production and agro-bulk transfer and storage. However, the agro-bulk terminal also requires silos, cooled storage and warehouses, therefore still requiring large adaptations to the current terminal infrastructure. The renewable energy production is also not likely to be introduced due to the absence of distribution network to the hinterland. It is therefore most likely that the current plastics production will be replaced by a sustainable production process, which only requires small adaptations to the current terminal infrastructure.

Sakko Commercial B.V.

This terminal is currently used to transfer and store oil products, which are then further distributed to the hinterland by trucks. The demand for oil products is projected to decline, therefore likely to result in a less successful port terminal. The infrastructure of this inland terminal is specified for the transfer and storage of liquid bulk cargo (containing pipelines, silos and a jetty for (un)loading liquid bulk vessels). Several port activities could possibly replace this port activity by requiring a matching port infrastructure: liquid agro-bulk transfer and storage, renewable energy production or the transfer and storage of sustainable fuels. However, the small terminal area and the absence of a distribution network seems not suitable for renewable energy production. On the other hand, the agro-bulk and sustainable fuels can be introduced in this facility, because they only require small adaptations on the current terminal infrastructure in order to perform these port activities.

Analysis of the potential to expand the capacities of the port activities

The potential to expand the capacity of the port activities can be measured in two different ways: by increasing the internal terminal capacity and by expanding the terminal area for the specific port activities. Both of these aspects are analysed to determine the flexibility of the port of Bergen op Zoom.

Internal terminal capacity

The inland port of Bergen op Zoom already uses advanced equipment for the transfer, storage and production at most of the terminals, therefore leaving little room for improving the processes in the current terminals. The container transfer activity is the only process which uses general cranes. The capacity of the container terminal can therefore be increased by improving this (un)loading process.

Potential terminal area

An analysis has been carried out on the areas and the quay lengths of potential terminal areas in the inland port (see Figure 23). This showed that 20% of the area along the port basin is not used by companies with port activities. Of this 20%, only 5% appears to be free area, where no activities are currently taking place. The other 15% is used by other companies, which are not tied to a location along the port basin. Due to this small amount of available area along the port basin, it is very difficult for the companies in Bergen op Zoom to expand in the short term. In the long term, the terminals could buy the land of the other companies along the port basin, so that these companies can be located at a new location.

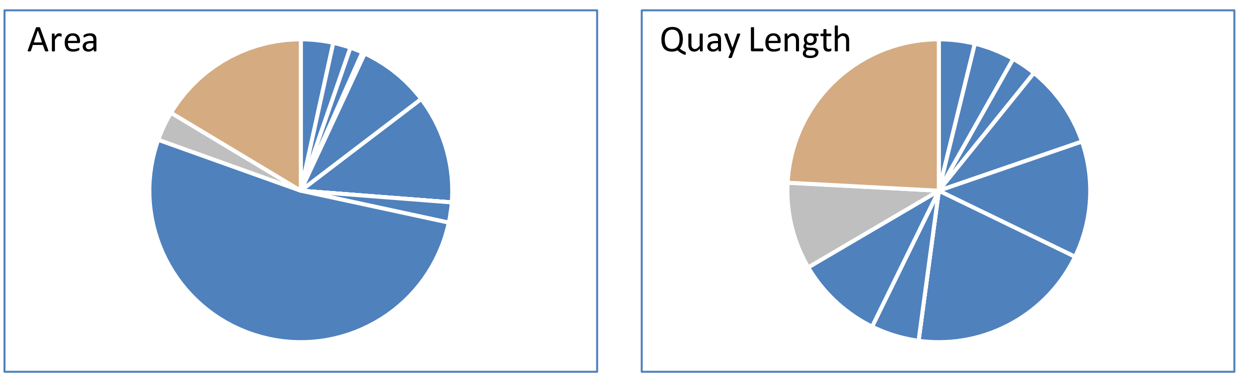


Figure 23: Potential area and quay length in Bergen op Zoom (blue = current use, grey = free area, brown = currently used by non-port activities)

Overall flexibility of the inland port of Bergen op Zoom

The overall flexibility of the inland port of Bergen op Zoom is considered to be sufficient to compensate for the negative impacts (identified in part 2 of the method). In the first place, the threatened port activities are likely to be replaced by other inland port activities, because the current port infrastructure is considered to match with port activities with projected opportunities. The conventional production method of plastics is likely to be transformed into a sustainable production method (bio-based plastics), while the liquid oil terminal is likely to be replaced by a terminal for sustainable oils or liquid agro-bulk. In this way, the inland port remains useful. On the other hand, the other port opportunities cannot be converted into new port activities, because there are hardly any possibilities to increase the port capacity. The main reason is the already high internal capacities in the inland port and the little free area to increase the terminal area. Overall, the flexibility of the inland port of Bergen op Zoom is considered to be sufficient to compensate for the negative impacts.

Part 4: Assessment of the future-proofness of the inland port of Bergen op Zoom

The SWOT-analysis (see Figure 24) presents an overview of the identified strengths, weaknesses, opportunities and threats of the inland port of Bergen op Zoom. This gives a first impression of the future-proofness of the inland port.

Strengths	***Weaknesses***
• CEMT-class Va • Diversity in port activities and companies • Good road & inland navigation accessibility • Large hinterland area • Large operational time • Large throughput volumes and quay length • Many inland port terminals	• Bad connection to rail network • Little free area in the inland port • Low capacities due to use of general equipment • Many companies without port activities along port basin • Very dependent on agro-bulk activity (Cargill BV) and production of plastics (SABIC Plastics BV)
Opportunities Activities concerning: • Container transfer and storage (*marginal*) • Sand and gravel transfer and storage (*marginal*) • Transfer of remaining types of cargo (*minimal*) • Agro-bulk transfer and processing (*marginal*) • Production of concrete and asphalt (*minimal*) • Recycling activities (*major*)	***Threats*** • Max. capacity may be reached due to limited potential area for new port activities • Max. internal terminal capacities may be reached due to use of advanced equipment Activities concerning: • Transfer and storage of oil products (*major*) • Production of plastics (*major*)

Figure 24: SWOT-analysis for inland port of Bergen op Zoom

The inland port can be considered as future-proof when the inland port remains useful and successful for the execution of the port functions, while being flexible enough in port services and infrastructure to deal with potential changes (see the definition in chapter 2). The three main questions (see page 36) have been set up to determine the future-proofness of the inland ports according to this usefulness, successfulness and flexibility. After answering these three questions, the degree of future-proofness of the inland port of Bergen op Zoom can be determined according to the general guideline from Table 4.

<u>(1) Is it projected that the inland port activities in the inland port are hardly threatened?</u>

The inland port of Bergen op Zoom contains numerous inland port activities. The demand for two of these port activities is projected to decrease substantially. These port activities are the liquid bulk transfer and storage activities (for mineral oil products) and the production of plastics. It is anticipated that the use of non-sustainable raw materials (such as oil products) will reduce to a minimum, as a result of which these port activities are no longer useful and successful for the inland port. Unfortunately, the production of plastics is the most dominant port activity, thereby risking that the throughput of the inland port decreases substantially. The risk that these two companies may leave the port area is likely to result in a less useful and successful (and thus less future-proof) inland port.

The first question can therefore not be answered positively, because two port activities are projected to be threatened. One of these port activities is the dominant port activity for the inland port, which makes this inland port vulnerable for a decline in demand for plastics. The risk of becoming less useful and successful is therefore relatively large.

(2) Are there sufficient opportunities to compensate for the anticipated threats?
It is projected that the demand for the majority of the present port activities in the inland port of Bergen op Zoom increases until 2050, therefore likely to increase the usefulness and successfulness of the inland port for these specific inland port activities. It is anticipated that the demand for the container terminals, sand and gravel terminal, agro-bulk terminal and the recycling terminal increases substantially, resulting in marginal and major opportunities. Furthermore, it is expected that the demand for the production of construction materials and the activities for the remaining types of commodities increases (resulting in a minimal opportunity).
The second question can therefore be answered positively. Although there are hardly any opportunities to increase the port activities by the absence of free port areas, there are sufficient port activities with opportunities. These port activities are likely to be sufficient for the inland port to compensate for the anticipated threats.

(3) Does the existing infrastructure match the infrastructure needed for these identified opportunities?
The threatened port activities are the production of plastics and the transfer and storage of liquid bulk products. The first port activity is located at a plastics production terminal. This terminal makes use of pipelines and a pumping system to (un)load the cargo from/to the inland vessels. The terminal equipment can be used (with minimal adaptations) for agro-bulk activities or bio-based plastic production (both activities are projected opportunities). The liquid bulk terminal (for oil products) may be transformed into a terminal for sustainable fuels, which requires minimal adaptation of the current port infrastructure. In addition, new port infrastructure can be constructed to expand the inland port activities in the port area. The inland port activities with marginal or major opportunities could carry these investment costs, thereby possibly improving the usefulness and successfulness of the inland port.
The third question can therefore also be answered positively. For this inland port, the threatened port activities are likely to be replaced by bio-based production of plastics, liquid agro-bulk activities or the transport and storage of sustainable fuels. The port infrastructure for these three port activities is similar to the current port infrastructure of the threatened port activities, which is beneficial for the attractiveness of the inland port for these ‘new’ port activities.

Overall future-proofness

According to the general guideline in Table 4, the inland port can be considered as future-proof (see Table 11). The biggest threat to the future-proofness is the risk of a decline in the demand for the current plastics and oil products. Fortunately, these large threats can be compensated by new port activities, which uses the same terminal infrastructure as in the current (to be threatened) terminals.

Question 1	Question 2	Question 3	Total
-	+	+	**Future-proof**

Table 11: Overview of the future-proofness of the inland port of Bergen op Zoom

6.5 Future-proofness assessment of case study port 2 (Oosterhout)

The assessment of the future-proofness of the inland port of Oosterhout will be performed in this paragraph. This assessment follows the same method as for the first case study. First, the port characteristics, impacts and the flexibility of the inland port are determined. Afterwards, these results are combined in order to assess the future-proofness of the inland port. A more detailed elaboration of this future-proofness assessment for the inland port of Oosterhout is presented in appendix C.

Part 1: Determination of the current inland ports strengths and weaknesses

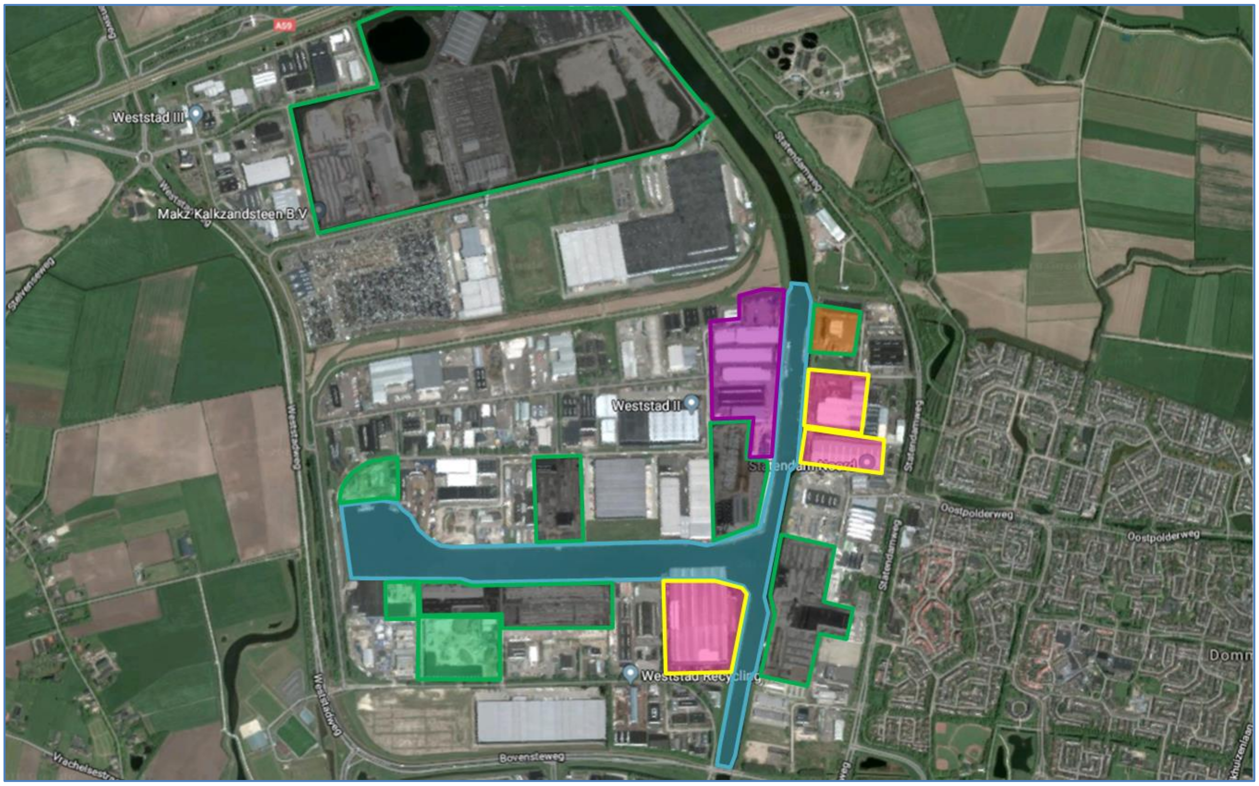


Figure 25: Overview of the port activities in the inland port of Oosterhout (the colours represent different activities)

The inland port of Oosterhout is a relatively large inland port with five different types of port activities and a total of eleven companies (see Figure 25 and appendix A for the meaning of the different colours). The following types of terminals are located in the inland port area: an agro-bulk terminal (feeder), concrete plants, dry bulk terminals (sand and gravel), a container terminal and some terminals, at which metal products are processed for final use. For this inland port, it has been found out that the main types of commodities are containers and the supply materials for concrete production. In port surface, the production of concrete occupies by far the biggest area. The company of Koninklijke HH Martens en Zonen B.V. alone covers as much as 60% of the entire inland port area. The inland port is therefore very dependent on this company, although the share in bulk throughput is only about 20%. Another important terminal is the container terminal, which transfers about 170,000 TEUs per year, which is one of the highest container throughputs for an inland port in the Netherlands. The throughput at the other nine companies are quite evenly divided, making the inland port not very vulnerable for the departure of one of these companies.

The inland port of Oosterhout is accessible for inland vessels up to CEMT-class Va with the following maximal dimensions (length x beam x draught): 110 m x 11.40 m x 3.50 m. The port configuration is as follows: several terminals along the Amertak/Wilhelminakanaal and one port basin (Insteekhaven). The port has an open connection to the main waterway, which makes the inland port vulnerable to extreme hydraulic conditions, but also well-accessible for the inland vessels.

The good road accessibility, rail accessibility and the very large operational time are considered to be a strength for the inland port. There is some potential port area left for future port activities, but this requires the relocation of existing companies without port activities. Because of this intensive relocation process of the companies, this inland port cannot be expanded easily. The hinterland size is limited (due to the proximity of the inland ports of Moerdijk, Breda, Tilburg and Waalwijk).

Strengths	**Weaknesses**
CEMT-class Va	Little free area in the inland port
Good overall accessibility (road / rail / IWT)	Limited diversity in port activities
High container throughput (gantry cranes)	Limited hinterland size
Large throughput volumes and quay length	Many companies without port activ. along basin
Many inland port terminals	Very dependent on two activities / companies
No restrictions in operational time	

Table 12: Overview of inland port strengths and weaknesses for Oosterhout

Part 2: Determination of the port specific opportunities and threats

Table 13 presents an overview of the trend-based narratives for the different port activities for the inland port of Oosterhout (which are described in part 2 of appendix C). The degree of the impacts (minimal, marginal or major) is equal as described in paragraph 4.4. The last column in Table 13 presents this projected impact of these trend-based narratives on the port activities in Oosterhout.

	Port activity	**Trend-based narrative**	**Projected impact**
1	Container transfer and storage	Opportunity to increase the container throughput	Marginal opportunity
2	Dry bulk transfer and storage	Opportunity to increase the sand/gravel throughput (dry bulk)	Marginal opportunity
3	Liquid bulk transfer and storage	Opportunity to introduce the transfer and storage of sustainable fuels (liquid bulk)	Minimal opportunity
4	Transfer and storage of remaining cargo types	Opportunity to create a terminal for break-bulk, neo-bulk or special goods	Minimal opportunity
5	Agro-bulk production	Opportunity to increase the agro-bulk throughput and production	Marginal opportunity
6	Construction materials production	Opportunity to create a hub for the construction materials production	Minimal opportunity
7	Energy production	Opportunity to introduce renewable energy production in the inland port	Minimal opportunity
8	Recycling activities	Opportunity to introduce recycling activities in the inland port	Marginal opportunity
9	Steel processing activities	Threat of decline in the demand for steel processing	Marginal threat

Table 13: Projected impacts of the trend-based narratives for the various port activities in the inland port of Oosterhout

The trend-based narratives of the inland port of Oosterhout indicate that eight of the nine main port activities are projected to create opportunities for the inland port (three of these port activities may be introduced in the inland port, but are currently absent in the port area). The only projected threatened port activity in Oosterhout is the industrial processing of steel products. The main reasons for this threat are the relocation of these (low-value) industrial processes towards developing countries and the expected reduced product demand after 2030.

The five port activities with projected opportunities in the inland port are: the container transfer and storage, sand/gravel transfer and storage (dry bulk), transfer of remaining cargo types, the production of agro-bulk and the production of construction materials. For the transfer of remaining cargo goods, a very small increase in transport demand is expected, therefore categorising this impact as a minimal impact. The production of construction materials (concrete plants) is also expected to lead to a minimal opportunity, mainly because the inland port is already used extensively for this port activity. When the number of concrete plants may further increase, the inland port becomes even more dependent on this type of port activity.

According to the trend-based narratives, the demand for container, sand/gravel and agro-bulk activities are projected to increase significantly. For these inland port activities, it may be required to increase the terminal capacity in order to meet this future demand. It may also be possible that new companies will take advantage of this opportunity and chose the inland port of Oosterhout as their location to perform this port activity.

Finally, it may be possible that new port activities enter the inland port area: (sustainable) liquid bulk transfer and storage, (renewable) energy production and recycling activities. The demand for the first two port activities in the future is projected to be lower than the current demand for the conventional variants of these port activities (e.g. current fossil fuel demand is projected to be higher than the future sustainable fuel demand). It is likely that the sustainable liquid bulk activities and renewable energy production will stay in the inland ports with current liquid bulk and energy production activities, because these facilities can be adapted relatively easily to the new activities. The two port activities are considered as minimal opportunities for the inland port, because the infrastructure for these conventional variants is not present in the inland port. However, the introduction of recycling activities is expected to create a marginal opportunity for the inland port of Oosterhout, because many trends point out that the demand for recycled materials will increase significantly up to 2050. Many new processes for recycling are expected to be introduced in the society, for which the inland port may be a good location, because the inland vessels can transport many scrap and waste (or other raw materials) for the recycling process.

The overall impact on the total inland port are presented in relation to the total port area, quay length and bulk throughput volumes. Figure 26 presents the share of the various types of impacts in relation to the inland port area, quay length and bulk throughput respectively. The green colours represent the port activities with opportunities, while the red colours represent the port activities with threats. The darker the red and green parts, the larger the projected impacts of the threats and opportunities respectively.

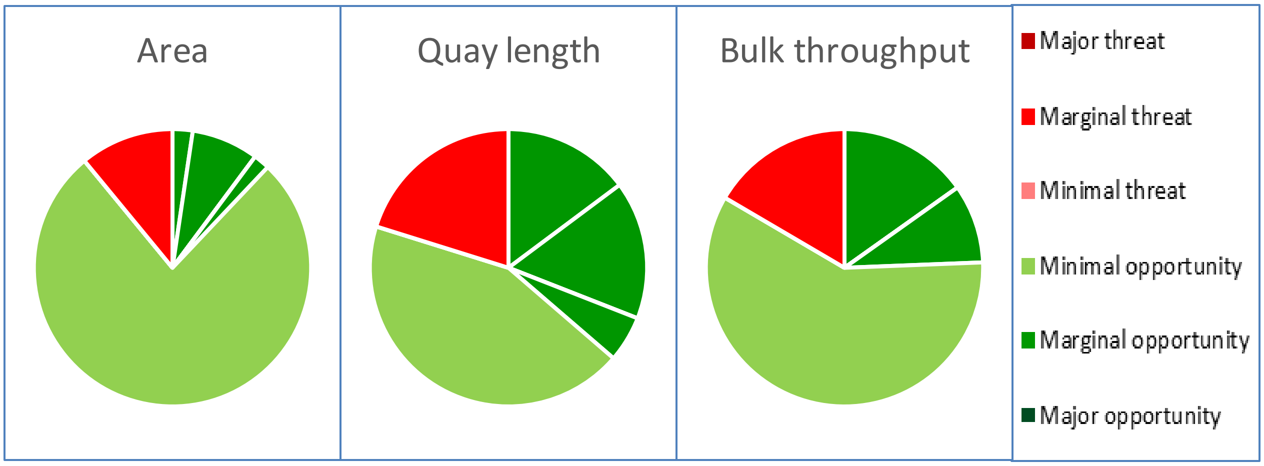


Figure 26: The share of port activities with opportunities (green) or threats (red) in the inland port of Oosterhout with relation to the total port area, total quay length and total throughput volumes in the port

From the identification of the impacts of the trend-based narratives on the port activities, it could be concluded that the inland port of Oosterhout was hardly affected by any threats. Figure 26 presents a similar result, because the threatened activities still presents a relatively small share in relation to the total inland port.

The figure shows that around 10% of the port area is covered by marginal threatened port activities. When these port activities would leave the inland port, this area becomes not useful anymore. On the other hand, it can be used to enlarge the capacities for the inland port activities with marginal opportunities, which also cover just around 10% of the total port area.

Comparing the second figure with the first figure, it is found that the construction material terminals have a relative small quay length compared to their port area. The terminals of the other inland port activities therefore include a relative high quay length. For the threatened terminals, this is equal to 20% of the total quay length, while the quay length of the activities with opportunities is equal to 40% of the total quay length in the inland port.

The third and final circle diagram represents the share of the various port activities in bulk throughput. This means that the container throughput is not taken into account in this figure, which is very large for this inland port (170,000 TEUs per year). This third figure shows that less than 20% of the total bulk throughput may disappear in the period until 2050, which is a relative small volume. It is therefore not expected that this may lead to big problems for the inland port of Oosterhout. The sand/gravel and agro-bulk throughput cover around 25% of the current bulk throughput. The opportunities of these port activities can be converted into higher throughput volumes, for which the inland port may remain successful.

Overall, the share of threatened port activities is low in relation to the total port. The inland port of Oosterhout has to deal with the potential departure of steel processing activities in order to reduce the negative effects. In order to remain future-proof, it is also required to retain the port activities with future prospects in the inland port in order to become future-proof, which seems likely due to the projected opportunities for these inland port activities. Finally, the inland port could attract recycling activities, because it is expected that this port activity creates a marginal opportunity for the inland port.

Part 3: Determination of the flexibility of the inland port of Oosterhout

The third part of the method is used to determine the flexibility of the inland port. The flexibility of the inland port represents the adaptability of the inland port to changing future demand for port activities. The higher the potential to reduce its negative impacts and the bigger the possibility to increase the capacity of (new) activities, the more flexible the inland port. However, this flexibility cannot be measured directly. Therefore two different aspects are analysed: the potential reduction of negative impacts by replacing them with new port activities and the potential to increase the capacities of port activities (by converting the opportunities into new port activities at new terminal areas). In this section, the flexibility of the inland port of Oosterhout is determined by analysing both aspects (see part 3 in appendix C for a more detailed analysis).

Analysis of the current port infrastructure of the threatened port activities for new port activities

The current infrastructure of the projected threatened port activities is analysed in order to determine whether this infrastructure can be used for the new port activities. In this way, it can be determined whether the inland port could reduce its threats (and thus remain useful and successful in the future). The three terminals with threatened port activities will be treated together, because the same port activity is performed at these terminals.

Staalstraal Brabant, Ancoferwaldram Steelplates & Deltastaal

These three companies are focused on processing steel products (e.g. pipes, beams, plates) for final use. It is anticipated that the demand for these activities may decrease until 2050 due to the potential decline in general product demand and the relocation of the low-value industrial processes towards developing countries. It is therefore not likely that all three terminals will remain successful in the inland port of Oosterhout. All three terminals have a similar terminal infrastructure, which includes cranes in order to transfer the steel products from/to the inland vessels and within the storage area. Furthermore, large parts of the storage yards are covered in warehouses to protect the steel products against weather conditions.

Two port activities (with an anticipated increase in demand) have been identified, which can use a similar terminal infrastructure as in the current steel processing terminals: a general terminal dedicated to break-bulk, neo-bulk and special bulk and a recycling terminal, which transfers and stores different types of scrap. Although the transfer and storage activities for recycling may be located at these existing terminals, the recycling company has to invest in the construction of special infrastructure for recycling processes. It is therefore not likely that recycling companies take over these threatened terminal(s). The construction of a terminal for break-bulk, neo-bulk and special goods is more likely to replace (some of) the steel processing terminals. These transfer and storage activities require a similar infrastructure as the steel products, but it is not certain if the companies with these port activities are able to remain successful in the inland port.

Analysis of the potential to expand the capacities of the port activities

The capacity of the port activities in the inland port of Oosterhout can be increased in two different ways: by increasing the internal terminal capacity and by expanding the terminal area for the specific port activities. This section present the results of the analysis of these two aspects and is used to determine the flexibility of the inland port of Oosterhout.

Internal terminal capacity

Many of the terminals in the inland port of Oosterhout use advanced equipment for the transfer, storage and production of various types of commodities, therefore leaving little room for improving the capacity of these activities in the current terminals. The two exceptions are the public quay and one sand/gravel terminal, which still use general cranes on top of the inland vessel or a mobile crane on the quay. These capacities may be increased in the future, but this increase is expected to be limited. Overall, it is expected that the terminal capacity cannot be increased substantially.

Potential terminal area

Similar to the previous case study, an analysis has been carried out to determine the potential port area and quay lengths, which can still be used to expand the number of port activities (see Figure 27). This showed that less than 20% of the area along the port basin can be used to increase the area for port activities. In addition, about 40% of the total quay along the port basin can be included for port activities. However, this potential area only contains area, which is currently occupied by companies without any port activities. In order to use this area for port activities, the current companies have to be relocated from these areas, for which a long process has to be followed. It can therefore be concluded that expanding the port area and quay length for the port activities is possible, but that this may take a long time until this potential area becomes available.

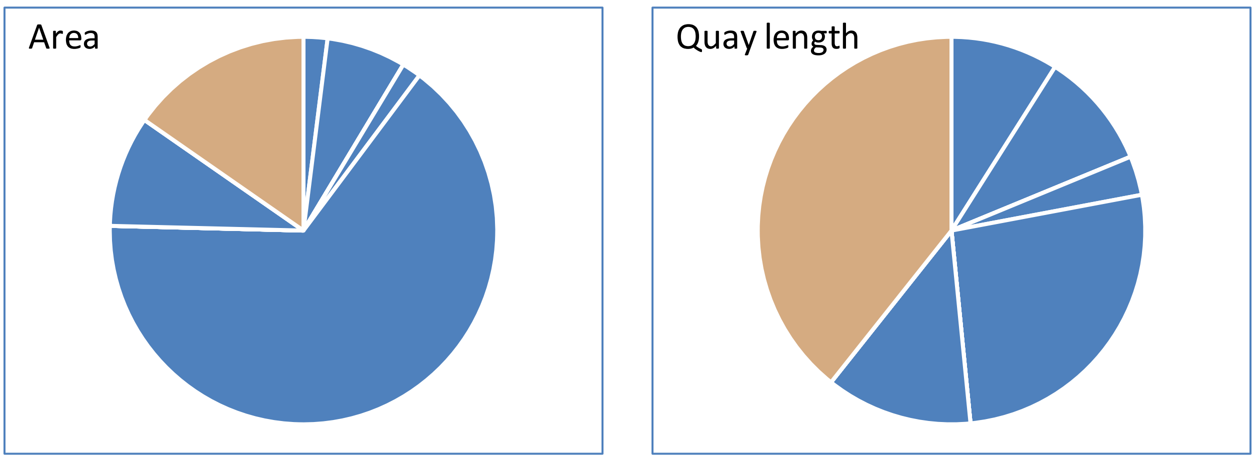


Figure 27: Potential area and quay length in Oosterhout (blue = current use, brown = currently used by non-port activities)

Overall flexibility of the inland port of Oosterhout

The overall flexibility of the inland port of Oosterhout is considered to face some challenges. The main reason is the limited area to improve the port successfulness, because there are hardly any possibilities to increase the capacities of the current port activities. Furthermore, there are hardly any possibilities to convert the other opportunities into new port activities, because there is no free area in the port area to attract these port activities. In this way, the port cannot increase its capacities ant therefore not improve its successfulness. In addition, the few threatened port activities (the transfer, storage and processing of steel products) are not likely to be compensated by replacing them with new port activities, because it requires large investments to adapt the current terminals to the potential future activities. The overall flexibility of the inland port of Oosterhout is therefore not considered to be sufficient to compensate for the anticipated negative impacts.

Part 4: Assessment of the future-proofness of the inland port of Oosterhout

The final step of the overall method is the assessment of the future-proofness of the inland port. The information about the port characteristics (strengths and weaknesses), projected impacts (activities with opportunities and threats) and the flexibility is used in this assessment, which uses a SWOT-analysis. The SWOT-analysis is set up to present a first impression of the future-proofness of the inland port of Oosterhout and the result is presented in Figure 28.

Strengths • CEMT-class Va • Good overall accessibility (road / rail / IWT) • High container throughput • Large bulk throughput volumes and quay length • Many inland port terminals • No restrictions in operational time	***Weaknesses*** • Limited diversity in port activities • Limited hinterland size • Many companies without port activities along port basin • No free area in the inland port • Very dependent on container terminal (OCT BV) & production of concrete (HH Martens & Zoon)
Opportunities Activities concerning: • Container transfer and storage (*marginal*) • Sand and gravel transfer and storage (*marginal*) • Transfer of remaining types of cargo (*minimal*) • Agro-bulk transfer and processing (*marginal*) • Production of concrete (*minimal*) • New port activities (minimal)	***Threats*** • Max. capacity may be reached due to limited potential area for new port activities • Max. internal terminal capacities may be reached due to use of advanced equipment Activities concerning: • Processing of steel products (*marginal*)

Figure 28: SWOT-analysis for inland port of Oosterhout

The inland port can be considered as future-proof when the inland port remains useful and successful for the performance of the port functions, while being flexible enough in port services and infrastructure to deal with potential changes (see the definition in chapter 2). The three main questions (see 36) have been set up to determine the future-proofness of the inland ports according to this usefulness, successfulness and flexibility. After answering these three questions, the degree of future-proofness of the inland port of Oosterhout can be determined according to the general guideline from Table 4. A more extensive determination of the future-proofness is presented in part 4 of appendix C.

<u>(1) Is it projected that the inland port activities in the inland port are hardly threatened?</u>

The inland port of Oosterhout has eleven terminals with various inland port activities. The demand for one of these port activities may decrease substantially. This port activity is the processing of steel products, which is currently performed at three terminals within the inland port of Oosterhout. It is anticipated that three terminals for the same port activity is relatively high, therefore risking that at least one of these terminals leaves the inland port. The main reasons for the potential departure of this port activity is the decreasing demand for products and the relocation of low-value industrial processes to developing countries. The steel processing terminals are therefore in risk to become useless.

The first question can still be answered positively, because all other port activities are not projected to be threatened. It is also taken into account that the steel processing activities do not form a dominant port activity within the port of Oosterhout, as a result of which the negative impact remains relatively small. The risk of becoming a less useful and successful port are therefore relatively small.

(2) Are there sufficient opportunities to compensate for the anticipated threats?
For all present port activities (except for processing steel products) it is anticipated that the demand will increase until 2050. It is therefore also likely that the inland port remains useful and successful for these port activities. It is anticipated that the demand for the container terminals, sand and gravel terminals, and the agro-bulk terminal are likely to increase substantially, resulting in marginal opportunities for the inland port. Furthermore, it is expected that the demand for the production of construction materials and the activities for the remaining types of commodities increases (resulting in a minimal opportunity). Finally, a minimal opportunity is anticipated to introduce (sustainable) energy production activities, recycling activities or transfer and storage activities for sustainable liquid bulk in the inland port area. The second question is therefore also answered positively. Although there are hardly any opportunities to increase the port activities by the absence of free port areas, there are sufficient port activities to create opportunities. These port activities are likely to be sufficient for the inland port to compensate for the anticipated threats.

(3) Does the existing infrastructure match the infrastructure needed for these identified opportunities?
The threatened port activity is the processing of steel products, for which three terminals are used to perform these current port activities. These terminals include large halls in which the cargo can be stacked before it is processed and further transported to the hinterland. The steel pipes, beams and other products are (un)loaded by big cranes. The transport of these products within the terminal is executed by cranes on rails. Unfortunately, there are no port activities identified that use the same port infrastructure as the described terminals. It is therefore not likely that new port activities may replace these threatened port activity, because it requires a lot of investments to adapt the port infrastructure. In addition, new port infrastructure has to be constructed to expand the inland port activities in the port area, but the inland port activities with marginal or major opportunities could carry these investment costs, thereby possibly improving the usefulness and successfulness of the inland port.
The third question can only be answered negatively, because there are no port activities (with opportunities) identified that can use the port infrastructure of the threatened terminals. This always requires large adaptations to the port infrastructure, which includes large investment costs.

Overall future-proofness

According to the general guideline in Table 4, the inland port can still be considered as future-proof (see Table 14). The biggest threat to the future-proofness is the fact that the port infrastructure of the anticipated threatened port activities do not match the requirements of the port activities with opportunities. Fortunately, these threatened port activities are limited and there are many port activities with opportunities, which could compensate for the negative impacts.

Question 1	Question 2	Question 3	Total
+	+	-	Future-proofness

Table 14: Overview of the future-proofness of the inland port of Oosterhout

6.6 Future-proofness assessment of case study port 3 (Wageningen)

The final case study is the inland port of Wageningen. The assessment of the future-proofness of this inland port will be performed in this paragraph. This assessment follows the same method as for the previous case studies. A more detailed description of the future-proofness assessment for the inland port of Wageningen can be found in appendix D.

Part 1: Determination of the current inland ports strengths and weaknesses

Figure 29: Overview of the port activities in the inland port of Wageningen (the colours represent different activities)

The inland port of Wageningen is a relatively small inland port, operated by just four different companies (see Figure 29 and appendix A for the definition of the various colours). These four activities vary in the production of agro-bulk cargo, the production of concrete, a dry bulk terminal (sand and gravel) and a liquid bulk terminal (mineral oil products). The port area is divided quite evenly under the different port activities. The cargo throughput volumes are not evenly distributed, because the agro-bulk throughput is equal to more than 50% of the total bulk throughput. From this point of view, it is assumed that the inland port is very dependent on the agro-bulk terminals and the related company, which is AgruniekRijnvallei Wageningen. The other three inland port companies have similar cargo throughputs (± 200,000 tonnage a year) and areas (± 15,000 m^2) in this inland port, making the port less vulnerable for the departure of one of these other companies.

The inland port is accessible for inland vessels up to CEMT-class Va, which is equal to the inland vessels on the Nederrijn. The maximum dimensions for the inland vessels are as follows (length x beam x draught): 110 m x 11.40 m x 3.50 m. The port configuration includes one port basin with an open connection to the Nederrijn. The inland port is therefore having the same hydraulic conditions as the main waterway. This makes the inland port vulnerable to extreme hydraulic conditions, but also well-accessible for the inland vessels.

The overall accessibility of this inland port is relatively bad, because the port is not very well connected to the motorways. On the other hand, the inland port is located next to the main waterway, which results in a good accessibility for inland vessels. The inland port also has a large hinterland, because there are hardly any inland ports in the proximity of Wageningen. There is still a lot of free area left for potential future activities in the inland port, which can be used as port terminals in the future.

Strengths	Weaknesses
CEMT-class Va	Bad road & rail accessibility
Good inland navigation accessibility	Limited diversity in port activities
Large hinterland area	Small throughput volumes
Many free area for expanding port activities	Small terminal areas
Mainly port-related activities in the inland port	Restricted operational time
	Very dependent on agro-bulk transfer and storage

Table 15: Overview of inland port strengths and weaknesses for Wageningen

Part 2: Determination of the port specific opportunities and threats

Table 16 presents an overview of the trend-based narratives for the different port activities in Wageningen, which are presented in appendix D. The degree of the impacts (minimal, marginal or major) is presented in the last column in Table 16, according to the definitions in paragraph 4.4.

	Port activity	Trend-based narrative	Projected impact
1	Container transfer and storage	Opportunity to introduce container transfer and storage activities	Marginal opportunity
2	Dry bulk transfer and storage	Opportunity to increase the sand & gravel throughput	Marginal opportunity
3	Liquid bulk transfer and storage	Threat of decline of mineral oil products	Major threat
4	Transfer and storage of remaining cargo types	Opportunity to create a terminal for break-bulk, neo-bulk or special goods	Minimal opportunity
5	Agro-bulk production	Opportunity to create an agro-bulk hub	Major opportunity
6	Construction materials production	Opportunity to increase the construction materials production throughput	Marginal opportunity
7	Energy production	Opportunity to introduce renewable energy production activities	Minimal opportunity
8	Recycling activities	Opportunity to introduce recycling activities	Marginal opportunity
9	Production of other goods	Opportunity to introduce new production activities	Minimal opportunity

Table 16: Overview of the identified narratives and the projected impact per port activity for the inland port of Wageningen

The trend-based narratives indicate that eight of the nine port activities are projected to create opportunities for the inland port of Wageningen (four of these port activities may be introduced in the inland port, but are currently absent in the port area). The only projected threatened port activity in Wageningen is the transfer and storage of mineral oils at the liquid bulk terminal. The main reason for this threat is the transition from fossil fuels into sustainable fuels and the trend to avoid raw materials, which can be depleted. This results in a risk that the demand for these liquid bulk activities reduces substantially, which could result in a less useful and successful inland port.

The four port activities with projected opportunities (and already present in the inland port) are: the sand/gravel transfer and storage activities (dry bulk), the transfer of other cargo types, the production of agro-bulk and the production of construction materials. For the transfer of other cargo goods, a very small increase in transport demand is expected, therefore categorising this impact as a minimal impact.

According to the trend-based narratives, the demand for sand/gravel, agro-bulk and concrete production activities are projected to increase significantly. For these inland port activities, it may be required to increase the terminal capacity in order to meet this future demand. It may also be possible that new companies will take advantage of this opportunity and chose the inland port of Wageningen as their location to perform this port activity. The proximity of the latest knowledge about agricultural products may contribute positively to attract agro-bulk producers to the inland port of Wageningen.

Finally, it may be possible that new port activities enter the inland port area: container transfer and storage activities, (renewable) energy production, recycling activities and the production of other goods. The future demand for the first port activity is projected to be lower than the current demand for these port activities (e.g. current energy demand is projected to be higher than the future renewable energy demand). It is likely that the sustainable renewable energy production will stay in the inland ports with current energy production activities, because these facilities can be adapted relatively easily for the new activities. The port activity is considered to be a minimal opportunity for the inland port, because the infrastructure for this conventional energy production is not present in the inland port. The introduction of production of other goods is also projected to create a minimal opportunity, because it is not likely that new production activities will be introduced in the inland port until 2050. The introduction of recycling activities is expected to create a marginal opportunity for the inland port of Wageningen, because many trends point out that the demand for recycled materials will increase significantly up to 2050. Many new processes for recycling are expected to be introduced and more and more types of materials can possibly be recycled, for which the inland port may be a good location, because the inland vessels can transport a large volume of scrap and waste for the recycling process.

The number of port activities with positive and negative impacts on its own does not give a good representation of the projected overall impact on the inland port. The port characteristics are therefore taken into account to obtain additional insights in these impacts for the inland port of Wageningen, which is similar as for the precious case studies. Figure 30 presents the share of the various types of impacts in relation to the inland port area, quay length and bulk throughput respectively, presenting the projected impacts in relation to the total port. The green colours represent the port activities with opportunities, while the red colours represent the port activities with threats. The darker the red and green parts, the larger the projected impacts of the threats and opportunities respectively.

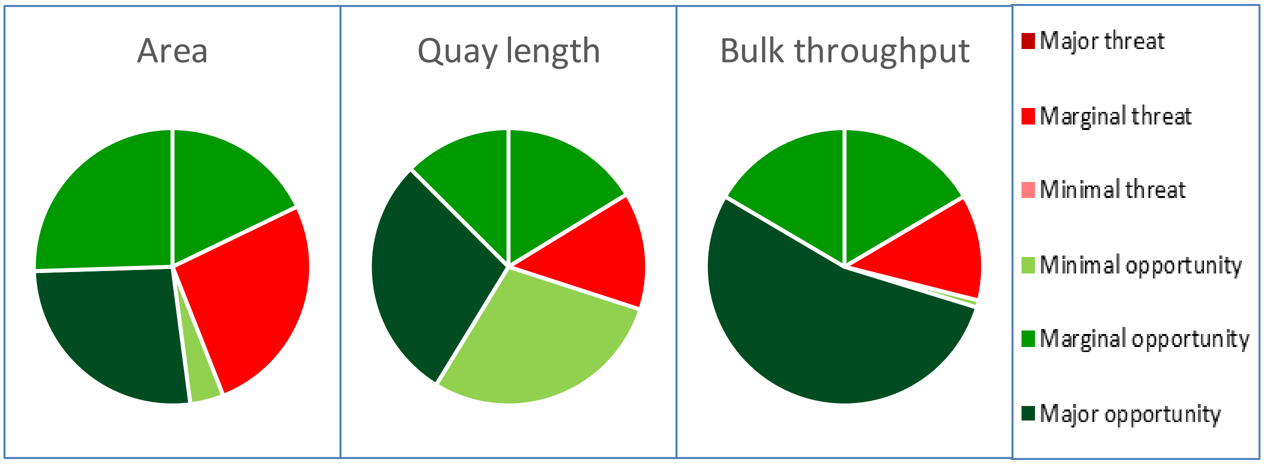


Figure 30: The share of port activities with opportunities (green) or threats (red) in the inland port of Wageningen with relation to the total port area, total quay length and total throughput volumes in the port

From the identification of the impacts of the trend-based narratives on the port activities, it could be concluded that the inland port of Wageningen is hardly affected by any threats. Figure 30 presents a similar result, although the threatened port activity is still relatively big compared to the overall inland port. The main reason for this high share of threatened port activities is based on the fact that the inland port has only four terminals and two public quays.
The figure shows that around 25% of the port area is covered by the marginal threatened port activity. When these port activities would leave the inland port, this area becomes not useful anymore. On the other hand, it can be used to enlarge the capacities for the inland port activities with marginal opportunities, which also cover just around 40% of the total port area. 25% of the port area is covered by the port activity with a major threat.
Compared with the port area, the quay length of the liquid bulk terminal is rather small (only 15% of the total quay length). The quay length for the agro-bulk terminal remains around 25%, while the quay length for the marginal opportunities is decreased to 25%. It can therefore be concluded that these terminals do have a relatively small quay length, while the public quays have a relative big quay length (compare to their area and throughput volumes).
The third and final circle diagram represents the share of the various port activities in bulk throughput. This figure shows that around 15% of the total bulk throughput may disappear in the period until 2050, which is a relative small share. It is therefore not expected that this port activity may lead to problems for the future-proofness of the inland port of Wageningen. The agro-bulk throughput cover around 50% of the current bulk throughput (making it the most important activity in the inland port), while the sand/gravel and concrete plant are responsible for the remaining throughput volume.

Overall, the share of threatened port activity is low in relation to the total port. The inland port of Wageningen has to reduce the negative effects of the potential departure of the liquid bulk activities from the inland port. In order to remain future-proof, it is also required to attract new port activities and to retain the port activities with future prospects in the inland port, which seems likely due to the anticipated opportunities for these inland port activities. In particular for agro-bulk activities (and to a lesser extent for recycling and containers), there are many opportunities to locate them in this port area.

Part 3: Determination of the flexibility of the inland port of Wageningen

This third part of the method is used to determine the flexibility of the inland port. The flexibility represents the degree in which the inland port can adapt to the future demand for port activities. Similar as the previous case studies, this flexibility for the inland port cannot be measured directly, because it depends on various external factors (e.g. decisions from port authorities, municipalities or other institutes, which may change over time). Therefore two different aspects of the inland port are analysed: the potential reduction of negative impacts by replacing them with new port activities and the potential to increase the capacities of port activities (by converting the opportunities into new port activities at new terminal areas). The higher the potential to reduce its negative impacts and the bigger the possibility to increase the capacity of (new) activities, the more flexible the inland port. In this section, the flexibility of the inland port of Wageningen is determined (see part 3 in appendix D for a more detailed analysis).

Analysis of the current port infrastructure of the threatened port activities for new port activities

First, the current infrastructure of the projected threatened port activities in the inland port is analysed in order to determine whether this infrastructure can be used for the new port activities. In this way, it can be determined whether the inland port could reduce its threats (and thus remain useful and successful in the future).

Argos Energy Terminal Wageningen

The Argos Energy Terminal Wageningen transfers and stores oil products, which are further transported to the hinterland from this terminal by trucks. The demand for oil products is projected to decline, can result in a less successful port terminal in 2050. The infrastructure of this inland terminal is specified for the transfer and storage of liquid bulk cargo (containing pipelines, multiple tanks and a jetty for (un)loading liquid bulk vessels).

Fortunately, several port activities may replace this threatened port activity. A requirement for this replacement is a matching terminal infrastructure for the new port activity, otherwise large investments have to be taken to adapt the terminal to the new port activity. The potential new port activities for the threatened terminals are liquid agro-bulk transfer and storage activities, renewable energy production activities or the transfer and storage activities for sustainable fuels. However, the small terminal area and the absence of a distribution network seems not suitable for renewable energy production. On the other hand, the terminal can be transformed relatively easy into a terminal for sustainable fuels or liquid agro-bulk products. This transformation is relatively small and does therefore not require high investment costs, which makes it attractive for companies related to these port activities.

Analysis of the potential to expand the capacities of the port activities

The potential to expand the capacity of the port activities can be measured in two different ways: by increasing the internal terminal capacity and by expanding the terminal area for the port activities. Both of these aspects are analysed to determine the flexibility of the port of Wageningen.

Internal terminal capacity

All the terminals in the inland port of Wageningen use advanced equipment for the transfer, storage and production of various types of commodities, therefore leaving little room for improving the capacity of these activities in the current terminals. The only exceptions are the two public quays, at which cranes on top of the inland vessel or a mobile crane on the quay has to be used. The throughput on these quays is very low and is not projected to increase substantially. It is therefore not required to optimise the quay capacity of these public quays by using advanced cranes.

Potential terminal area

Similar to the previous case studies, the potential port area and quay lengths for future port activities have been determined (see Figure 31). This showed that around 50% of the total area along the port basin is considered as free area. Another 20% of the port area can be considered potential port area, but this concerns occupied port areas without any port activities. More than 50% of the quay along the port basin can be included for port activities. However, 20% of this potential quay length is currently located at the areas without any port activities. The free areas may be immediately used to increase the area for port activities. In order to use the other potential area for port activities, the current companies have to be relocated from these areas. It can therefore be concluded that increasing the capacities for various port activities may be achieved relatively easily for the inland port of Wageningen, because there is many free area available along the port basin.

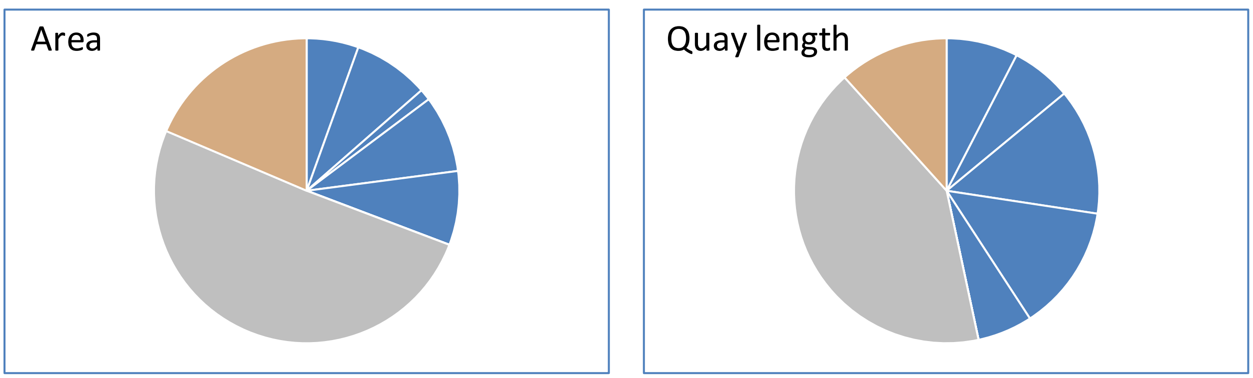


Figure 31: Potential area and quay length in Wageningen (blue = current use, grey = free area, brown = currently used by non-port activities)

Overall flexibility of the inland port of Wageningen

The overall flexibility of the inland port of Wageningen is considered to be very good. In the first place, it is considered that there are sufficient port activities to compensate for the potential negative impacts, which have been identified in part 2 of this method. The threatened port activities (the transfer and storage of oil products) are likely to be replaced by other inland port activities (e.g. transfer and storage activities for sustainable fuels or liquid agro-bulk), because the current port infrastructure matches the requirements for these port activities. The inland port remains therefore useful.

In addition, there is plenty of potential to increase the port capacity. The main reason for this high potential lays in the relatively large available area for new port activities. Because of this large free area, the port may attract many port activities with opportunities to the inland port and thereby increases the successfulness of the inland port. Overall, the flexibility of the inland port of Wageningen is considered to be sufficient to compensate for the negative impacts.

Part 4: Assessment of the future-proofness of the inland port of Wageningen

The strengths, weaknesses, opportunities, threats for the inland port of Wageningen are known, which are included in a SWOT-analysis Figure 32. The combination of the strengths, weaknesses, opportunities and threats is used to present a first insight whether it is likely that the inland port remains successful and useful in the changing conditions up to 2050.

Strengths	***Weaknesses***
• CEMT-class Va • Good inland navigation accessibility • Large hinterland area • Many free area for expanding port activities • Mainly port-related activities in the port area	• Bad rail and road accessibility • Limited diversity in port activities • Small throughput volumes • Small total port areas • Restricted operational time • Very dependent on agro-bulk terminal (AgruniekRijnvallei)
Opportunities	***Threats***
• Many potential area available for new activities Activities concerning: • Sand and gravel transfer and storage (*marginal*) • Transfer of remaining types of cargo (*minimal*) • Agro-bulk transfer and processing (*major*) • Production of concrete (*marginal*) • New port activities (minimal or marginal)	• Max. internal terminal capacities may be reached due to use of advanced equipment Activities concerning: • Mineral oil transfer and storage (*major*)

Figure 32: SWOT-analysis for inland port of Wageningen

The inland port can be considered as future-proof when the inland port remains useful and successful in performing the port functions in the future, while being flexible enough in port services and infrastructure to deal with potential changes (see the definition in chapter 2). Similar to the previous case studies, the future-proofness of the inland port of Wageningen has been determined with help from the three main questions (see page 36) and the general guideline in Table 4.

<u>(1) Is it projected that the inland port activities in the inland port are hardly threatened?</u>

The inland port of Wageningen is relatively small, compared to the previous two inland ports. The inland port therefore only has five different port activities: transfer of cargo at the general quay, agro-bulk production, production of construction materials, the transfer and storage of sand/gravel and the transfer and storage of liquid bulk. The demand for the latter port activity is projected to decrease substantially. It is anticipated that the use of non-sustainable raw materials (oil products) will reduce to a minimum, as a result of which this liquid bulk terminal may become no longer useful and successful for the inland port. Fortunately, the liquid bulk terminal is not a very important activity for the inland port of Wageningen, because it covers a relatively small share in area, quay length and bulk throughput in relation to the total inland port. The risk that this activity leaves the port area is therefore likely to result in a relatively small negative impact for the inland port.

The first question can be answered positively, because all other port activities are not projected to be threatened. It is also taken into account that the liquid bulk activities are not a dominant port activity within the inland port of Wageningen, as a result of which the negative impact remains relatively small. The risk of becoming a less useful and successful port is therefore also relatively small.

(2) Are there sufficient opportunities to compensate for the anticipated threats?
The demand for the five present port activities (except for the liquid bulk activities) is expected to increase until 2050. It is therefore also likely that the inland port remains useful and successful for these port activities. It is anticipated that the demand for the sand and gravel terminals and the production of construction materials are likely to increase substantially, resulting in marginal opportunities for the inland port. Furthermore, agro-bulk terminal is expected to create a major opportunity, because of the increased demand for agro-bulk products and the proximity of the University of Wageningen. Finally, there is are several opportunities to introduce the container activities, sustainable energy production activities and recycling activities in the inland port area.
The second question is therefore also answered positively. In addition to these many port activities with opportunities, there is also many free area left in the inland port to increase the (capacity of these) port activities. The number of port activities with opportunities and the large free areas in the inland port is likely to be sufficient for the inland port to compensate for the anticipated threats.

(3) Does the existing infrastructure match the infrastructure needed for these identified opportunities?
The threatened port activity is the transfer and storage of liquid bulk products. The current terminal uses a system of pipelines and a pumping system to (un)load the cargo from/to the inland vessels and to transport the cargo within the terminal. The oil products are stored at the big tanks. The terminal equipment can be used (with minimal adaptations) for agro-bulk activities or bio-based fuels, for which port activities opportunities are projected. In addition, new port infrastructure has to be constructed to expand the inland port activities in the port area, but the inland port activities with marginal or major opportunities could carry these investment costs, thereby possibly improving the usefulness and successfulness of the inland port.
The third question can therefore also be answered positively. For this inland port, the threatened port activity is likely to be replaced by liquid agro-bulk activities or the transport and storage of sustainable fuels. The port infrastructure for these three port activities is similar to the current port infrastructure of the threatened port activities, which is beneficial for the attractiveness of the inland port for these 'new' port activities.

Overall future-proofness

According to the general guideline in Table 4, the inland port can be considered as very future-proof (see Table 17). This excellent score tells us that this inland port is expected to remain useful and successful for performing future port activities and it is also flexible enough to deal with potential changes in the demand for the various port activities.

Question 1	Question 2	Question 3	Total
+	+	+	**Very Future-proof**

Table 17: Overview of the future-proofness of the inland port of Wageningen

6.7 Comparison of the results of the three case studies

The assessment of the future-proofness of the three case study ports have resulted in three different results. The results of these assessments are compared in this paragraph. In this way, it may be possible to identify general patterns that may give some more insight whether an inland port can be considered as future-proof.

Table 18 presents an overview of the results of the three case study ports for the three different questions, which were generated for part 4 of the method. Table 4 (see page 38) is used to determine the future-proofness of these inland ports.

	Bergen op Zoom	Oosterhout	Wageningen
Question 1	-	+	+
Question 2	+	+	+
Question 3	+	-	+
Future-proofness	**Future-proof**	**Future-proof**	**Very future-proof**

Table 18: Future-proofness of the case-study ports and the answers on the three questions of part 4 of the method

From the analysis of the three inland ports, it was found that larger inland ports in general attract a larger diversity of port activities, which makes the inland port less dependent on one specific inland port activity. This large diversity is likely to increase the flexibility of the inland port, because it spreads the risks of the future threats on the different port activities. The inland ports with only a few port activities are therefore considered to be more vulnerable for the (negative) impact of one of the port activities, which may reduce their future-proofness.

It has also been found out that many of the port activities with a generic threat (see Table 7) are not located in the Dutch inland ports. These port activities (for example the energy production and chemical companies) are mainly clustered in the seaports or in the large inland ports in Germany. There are some exceptions, such as the energy production company in the inland port of Utrecht and the plastics producer in Bergen op Zoom. Generally, it can be stated that the absence of the port activities with generic threats in the inland ports is beneficial for the future-proofness of the inland ports in general.

On the other hand, the demand for many of the typical inland port activities (such as sand/gravel transfer and storage, agro-bulk transfer and storage and the construction material production) are projected to increase substantially until 2050. It is therefore projected that most of the port activities remain successful in the inland port. In this way, the inland ports may also remain useful for performing the transfer of goods, storage of goods and the industrial production of goods in the Netherlands.

Finally, the inland ports along the small waterways are likely to be less future-proof than the inland ports along the larger inland ports. The main reason is the projected increase in vessel size in order to lower the transport costs. At a certain moment in time, it is expected that the 'small' inland vessels will be only used for special transport to these 'small' inland ports, which makes these inland ports not useful anymore.

6.8 Conclusion

This chapter has focused on the determination of the future-proofness of three existing inland ports by using the proposed method from chapter 4. This is also presented in the sub question answered in this chapter: "What is the future-proofness of the three case study inland ports?". This paragraph gives an overview of the content of this chapter and answers the sub question.

In the first paragraph of this chapter, three case study inland ports have been selected. It was required to select three different types of inland ports, because the differences in the future-proofness may then be identified. In addition, it was decided to only select inland ports with transhipment activities for cargo. In the end, the selection was based on two criteria: the amount of available information about the inland port and the requirement that the composition of port activities differs between the selected inland ports. This lead to the selection of Bergen op Zoom, Oosterhout and Wageningen as the case study ports.

Subsequently, the future-proofness of the three case study ports has been assessed according to the four parts of the prescribed method: the determination of the port characteristics (the strengths and weaknesses (part 1)), the impacts of the trend-based narratives on port activities (the opportunities and threats (part 2)), the flexibility (part 3) and the final determination of the future-proofness (part 4). The main results are presented in Table 19. Below the table, a brief summary of the results is presented.

	Bergen op Zoom	Oosterhout	Wageningen
Question 1	-	+	+
Question 2	+	+	+
Question 3	+	-	+
Future-proofness	**Future-proof**	**Future-proof**	**Very future-proof**

Table 19: Future-proofness of the case-study ports and the answers on the three questions of part 4 of the method

According to the general guidelines in Table 4, all three inland ports can be considered to be future-proof. The inland port of Wageningen is even expected to be very future-proof. The inland ports of Bergen op Zoom and Oosterhout are still facing some minor challenges, therefore considered as future-proof instead of very future-proof.

The inland port of Wageningen is considered as very future-proof, because it is likely that this inland port remains useful and successful in the future. In addition, this inland port is expected to be flexible enough to reduce the negative impacts and to attract other port activities to the inland port without large adaptations of the current port infrastructure.

For the inland port of Bergen op Zoom, the biggest challenge is the risk of a decline in the demand for the current plastics and oil products, which is the most dominant port activity of this port. Fortunately, these large threats can be compensated by new port activities, which make use of the same port infrastructure as the current port infrastructure.

The biggest threat to the future-proofness of the inland port of Oosterhout is the fact that the terminal infrastructure of the anticipated threatened port activities do not match the required infrastructure for the port activities with opportunities. Fortunately, these threatened port activities are limited and there are many port activities with opportunities, which still could compensate for the negative impacts.

7. Conclusion and recommendations

This chapter discusses the conclusions that can be drawn from the conducted research. Before the main research question will be answered, a brief summation of the answers on the sub questions is presented. Furthermore, the results of the three case study ports and the usability of the method will be discussed. Recommendations are made to improve the method assessing the future-proofness of the inland port, followed by recommendations for the three case study ports in order to improve its future-proofness.

7.1 Conclusion

The objective of this research was to establish a method to assess the future-proofness of inland ports in the Netherlands. The main research question and the sub questions were defined in paragraph 1.2 to address this research objective. The research sub questions were already answered in detail in chapter 2 until 4. These sub questions will therefore briefly be answered to present the most important findings of these chapters. Subsequently, the gained knowledge from addressing these sub questions is used to answer the main research question. Finally, the last sub question will be answered by providing the future-proofness of three case study inland ports, which was the additional objective for this research. This future-proofness is determined by the proposed method to assess the future-proofness of inland ports.

Answers to the research sub questions 1 to 3

Research sub question 1: What is a future-proof inland port?

Chapter 2 was used to answer the first sub question for this research. Before assessing the future-proofness of the inland port, it was required to define a future-proof inland port.

First, a literature study has been carried out to define future-proofness in general. The different definitions for the future-proofness showed two conditions in order to become a future-proof object: it should remain useful and successful in the future and it should be flexible enough when the conditions change.

Subsequently, a future-proof inland port was defined. It was defined that the inland port can be considered future-proof when the inland port remains useful and successful in the transfer of goods, the storage of goods and the industrial production of cargo in the future and is flexible enough in port services and infrastructure to deal with potential changes. It is considered that the main functions of the port remained the same over time, but that the needs are likely to change. Therefore the inland ports must evolve to remain useful and successful. The port can only be considered useful when the inland port still fulfils its primary functions in the future by providing the requested services and infrastructure. It remains successful when the inland port is able to sustain effective on the long-term in an efficient manner (as long as it remains useful). For the inland ports, a high effectiveness can be reached when the inland port is able to address the demand, while high efficiency is reached when the activities are conducted with a minimum wasted effort.

Research sub question 2: What main port activities take place in the Dutch inland ports?

Chapter 3 has focused on answering the second sub question. In order to determine the future-proofness of the inland ports, it is necessary to know the port activities in the inland port, because they present the usefulness and successfulness of the inland port in relation to the current and projected future demand.

In the first place, more information about the three main functions of the inland ports was obtained using a literature study. These main functions are the transfer of goods, the storage of goods and the industrial production of goods. They are performed by various inland port activities. The main port activities have been identified with help from these main port functions, port visits and interviews with port activities. The following main port activities have been identified:

1. Container transfer
2. Dry bulk transfer
3. Liquid bulk transfer
4. Transfer of remaining goods
5. Storage of containers
6. Storage of dry bulk
7. Storage of liquid bulk
8. Storage of remaining goods
9. Agro-bulk production
10. Construction materials production
11. Energy production
12. Recycling activities
13. Remaining industrial production activities

In order to determine the future-proofness of the inland ports, port indicators have been generated to determine the port strengths and weaknesses. These port indicators are: accessibility, capacities of the various inland port activities, dependency on companies with port activities, dependency on type of port activities, dimensions of port basins, hinterland size, operational time by extreme hydraulic conditions, operational time by municipal permits and potential area for future port activities.

Research sub question 3: What method can be provided to assess the future-proofness of inland ports?

Chapter 4 has focused on answering sub question 3 (which is equal to the main research question of this research). Before the method could be provided, it was required to obtain more insights in the uncertainties in the long-term developments and the related methods to deal with these uncertainties. The following sub sub questions (SSQ) had been set up.

SSQ 1: What type of uncertainties can be found in long-term developments?

SSQ 2: Which methods can be used to deal with uncertainties in long-term developments?

SSQ 3: Which method is considered to be most suitable for the assessment of future-proof inland ports?

The first two sub sub questions have been answered by a literature study about forward-looking disciplines and different type of uncertainties in long-term developments. The type of uncertainties were categorised by the research of Walker et al. (2003), resulting in four different uncertainty levels (ranging from absolute certainty to absolute uncertainty). The link between the forward-looking disciplines and the different levels of uncertainties is described in the work of Van Dorsser et al. (2018), resulting in four different categories of forward-looking disciplines: Deterministic Forecasting, Probabilistic Forecasting, Foresights and Futures.

The final sub sub question is also answered in chapter 4. It was found that the methods from the third layer of the Futures Pyramid (Van Dorsser, Walker, Taneja, & Marchau, 2018) were best suited to deal with the uncertainties in the long-term developments, because the level of uncertainties for the relevant developments was equal to the level 3 uncertainties. The methods from this third layer use a range of plausible trend-based narratives that reflects the identified threats and opportunities for the inland ports. This method of trend-based narratives was recently developed at the TU Delft (Van Dorsser, Taneja, & Vellinga, 2018).

Answer to the main research question

After answering the previous mentioned research sub questions and the sub sub questions, it is possible to answer the main research question, which is:

What method can be provided to assess the future-proofness of an inland port in the Netherlands until 2050 with regard to the current port activities?

The gained knowledge about a future-proof inland port, the port activities and the methods to deal with uncertainties in long-term developments is used to set-up a method to assess the future-proofness of an inland port. This overall method to assess the future-proofness of the inland port exists of four parts:

- Part 1: Determination of the current inland port's strengths and weaknesses (port characteristics)
- Part 2: Determination of the port specific opportunities and threats (impacts)
- Part 3: Determination of the flexibility of the specific inland port
- Part 4: Assessment of the future-proofness of the specific inland port

The first part uses the current information about the port activities and the port indicators in order to determine the specific inland port's strengths and weaknesses. The better these port characteristics, the less vulnerable the inland port is to changes in the demand for port activities and the more attractive the inland port for port activities. Good port characteristics are likely to improve the future-proofness.

The second part of the method defines the projected impact of the trend-based narratives on the different port activities in the inland port. These projected impacts have to be generated with help from generic long-term developments and the determined port characteristics in the previous part. The smaller the negative impacts on the inland port, the more likely that the inland port can be considered as future-proof.

The third part of the method is used to determine the flexibility of the inland port. This flexibility represents the adaptability of the inland port to the projected future situation. This can be qualitatively determined by identifying the potential to reduce the negative impacts and the potential to increase the capacity of the various port activities in the inland port. The higher this flexibility, the more likely that the inland port remains useful and successful in the future.

The fourth part of the method assesses the future-proofness of the inland port. The results of the first three parts are combined to determine whether the inland port will remain useful and successful until 2050. Ultimately, the combination of answers on three questions (set up to cover the degree of usefulness, successfulness and flexibility until 2050) determines the future-proofness of the inland port.

Answer to research sub question 4 (case studies)

Chapter 6 was used to determine the future-proofness of three existing inland ports, for which the proposed method is used. This chapter therefore also answers the fourth and final sub-question of this research, with which the additional research objective is reached. This fourth sub question is: What is the future-proofness of the three case study inland ports?

The inland port of Bergen op Zoom, Oosterhout and Wageningen were selected as the case study ports. For these inland ports, the future-proofness is determined according to the proposed method. This resulted in the following results for the selected case study ports.

The inland port of Bergen op Zoom is determined to be future-proof. The port characteristics of the inland port of Bergen op Zoom are considered to be good due to the many port activities, the many terminal companies, the good accessibility and the large hinterland area. However, a large negative impact on the port is expected for the production of plastics. This port activity is the dominant activity in the current inland port and it is therefore anticipated to affect the inland port in a very negative way. On the other hand, all other port activities are projected to provide opportunities, thereby creating opportunities for the inland port to compensate these negative effects. The fact that the terminal infrastructure of the threatened port activities matches the required infrastructure for the 'new' port activities, makes these terminal areas also attractive for these new activities. In this case, the production of plastics is likely to be replaced by a new (bio-based) production of plastics or by liquid agro-bulk activities. In this way, the inland port of Bergen op Zoom is likely to remain useful and successful.

The inland port of Oosterhout is also projected to be future-proof. The port characteristics are considered to be good due to the diverse type of port activities/companies, the good accessibility and large operational time. In addition, the negative impact of the trend-based narratives is projected to be relatively small, because only steel processing port activities are projected to face a declining demand. Fortunately, this port activity is a relatively small port activity in the inland port, resulting in a small negative impact. The demand for all other inland port activities are anticipated to increase, creating opportunities to compensate for the negative impacts. Unfortunately, the current terminal infrastructure of these threatened port activities do not match the required infrastructure for the port activities with an increasing demand. It is therefore required to adapt the current port terminals to the new activity, which requires a lot of investment costs. The flexibility of the inland port can therefore be further improved in order to become even more future-proof.

The final case study, the inland port of Wageningen, is determined to be very future-proof. This inland port has good port characteristics, hardly any negative impacts and a good flexibility. The port characteristics of the inland port are considered to be good, although the terminal areas are relatively small and there is a limited operational time. In addition, it is anticipated that only a small share of the total inland port will be threatened, because only the demand for transfer and storage activities for oil products is projected to decline, which is a relatively small inland port activity in the inland port of Wageningen. The demand for all other current port activities is projected to increase up to 2050, creating multiple port activities with opportunities to compensate for the projected negative impact. Fortunately, the terminal infrastructure of these threatened port activities matches the required infrastructure of some of the port activities with opportunities, resulting in a good flexibility of the port.

7.2 Recommendations

Recommendations for further research

The proposed method of this research can be considered as a new concept to assess the future-proofness of inland ports. This section presents recommendations for further studies to improve this method.

Obtain more and accurate data

The applicability of the method and the reliability of its results can be improved. However, this requires more and more accurate data. It is therefore recommended for Movares to put effort into acquiring the information from their network. When Movares cannot acquire the required amount of data, it is also possible to collect the data by themselves. Big data can be used to assist in the collection, sorting and processing of this information, thereby improving the input for the assessment of future-proofness of inland ports.

Update the trends and trend-based narratives when more knowledge is obtained

The applicability of the trend-based narratives is dependent on the level of knowledge about the uncertainties of the long-term trends. When more (accurate) information about certain inland port-related trends becomes available, the current trends can be adapted or added to the list of trends (in chapter 5). These changes in the trends require a review of the trend-based narratives for the various port activities for the specific inland ports. It should be checked whether these trends change the anticipated impacts on the inland port and whether the level of future-proofness for these ports may change. Updating the trends and trend-based narratives is therefore essential to present the future-proofness of inland ports.

Adapt the method to other time periods

The proposed method is applicable to assess the future-proofness of an inland port until 2050, which is equal to a timeframe of around 30 years. Movares could consider to adapt this method to other timeframes in order to determine the future-proofness of inland ports for a shorter period of time (e.g. 10 years) or longer periods of time (e.g. 50 years). These various timeframes imply different degrees of uncertainties for the long-term trends (and thus different forward-looking methods to determine the impacts of the inland ports). By using these different forward-looking disciplines for the determination of the trends, the inland port can be optimised for a required time period, when the method is adapted to the same time period.

Include economic impacts in the method

The method could be extended by taking the economic impacts into account. The number of employees in the port area, the turnover of the companies in the inland port, the earned port fees and the investment costs to facilitate the port activities are some examples that can be taken into account. The inclusion of the economic data gives an insight in the economic value of the various companies within the inland port and the economic value of the total inland port, which can be used to determine the economic impact of the anticipated changes in the inland port. These economic numbers are very important for the decisions of the municipalities, which are in most cases the owners of the inland port.

Include the vision of the port authority in the method

The vision of the port authority for the future inland port is an important factor for the attractiveness of the inland port. Some port authorities are aiming at port activities with as many jobs as possible, while these do not necessary mean that these port activities are beneficial for the future-proofness of the inland port. Furthermore, some other port authorities are focussing on attracting only one kind of port activity to cluster these port activities and eventually become a specialised inland port. However, this makes the inland port very vulnerable for this specific port activity. Another port authority would not mind which port activity is introduced in the inland port, as long as the port area is used. These different visions of the port authorities could be included in the method, because it presents additional information about the progression of the usefulness, successfulness and flexibility of the inland port.

Develop a quickscan method

Movares could consider developing a quickscan application, in which the future-proofness of the inland ports can be assessed according to the proposed method. However, there is still a lot of information required to determine the future-proofness of the inland port in the current method. In a further investigation, more research can be done in restricting the required data of both port characteristics and trends in order to simplify the determination of the future-proofness of inland ports. This restricted amount of required information about the inland ports and the trends can then be used as input for a quickscan, which determines the future-proofness of inland ports with help from this data.

Develop a method to assess measures to improve the future-proofness

This research can also be used as a starting point to assess the measures to improve the future-proofness. When the port has been analysed to determine the future-proofness, the strong and weak points of the inland port have been identified. For these weak points, it is likely that various measures can be taken to improve the future-proofness. However, not every measure is equally effective. By assessing the future-proofness of the inland port for all individual measures, it can be determined which measure is most effective to improve the future-proofness. Movares could use this application to present the port authorities which measures are best to improve the future-proofness of the inland port. By executing the most effective measures, the inland port authority could possibly save investment costs, because the unnecessary measures do not have to be taken.

Recommendations for the port authorities of the case studies

This section presents some suggestions for the port authorities of the case studies to increase the future-proofness of their inland port.

Bergen op Zoom

It is recommended that the port authority in Bergen op Zoom focuses on the reduction of the negative effects of threatened port activities. In this section, some examples are presented to achieve this:

- The port authority could encourage the producer of plastics to invest in adapting the terminal for sustainable production processes (e.g. bio-based plastics) or for other port activities.
- The port authority could consider creating a back-up plan in case the producer of plastics may leave the inland port area.
- The port authority could encourage the liquid bulk terminal to invest in the adaptation to the transfer and storage of sustainable liquid bulk products or agro-bulk products.
- The port authority could decide to only introduce companies with port activities to the free areas along the port basin (especially agro-bulk, container and recycling activities). In addition, the port authority could consider a process to relocate the companies without port activities along the port basin to increase the usefulness and successfulness (and thus the flexibility) of the inland port.

Oosterhout

Although the inland port of Oosterhout is already considered future-proof, it can still be improved. It is recommended that the port authority of the inland port of Oosterhout focuses on improving the flexibility of the inland port. This section presents some examples to improve the future-proofness:

- The port authority could start a process to encourage the steel processing companies to invest in adapting the terminal for other activities in order to remain successful.
- The port authority could consider creating a back-up plan in case the threatened port activities will leave the inland port area.
- The port authority could decide to only introduce companies with port activities to the free areas along the port basin (especially agro-bulk, container and recycling activities). In addition, the port authority may start a process to relocate the companies without port activities along the port basin to increase the usefulness and successfulness (and thus the flexibility) of the inland port.

Wageningen

The future-proofness of the inland port of Wageningen is already very good. However, there are still suggestions to improve the current future-proofness. In this section, some examples are presented:

- The port authority could consider to introduce more types of port activities and port companies into the inland port area (especially container and recycling activities). The inland port will then become less vulnerable to the small number of port activities and companies.
- The port authority could consider increasing its operational time. In the current situation, the inland port is not allowed to be operated during the night and during the weekends.
- The port authority should encourage the liquid bulk company to invest in the adaptation of the infrastructure for transfer and storage activities for sustainable liquid bulk products.

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Appendices

Appendix A: Overview of the case study ports

The next pages present an overview of the port activities in the existing inland ports, which serve as the case studies. These case studies are the inland port of Bergen op Zoom, Oosterhout and Wageningen in Figure 33, Figure 34 and Figure 35 respectively. The individual boxes are presenting the different companies in the inland port, which use the inland waterway for the transport of their supply or products. The colours, which are presented in these figures, are presented below. A distinction is made here between the colour of the outline and the volume of the figure itself.

Colour of outline

- *Purple*: Quay/Jetty dedicated to container transfer
- *Green*: Quay/Jetty dedicated to dry bulk transfer
- *Red*: Quay/Jetty dedicated to liquid bulk transfer
- *Yellow*: Quay/Jetty dedicated to the transfer of remaining goods (break-bulk, neo-bulk or special bulk) or general cargo quay

Colour of the volume

- *Purple*: Terminal with container storage
- *Green*: Terminal with dry bulk storage
- *Red*: Terminal with liquid bulk storage
- *Yellow*: Terminal with storage of the remaining type of commodities (break-bulk, neo-bulk or special bulk)
- *Orange*: Agro-bulk production area
- *Black*: Production area for construction materials (e.g. asphalt, concrete)
- *White*: Energy production area
- *Turquoise*: Recycling area
- *Pink*: Production area for other industrial processes (e.g. production of paper, chemicals, plastics)

Other

- *Blue*: Port basin

Bergen op Zoom

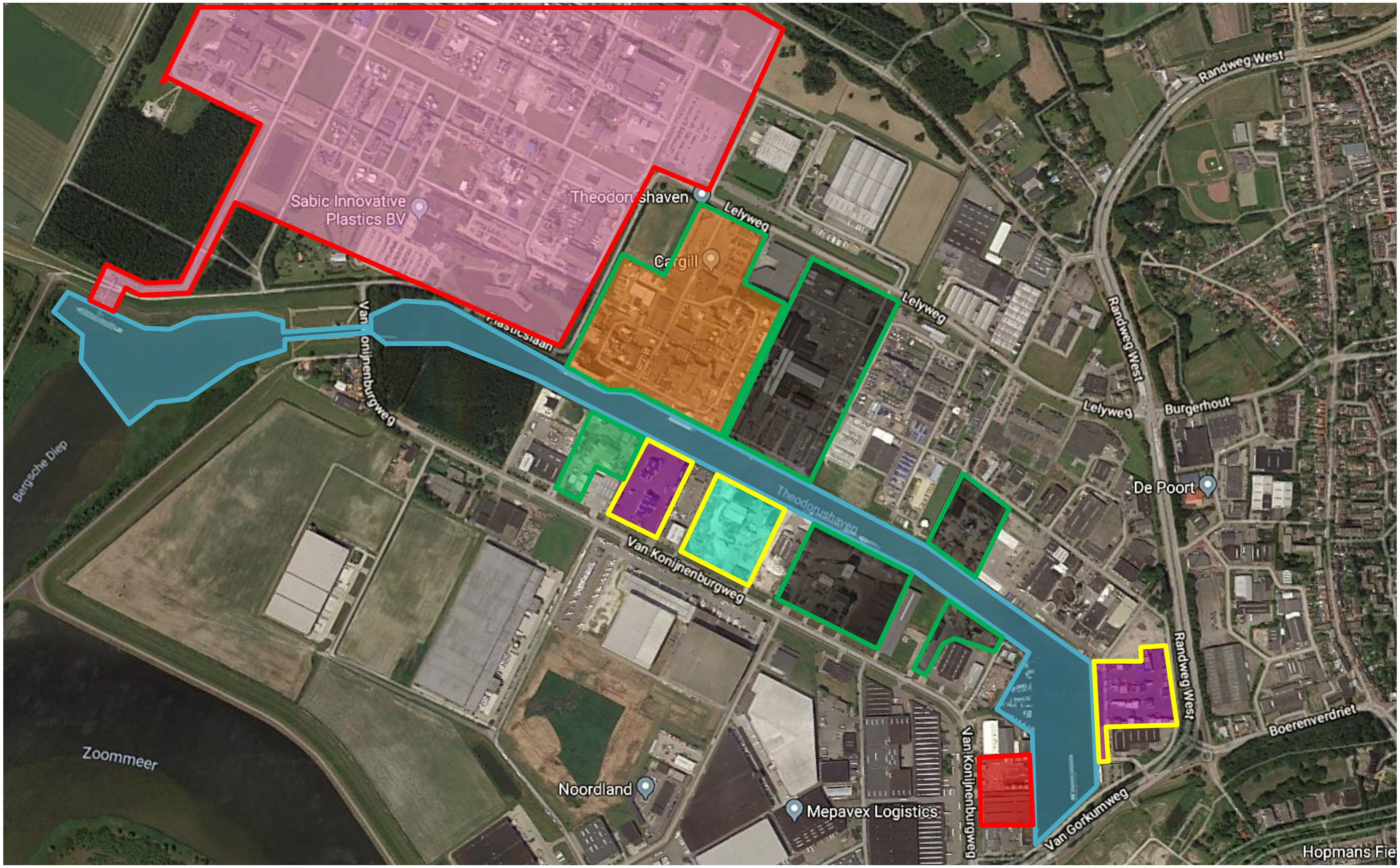


Figure 33: Overview of the port activities in the inland port of Bergen op Zoom

Oosterhout

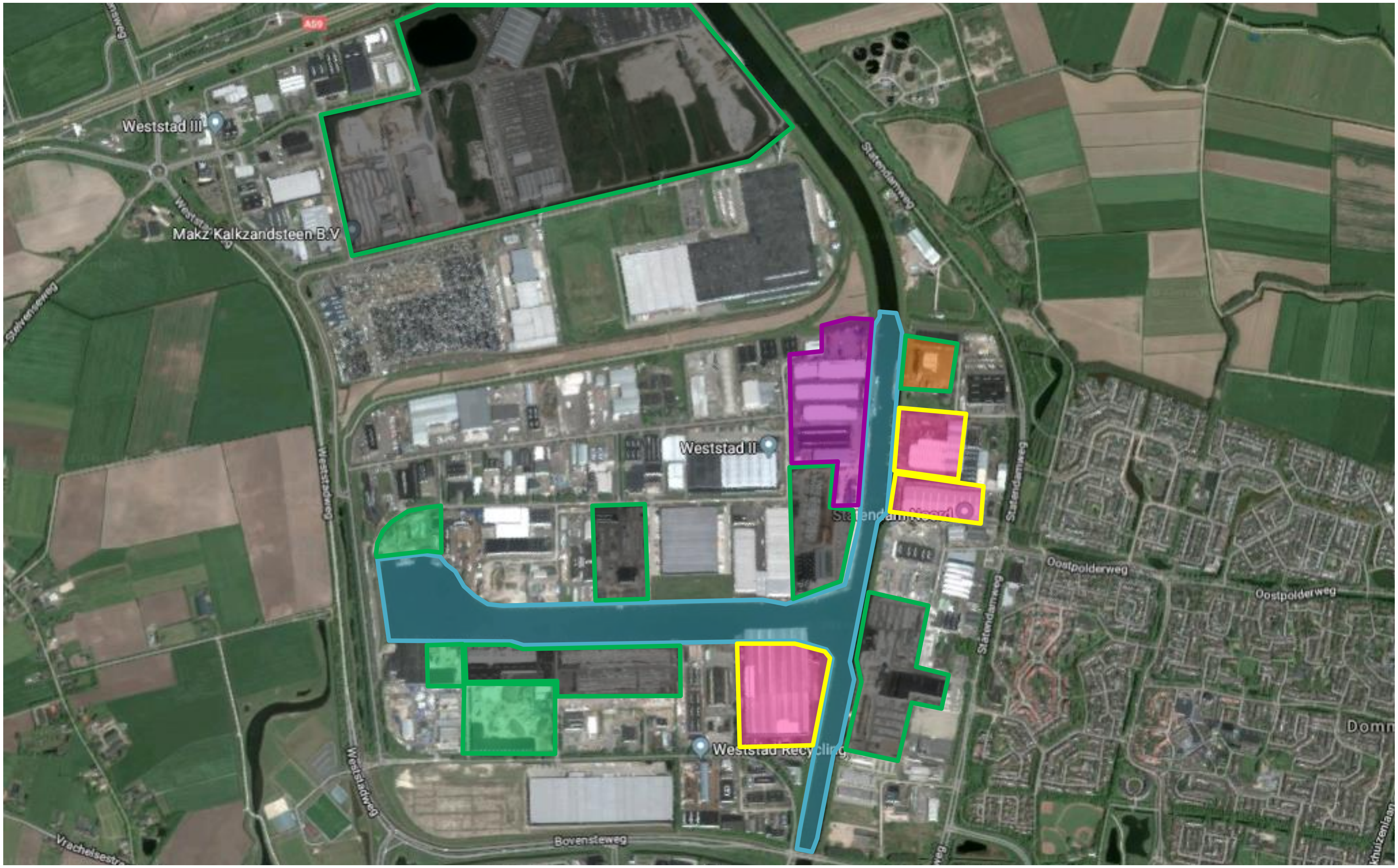


Figure 34: Overview of the port activities in the inland port of Oosterhout

Wageningen

Figure 35: Overview of the port activities in the inland port of Wageningen

Appendix B: Case study 1 (Bergen op Zoom)

The assessment of the future-proofness of the inland port of Bergen op Zoom (case study 1) will be presented in this appendix. This appendix is structured according to the four different parts of the method.

Part 1: Determination of the current inland ports strengths and weaknesses

The first part of the framework includes the qualitative determination of the strengths and weaknesses of the inland port. When available, quantitative information can be used in order to support this determination. Therefore it is first required to determine the characteristics of the inland port of Bergen op Zoom according to the identified port indicators. These port characteristics can then be used to determine which inland port activities could be potentially affected by the plausible trends.

Accessibility

The inland port of Bergen op Zoom is located on the western part of the city. The port basin is located behind a lock, which separates the Theodorushaven from the Bergsche Diep. The Bergsche Diep is around 2 kilometres long and connects the port with the main inland waterway: Schelde-Rijnkanaal. This inland waterway connects the Port of Rotterdam with the Port of Antwerp and also serves as the connection between the hinterlands for these two ports.

Furthermore, Bergen op Zoom is connected to two motorways, which are located on the eastern and southern edge of the city. These are the A4, connecting the city to both Rotterdam and Antwerp, and the A58, connecting the city to Vlissingen and Roosendaal. Although the access to the motorway is on the other side of the city, it can be reached within 5 minutes (± 4 kilometres) (Google Maps, 2018).

There is no train connection in the inland port area of Bergen Op Zoom, because this was removed in 2013 and 2014 (Boer, 2018). This decision was made by the municipal government due to the fact that the rail connection was not used frequently and the maintenance costs were very high.

Except for the rail network, the overall accessibility for the different transport modes is quite good. The main waterway and the motorways are quite close to the inland port, making it an attractive location for port activities.

Capacities of the various inland port activities

As can be seen in Figure 33 in appendix A, the inland port of Bergen op Zoom contains relatively many industrial processes in the inland port. It contains one agro-bulk producer (sweeteners), three concrete plants and one asphalt plant, for which all a dry bulk transfer area is constructed. In addition, there is also one recycling company with a general transfer area and a producer of plastics (with liquid bulk transfer activities). Apart from these production companies, there are also terminals for the storage and transfer of goods: two container terminals with quay for general cargo, a liquid bulk terminal and a sand/gravel company (dry bulk terminal).

The capacities of these different port areas for the various port activities are not known. It is therefore decided to use sub-optimal data, such as terminal areas, quay lengths and the throughput data of 2017, which have been achieved by using Google Maps and correspondence with N. Boer (Port master and Coordinator urban development for the municipality of Bergen op Zoom) (2018).

Port activity	Area	Quay length	Throughput volumes
Container terminal	37,000 m^2	103 m	70,060 TEUs
Dry bulk terminal	20,125 m^2	117 m	125,086 tonnage
Liquid bulk terminal	14,500 m^2	71 m	25,820 tonnage
Terminal for remaining cargo	3,000 m^2	240 m	40,563 tonnage
Agro-bulk producer	82,800 m^2	335 m	1,138,850 tonnage
Construction mat. producer	124,550 m^2	537 m	468,361 tonnage
Energy producer	-	-	-
Recycling company	23,100 m^2	138 m	18,826 tonnage
Remaining industrial producer	560,000 m^2	250 m	646,252 tonnage
Total	**865,075 m^2**	**1,791 m**	**2,463,758 tonnage + 70,060 TEUs**

Table 20: Sub-optimal data about the capacity of the inland port activities in Bergen op Zoom

From this data, is can be concluded that the inland port area of the inland port of Bergen op Zoom is rather large. In addition it also has a quite a large quay lengths at which the transfer activities can take place. The total throughput volumes are presented in the last column, which has to be the minimum capacity of the inland port of Bergen op Zoom. In addition, it is detected that many of the terminal activities are performed by equipment for the specific type of commodities, which is likely to result in a high terminal capacity. The exceptions are the two container terminals and the recycling terminal, which still transfers the cargo with help from mobile cranes on a general cargo quay.

Dependency on companies with port activities

With help from Figure 33 in appendix A, it can be seen that there are eleven companies located in the inland port area with port activities. These are: two container terminals, one dry bulk terminal, one liquid bulk terminal, one agro-bulk producer, four construction material producers, one recycling company and one producer of plastics. The number of port companies would normally be large enough to be invulnerable for the eventual departure of (a few) companies from the port area, but in this case about 75% of the bulk throughput are located at only two companies: SABIC Innovative Plastics BV and Cargill BV. When one of these two companies would leave, the throughput volumes will decrease sharply. The inland port is therefore considered to be very dependent (and thus vulnerable) to these two port companies.

Dependency on type of port activities

For the dependency of the inland port on the port activities, Figure 33 in appendix A and Table 20 are used. It can be seen that the a big diversity in inland port activities can be found in the port area. Apart from the energy production, all other selected port activities are taking place in this inland port area. The inland port of Bergen of Zoom is therefore not very dependent on a specific type of port activity. However, when you look at the areas, it can be found that more than half of the port area is occupied by the production of plastics (producer of other goods), while almost half of the throughput is generated by the agro-bulk production. Altogether, the diversity of the port activities is quite large, but around 75% of the bulk throughput is assigned to two types of port activities: agro-bulk production and the production of plastics. The inland port is therefore quite dependent on the demand for these two port activities.

Dimensions of port basins

The inland port includes one port basin, which is around 1,500 meters long and has an width of 60 meters. The access channel has an length of around 2,000 meters with a varying width between 40 and 150 meters. For both channels, the depth is equal to 5.50 meter. However, a lock is present between the port basin and the access channel. This lock has the following dimensions (l x w x d): 120 x 12 x 5.5 meters (Boer, 2018). In addition, there are no height restrictions in the inland port or access channel.
The CEMT-class of the main waterway is VIb, while inland vessels up to Class Va are allowed to enter the inland port (Rijkswaterstaat, 2013). This means that very large type of inland vessels is still able to reach the inland port of Bergen op Zoom, which is a strength for this inland port.

Hinterland size

The size of the hinterland is also important for the performance of the inland port. A large hinterland is likely to include more companies, related to transport. Therefore it is more likely that these companies use the inland port for the transport of their products. Bergen op Zoom is the only inland port for inland ports of Class Va and larger in the area. The closest inland port with similar inland vessel dimensions is located in Antwerp (at a distance of 20 kilometres). North of the inland port, there is even no inland port until Moerdijk (at 30 kilometres distance) (Google Maps, 2018). The inland port of Roosendaal is closer to Bergen op Zoom, but is located on a less preferred location with maximum CEMT-Class IV. The inland port is therefore considered to have a large hinterland, which is defined as a strength.

Operational time

The inland port companies are allowed to perform their activities between 06:00 and 22:00. The container terminals are an exception to this restriction, because they are allowed to operate 24/7. However, these container activities are restricted to a maximum noise level (Boer, 2018).
The operational time of the inland ports is also dependent on the extreme hydraulic conditions in the inland port. The port of Bergen op Zoom has an advantage over some other ports, because it is protected by the lock at the entrance of the port basin. The activities within the inland port can therefore always continue, although it may not be possible to enter and leave the inland port. This closure takes place for a maximum of two days per year. The overall operation time for this inland port is therefore considered to be quite large.

Potential area for future port activities

Along the inland port basin, there is still a lot of area available for port activities. In the southern bank at the entrance of the inland port there is still an empty area, which covers 33,750 m^2. At the end of the port basin, there is also a marina for recreational vessels, which covers around 10,150 m^2. When this space is required for inland port activities, this marina could be relocated to an area outside the inland port. In addition, there is also a lot of area along the port basin, which is occupied by companies without port activities. These companies could be replaced to other locations in the port area, which leaves space for the companies with port activities. This potential area is equal to 166,100 m^2, which cannot be enlarged due to the residential areas close to the inland port area. In total, 210,000 m^2 is left as potential area for port activities, which is around 20% of the current port area. The quay length could be increased with a maximum of 900 meters, which is equal to 50% of the current quay length. The inland port of Bergen op Zoom has still some area for expansion, but this mainly requires relocation of non-port-related companies.

Part 2: Determination of the port specific opportunities and threats

The second part of the method includes the determination of the projected impacts of the long-term developments on the port activities in Bergen op Zoom. These can be identified with help from trend-based narratives, which presents the projected port specific threats and opportunities for the specific inland port activities. These trend-based narratives can be generated by combining the identified trends and their determined generic impacts (see Table 7 in chapter 5) with the specific inland ports strengths and weaknesses (part 1 of the method). In this section, these port specific trend-based narratives for the inland port activities of Bergen op Zoom will be determined. These trend-based narratives exist of one main trend, while alternatives can be identified.

Narrative #1. Opportunity to increase the container throughput

Present container activities in the inland port

The inland port of Bergen op Zoom already facilitates two container terminals. These terminals cover 37,000 m^2 and one of these terminals has a quay length of 103 m. The other terminal uses the public quay to (un)load the terminals from the inland vessels. The combined transport of these two terminals is about 70,000 TEUs per year.

Projected future demand for container activities according to the narrative

The joint trends with regard to the container activities indicate that the container transport will continue to grow until 2050. The main reasons are the current increase in product demand in the Netherlands, the shift from the transport of raw materials towards finished products (which are mainly transported by containers) and the continuation of scale of container inland vessels. In addition, the container IWT can be improved significantly, therefore creating opportunities to increase the market share of the IWT. It is therefore considered that this port activity may create opportunities for the inland port.
However, there are also some trends which may limit the demand for container transport. The biggest threat is the projected stagnation (or even decrease) in product demand after 2030, therefore possibly limiting the increase in container throughput volumes from 2030. In addition, the introduction of 3D-printing is projected to reduce the total throughput volumes, but it is expected that this reduction will be very small until 2050. The more frequent extreme hydraulic conditions are projected to reduce the total operational time of the inland port, therefore potentially resulting in a decline of market share.
Overall, it is expected that the container throughput will increase until at least 2030. The increase is projected to decline afterwards because of the reduced product demand, but the total throughput volumes may still increase due to the increasing market share of the IWT.

Impact on the inland port of Bergen op Zoom

The increased demand for container transport requires a higher capacity for the transfer and storage of containers. For the inland port of Bergen op Zoom, this creates opportunities. The container terminals can be expanded (when there is free area next to the container terminals) or the internal terminal capacity may be increased in order to meet the future demand. As it is not expected that the infrastructure, equipment or activities of the container transfer and storage will change significantly in the future, this activity can be considered as an marginal opportunity for the inland port.

Narrative #2: Opportunity to increase the sand/gravel throughput (dry bulk)

Present dry bulk activities in the inland port

The inland port of Bergen op Zoom facilitates various dry bulk terminals, varying between agro-bulk, construction materials and a sand/gravel terminal. In this section, only the sand/gravel terminal will be presented, because the other terminals will be treated in the next narratives (as it also includes the production activities of cargo). The sand/gravel terminal covers an area of 20,125 m^2 with a quay length of 117 m. The throughput volume of this terminal is 125,086 tonnes per year.

Projected future demand for dry bulk activities according to the narrative

The joint trends with a relevance to the sand/gravel activities indicate that the demand for sand and gravel transport is projected to increase in the future. The main reason for this increase is the projected increased demand for sand and gravel with regard to the shortage of housing. At least until 2050, many houses and other constructions may be constructed. These constructions require a lot of sand and gravel, both for the stabilisation of the subsoil and the production of construction materials. The IWT is seen as the preferred transport mode for these sand and gravel materials, because the big scale of the inland vessels makes it possible to transport a large volume at once. This inland port activity is therefore expected to result in an opportunity for Bergen op Zoom.

On the other hand, some minor threats are identified, which may limit the opportunity. The more frequent extreme hydraulic conditions are projected to reduce the operational time of the port activities, because the transport capacity may be limited during high and low waters. As a result, the market share of the IWT may decrease and therefore also the demand for dry bulk activities in the inland port.

The decline in throughput volumes due to climate change is expected to be very small compared to the expected increase in demand. It is therefore expected that the sand/gravel throughput will increases until 2050, therefore creating an opportunity for the inland port of Bergen op Zoom.

Impact on the inland port of Bergen op Zoom

The increased demand for sand and gravel transport requires a higher capacity for the dry bulk capacities. This creates opportunities for the inland port of Bergen op Zoom, as it already contains one dry bulk terminal. This dry bulk terminal can be expanded (when there is free area next to the container terminals) or the internal terminal capacity may be increased in order to meet the future demand. As it is not expected that the infrastructure, equipment or activities of the dry bulk transfer and storage will change significantly in the future, this activity can be considered as a marginal opportunity for the inland port.

Narrative #3: Threat of decline in the transfer and storage throughput of oil products (liquid bulk)

Present liquid bulk activities in the inland port

The inland port of Bergen op Zoom facilitates two terminals with the transfer and storage activities of liquid bulks. The most important terminal using the liquid bulk transfer and storage activities, is the biggest terminal of the inland port (560,000 m^2). This is a producer of plastics and uses oil products as a supply material for these products. The other liquid bulk terminal is much smaller (14,500 m^2) and is used for the storage of oil products. In combined throughput of these terminals is approximately 670,000 tonnes per year, which is around 30% of the total bulk throughput volumes of the inland port.

Projected future demand for liquid bulk activities according to the narrative

The joint trends with regard to the liquid bulk activities indicate that the liquid bulk transport is likely to decrease until 2050. The main reason is the current transition from fossil fuels to (more) sustainable alternatives, thereby reducing the emissions of greenhouse gasses and other polluting gasses. The increasing awareness about the sustainability also results in the transition to sustainable raw materials, which cannot be depleted. The use of oil products in the society is therefore projected to be limited to a minimum, therefore reducing the transport of these oil products in the inland port. This port activity is therefore considered to become a threat for the inland port of Bergen op Zoom.

On the other hand, it also creates some minor opportunities. The introduction of sustainable fuels creates new potential port activities and can use the same facilities as the current liquid bulk products (after some adjustments). However, the throughput volumes for the sustainable fuels are not expected to be enough to counter the projected decrease, because the electrification is likely to reduce the total fuel demand.

Overall, it is expected that the liquid bulk throughput will decrease significantly until 2050, mainly because of the transition towards sustainable energy sources and raw materials.

Impact on the inland port of Bergen op Zoom

The decreased demand for liquid bulk transport makes the liquid bulk terminals not useful anymore for one of the port functions (transfer and storage of liquid bulk activities). These inland port activities are therefore not future-proof and create a big threat for the inland port of Bergen op Zoom. This narrative does not only expect a change in throughput volumes, but also in type of commodity, infrastructure and equipment. It is therefore considered as a major threat for the inland port of Bergen op Zoom.

Narrative #4: Opportunity to create a terminal for break-bulk, neo-bulk or special goods

Present transfer and storage activities for other cargo types in the inland port

There are no terminals in the inland port of Bergen op Zoom, which facilitates the storage of the remaining cargo types. On the other hand, one large public quay is located in the south-eastern part of the port area. With help from mobile cranes, this public quay can be used to (un)load all kinds of cargo, including break-bulk, neo-bulk and special cargo. The quay length is 240 meters long, but it does not provide a storage area for these cargo types.

Projected future demand for transfer and storage of other goods according to the narrative

The demand of transport of break-bulk, neo-bulk and other special cargo types is expected to increase slightly, mainly because of the introduction of 3D-printers. However, due to the smaller operational time due to climate change, the IWT in general may reduce in market share.

Impact on the inland port of Bergen op Zoom

The slightly increasing demand for the transfer and storage of other bulk types is not expected to have a big impact on the current port activity. The large public quay is likely to be sufficient for the future demand for transfer activities. Potentially, a small storage area could be constructed for these bulk types, but this is not necessary. Many of these bulk products will be directly transported to the destination and therefore not be stored on the quay. This port activity is therefore only expected to result in a minimal opportunity, in which hardly any changes in throughput volume are expected.

Narrative #5: Opportunity to increase the agro-bulk throughput and production

Present agro-bulk processing activities in the inland port

The inland port of Bergen op Zoom facilitates one big agro-bulk terminal, which is the terminal with the largest throughput volumes in the port (1,138,850 tonnage per year). This activity can be therefore considered as one of the most important port activities for this inland port. The terminal covers an area of 82,500 m^2 and a quay length of 335 m.

Projected future demand for agro-bulk activities according to the narrative

The combination of trends, related to agro-bulk activities, indicate that the demand for agro-bulk production and transport is projected to increase in the future. The increasing demand can be largely attributed to the increased demand for reliable Dutch agricultural products, because many foreign producers of agro-bulk products do not count as reliable. In addition, the domestic demand is also projected to increase, which is underlined in the trend to grow our food and other agro-bulk products locally. The agro-bulk activities are therefore considered as opportunities for the inland port.
However, the decreasing product demand in the Netherlands may reduce the domestic demand for these agro-bulk products. In addition, the international demand for the Dutch agro-bulk may decrease when the knowledge is used to process the agricultural products locally in the developing countries. Finally, the IWT may lose some of its market share due to the increased frequency of extreme hydraulic conditions.
Overall, it is expected that these threats will be large enough to counter the expected opportunities because of the increasing demand for agro-bulk, therefore creating an opportunity for the inland port of Bergen op Zoom.

Impact on the inland port of Bergen op Zoom

The increasing demand for agro-bulk activities (both transport and production) may require a higher capacity for the agro-bulk capacities. This creates opportunities for the inland port of Bergen op Zoom, as it already contains a big agro-bulk terminal. This increase in capacity can be achieved in two ways: expanding the terminal area (possible when there is free area next to the container terminals or constructing an new terminal area) or the internal terminal capacity may be increased in order to meet the future demand. As it is not expected that the infrastructure, equipment or activities of the transfer, storage and production of agro-bulk will change significantly in the future, this activity can be considered as an marginal opportunity for the inland port.

Narrative #6: Opportunity to create a hub for the construction materials production

Present construction material production in the inland port

The inland port of Bergen op Zoom facilitates four terminals for the production of construction materials. These four terminals cover a total area of 124,500 m^2, which is around 20% of the total port area. The total quay length for these terminals is around 550 meters, which is more than 30% of the total quay length in the inland port. The total throughput volumes of this port activity are equal to 468,361 tonnage, which is slightly less than 20% of the total bulk throughput of the inland port. This production of construction material can therefore be considered as one of the most important port activities.

Projected future demand for construction materials according to the narrative

The joint trends with regard to the production of construction materials creates a narrative, which shows that the throughput volumes of the production of construction materials may increase even more in the future. The main indicator is the increased demand for buildings and other construction materials. The shortage in housing is projected to reduce in until 2050, while the number of required building continues to grow due to smaller households.

The introduction of 3D-printing may result in an decrease in demand for the current construction materials, which are produced at special terminals (e.g. concrete plant, asphalt plant). The locally printed construction materials may be used for the construction of buildings and other constructions. However, the current 3D-printing is mainly used for the printing of small missing parts and is not developed yet to construct large constructions. The printed materials are therefore not likely to replace the conventional construction materials. Another small threat is the fact that the production of concrete and asphalt is a very polluting process. Due to sustainability reasons, it may be possible that process cannot be executed in this conventional way, therefore requiring cleaner techniques must be found. Fortunately, improvements have already been made to make this process more sustainable and this is likely to continue. In this narrative, it is expected that the impacts of these threats may not be large enough to reduce the expected increase in demand for the production of construction materials in 2050.

Impact on the inland port of Bergen op Zoom

The increasing demand for the production activities for construction materials (e.g. asphalt or concrete) may require a higher capacity for the current terminals. This projected increase in demand may create opportunities for the inland port of Bergen op Zoom, because it already includes four producers of these construction materials. These terminals can increase their throughput and production volumes in order to become more successful. However, it may be required to increase the terminal capacity by improving the internal capacity or by expanding the terminal into other areas of the inland port. However, the increase in demand is not expected to be very large and could be reduced by the minor threats for this port activity. Therefore, this port activity is only considered to create a minimal opportunity.

Narrative #7: Opportunity to introduce renewable energy production in the inland port

Present energy production in the inland port

There is no energy production activity in the inland port of Bergen op Zoom at the moment.

Projected future demand for energy production according to the narrative

For this inland port, it is only relevant to take the trends with opportunities into account for the identification of the trend-based narrative. The energy transition from the conventional fossil fuels into renewable energy sources is considered to be the main trend for this port activity. As there is no energy production activity in the current inland port, the inland port cannot be threatened by the negative impacts of this trend. On the other hand, the positive impacts could lead to the introduction of the new port activities in the inland port area, therefore creating an opportunity. For the inland port of Bergen op Zoom this opportunity may be created when the renewable energy production activity will be introduced in the port area, because an increase in the demand for this renewable energy production activities is projected.

Impact on the inland port of Bergen op Zoom

The renewable energy production is not yet located in the inland port of Bergen op Zoom. It is therefore required to use the free area in the inland port of Bergen op Zoom. However, there is not a lot of free area left in this inland port, making it unlikely that this potential opportunity could be translated into the introduction of a new port activity, resulting in a minimal opportunity for the inland port.

Narrative #8: Opportunity to create a recycling hub

Present recycling activities in the inland port

The inland port of Bergen op Zoom facilitates one recycling terminal. This recycling terminal collects scrap and then melts it into new metals, which can be used again for various purposes. The terminal covers an area of 23,100 m^2 and has a quay length of 138 meters. This quay does not provide facilities for the (un)loading activities, therefore using mobile cranes and cranes on the vessels itself. The total throughput of this recycling activity is equal to 18,826 tonnages per year.

Projected future demand for recycling activities according to the narrative

The joint trends with relevance to recycling activities indicate that the demand for recycling activities may increase in the future. The main reason for this increase is the societal demand to use as less raw materials as possible. In order to meet the product demand of the society, more materials have to be reused and recycled. The trend has already resulted in new recycling processes, which includes more types of materials, and also improves the recycling process itself. This trend is likely to continue, therefore leading to more demand for recycling processes and also more types of recycling activities. The recycling activities can be therefore considered as an opportunity for the inland port, also because the IWT is able to transport large quantities of scrap and waste in only one inland vessel.

Two minor threats have been identified, which may limit the opportunities of these recycling activities in the inland port. These minor threats are the potential decline in IWT due to climate change (more frequent extreme hydraulic conditions) and the expected decline in product demand after 2030 (although this is not likely to hold for products with recycled materials).

Overall, an increase in the demand for recycling activities is projected.

Impact on the inland port of Bergen op Zoom

The projected increase in demand for recycling activities requires a higher capacity than the current capacity in the inland port of Bergen op Zoom. The capacity of the terminal can be increased by optimising the internal port activity, which includes the capacity of the quay handling and terminal equipment. The other option is to expand the recycling terminal area and thereby increasing its recycling capacity. In addition, the inland port could create new recycling terminals, which could recycle other type of materials and therefore creating a recycling hub in the inland port of Bergen op Zoom. Overall, this inland port activity is expected to create a major opportunity, because this is expected to influence both the inland port throughput volumes, type of commodities and the port equipment.

Narrative #9: Threat of decline in the demand for plastics

Present industrial production of other cargo types in the inland port

The inland port of Bergen op Zoom facilitates one very large terminal for the production of other products. In this particular case, it is a production location of plastics. This production area covers a total area of 560,000 m^2, which is around 60% of the total port area. The total quay length for this terminal is around 250 meters, presenting only two berths for the (un)loading of oil products, which serves as a supply material for the production of plastics. This (un)loading takes place by a system with pipelines and transferred 646,252 tonnages in 2016. This is equal to 25% of the total throughput volumes of the total port activity. The production of plastics can be therefore considered as (one of) the most important port activities in the inland port of Bergen op Zoom.

Projected future demand for the production of plastics according to the narrative

The combination of identified trends with relevance for the production of plastics indicates that the demand for this activity will decrease significantly in the future. The main reason of this decrease lays in the societal demand to use sustainable materials instead of oil products, which is the main raw material of plastics. It is therefore expected that this plastics production is under big threat and may even leave the inland port area, therefore likely to create a very big threat for the inland port of Bergen op Zoom. There are also some other trends, which may influence the future demand for this type of activity. The negative influences are caused by the projected decrease in product demand, potential relocation of industrial processes and the potential decline of market share for IWT due to the climate change.
Overall, it is expected that the demand for this port activity will be decreased significantly in 2050, mainly because of the oil products as supply material for the production of plastics

Impact on the inland port of Bergen op Zoom

The projected decreasing demand for the production of plastics may result in the departure of these inland port activities from the inland port area, because the company may not make enough money to remain successful. In addition, the inland port activity does not become useful anymore, because there might be no demand for plastics anymore. Even when this inland port activity remains in the port area, then changes in the type of commodities are expected, because the oil products will then likely be replaced by more sustainable materials for the production of plastics. Because of this decreased demand for plastic products, the very large terminal area may also be reduced significantly. This port activity is therefore considered as a major threat for the inland port.

Projected impacts of the narratives

In Table 21, an overview of the trend-based narratives and their related impact is presented per port activity in Bergen op Zoom. For many of the current port activities, it is projected that they could create opportunities for this specific inland port. Only two of the current port activities are projected to be threatened. It is therefore likely that the inland port can be considered as future-proof for the inland port, when you only look at the number of opportunities in relation to the number of threats.

	Port activity	**Trend-based narrative**	**Projected impact**
1	Container transfer and storage	Opportunity to increase the container throughput	Marginal opportunity
2	Dry bulk transfer and storage	Opportunity to increase the sand/gravel throughput (dry bulk)	Marginal opportunity
3	Liquid bulk transfer and storage	Threat of decline in the transfer and storage throughput of oil products (liquid bulk)	Major threat
4	Transfer and storage of remaining cargo types	Opportunity to create a terminal for break-bulk, neo-bulk or special goods	Minimal opportunity
5	Agro-bulk production	Opportunity to increase the agro-bulk throughput and production	Marginal opportunity
6	Construction materials production	Opportunity to create a hub for the construction materials production	Minimal opportunity
7	Energy production	Opportunity to introduce renewable energy production in the inland port	Minimal opportunity
8	Recycling activities	Opportunity to create a recycling hub	Major opportunity
9	Plastics production	Threat of decline in the demand for plastics	Major threat

Table 21: Overview of the identified narratives and the projected impact per port activity for the inland port of Bergen op Zoom

The number of port activities with projected opportunities in relation to the number of threats does not give a good representation of the actual projected impacts on the inland port. It is therefore required to obtain additional insights in these impacts for the inland port of Bergen op Zoom. This additional insight can be identified by taking the port characteristics into account. In this way, the projected impacts can be presented in relation to the total inland port, for example by calculating the share of threatened port activities in relation to the total port area, quay length and bulk throughput volumes. For the inland port of Bergen op Zoom, this has been presented in Figure 36. The green colours represent the port activities with opportunities, while the red colours represent the port activities, which are projected to be threatened. The darker the red and green parts, the larger the projected impacts of the threats and opportunities respectively.

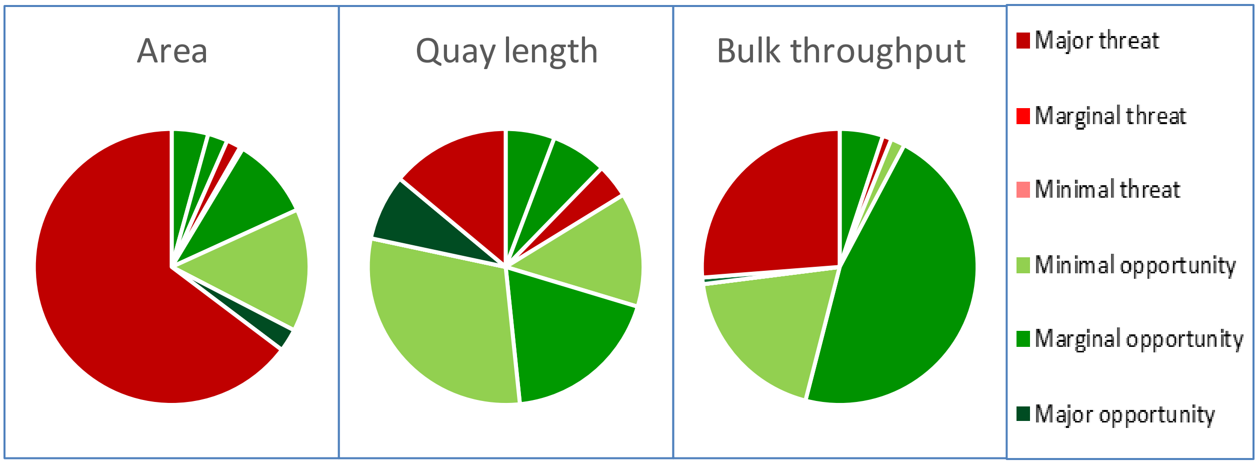


Figure 36: The share of port activities with opportunities (green) or threats (red) in the inland port of Bergen op Zoom with relation to the total port area, total quay length and total throughput volumes in the port

From the identification of the impacts of the trend based-narratives on the port activities, it seemed like the inland port of Bergen op Zoom was hardly affected by any threats. Figure 36 shows a different outcome as more than 65% of the total port area along the inland port basin is occupied by port activities, which are projected to be threatened up to 2050. The share of the quay length of these threatened activities is relatively low (20%) compared to the share for the port area, because the producer of plastics has only one berth. The share of throughput volumes of the threatened port activities is about 25% of the total bulk throughput, mainly because of the relatively high throughput volumes of the agro-bulk terminals.

Overall, the share of threatened port activities is relatively high in relation to the total port. In order to become a future-proof inland port, the inland port of Bergen op Zoom requires a lot of measures to reduce the projected threats. In addition, it must retain the port activities with future prospects in the inland port and try to attract new port activities into the inland port area. In this way, the inland port may become future-proof.

Part 3: Determination of the flexibility of the inland ports

The third part of the method is used to determine the flexibility of the inland port. The flexibility of the inland port represents the degree, in which the inland port can adapt to the future demand for port activities. This adaptability cannot be measured directly, but two different approaches will be measured: the potential reduction of negative impacts by replacing them with new port activities and the potential to increase the capacities of current activities (by converting the opportunities into new port activities at new terminal areas). The higher the potential to reduce its negative impacts and the more likely that the capacity of new activities can be increased, the more flexible the inland port may be.

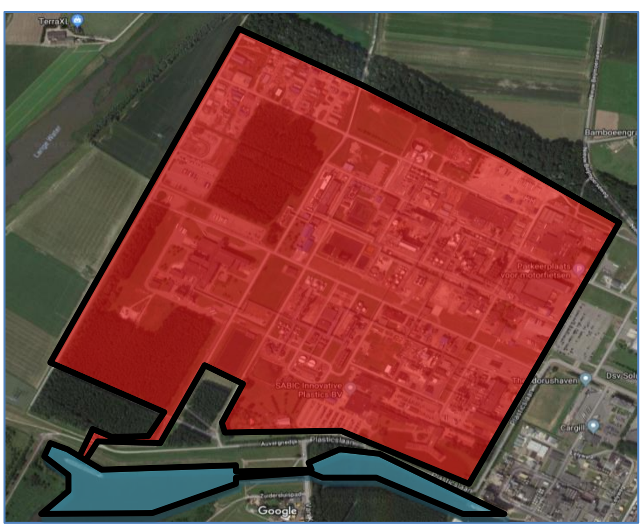
Analysis of the current port infrastructure of the threatened port activities for new port activities

The current infrastructure of the projected threatened port activities has to be analysed in order to determine whether this infrastructure can be used for the new port activities. In this way, it can be determined whether the inland port could reduce its threats (and thus remain useful and successful in the future). The two terminals with threatened port activities will be treated separately in this section.

SABIC Innovative Plastics B.V.

The surface of this company is equal to 65% of the current port area (50% when all potential port area is taken into account). This company produces high-quality plastics, which is currently being manufactured with non-sustainable raw materials: oil products. This non-sustainable method of production of plastics will possibly disappear, as a result of which these port activities will no longer be successful.

The terminal is located at the north-western part of the inland port (even outside the port basin) (see Figure 37). The big terminal has only one jetty, at which the inland vessels can be (un)loaded. This jetty uses a pumping system and pipelines to (un)load the liquid bulk from/to the inland vessels. Furthermore, the liquid bulk is further transported towards the storage or production areas by a very extensive network of pipelines, which cover the entire terminal area. The terminal itself is located behind the flood protection, which makes it safe for extreme hydraulic conditions. However, the jetty is not protected for extreme water levels, because it has been located outside the flood protection. The main characteristics of this terminal are presented in Figure 37.



SABIC Innovative Plastics B.V.	
Area	560,000 m²
Quay length	250 m
Current throughput	646,252 tonnage
Current activities	Liquid bulk transfer & storage Production of plastics
Current cargo type	Liquid oil products and chemicals
Quay equipment	Pumping system
Terminal equipment	Pipelines
Storage equipment	Storage tanks

Figure 37: Location of SABIC Innovative Plastics B.V. and its terminal characteristics

The infrastructure of this inland terminal (containing an extensive network of pipeline connections) is specified for production activities with liquid bulk products (both transfer and storage). Fortunately, a few trend-based narratives project an increase in demand for some of the other liquid bulk transfer and storage activities. These trend-narratives are:

- Opportunity to increase the agro-bulk production throughput and production
- Opportunity to introduce renewable energy production activities
- Opportunity to transform the current plastics production into bio-based plastics production

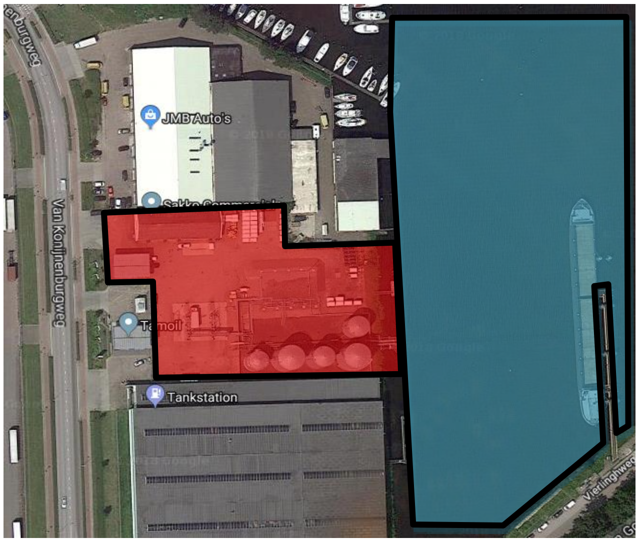
Trend-based narratives project that the demand for three activities with regard to liquid bulk may increase, which may result in the fact that the threatened port activity will be replaced by a new liquid bulk terminal in this specific inland port. It is most likely that SABIC B.V. remains at this inland port, but changes the production process in order to remain successful. In these cases the oil products have to be replaced by bio-based products, which can be also supplied as liquid bulk products. In this case, the current port infrastructure can still be used for the production of plastics, which reduces the projected negative impacts of the non-sustainable production activities for plastics. The production of renewable energy is less likely to be introduced in the inland port, because this terminal does not have the infrastructure for these port activities. The increase of agro-bulk throughput is also possible, because the current inland port infrastructure matches the requirements for agro-bulk storage and transfer activities.

It is expected that the negative impacts of the threatened liquid bulk terminal will be reduced by adapting the current production processes to a sustainable production of plastics.

Sakko Commercial B.V.

The surface of this threatened company is much smaller than SABIC Innovative Plastics B.V., because it covers less than 2% of the current port area. This terminal is currently used to transfer and store oil products, which are then further distributed to the hinterland by trucks. However, the demand for oil products is projected to decline, which is likely to result in a less successful port terminal.

The terminal is located at the south-eastern part of the inland port and is located on the western bank of the port basin (see Figure 38). The terminal has one jetty, at which the inland vessels can be (un)loaded. This jetty uses a pumping system and pipelines to (un)load the liquid bulk from/to the inland vessels. Furthermore, the liquid bulk is further transported by a pipeline towards the storage, which are represented by five big tanks. The main characteristics of this terminal are presented in Figure 38.



Sakko Commercial B.V.	
Area	14,500 m^2
Quay length	71 m
Current throughput	25,820 tonnage
Current activities	Liquid bulk transfer & storage
Current cargo type	Liquid oil products
Quay equipment	Pumping system
Terminal equipment	Pipelines
Storage equipment	Storage tanks

Figure 38: Location of Sakko Commercial B.V. and its terminal characteristics

The infrastructure of this inland terminal is specified for the transfer and storage of liquid bulk cargo. Fortunately, the following trend-based narratives have been identified, which project an increase in demand for liquid bulk activities:

- Opportunity to increase the agro-bulk production throughput and production
- Opportunity to introduce renewable energy production activities
- Opportunity to transfer the storage and transfer for oil products into sustainable oil products.

These three trend-based narratives may result in the replacement of the current transfer and storage of oil products. However, the small surface makes this terminal not suitable for the production of renewable energy. This port activity can therefore not be executed at this terminal. With some investments, it may be possible to facilitate an agro-bulk terminal at this location, but this requires new storages. It is more likely that the current infrastructure will be used to facilitate the transfer and storage of sustainable fuels. Overall, the negative impact of this terminal is likely to be compensated by the potential new port activities for this terminal area.

Analysis of the potential to expand the capacities of the port activities

The potential to expand the capacity of the port activities can be measured in two different ways: by increasing the internal terminal capacity and by expanding the terminal area for the specific port activities. This section looks at these two aspects to determine whether there are still opportunities to expand port capacity for the Bergen op Zoom port.

Internal terminal capacity

The inland port of Bergen op Zoom mainly uses equipment, which is required for the type of commodity to be transferred. The transfer capacities at these terminals can therefore not be optimised significantly. For the (un)loading process of containers, only mobile cranes and reach stackers are used. This quay capacity can therefore be improved by using specialised quay equipment for containers.

At the terminals itself, an efficient and effective system is in place for the storage and transport of the cargo. Some examples of this system includes the use of reach stackers at the container terminal, the pipelines for the transport of liquid bulk and the use of conveyor belts to transport the sand and gravel (see Figure 39). The use of these efficient and effective methods and equipment for storage and (internal) transport in terminals ensures that the internal capacity of the current terminals cannot be increased.

Figure 39: Transport system at the liquid bulk berth (left) and the asphalt plant (right)

Possibility to increase the area for port activities

The other possibility to increase the capacities of the inland port (in order to meet the increasing demand) can be reached by expanding the area with port activities. This potential area for port activities also presents whether it is possible to facilitate new port activities in the inland port. In order to determine the options for expanding the port activities, a distinction has been made between free areas and areas, which are currently used by companies without any port-related activities. These free areas can be bought and then be used to construct terminal facilities. The existing company has to be relocated to another location when the port wants to use the areas with companies without port activities, which may take a long time. Free area along the port basin is therefore preferred over the other potential areas in order to increase the terminal capacity.

The free areas and areas with non-port activities in the inland port of Bergen op Zoom have been identified (Boer, 2018; Google Maps, 2018), which is presented in Figure 40. The black area represents the free area, while the brown areas represent the port area without port activities.

Figure 40: Location of the free areas (black) and the areas without port activities (brown) in the port of Bergen op Zoom

The free area can be used to construct a new port terminal, which could be used for both new activities (e.g. renewable energy production) or port activities with projected opportunities (e.g. sand/gravel terminal, agro-bulk production). The other terminals can only be expanded when the companies without port activities are relocated from the areas along the port basin. For many of the different terminals in this port, only the last option can be used to expand the terminal area, therefore reducing the possibilities to expand.

In order to present the overall flexibility of the inland port, the share of the potential port areas is presented in relation to the total port area along the port basin and the total quay length (see Figure 41). The blue colour represents the area or quay length, which is currently used for the port activities. The grey parts represents the share of free area and its quay length, while the brown parts represents the area and quay length along the port basin that is used by companies without port activities.

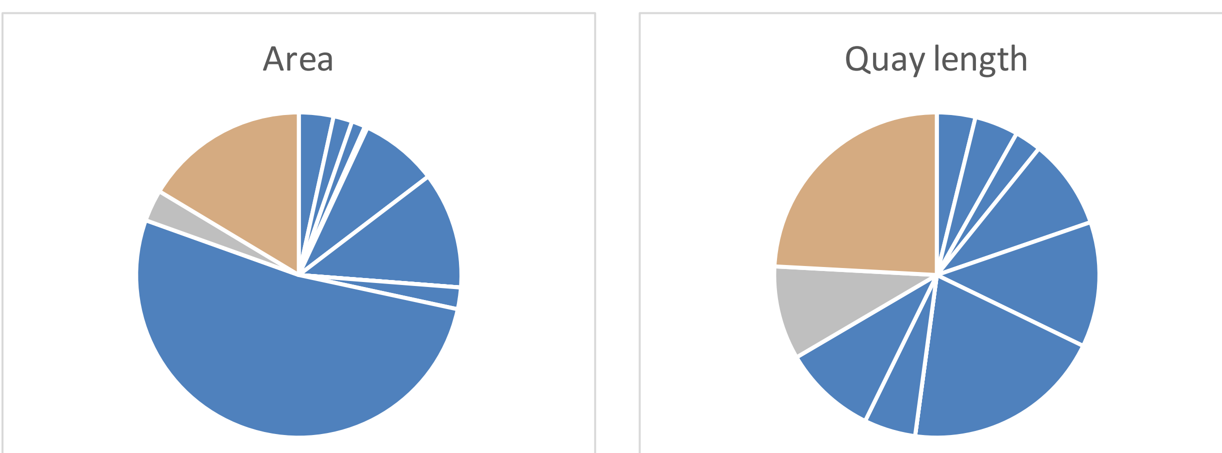


Figure 41: Potential area and quay length in Bergen op Zoom (blue = current use, grey = free area, brown = currently used by non-port activities)

Figure 41 shows that almost 20% of the total inland port area is not used for inland port activities. This area (around 200,000 m^2) could be potentially used to increase the capacity of the various inland port activities. Unfortunately, around 75% of this potential port area is directed to areas with non-port companies. These companies have to be relocated in order to use these as inland port terminals, which could take many years and can there be considered as a difficult process. Only 5% of the total port area can immediately be used for port activities. It can be therefore concluded that the capacity of the inland port is already near the maximum capacity.

The potential increase in quay length could be up to 900 meters, which is around 35% of the total length along the port basin. Around 10% of this total quay length is freely available as this is located at the free areas. The other 25% of the potential quay length is located at the areas, which facilitates the companies without any port activities. It can be therefore concluded that the quay length could still be increased. In this way, the transfer capacity may be increased.

Overall flexibility of the inland port of Bergen op Zoom

The overall flexibility of the inland port of Bergen op Zoom is considered to be sufficie nt to compensate for the negative impacts (identified in part 2 of the method). In the first place, the threatened port activities are likely to be replaced by other inland port activities, because the current port infrastructure are considered to match the port activities with projected opportunities. The conventional production method of plastics is likely to be transformed into a sustainable production method (bio-based plastics), while the oil terminal is likely to be replaced by a terminal for sustainable oils or liquid agro-bulk. In this way, these terminals (and thus the inland port) remains useful. On the other hand, the other opportunities cannot be converted into new port activities, because there are hardly any possibilities to increase the port capacity. The main reason is the already high internal capacities in the inland port and the little area to increase the terminal area.

Furthermore, the port characteristics suggest that the inland port of Bergen op Zoom is very dependent on the two terminals and two port activities: the agro-bulk production and the production of plastics (see results part 1). The inland port is therefore not considered to be very diverse, which is not preferred for a high flexibility. By becoming less dependent on these port activities, the inland port may become more flexible.

Part 4: Assessment of the future-proofness of the inland port of Bergen op Zoom

The strengths, weaknesses, opportunities and threats for the inland port are known, which can be included in a SWOT-analysis. In addition, the flexibility for the inland port is included in the SWOT-analysis to present whether the inland port can convert these opportunities into more port activities. The combination of the strengths, weaknesses, opportunities, threats is used to present a first insight whether it is likely that the inland port remains successful and useful in the changing conditions up to 2050. This SWOT-analysis therefore serves as a first step to determine whether the inland port can be considered as a future-proof.

SWOT-analysis

The SWOT-analysis (see Figure 42) presents an overview of the identified strengths, weaknesses, opportunities and threats of the inland port of Bergen op Zoom. This gives a first impression of the future-proofness of the inland port.

Strengths

- CEMT-class Va
- Diversity in port activities and companies
- Good road & inland navigation accessibility
- Large hinterland area
- Large operational time
- Large throughput volumes and quay length
- Many inland port terminals

Weaknesses

- Bad connection to rail network
- Little free area in the inland port
- Low capacities due to use of general equipment
- Many companies without port activities along port basin
- Very dependent on agro-bulk activity (Cargill BV) and production of plastics (SABIC Plastics BV)

Opportunities

Activities concerning:

- Container transfer and storage (*marginal*)
- Sand and gravel transfer and storage (*marginal*)
- Transfer of remaining types of cargo (*minimal*)
- Agro-bulk transfer and processing (*marginal*)
- Production of concrete and asphalt (*minimal*)
- Recycling activities (*major*)

Threats

- Max. capacity may be reached due to limited potential area for new port activities
- Max. internal terminal capacities may be reached due to use of advanced equipment

Activities concerning:

- Transfer and storage of oil products (*major*)
- Production of plastics (*major*)

Figure 42: SWOT-analysis for inland port of Bergen op Zoom

The port specific information about the port characteristics, the projected impacts and the flexibility are collected in the presented SWOT-analysis. This means that it is possible to assess the future-proofness of the inland port of Bergen op Zoom.

The inland port can be considered as future-proof when the inland port remains useful and successful for the execution of the port functions, while being flexible enough in port services and infrastructure to deal with potential changes (see the definition in chapter 2). First, the projected usefulness and successfulness of the inland port needs to be determined. Thereafter, the general result of the future-proofness of the case study port will be determined according to the combination of the answers, which is defined in Table 4.

Usefulness

The port can be considered as useful when there are sufficient port activities to use the port area and infrastructure in a useful way in order to perform the primary functions of the inland port. This can only be achieved when the inland port provides sufficient services and infrastructure to perform these main functions.

The inland port of Bergen op Zoom contains numerous inland port activities. For the majority of these inland port activities, it is projected that the demand increases until 2050. It is found that the demand for the container terminals, sand and gravel terminal and the recycling terminal may increase substantially. These terminals therefore require an increase in the terminal capacity, which can only be achieved by increasing the internal capacity or by expanding the terminal area. For the container terminals, the internal capacity can be improved by using dedicated container cranes at the quay instead of the current mobile cranes. This improvement seems not sufficient to meet the future demand, which also holds for the sand/gravel terminal and the recycling terminal. For these inland port activities, free areas can be used to expand its terminal activities, but this free area is limited.

Furthermore, a small increase in the capacity of agro-bulk terminals and the production areas for construction materials is required, which can be achieved by an internal increase of the capacity. By improving the transfer, storage and production processes at these terminals, the capacity is projected to be sufficiently increased to meet the future demand. It is therefore not required to increase the terminal areas for these terminals.

However, the demand for the liquid bulk terminal and the production of plastics is projected to decrease substantially. There is a risk that these two companies may leave the port area, which makes the inland port less useful (and thus less future-proof). Fortunately, there are several port activities with the same port infrastructure, which can be attracted to replace these threatened port activities (such as the transfer and storage of renewable fuels and the production of bio-based plastics).

Overall, the usefulness of the inland port faces some challenges, which is mainly based on the risk of the departure of the production of plastics (which is the most dominant port activity in the inland port).

Successfulness

The inland port of Bergen op Zoom can be considered as successful when the inland port activities remain effective and efficient on the long-term, so that the port activity can continue to exist in the inland port area (on condition that it remains useful). For the inland port activities, the effectiveness can be defined as the state at which the inland port is able to address a certain demand, while the efficiency is the extent at which the activities can be conducted with a minimum wasted effort.

For most of the present activities in the inland port of Bergen op Zoom, it is expected that they remain successful in the inland port. These port activities are therefore expected to remain in the inland port until at least 2050. The efficiency and effectiveness of the inland port of Bergen op Zoom can still be improved by increasing the port capacity for the internal processes. For the container storage and transfer activities, the transfer process can be improved by using more advanced quay equipment, specified for container transfer activities. The other terminals do already use the advanced types of storage and transfer equipment, resulting in an efficient an effective port activity. It becomes therefore more attractive for companies to use the inland port for their inland waterway transport.

However, the successfulness for some of the inland port activities in Bergen op Zoom is under threat. The biggest contributor to this threat is the anticipated reduced demand for plastics, which is produced in the largest company in the inland port area. This company occupies more than 65% of the current port area with access to the port basin. The projected decrease in demand may result in a significant decrease in total cargo volumes in the inland port. This port activity is therefore not likely to remain successful as the inland port company may not sustain in the inland port.
In addition to the production of plastics, the inland port also contains a liquid bulk terminal, which transfers and stores oil products. This terminal will also not be considered as successful in 2050, because the demand for these inland port activities is projected to decrease.
Overall, it is considered that the inland port remains quite successful, because the majority of the port activities are projected to result in an opportunity. On the other hand, there is a risk that some port activities leave the inland port. Furthermore, the successfulness cannot be improved, because the current port area cannot be expanded.

Future-proofness

In this last step, the future-proofness of the inland port of Bergen op Zoom is determined. The general guideline from Table 4 is used to determine this future-proofness, for which the following questions have to be answered:

1. Is it projected that the inland port activities in the inland port are hardly threatened?
2. Are there sufficient opportunities to compensate for the anticipated threats?
3. Does the existing infrastructure match the infrastructure needed for these identified opportunities?

The first question cannot be answered positively, because two port activities are projected to be threatened. One of these port activities is the dominant port activity for the inland port, which makes this inland port vulnerable for a decline in demand for plastics. The risks of becoming less useful and successful are therefore relatively large.
The second question can be answered positively. Although there are hardly any opportunities to increase the port activities by the absence of free port areas, there are sufficient port activities with opportunities. These port activities are likely to be sufficient for the inland port to compensate for the anticipated threats.
The third question can also be answered positively. For this inland port, the threatened port activities are related to liquid bulk transfer and storage or the production of plastics. The latter production process may be replaced by bio-based production of plastics, for which the same port infrastructure can be used. The oil products can be replaced by sustainable fuels or liquid agro-bulk products.

According to the general guideline in Table 4, the inland port can still be considered as future-proof (see Table 22). The biggest threat to the future-proofness is the anticipated decline in demand for the current plastics and oil products. Fortunately, these large threat can be compensated by new port activities, which make use of the same port infrastructure as the current port infrastructure.

Question 1	Question 2	Question 3	Total
-	+	+	**Future-proof**

Table 22: Overview of the future-proofness of the inland port of Bergen op Zoom

Appendix C: Case study 2 (Oosterhout)

This appendix contains the assessment of the future-proofness of the inland port of Oosterhout, which is case study 2. The appendix is structured in the same way as the previous appendix, which is according to the four different parts of the method.

Part 1: Determination of the current inland ports strengths and weaknesses

The first part of the overall method contains the qualitative assessment of the current inland ports strengths and weaknesses. When available, quantitative information can be used in order to support this determination. With help from the identified port indicators, the port characteristics can be determined for the inland port of Oosterhout. These port characteristics can then be used to determine which inland port activities could be potentially affected by the plausible trends.

Accessibility

The considered inland port of Oosterhout (Weststad/Statendam) is located on the north-western part of the city. The port basin has an open connection to the Amer, which is part of the Bergsche Maas. This main waterway can be reached by the Amertak, which is around 5 kilometres long. In addition, the Donge could also serve as an access to the inland port, although the distance is larger (around 7.kilometres) and it crosses the city of Geertruidenberg. Further into the hinterland, the inland port is connected to both Tilburg (Wilhelminakanaal) and Breda (Markkanaal), but the inland vessel dimensions are limited for these inland waterways.

Furthermore, the port is located close to two different motorways, which are located on the northern and eastern edge of the inland port area. These are the A59, connecting the port to the areas in the direction of Waalwijk and Den Bosch, while the A27 connects the port with the areas in the direction of Utrecht and Breda. The access to motorway A59 is about 3 kilometres (± 4 minutes), while the A27 can also be reached within 3 kilometres (± 3 minutes) (Google Maps, 2018).

The inland port of Oosterhout still maintains a rail connection, which is used frequently (approximately once per week). As one of the only inland port in the Netherlands, it has a location at which inland vessels with CEMT-class Va (Rijkswaterstaat, 2013) and a railway are connected at the same (public) quay, which is located at the western end of the Insteekhaven. The rail connection is connected to the national rail network at Zevenbergschen Hoek (about 16 kilometres form the inland port), at which the train can go in the direction of Breda or Rotterdam.

The fact that all three transport modalities are well connected to the inland port of Oosterhout, makes this inland port very attractive for port activities. It is therefore considered that the accessibility can be considered as an inland port strength.

Capacities of the various inland port activities

As can be seen in Figure 34 in appendix A, the inland port of Oosterhout contains a lot of different port activities. It contains one agro-bulk producer (producing compound feed) and four concrete plants, at which dry bulk transfer activities are performed. In addition, there also two terminals in the inland ports, which are dedicated to transfer and storage of sand and gravel (dry bulk). There are also three inland port terminals, which are used for the transfer, storage and machining of steel products. Finally, one container terminal can be found, which uses gantry cranes for the container transfer activities and stores the containers on the terminal area.

The capacities of the terminals for the various port activities are not known. It is therefore decided to use the same sub-optimal data as for the previous case study: terminal areas, quay lengths and the throughput data of 2011, which have been achieved by using Google Maps, Havenatlas Midden-Brabant (2014) and correspondence with H. Klerks (Policy officer urban development / economy for the municipally of Oosterhout) and A. Rietveld (Director Oosterhout Container Terminal B.V.) (2018).

Port activity	**Area**	**Quay length**	**Throughput volumes**
Container terminal	30,000 m^2	330 m	170,000 TEUs
Dry bulk terminal	100,000 m^2	360 m	261,000 tonnage
Liquid bulk terminal	-	-	-
Terminal for remaining cargo	-	-	-
Agro-bulk producer	24,000 m^2	120 m	158,541 tonnage
Construction mat. producer	983,000 m^2	970 m	1,016,329 tonnage
Energy producer	-	-	-
Recycling company	-	-	-
Remaining industrial producer	140,000 m^2	470 m	285,000 tonnage
Total	**1,277,000 m^2**	**2,250 m**	**1,720,870 tonnage + 170,000 TEU**

Table 23: Sub-optimal data about the capacity of the inland port activities in Oosterhout

From this data, is can be concluded that the area of the inland port of Oosterhout is relatively large. The configuration of the port basins results in a large quay lengths at which the transfer activities take place. The total throughput volumes are presented in the last column, which has to be the minimum capacity of the inland port of Oosterhout. The amount of throughput is quite large, especially for the container throughput and for the production of the construction materials. In addition, it is identified that many of the terminal activities are performed by equipment for the specific type of commodities, which is likely to result in a high transfer capacity. The exceptions are the small sand and gravel terminal and the public quay, which are both located at the western end of the Insteekhaven. At these two terminals, mobile cranes or cranes on the inland vessels have to be used.

Dependency on companies with port activities

With help from Figure 34 in appendix A, it can be seen that there are twelve terminals located in the inland port area with different port activities: One container terminal, two dry bulk terminals, one agro-bulk production company, five concrete plants and three companies involved in the machining of steel products. Two of these terminals belong to the same company: Koninklijke HH Martens en Zonen BV. These are two concrete plants and storage areas with a combined area of 800,000 m^2, which is more than 60% of the current area with port activities. In throughput rates, these companies transfer around 25% of the total bulk throughput.

The number of different port companies (eleven) would normally be large enough to be quite invulnerable for the eventual departure of (a few) companies from the port area, but in this case about 25% of the bulk throughput is transferred at only one terminal. In land use, the inland port is even more dependent on this company. When this company would leave the inland port of Oosterhout, the throughput volumes will drop significantly.

Dependency on type of port activities

The inland port is mainly dependent on the production of concrete and the transfer and storage of containers (see Figure 34 in appendix A and Table 23). More than 75% of the current port area is used for the production of concrete. In quay length, slightly less than 45% of the total quay length is located in the terminals for the construction material production. The throughput volumes are also dominated by the concrete plants, while the container throughput is also very high.

Furthermore, it can be seen that only three other activities are performed at the inland port: the transfer of sand and gravel at the dry bulk terminals, the transfer of dry bulk at the agro-bulk production terminal and the transfer, storage and machining of steel products in three different terminals.

The total of five different port activities is not very high, making the inland port of Oosterhout quite vulnerable to fluctuations in the demand for these port activities, in particular the demand for container transport and construction material production.

Dimensions of port basins

The inland port is located along the Amertak / Wilheminakanaal. About 2 kilometres of this inland waterway is used for port activities in the inland port. The Insteekhaven is constructed to enlarge the inland port, with a total length of 1300 meters. The minimal width of the Wilhelminakanaal and the Insteekkanaal is 45 metres, while the depth is kept at minimal 5.00 meters. This is conform the CEMT-guidelines for class Va.

In order to reach Breda or Tilburg, a lock should be passed. These inland waterways can only be used by smaller inland vessels: Class IV and Class II to Breda (Markkanaal) and Tilburg (Wilhelminakanaal) respectively (Rijkswaterstaat, 2013). The CEMT-class of the main waterway is equal to Class VIc on the Amer and Class VI on the Bergsche Maas.

Overall, it can be concluded that very large type of inland vessels are still able to reach the inland port of Oosterhout, which can be considered as a strength for this port.

Hinterland size

The size of the hinterland for the inland port of Oosterhout is relatively large. This inland port is the only inland port able to handle inland vessels with CEMT-class Va in the centre of Noord-Brabant. The surrounding inland ports (e.g. Breda, Tilburg and Waalwijk) are not able to facilitate these inland vessels. The closest inland port, which is able to facilitate the port activities for at least the same type of inland vessels, is Moerdijk on the West (approximately 20 kilometres away from Oosterhout (Google Maps, 2018)). The good accessibility would also help to increase this hinterland size and therefore result in potentially more companies to use the inland port for their transport activities.

Overall, the inland port is considered to have a large hinterland. This is considered as a strength, because it may attract a lot of companies from the surrounding area to use the inland port of Oosterhout for activities in order to make use of the IWT.

Operational time

The inland port companies have no restrictions in operational time. It is allowed to perform all port activities during 24 hours during all days (Klerks & Rietveld, 2018). This large operational time makes it attractive to use the inland port for the transfer, storage and industrial production activities.

The hydraulic conditions in the inland port of Oosterhout are equal to the hydraulic conditions of the Bergsche Maas. For the Maas, the water level can be stated as extreme condition when the water level has exceeded 280 cm above NAP or has become lower than 50 cm below NAP. These conditions take place only once in 1,000 years, which makes the downtime of the inland port due to the extreme hydraulic conditions extreme small. However, the capacity of the inland vessels would already drop in less extreme conditions. Altogether, it can be stated that the operational time of this inland port is very large and is therefore considered to be a strength.

Potential area for future port activities

Along the inland port basin, there is still a lot of area available for port activities, in particular at the northern bank of the Insteekhaven (177,800 m^2 with a potential quay length of 810 m). The southern bank is used by more port-related companies, but there is still some room left (43,200 m^2 with a potential quay length of 160 m). Finally, the eastern bank of the Amertak/Wilhelmina kanaal also provides some space for port activities (70,200 m^2 with a potential quay length of 475 m). This makes a total of 231,200 m^2 for potential port activities and a potential quay length of 1445 m, which is equal to 20% of the current port area and 65% of the current used quay length. The fact that the port area and in particular the quay length can be increased quite easily is considered to be a strength of the inland port, although it is not possible to enlarge the inland port due to residential areas around the inland port.

Part 2: Determination of the port specific opportunities and threats

The second part of the method is the determination of the projected impacts of the long-term developments on the port activities in Oosterhout. These can be identified in the same way as for Bergen op Zoom. It is therefore required to determine trend-based narratives for the various port activities, which presents the projected port specific threats and opportunities. These trend-based narratives are generated by combining the identified trends and the determined generic impacts (see Table 7 in chapter 5) with the specific inland ports strengths and weaknesses (part 1 of the method). These trend-based narratives exist of one main trend, while alternatives can be identified. The port specific trend-based narratives for the inland port activities of Oosterhout will be determined in this section. With help from these trend-based narratives, the impacts of these plausible developments can be determined for the port activities.

Narrative #1. Opportunity to increase the container throughput

Present container activities in the inland port

The inland port of Oosterhout already facilitates one container terminal with a high throughput (170,000 TEUs per year). This terminal covers 30,000 m^2 and has a quay length of 330 m. Over this quay length no less than three gantry cranes have been constructed, so that the containers can be (un)loaded very quickly. Other advanced container equipment is used to store the containers in the terminal area in an efficient way. In this way, the terminal area is used optimally.

Projected future demand for container activities according to the narrative

The combination of the identified trends with regard to container activities indicates that the container transport is projected to continue to grow until 2050. The main reasons are the current increase in product demand in the Netherlands, the shift from the transport of raw materials towards finished products (which are mainly transported by containers) and the continuation of scale of container inland vessels. The hinterland transport by IWT for containers can be improved significantly, therefore creating opportunities to increase the market share of the IWT in the hinterland transport. It is therefore considered that this port activity may create opportunities for the inland port of Oosterhout.

However, there are also some trends which may limit the increasing demand for container transport. The biggest threat is the projected stagnation (or even decrease) in product demand after 2030, therefore limiting the increase in container throughput volumes after 2030. In addition, the introduction of 3D-printing is projected to reduce the total throughput volumes, but it is assumed that this reduction in demand will be very small until 2050. The more frequent extreme hydraulic conditions are projected to reduce the total operational time of the inland port and may result in a decline in the market share compared to the other transport modes.

Overall, it is expected that the container throughput will increase until at least 2030. The increase is projected to reduce afterwards because of the reduced product demand, but the total throughput volumes may still increase due to the increasing market share of the IWT.

Impact on the inland port of Oosterhout

The increased demand for container transport requires a higher capacity for the transfer and storage of containers. This creates opportunities for the inland port of Oosterhout, because it is the only container terminal in a radius of 20 kilometres. The container terminals can be expanded (when there is free area next to the container terminals) or the internal terminal capacity may be increased in order to meet the future demand. As it is not expected that the infrastructure, equipment or methods for transfer and storage activities will change in the future, this activity can be considered as a marginal opportunity for the inland port.

Narrative #2: Opportunity to increase the sand/gravel throughput (dry bulk)

Present dry bulk activities in the inland port

The inland port of Oosterhout facilitates eight dry bulk terminals: one agro-bulk terminal, five concrete plants (production of construction materials) and two sand/gravel terminals (dry bulk terminals). In this section, only the trend-based narrative for sand/gravel terminals will be presented, because the other terminals will be treated in the next narratives. The sand/gravel terminals have a combined quay length of 360 meters, while it covers an area of around 100,000 m^2. The throughput volume of these terminals is equal to 261,000 tonnages per year.

Projected future demand for dry bulk activities according to the narrative

The joint trends with a relevance to the sand/gravel activities indicate that the demand for sand and gravel transport is projected to increase in the future. The main reason for this increase is the projected increasing demand for sand and gravel due to shortage of housing. At least until 2050, many houses and other constructions have to be constructed in order to reduce this shortage of housing. The construction of these houses requires a lot of sand and gravel, which can be used for both the stabilisation of the subsoil and the production of construction materials. The IWT is the preferred transport mode for this type of cargo, because the relatively big inland vessels can transport a larger volume at once, compared to trucks. Because of the fact that the demand for these port activities is projected to increase and that it is not likely that the sand and gravel will be transported by another transport mode, it is expected that this port activity creates opportunities for the inland port of Oosterhout.

On the other hand, some minor threats are identified. This increasing demand for sand/gravel activities, which is projected by the dominant trends, may reduce by these minor threats. The most important threat is the expected increasing frequency of extreme hydraulic conditions, which may reduce the operational time of the port activities, because the transport capacity may be limited during high and low waters. As a result, the market share of the IWT may decrease and therefore also the demand for dry bulk activities in the inland port.

The decline in throughput volumes due to climate change is expected to be very small compared to the expected increase in demand. It is therefore expected that the sand/gravel throughput will increase until 2050, therefore creating an opportunity for the inland port of Oosterhout.

Impact on the inland port of Oosterhout

The projected increase in demand for sand and gravel transport and storage requires a higher capacity for the dry bulk terminals. There are already two sand/gravel terminals in the inland port of Oosterhout, which may be sufficient to meet the future demand of the sand/gravel. It may be required to improve the internal terminal capacity in order to meet this future demand (e.g. by improving the quay equipment). Otherwise, the terminal capacity can be increased by expanding the terminal area, when there is free area available next to the terminal. It is not expected that the infrastructure, equipment or method of the sand/gravel transfer and storage will change significantly in the future. This activity can therefore be considered as a marginal opportunity for the inland port.

Narrative #3: Opportunity to introduce the transfer and storage of sustainable fuels (liquid bulk)

Present liquid bulk activities in the inland port

At the moment, the inland port of Oosterhout does not include any facilities for the transfer and storage of liquid bulk.

Projected future demand for liquid bulk activities according to the narrative

For this inland port, it is only relevant to take the opportunities into account for the identification of the trend-based narrative, because the negative impacts cannot affect the current inland port. The opportunities may result in the introduction of this port activity in the inland port, creating an opportunity for the inland port. The energy transition from the conventional fossil fuels into renewable energy sources is considered to be the main trend for this port activity. The introduction of a liquid bulk terminal with sustainable fuels may therefore create an opportunity for the inland port, because the sustainable fuels are likely to replace (a part of) the current polluting fossil fuels.

Impact on the inland port of Oosterhout

The liquid bulk facilities are not yet present in the inland port of Oosterhout. It is therefore required to use the free area in the inland port to facilitate these port activities. There is not a lot of free area left in this inland port, making it unlikely that the new port activity will be introduced in this inland port. In addition, it is more likely that this port activity will be introduced in inland ports, which already have the facilities for transfer and storage of conventional liquid bulk products. These terminals can be ‘adapted’ quite easily to the new fuel products, which is more practical than constructing a new terminal. As a result, the possibility that this opportunity is converted into new port activities is very limited, therefore not likely to create an increasing throughput volume. This is equal to a minimal opportunity.

Narrative #4: Opportunity to create a terminal for break-bulk, neo-bulk or special goods

Present transfer and storage activities for other cargo types in the inland port

There are no facilities for the storage of the remaining cargo types in the inland port of Oosterhout (apart from the terminals for processing steel products). On the other hand, a large public quay is located in the western end of the Insteekhaven, which is also connected to the rail network. With help from mobile cranes and quays on the inland vessels, this public quay can be used to (un)load all kinds of cargo, including break-bulk, neo-bulk and special cargo. The quay length is around 200 meters long, but it does not provide a storage area for these cargo types.

Projected future demand for transfer and storage of other goods according to the narrative

The joint trends project an increasing demand for break-bulk, neo-bulk and other special cargo types. The main reason for this increase are the relocation of industrial production processes to developing countries (therefore increasing the transport volumes of finished products) and the introduction of 3D-printing (reducing the number of transported goods). Due to the smaller operational time due to climate change, the IWT in general may also reduce in market share.

Impact on the inland port of Oosterhout

The slightly increasing demand for the transfer and storage of other bulk types is not expected to have a big impact on the inland port of Oosterhout. The large public quay is likely to be sufficient for the future demand for these transfer activities. Potentially, a small storage area could be constructed for these bulk types, but the public quay may be sufficient to store this cargo temporarily. Many of these bulk products will be directly transported to the destination and are therefore not stored on the quay at all. This port activity is therefore only expected to result in a minimal opportunity, in which hardly any changes in throughput volume are expected.

Narrative #5: Opportunity to increase the agro-bulk throughput and production

Present agro-bulk processing activities in the inland port

The inland port of Bergen op Zoom facilitates one small agro-bulk terminal, which is located at the most north-eastern location of the inland port area. The agro-bulk terminal produces compound feed for animals. The terminal covers 24,000 m^2 and has a quay length of 120 meters. The throughput volume of this terminal was equal to 158,541 tonnages in 2014.

Projected future demand for agro-bulk activities according to the narrative

The identified trends, related to agro-bulk activities, indicate that the demand for agro-bulk production is projected to increase in the future. The increasing demand can be largely attributed to the increased demand for reliable Dutch agricultural products, because the use of local products becomes more important for Dutch consumers. In addition, the many foreign producers of agro-bulk products are not considered to be reliable, which makes the Dutch agro-bulk producers also attractive for foreign consumers. The agro-bulk activities are therefore considered to be opportunities for the inland port.

However, the decreasing product demand in the Netherlands may reduce the domestic demand for these agro-bulk products. The growing knowledge in the developing countries may also reduce the demand for the Dutch agro-products over time, because these countries are able to produce reliable agro-bulk themselves. Finally, the IWT may lose some of its market share due to the increased frequency of extreme hydraulic conditions.

Overall, it is expected that these opportunities will be larger than the threats. The agro-bulk activities are therefore considered to be an opportunity for the inland port of Oosterhout.

Impact on the inland port of Oosterhout

The increasing demand for agro-bulk activities may require a higher capacity for the agro-bulk capacities. This increase in societal demand may therefore create opportunities for the inland port of Oosterhout, because it may transfer, store and produce higher volumes of agro-bulk in the future. The inland port of Oosterhout already has one (small) agro-bulk terminal, which may increase by improving its terminal capacity by creating a more efficient production process or by expanding its agro-bulk production area. As it is not expected that the infrastructure, equipment or activities of the agro-bulk activities will change in the future, this activity can be considered as a marginal opportunity for the inland port.

Narrative #6: Opportunity to create a hub for the construction materials production

Present construction material production in the inland port

The inland port of Oosterhout facilitates five terminals for the production of construction materials. In this inland port, all these terminals produce concrete. These five terminals cover a total area of 983,000 m^2, which is around 75% of the total port area. Two of these terminals (owned by the same company) cover an area of 800,000 m^2, which is equal to 65% of the total port area. The total quay length for these terminals is around 970 meters, which is almost equal to 45% of the total quay length in the inland port. The total throughput volumes of this activity are equal to 1,016,329 tonnages, which is slightly less than 60% of the total bulk throughput of the inland port. This production of construction materials can therefore be considered as one of the most important port activities in the inland port.

Projected future demand for construction materials according to the narrative

The joint trends with regard to the production of construction materials indicate that the demand for the production of construction materials may increase in the future. The main indicator for this trend is the increased demand for buildings and other construction materials due to the increasing shortage of housing. In order to reduce this shortage, many houses will be constructed until at least 2050, therefore creating an opportunity for the production of construction materials.

The introduction of 3D-printing may result in a decrease in demand for the current construction materials (e.g. concrete plant, asphalt plant). However, the 3D-printing is mainly used for the printing of small missing parts and is not developed yet to construct large constructions. The printed materials are not projected to replace the conventional construction materials within the coming 30 years, which will therefore not result in a significant decrease in the demand of construction materials. Another small threat is the fact that the production of concrete is a very polluting process. Due to sustainability reasons, it may be possible that this process requires cleaner techniques. Fortunately, improvements have already been made to make this process more sustainable and this is likely to continue. It is therefore expected that the impacts of these threats is not large enough to reduce the expected increase in demand for the production of construction materials in 2050.

Impact on the inland port of Oosterhout

The increasing demand for the production of concrete may result in higher production, storage and transfer volumes for the concrete plants. The inland port of Bergen op Zoom is already having five concrete plants with a very large terminal area. It is expected that the terminals will be large enough to meet the future demand for concrete products. The inland port of Oosterhout is therefore likely to take advantage of this increasing demand. However, the increase in demand is not expected to be very large and could be potentially reduced by the minor threats for this port activity. Therefore, this port activity is only considered to create a minimal opportunity.

Narrative #7: Opportunity to introduce renewable energy production in the inland port

Present energy production in the inland port

There is no energy production activity present in the inland port of Oosterhout.

Projected future demand for energy production according to the narrative

For this inland port, it is only relevant to take the trends with opportunities into account for the identification of the trend-based narrative, because this could lead to the introduction of new port activities with relevance to energy production. As there is no energy production activity in the current inland port, the inland port cannot be threatened by the negative impacts of these trends. The energy transition from the conventional fossil fuels into renewable energy sources is considered to be the main trend for this port activity. The renewable energy production may therefore be introduced in the inland port in order to take advantage of the energy transition.

Impact on the inland port of Oosterhout

The facilities for renewable energy production activities are not yet located in the inland port of Oosterhout, because there is no energy production in the inland port. It is therefore required to construct this new terminal on the free areas in the inland port of Oosterhout, but there is not a lot of free area left in this inland port. It is therefore unlikely that this new port activity will be introduced in the inland port, resulting in a minimal opportunity for the inland port of Oosterhout.

Narrative #8: Opportunity to introduce recycling activities in the inland port

Present recycling activities in the inland port

The inland port of Oosterhout does not have any facilities for recycling activities along the port basin.

Projected future demand for recycling activities according to the narrative

For this inland port, it is only relevant to take the trends with opportunities into account for the identification of the trend-based narrative, because this could lead to the introduction of recycling activities. As there is no recycling activity in the current inland port, the inland port cannot be threatened by the expected negative impacts of these long-term developments. The transition from the conventional raw materials to more sustainable and recycled materials is considered to be the main trend for this port activity, resulting in a significant increase in recycled materials. The introduction of recycling activities is therefore considered to become an opportunity for the inland port.

Impact on the inland port of Oosterhout

There are no facilities for recycling activities in the inland port of Oosterhout. It is therefore required to construct a new recycling terminal on a free area in the inland port, but there is not a lot of free area left in this inland port. Overall, this port activity is considered to be a marginal opportunity, because the throughput volumes are expected to increase significantly.

Narrative #9: Threat of decline in the demand for steel processing

Present industrial production of other cargo types in the inland port

The inland port of Oosterhout facilitates three terminals, which are used to transfer, storage and process intermediate steel products. This production area covers a total area of 140,000 m^2, which is around 10% of the total port area. The total quay length for this terminal is around 470 meters, on which the steel products are (un)loaded with help from big cranes. The total throughput volume is equal to 285,000 tonnages. This inland port activity is therefore not considered to be a very important port activity for the inland port of Oosterhout.

Projected future demand for the steel processing activities according to the narrative

The combination of the trends with relevance for the processing of steel products indicates that the demand for this activity will decrease in the future. The main reason for this decrease lays in the societal decrease in demand for products and the relocation of (low-value) industrial processes. It is likely that the processing of steel products may leave the port area and only finished steel products may be transported to the inland port, making this port activity no longer useful for these activities. The departure of the port activity is considered to be a threat for the inland port of Oosterhout. There other related trend, which may reduce the future demand for this type of activity, is the potential decline of market share for IWT due to the climate change.

Overall, it is expected that the demand for this port activity will decrease in 2050, mainly because of the projected relocation of this low-value industrial process.

Impact on the inland port of Oosterhout

The projected decreasing demand for processing steel products may result in the departure of these inland port activities from the inland port area, because of the decrease in general demand for products. Even when this inland port activity remains in the port area, then changes in the type of commodities can be expected, because the steel products may change from intermediate goods to final products, which do not have to be processed anymore in the inland port. This port activity is therefore considered as a marginal threat for this inland port.

Projected impacts of the narratives

In Table 24, an overview of the trend-based narratives and their related impacts is presented per activity for the inland port of Oosterhout. For all but one port activity, it is projected that these activities can create opportunities for this specific inland port. The only port activity, which is expected to be threatened, is the processing of steel products. It is therefore likely that the inland port can be considered as future-proof for the inland port, when you only look at the number of opportunities in relation to the number of threats.

	Port activity	Trend-based narrative	Projected impact
1	Container transfer and storage	Opportunity to increase the container throughput	Marginal opportunity
2	Dry bulk transfer and storage	Opportunity to increase the sand/gravel throughput (dry bulk)	Marginal opportunity
3	Liquid bulk transfer and storage	Opportunity to introduce the transfer and storage of sustainable fuels (liquid bulk)	Minimal opportunity
4	Transfer and storage of remaining cargo types	Opportunity to create a terminal for break-bulk, neo-bulk or special goods	Minimal opportunity
5	Agro-bulk production	Opportunity to increase the agro-bulk throughput and production	Marginal opportunity
6	Construction materials production	Opportunity to create a hub for the construction materials production	Minimal opportunity
7	Energy production	Opportunity to introduce renewable energy production in the inland port	Minimal opportunity
8	Recycling activities	Opportunity to introduce recycling activities in the inland port	Marginal opportunity
9	Steel processing activities	Threat of decline in the demand for steel processing	Marginal threat

Table 24: Overview of the identified narratives and the projected impact per port activity for the inland port of Oosterhout

The number of port activities with projected opportunities in relation to the number of threats does not give a good representation of the actual projected impacts on the inland port. Additional insights have been obtained to understand the impacts for the inland port of Oosterhout. This impact is identified by taking the port characteristics into account. In this way, the projected impacts can be presented in relation to the total inland port, by calculating the share of threatened port activities in relation to the total port area, quay length and bulk throughput volumes. For the inland port of Bergen op Zoom, this has been presented in Figure 43. The green colours represent the port activities with opportunities, while the red colours represent the port activities, which are projected to be threatened. The darker the red and green parts, the larger the projected impacts of the threats and opportunities respectively.

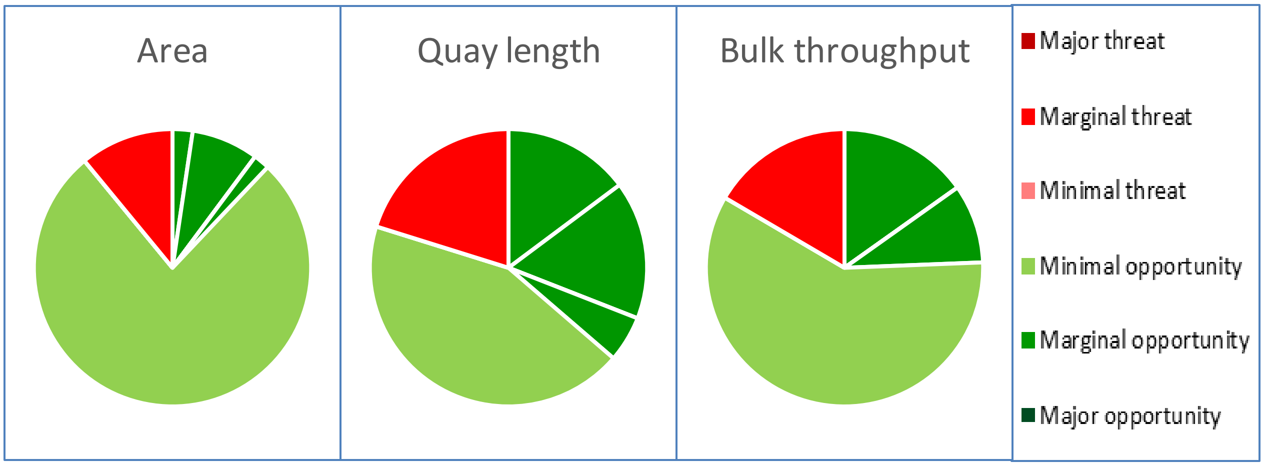


Figure 43: The share of port activities with opportunities (green) or threats (red) in the inland port of Oosterhout with relation to the total port area, total quay length and total throughput volumes in the port

The impacts of the trend-based narratives showed that the demand for only one of the port activities was projected to decrease: the processing of steel products. In this way, it looked like the inland port of Oosterhout was almost entirely operated by port activities with opportunities. Figure 43 shows a slightly different outcome as around 10% of the total port area along the inland port basin is occupied by these threatened port activities. On the other hand, the marginal opportunities are also contributing for around 10% of the total port area. The other port area is entirely occupied by the production of construction materials, which is the by far the most important port activity for the inland port of Oosterhout.

The share of the quay length of these threatened activities is relatively high (20%) compared to the share for the port area, because the concrete plants have a relatively low quay length compared to the other inland port activities. The share of throughput volumes of the threatened port activity is equal to the share of the quay length: also around 20% of the total bulk throughput. This 20% of the total bulk throughput may disappear because of the future threats.

Overall, the share of threatened port activities is relatively low in relation to the total port. In order to become a future-proof inland port, the inland port of Oosterhout has to reduce the negative impacts on the port activities related to the processing of steel. On the other hand, the inland port has to attract new port activities and retain the port activities with future prospects in the inland port. In this way, the inland port may remain future-proof.

Part 3: Determination of the flexibility of the inland port

The third part of the method is used to determine the flexibility of the inland port. The flexibility of the inland port represents the degree in which the inland port can adapt to the future demand for port activities. This adaptability cannot be measured directly, but two different aspects will be determined: the potential reduction of negative impacts by replacing them with new port activities and the potential to increase the capacities of current activities (by converting the opportunities into new port activities at new terminal areas). The higher the potential to reduce its negative impacts and the more likely that the capacity of new activities can be increased, the more flexible the inland port may be. These two aspects of the inland port of Oosterhout are determined in this section.

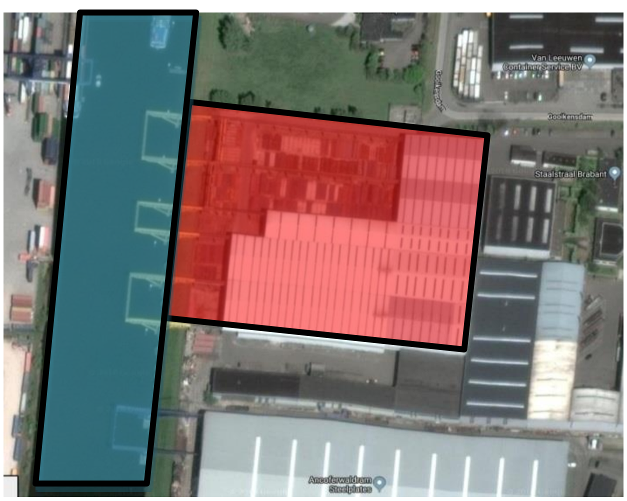
Analysis of the current port infrastructure of the threatened port activities for new port activities

The current infrastructure of the projected threatened port activities is analysed in order to determine whether this infrastructure can be used for the new port activities. In this way, it can be determined whether the inland port could reduce its threats (and thus remain useful and successful in the future). The characteristics of the three threatened terminals will be treated separately in this section, while the possibilities to reduce the threats will be presented for all terminals, because it concerns the same port activities.

Staalstraal Brabant B.V.

Staalstraat Brabant B.V. is a company which covers slightly less than 5% of the total port area. The company imports (semi)finished steel products, which are processed into a final product at this terminal area. The anticipated decline in product demand and the relocation of the low-value industrial processes projects that the demand for this type of activities may decrease until 2050.

The terminal is located at the eastern bank of the Wilhelminakanaal on the north-eastern part of the inland port (see Figure 44). Three big cranes are constructed in order to transfer the steel products simultaneously from/to the inland vessels. These cranes are also used to store these cargo on the storage yard, which is completely covered by these cranes. The storage yard is partly covered, but the majority of the cargo is stacked on the surface of the terminal in the open air. The terminal characteristics are presented in the table in Figure 44.



Staalstraat Brabant B.V.	
Area	60,000 m^2
Quay length	190 m
Current throughput	100,000 tonnage
Current activities	Transfer and storage of steel products & steel processing
Current cargo type	Steel products
Quay equipment	Cranes
Terminal equipment	Quay crane
Storage equipment	Storage on the surface

Figure 44: Location of Staalstraat Brabant B.V. and its terminal characteristics

Ancoferwaldram Steelplates B.V.

Ancoferwaldram Steelplates B.V. is performing similar port activities as Staalstraat Brabant B.V, which means that it mainly imports (semi-)finished steel products, which are then further processes at this terminal. The anticipated decline in product demand and the relocation of the low-value industrial processes projects that the demand for this type of activities may decrease until 2050, which is similar to the previous treated terminal area.

The terminal covers an area of 30.000 m^2, which is equal to 2% of the current port terminals in the entire inland port of Oosterhout. It is located at the eastern bank of the Wilhelminakanaal, just south of Staalstraat Brabant B.V. (see Figure 45). One quay crane is constructed in order to transfer the steel products from the inland vessels towards the covered storage yard and vice versa. Within the covered storage yard, numerous cranes on rails are used to transport the steel plates within the storage areas. An overview of the terminal characteristics are presented in the table in Figure 45.

Ancoferwaldram Steelplates B.V.	
Area	30,000 m^2
Quay length	100 m
Current throughput	85,000
Current activities	Transfer and storage of steel plates & steel processing
Current cargo type	Steel plates
Quay equipment	Crane
Terminal equipment	Quay cranes
Storage equipment	On the surface

Figure 45: Location of Ancoferwaldram Steelplates B.V. and its terminal characteristics

Salzgitter Mannesmann Staalhandel B.V. (Deltastaal)

Salzgitter Mannesmann Staalhandel B.V. (Deltastaal) is performing the same port activities as the previous two terminals, which means that it mainly imports (semi-)finished steel products, which are then further processed at this terminal. For example, this process includes cutting, bending and plating of beams and tubes. Similar to the previous treated terminals, the anticipated decline in product demand and the relocation of the low-value industrial processes projects that the demand for this type of activities may decrease until 2050.

The terminal covers an area of 50.000 m^2, which is around 4% of the current terminal area in the inland port of Oosterhout. It is located at the southern bank of the Insteekhaven, just west of the Wilhelminakanaal (see Figure 46). Numerous quay cranes are constructed in order to transfer the steel products from the inland vessels towards the covered storage yard and vice versa. Within the covered storage yard, cranes on rails are used to transport the steel products within the storage area and towards the processing area. An overview of the terminal characteristics is presented in Figure 46.

Deltastaal	
Area	50,000 m^2
Quay length	180 m
Current throughput	100,000 tonnage
Current activities	Transfer and storage of steel plates & steel processing
Current cargo type	Steel plates
Quay equipment	Crane
Terminal equipment	Quay cranes
Storage equipment	On the surface

Figure 46: Location of Deltastaal and its terminal characteristics

The infrastructure of these three inland terminals is specified for the transfer, storage and processing activities of general cargo (mainly steel plates, beams and pipes). The following trend-based narratives are identified to project an increase in the demand for the transfer, storage and production of general cargo. These trend-narratives are:

- Opportunity to create a terminal for break-bulk, neo-bulk or special goods
- Opportunity to introduce recycling activities in the inland port

Although it is expected that the demand for the processing of steel products may decrease, it is not likely that all three terminals will be relocated in 2050, because the processing of steel products will be still required in the future.
Unfortunately, the introduction of recycling activities cannot be considered as a suitable solution to replace the threatened port activity, because it requires different infrastructure. It is therefore required to invest in facilities for the recycling process itself. However, it is not likely that these terminals are used to construct new port facilities. The construction of a terminal for break-bulk, neo-bulk or special goods is more likely to replace (some of) the steel processing terminals. These transfer and storage activities require a similar infrastructure as the steel products. It is therefore more likely that this terminal may be transformed in a terminal for general bulk products instead of steel products only.

It is not expected that the negative impacts of the threatened steel processes will be fully compensated by adapting the current production processes to new port activities.

Analysis of the potential to expand the capacities of the port activities

The capacity of the port activities in the inland port of Oosterhout can be increased in two different ways: by increasing the internal terminal capacity and by expanding the terminal area for the specific port activities. This section looks at these two aspects to determine whether there are opportunities to increase the capacity for port activities in the inland port of Oosterhout.

Internal terminal capacity

Most terminals within the inland port of Oosterhout use advanced terminal and quay equipment for carrying out the port activities. The transfer capacities at these terminals can therefore not be optimised significantly. Only the sand/gravel terminal and the public quay make use of mobile cranes (on the quay and on the inland vessels). The quay capacity for these terminals can therefore be improved by using advanced quay equipment for the cargo.

At the other terminals, an efficient and effective system is in place for the transfer and storage of the cargo. Some examples of this system includes the use of gantry cranes at the container terminal, the use of conveyor belts to transport the raw materials for concrete plants and pipelines for the agro-bulk terminal (see Figure 47). The use of these efficient and effective methods and equipment for storage and (internal) transport in terminals ensures that the internal capacity of the current terminals cannot be increased significantly, unless the terminal configuration will be changed.

Figure 47: Quay equipment at the agro-bulk terminal (left) and the container terminal (right)

Possibility to increase the area for port activities

The other possibility to increase the capacities of the inland port can be reached by expanding the area with port activities. This potential area for port activities presents whether it is possible to facilitate new port activities in the inland port. A distinction has been made between free areas and areas, which are currently used by companies without any port-related activities. These free areas can be bought and then be used to construct terminal facilities. The existing company has to be relocated to another location when the port wants to use the areas with companies without port activities, which may take a long time. Free area along the port basin is therefore preferred over the other potential areas in order to increase the terminal capacity.

The free areas and areas with non-port activities in the inland port of Oosterhout have been identified (Klerks & Rietveld, 2018; Google Maps, 2018), which is presented in Figure 48. The brown areas represent the port area along the port basin without any port activities. There are no free areas in the inland port.

Figure 48: Location of the areas without port activities (brown) in the port of Oosterhout

In order to expand the current port terminals or to attract new activities in the inland port area, no free areas can be used in the inland port. The only way to expand the area for port activities is to use the area without any port activities. This process of relocation of the current company towards another location can take a long time and reduces the possibilities to expand the terminal capacities. The fact that there is no free area available is therefore not preferred for the flexibility of the inland port.

In order to present the overall potential areas of the inland port, the share of the potential port areas is presented in relation to the total port area along the port basin and the total quay length (see Figure 49). The blue colour represents the area or quay length, which is currently used for the port activities, while the brown parts represents the area and quay length along the port basin that is used by companies without any port activities.

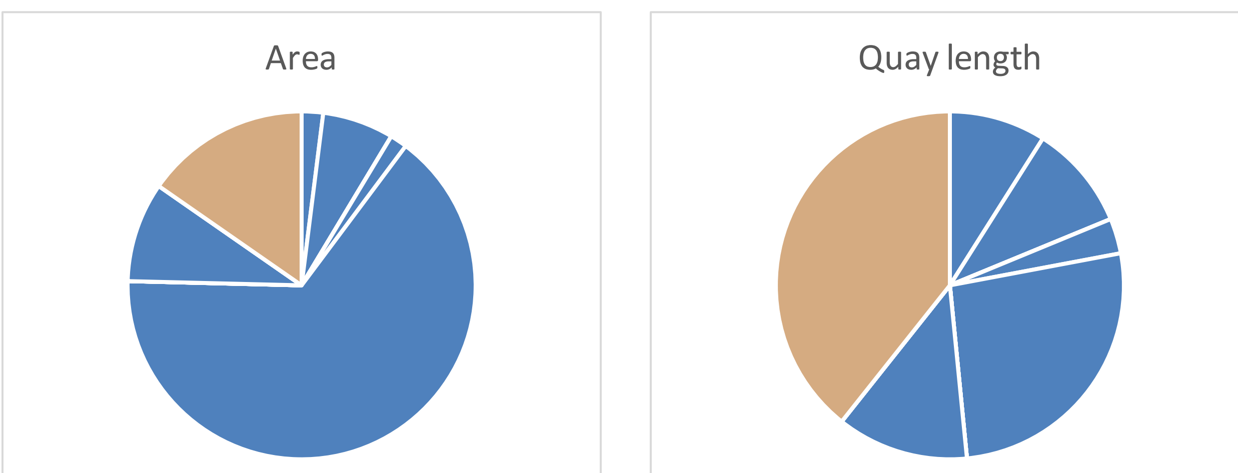


Figure 49: Potential area and quay length in Oosterhout (blue = current use, brown = currently used by non-port activities)

Figure 49 shows that almost 20% of the total inland port area is not used for inland port activities. This area (around 230,000 m^2) could be potentially used to increase the capacity of the various inland port activities. Unfortunately, this includes only potential area, already occupied by companies without port activities. These companies have to be relocated in order to use these as inland port terminals, which could take many years and can there be considered as a difficult process.

The potential increase in quay length could be increased by 1445 meters, which is around 40% of the total quay length along the port basin. This quay length is currently occupied by companies without any port activities, therefore not using this quay length. It can be therefore concluded that the quay length could still be increased significantly. In this way, the transfer capacity may be increased, but this process can be very difficult.

Overall flexibility of the inland port of Oosterhout

The overall flexibility of the inland port of Oosterhout is considered to face some challenges. The main reason is the limited area to improve the port successfulness, because there are hardly any possibilities to increase the capacities of the current port activities. Furthermore, there are hardly any possibilities to convert the other opportunities into new port activities, because there is no free are a in the port area to attract these port activities. In this way, the port cannot increase its capacities and therefore not improve its successfulness. On the other hand, the few threatened port activities (the transfer, storage and processing of steel products) are likely to be compensated by replacing them with new port activities, such as a general terminal for break-bulk, neo-bulk and special bulk. This is the only port activity which requires a port infrastructure, which matches the current port infrastructure in the threatened terminals.

In addition, part 1 has showed that there are large diversity of port activities in the inland port. On the other hand, it also showed that the inland port is very dependent on two port activities: the production of construction materials and the container activities. The flexibility of this inland port can therefore be improved by attracting more diverse port activities in order to become less dependent on these two port activities.

Part 4: Assessment of the future-proofness of the inland port of Oosterhout

The strengths, weaknesses, opportunities and threats for the inland port of Oosterhout are known, which are included in a SWOT-analysis. In addition, the flexibility for the inland port is included in the SWOT-analysis to present whether the inland port can convert these opportunities into more port activities. The combination of the strengths, weaknesses, opportunities, threats and the flexibility is used to determine whether it is likely that the inland port remains successful and useful in the changing conditions up to 2050. This SWOT-analysis therefore serves as a guideline for the assessment whether the inland port can be considered as a future-proof.

SWOT-analysis

The SWOT-analysis (see Figure 50) presents an overview of the identified strengths, weaknesses, opportunities and threats of the inland port of Oosterhout. This gives a first impression of the future-proofness of the inland port.

Strengths

- CEMT-class Va
- Good overall accessibility (road / rail / IWT)
- High container throughput
- Large bulk throughput volumes and quay length
- Many inland port terminals
- No restrictions in operational time

Weaknesses

- Limited diversity in port activities
- Limited hinterland size
- Many companies without port activities along port basin
- No free area in the inland port
- Very dependent on container terminal (OCT BV) & production of concrete (HH Martens & Zoon)

Opportunities

Activities concerning:

- Container transfer and storage (*marginal*)
- Sand and gravel transfer and storage (*marginal*)
- Transfer of remaining types of cargo (*minimal*)
- Agro-bulk transfer and processing (*marginal*)
- Production of concrete (*minimal*)
- New port activities (minimal)

Threats

- Max. capacity may be reached due to limited potential area for new port activities
- Max. internal terminal capacities may be reached due to use of advanced equipment

Activities concerning:

- Processing of steel products (*marginal*)

Figure 50: SWOT-analysis for inland port of Oosterhout

The port specific information about the port characteristics, the projected impacts and the flexibility are included in the presented SWOT-analysis. This means that it is possible to assess the future-proofness of the inland port of Oosterhout.

The inland port can be considered as future-proof when the inland port remains useful and successful for the execution of the port functions, while being flexible enough in port services and infrastructure to deal with potential changes (see the definition in chapter 2). First, the projected usefulness and successfulness of the inland port needs to be determined. Thereafter, the general result of the future-proofness of the case study port will be determined according to the combination of answers on the three questions (as categorised in Table 4).

Usefulness

The port can be considered as useful when there are sufficient port activities to use the port area and infrastructure in a useful way in order to perform the primary functions of the inland port. This can only be achieved when the inland port provides sufficient services and infrastructure to perform these main functions.

The inland port has a large diversity of inland port activities. For the majority of these inland port activities, it is projected that the demand increases until 2050. It is found that the demand for the activities in the container terminal, sand and gravel terminals and the agro-bulk terminal may increase substantially. These terminals therefore require an increase in the terminal capacity in order to meet the demand, which can only be achieved by increasing the internal capacity or by expanding the terminal area. For one of the sand/gravel terminals, the internal capacity can be improved by using dedicated quay equipment instead of current mobile cranes. This improvement may seem sufficient to meet the future demand. However, for the container and agro-bulk terminals, the maximum capacity is almost reached. For these inland port activities it is required to expand the terminal area in order to meet the future demand for these port activities and to remain useful for these inland port activities.

Furthermore, a small increase in the demand for the production of concrete and the transfer of the other cargo types (e.g. break-bulk, neo-bulk) is expected, but the terminal capacity seems to be sufficient to meet these projected small increases in demand for these port activities. It is therefore not required to increase the terminal areas for these port activities in order to remain useful.

However, the usefulness of the inland port is under risk by threatened port activities, which may make the port space and infrastructure no longer useful when these activities leave the inland port. For the inland port of Oosterhout, the threatened port activity is the transfer, storage and processing of steel products, which takes place at three terminals in this inland port. Fortunately, it is not likely that all three terminals may become useless, because the processing of steel is likely to remain required. The threatened port terminal can be transformed into a terminal for general cargo, break-bulk and special bulk, for which the demand is likely to increase.

Overall, the usefulness of the inland port faces minor challenges, which is mainly based on the risk of the departure of steel processing activities.

Successfulness

The inland port of Oosterhout is successful when the inland port activities remain effective and efficient on the long-term, so that the port activity can continue to exist in the inland port area (on condition that it remains useful). For the inland port activities, the effectiveness can be defined as the state at which the inland port is able to address a certain demand, while the efficiency is the extent at which the activities can be conducted with a minimum wasted effort.

The successfulness of the inland port of Oosterhout is considered to face minor challenges. This is underlined by the current efficiency and effectiveness of the inland port of Oosterhout. The efficiency and effectiveness of the port activities can be improved by increasing the port capacity of several port terminals. For the sand/gravel transfer activities, the transfer process can be improved by using more advanced (quay) equipment. The other terminals do already use the advanced types of storage and transfer equipment, resulting in an effective port activity. This may result in a more attractive port area for companies for their inland waterway transport.

The only port activity with a projected decrease in successfulness is the anticipated reduction in demand for the steel-processing activities, but this port activity is relatively small in the inland port (covering around 10% of the total port area and the throughput is around 20% of the total bulk throughput). Not all companies processing the steel products are expected to continue to exist until 2050, therefore it is not likely that this port activity remains successful and may not sustain in the inland port.
Overall, it is considered that the inland port of Oosterhout remains successful, because the majority of the port activities are projected to result in an opportunity. Furthermore, the threatened port activity is not a very dominant port activity within the inland port and may be replaced by other port activities. On the other hand, the successfulness cannot be improved substantially, because the current area for port activities cannot be expanded due to the absence of free space in the port area.

Future-proofness

In this last step, the future-proofness of the inland port of Oosterhout will be determined. The general guideline from Table 4 is used to determine this future-proofness, for which the three generated questions have to be answered:

1. Is it projected that the inland port activities in the inland port are hardly threatened?
2. Are there sufficient opportunities to compensate for the anticipated threats?
3. Does the existing infrastructure match the infrastructure needed for these identified opportunities?

The first question can be answered positively, because only one port activity is projected to be threatened. This port activity is located at three small terminals, which covers less than 10% of the total port area and throughput. The inland port is therefore not very dependent on the potential departure of (one of) these companies. The risks of becoming less useful and successful are then also relatively small.
The second question can also be answered positively. Similar to the previous inland port, there are hardly any opportunities to increase the port activities due to the absence of any free areas in the inland port. On the other hand, there are plenty of port activities, which are projected to create opportunities for the inland port. These port activities are expected to be able to compensate for the small identified threats in this inland port.
The third question cannot be answered positively. The threatened port activities (the transfer, storage and processing of steel products) require port infrastructure, which is specified for these products. The transfer of break-bulk, neo-bulk or special bulk could use the same infrastructure, but it is unlikely that this port activity will be introduced to these threatened port terminals, because it already has an location in this inland port. The other inland port activities with opportunities require other port infrastructure, which does not match the current terminal infrastructure in this port area.

According to the general guideline in Table 4, the inland port can still be considered as future-proof (see Table 25). Overall, it can be concluded that this inland port is not expected to be threatened substantially and that these threats can be compensated by the large number of port activities with opportunities. However, these opportunities do not require the infrastructure as in the current terminal.

Question 1	Question 2	Question 3	Total
+	+	-	Future-proofness

Table 25: Overview of the future-proofness of the inland port of Oosterhout

Appendix D: Case study 3 (Wageningen)

This appendix contains the assessment of the future-proofness of the third and last case study port, which is the inland port of Wageningen. This appendix is structured in the same way as the previous appendices, which is according to the proposed method in chapter 4.

Part 1: Determination of the current inland ports strengths and weaknesses

The first part of the method is the qualitative determination of the strengths and weaknesses of the inland port of Wageningen. When available, the quantitative information from Google Maps, the port visit and the meeting with Ton Kok (Port Master for the Wageningen municipality) (2018) will be used to determine the strengths and weaknesses of the inland port. These port characteristics can be determined with help from the port indicators. It can then be determined which port activities could potentially affect the overall port.

Accessibility

The inland port of Wageningen (Rijnhaven) is located on the northern bank of the Nederrijn, in the southwestern part of the city. The port basin has an open connection with the Nederrijn, which connects the port with Arnhem in the eastern direction and Utrecht in the western direction. The Havenkanaal is a relative short access channel (around 850 meters) for the small port basin. Most of the terminals are located along this access channel.

For road transport, the inland port is less accessible. Three motorways are located at some distance of the inland ports, connecting the inland port to Arnhem and Utrecht (A12), Barneveld (A30) and Nijmegen (A50). The closest motorway access is to the A12, which is located in Ede around 8.2 kilometres (± 12 minutes) from the inland port (Google Maps, 2018).

There is no train connection close to the inland port. The closest railway is located in Ede, where the railway connects Utrecht with Arnhem (Google Maps, 2018). This railway is not used for the transport of cargo, making it not useful for the inland port (Kok, 2018).

It can be concluded that the inland port is well accessible for inland vessels. However, the road network is less accessible, while the inland port cannot use the rail network at all. It is therefore considered that the accessibility of this inland port is quite weak.

Capacities of the various inland port activities

As can be seen in Figure 35 in appendix A, the inland port of Wageningen is mainly focused on agro-bulk. The inland port contains two agro-bulk production terminals (various types of feeder) with dry bulk transfer, one concrete plant (also with dry bulk transfer), one dry bulk terminal (sand and gravel), one liquid bulk terminal (mineral oils) and two public quays, at which several cargo types are handled.

The capacities of these different port areas for the various port activities are not known by the Port master. It is therefore decided to use the same sub-optimal data as for the previous case studies: terminal areas, quay lengths and the throughput volumes. This information is obtained by Google Maps and during the port visit with Ton Kok (2018).

Port activity	Area	Quay length	Throughput volumes
Container terminal	-	-	-
Dry bulk terminal	10,500 m^2	130 m	200,000 tonnage
Liquid bulk terminal	15,400 m^2	110 m	150,000 tonnage
Terminal for remaining cargo	2,300 m^2	230 m	Unknown (but small volumes)
Agro-bulk producer	15,625 m^2	230 m	650,000 tonnage
Construction mat. producer	15,000 m^2	100 m	200,000 tonnage
Energy producer	-	-	-
Recycling company	-	-	-
Remaining industrial producer	-	-	-
Total	**58,825 m^2**	**800 m**	**1,200,000 tonnage**

Table 26: Sub-optimal data about the capacity of the inland port activities in Wageningen

From this data, is can be concluded that the inland port area of the inland port of Wageningen is much smaller than Bergen op Zoom and Oosterhout (but still larger than many of the inland ports in the Netherlands). The quay lengths and throughput volumes are relatively large compared to the terminal areas. These high throughput volumes are mainly caused by the relatively large throughput of the agro-bulk terminal. These throughput volumes present the minimum capacity of the inland port of Wageningen, because the exact capacity of the inland port terminals is not known. In addition, it is identified that the terminal activities are performed by advanced equipment for the specific type of commodities, which is likely to result in a high terminal capacity. The exceptions are the small public quays, which uses cranes on the inland vessels to (un)load the cargo.

Dependency on companies with port activities

With help from Figure 35 in appendix A, it can be found that there are five terminals located in the inland port area with port activities. These two agro-bulk terminals are operated by the same company, resulting in four different port companies. The other companies are: one concrete plant, one dry bulk terminal and one liquid bulk terminal. This number of companies with port activities is small, making the inland port vulnerable to an eventual departure of (a few) companies from the port area. When the agro-bulk company would leave the inland port area, more than 50% of the through put will be lost. The inland port of Wageningen is therefore in particular vulnerable to the decisions of this company.

Dependency on type of port activities

For the determination of the dependency of the inland port on the various port activities, Figure 35 in appendix A and Table 26 are used. It can be seen that some diversity in inland port activities can be found in the port area. There are no container activities, energy production, recycling activities and no other industrial production activities. Normally, this diversity in port activities will distribute the dependency over the various port activities. However, the throughput volume in the port makes the inland port of Wageningen dependent on a specific port activity, although more than 50% of the throughput volumes are dedicated to agro-bulk activities. This means that the inland port is therefore quite vulnerable on the potential changes for the demand for agro-bulk activity.

Dimensions of port basins

The inland port includes one port basin (Rijnhaven), which is around 150 meters long and has a width of 100 meters. The access channel has a length of around 850 meters with a width varying between 45 and 80 meters. The minimal depth is 5.50 meters. For the port basin, the depth is equal to 4.00 meters. The CEMT-class of the main waterway is Va, which is the same as for the inland port (Rijkswaterstaat, 2013). This means that large types of inland vessels can reach the inland port of Wageningen and that this inland port is not likely to be affected by the scaling of inland vessels, which can be considered as a strength for this inland port.

Hinterland size

The hinterland size is also an important port characteristic of the inland port, because a large hinterland is likely to include more companies, which require the IWT for the transport of their supply materials or final products. The inland port of Wageningen is able to handle inland ports with CEMT-class Va. There are not many inland ports along the Nederrijn, which creates a big opportunities for the inland ports. The closest big inland port is located in Arnhem (around 20 kilometres away), while the next inland port on the west is located in Wijk bij Duurstede (around 25 kilometres away) (Google Maps, 2018).
The fact that there are no big inland ports in the proximity of Wageningen makes it likely that the inland port has a big hinterland. This is considered to be a strength for the inland port, because the inland port is likely to remain useful for port activities for companies from (the surroundings of) Wageningen.

Operational time

The inland port companies are allowed to perform their activities between 06:00 and 22:00 on Monday until Friday. On Saturdays, it is allowed to perform port activities between 06:00 and 12:00, but this hardly happens. On Sunday it is not allowed to perform any port activities. This decision to restrict the operational time is based on noise levels for the surrounding residential areas (Kok, 2018).
The operational time of the inland ports is also dependent on the extreme hydraulic conditions in the inland port. The hydraulic conditions in the port of Wageningen are equal to the hydraulic conditions on the Nederrijn. This would result in a maximum of 2 days per year, at which the inland port cannot be used for port activities. During these days, the water levels are too high or too low for safe inland navigation. The overall operation time for this inland port is small, mainly because of the restrictions in operational time in the inland port. It is therefore considered as a weakness of this inland port.

Potential area for future port activities

Along the access channel, there is a lot of free area, which is available for future port activities. At the southern bank at the access channel, there is free area with a potential quay length of 550 meters and a potential area of 77,000 m^2. On the northern bank, there a free area of about 19,800 m^2 available with a potential quay length of 165 m. When relocating the existing company without any port activities and the marina, it is possible to create another 35,550 m^2 for port activities. This would increase the quay length with another 200 m. The total potential area for port activities will then be 132,350 m^2, which is 2.25 times as big as the current inland port area. The quay length could be increased by 915 meters, which is more than the current quay length. The high numbers of potential area and potential quay length is considered to be a strength, because the new port activities with opportunities may be attracted to this inland port and the current port activities can be expanded relatively easy.

Part 2: Determination of the port specific opportunities and threats

The second part of the method is the determination of the projected opportunities and threats for the inland port of Wageningen. These opportunities and threats are identified in the same way as for the other case study ports. In the first place, it is required to determine the trend-based narratives for the various port activities, which are generated by combining the identified trends with the specific inland port characteristics. These trend-based narratives exist of one main storyline, while multiple alternatives can be identified. These narratives presents whether the various inland port activities are projected to result in a threat or an opportunity for the inland port of Wageningen. These port specific trend-based narratives for each port activity are determined in this section.

Narrative #1. Opportunity to introduce container transfer and storage activities

Present container activities in the inland port

At the moment, the inland port of Wageningen does not include any facilities for container transfer and storage activities, despite the fact that very occasionally a container is (un)loaded at the public quay.

Projected future demand for container activities according to the narrative

For the inland port of Wageningen, it is only relevant to take the trends with opportunities into account for the identification of the trend-based narrative, because this information will be decisive whether an inland port activity will be attracted to this inland port. In addition, it does not make any sense to look at the threats, because the absence of this activity cannot result in threats for the current port activities. The combination of the identified trends with regard to container activities indicates that the container transport volumes are projected to grow until 2050. The main reasons for this projected increase in container throughput volumes is the increasing product demand in the Netherlands, the shift from the transport of raw materials towards finished products and the continuation of scale of container inland vessels. The hinterland transport by IWT for containers can be improved significantly, therefore creating opportunities to increase the market share of the IWT in the hinterland transport. Overall, it is therefore considered that this port activity may create an opportunity for the inland port of Wageningen.
It should be kept in mind that the projected increase in container throughput may be reduced by alternative trends. The biggest threat is the projected stagnation (or even decrease) in product demand after 2030, therefore limiting the increase in container throughput volumes after 2030. In addition, the introduction of 3D-printing is projected to reduce the total throughput volumes, but it is assumed that this reduction in demand will be very small until 2050. The more frequent extreme hydraulic conditions are projected to reduce the total operational time of the inland port and may result in a decline in the market share compared to the other transport modes.

Impact on the inland port of Wageningen

The increased demand for container transport requires a higher capacity for the transfer and storage of containers. This creates opportunities for the inland port of Wageningen, because there are no container terminals in the close proximity of this inland port. The closest container terminals are located at Nijmegen and Tiel, which are located at 20 kilometres from Wageningen and both located at the banks of the Waal. The introduction of a container terminal creates an opportunity for Wageningen, as the throughput volumes are expected to increase until at least 2030. The projected impact for this port activity is therefore expected to marginal.

Narrative #2. Opportunity to increase the sand/gravel throughput (dry bulk)

Present dry bulk activities in the inland port

The inland port of Wageningen has a lot of facilities for dry bulk transfer and storage: two agro-bulk terminals, one concrete plant and one sand/gravel terminal. In this narrative, only the latter type of port activities is taken into account, because the other port activities are treated in the specific narratives for the agro-bulk and the production of construction materials (trend-based narrative 5 and 6 respectively). The sand and gravel terminal in the port of Wageningen covers an area of 10,500 m^2 and has a quay length of 130 m. The total throughput volume of this dry bulk terminal is equal to 200,000 tonnages per year.

Projected future demand for dry bulk activities according to the narrative

The joint trends with a relevance to the sand/gravel activities point out that the demand for sand and gravel transport is anticipated to increase until 2050. The biggest reason for this projected increase in demand for sand and gravel transfer is the shortage of housing. At least until 2050, many houses and other constructions have to be constructed in order to reduce this shortage of housing. The sand and gravel can be used for various purposes in the construction process: for the foundation and for the production of building materials. The IWT is the preferred transport mode for this type of cargo, because the relatively big inland vessels can transport larger volumes and many of the sand and gravel is extracted from river beds. Because of the fact that the demand for these port activities is projected to increase and that it is not likely that the sand and gravel will be transported by another transport mode, it is expected that this port activity creates opportunities for the inland port of Wageningen.

On the other hand, some minor threats have been identified. This increasing demand for sand/gravel activities, which is projected by the dominant trends, may reduce by these minor threats. The most important threat is the expected increasing frequency of extreme hydraulic conditions, which may reduce the operational time of the port activities, because the transport capacity may be limited during high and low waters. As a result, the market share of the IWT may decrease and therefore also the demand for dry bulk activities in the inland port.

The decline in throughput volumes due to climate change is expected to be very small compared to the expected increase in demand. It is therefore expected that the sand/gravel throughput will increase until 2050, therefore creating an opportunity for the inland port of Wageningen.

Impact on the inland port of Wageningen

The increase in demand for the dry bulk transfer and storage activities may result in a higher throughput volume for the sand and gravel terminal. This creates an opportunity for the sand/gravel terminal in this inland port, because it is therefore likely that the demand for this inland port will also increase. When the capacity of this terminal will not be sufficient to meet the future demand, it may be required to expand the terminal area or to construct a new terminal in the port area. It is not expected that the infrastructure, equipment or method of the sand/gravel transfer and storage will change significantly in the future. This activity can therefore be considered as a marginal opportunity for the inland port.

Narrative #3. Threat of decline of mineral oil products (liquid bulk)

Present liquid bulk activities in the inland port

The inland port of Wageningen facilitates one liquid bulk terminal, which is located on the northern bank of the access channel. The terminal transfers and stores mineral oils, which can be (un)loaded to/from the inland vessels with help from a pipeline system. The liquid bulk terminal covers 15,000 m^2 and has a quay length of 110 m. The throughput of these terminals is approximately 150,000 tonnages per year, which is around 10% of the total bulk throughput volumes of the inland port of Wageningen.

Projected future demand for liquid bulk activities according to the narrative

The joint trends with regard to the liquid bulk activities indicate that the mineral oil transport is likely to decrease until 2050. The main reason is the current transition from fossil fuels to (more) sustainable alternatives, thereby reducing the emissions of greenhouse gasses and other polluting gasses. The increasing awareness about the sustainability results in the transition to sustainable raw materials, which cannot be depleted (in contrast to fossil fuels). The use of oil products in the society is therefore projected to slowly disappear in the period up to 2050, therefore reducing the transport of these oil products in the inland port. This port activity is therefore considered to become a big threat for the inland port of Wageningen.

On the other hand, it also creates some minor opportunities. The introduction of sustainable fuels creates new potential port activities and can use the same facilities as the current liquid bulk products (after some adjustments). However, the throughput volumes for the sustainable fuels are not expected to be enough to counter the projected decrease, because the electrification is likely to reduce the total fuel demand.

Overall, it is expected that the liquid bulk throughput will decrease significantly until 2050, mainly because of the transition towards sustainable energy sources and raw materials.

Impact on the inland port of Wageningen

The decreased demand for oil products transport makes the liquid bulk terminals not useful anymore for the port functions (transfer, storage of liquid bulk activities). These inland port activities are therefore not future-proof and create a threat for the inland port of Wageningen. This narrative does not only expect a change in throughput volumes, but also in type of commodity, infrastructure and equipment. It is therefore considered as a major threat for the inland port of Wageningen.

Narrative #4. Opportunity to create a terminal for break-bulk, neo-bulk or special goods

Present transfer and storage activities for other cargo types in the inland port

There are two public quays at the inland port of Wageningen, which can be used to transfer all kinds of cargo. This means that this quay can also be used to (un)load the remaining type of cargo types (e.g. break-bulk, neo-bulk or special bulk). These public quays are located at the eastern bank of the port basin and the most eastern part of the northern bank of the access channel. Mobile cranes (on the quay or on the inland vessel) are used to perform the transfer activities, but these throughput volumes are very small. The combined quay length of these public quays is equal to 200 meters. These public quays do not contain a storage area for these cargo types, which results in the fact that the products have to be transported immediately to the next destination.

Projected future demand for transfer and storage of other goods according to the narrative

The trends with a relation to the demand for break-bulk, neo-bulk and other special cargo types indicate an increase in the demand for these products. The main reason for this increase are the relocation of industrial production processes to developing countries (therefore increasing the transport volumes of finished products) and the introduction of 3D-printing (resulting in an increase in transport for '3D-ink'). Due to the smaller operational time due to climate change, the IWT in general may reduce in market share.

Overall, it is expected that the increase in demand will be bigger than the decrease in demand. It is therefore likely that this trend-based narrative will result in an increased demand for this port activity.

Impact on the inland port of Wageningen

The projected increase in demand for the transfer and storage of other bulk types is not expected to have a large impact on the inland port of Wageningen. The two public quays are presumed to be sufficient to meet the future demand of the transfer activities in the inland port. When the transfer volumes of this type of cargo will increase significantly, it seems logical to construct a terminal for these specific cargo types. In this way, the cargo can be stored in the terminal area. In the current situation, the goods have to be transported immediately to its next destination. However, the growth in the demand for this type of products will not be significantly large, so that the presence of a storage facility is not required. The impact of these trends on the port activity will therefore be minimal, creating a minimal opportunity for the inland port of Wageningen

Narrative #5. Opportunity to create an agro-bulk hub

Present agro-bulk processing activities in the inland port

The main port activity for the inland port of Wageningen is the agro-bulk production. The inland port facilitates two agro-bulk terminals, which are both located at the northern bank of the access channel. These terminals are covering an area of 15,625 m^2 and have a quay length of 230 m. The combined throughput volume of these terminals is equal to 650,000 tonnage per year (Kok, 2018), which is equal to more than 50% of the bulk throughput volume of the whole inland port.

Projected future demand for agro-bulk activities according to the narrative

The joint trends, related to agro-bulk activities, indicate that the demand for agro-bulk production is expected to increase until 2050. The increasing demand can be largely attributed to the increased demand for Dutch agricultural products, because the use of local products becomes more important for Dutch consumers. In addition, the many foreign producers of agro-bulk products are not considered to be reliable, which makes the Dutch agro-bulk producers also attractive for foreign consumers. The agro-bulk activities are therefore considered as opportunities for the inland port.

However, the decreasing product demand in the Netherlands may reduce the domestic demand for these agro-bulk products. The growing knowledge in the developing countries may also reduce the demand for the Dutch agro-products over time, because these countries are able to produce reliable agro-bulk themselves. Finally, the IWT may lose some of its market share due to the increased frequency of extreme hydraulic conditions.

Overall, it is expected that this inland port activity will result in an opportunity for the inland port of Wageningen.

Impact on the inland port of Wageningen

The increasing demand for agro-bulk activities is likely to result in an increasing number of agro-bulk activities (for transfer, storage and production of these types of commodities). The fact that Wageningen is one of the main players in the field of agricultural products (e.g. presence of Wageningen University and Research (WUR) and many R&D institutes), makes it even more likely that the inland port will be used more extensively for these agro-bulk activities. This increased demand is likely to result in a higher throughput volume of these agro-bulk products, creating an opportunity for the inland port. It is therefore required to increase the capacity for the agro-bulk terminals. As there are already two agro-bulk terminals with advanced transfer and storage equipment present at the inland port, this increase in capacity can only be achieved by expanding the terminal area for this port activity. The opportunity to create an agro-bulk hub within the inland port of Wageningen is therefore considered to be a major opportunity.

Narrative #6. Opportunity to increase the construction materials production throughput

Present construction material production in the inland port

The inland port of Wageningen facilitates one production area for construction materials. This concrete plant covers an area of 15,000 m^2 and has a quay length of 230 meter. The throughput volume of this port activity is equal to 200,000 tonnages per year, which is slightly larger than 15% of the throughput volume of the total inland port.

Projected future demand for construction materials according to the narrative

The combination of trends with regard to the production of construction materials indicates that the demand for production of construction materials may increase in the future. The main indicator for this trend is the increased demand for buildings and other construction materials due to the increasing shortage of housing. In order to reduce this shortage, many houses will be constructed until at least 2050, therefore creating an opportunity for the production of construction materials.

The introduction of 3D-printing may result in a decrease in demand for the current construction materials (e.g. concrete plant, asphalt plant). However, the 3D-printing is mainly used for the printing of small missing parts and is not developed yet to construct large constructions. The printed materials are not projected to replace the conventional construction materials within the coming 30 years, which will therefore not result in a significant decrease in the demand of construction materials. Another small threat is the fact that the production of concrete is a very polluting process. Due to sustainability reasons, it may be possible that this process requires cleaner techniques. Fortunately, improvements have already been made to make this process more sustainable and this is likely to continue. It is therefore expected that the impacts of these threats is not large enough to reduce the expected increase in demand for the production of construction materials in 2050.

Impact on the inland port of Wageningen

The increased demand for the production of concrete may result in higher production, storage and transfer volumes for the concrete plant in the inland port of Wageningen. It is expected that the terminal is not large enough to meet the future demand for concrete products. It is therefore required to increase the capacity of these terminals, which can be achieved by expanding this port terminal or by constructing a new concrete plant. The inland port of Wageningen may take advantage of this increasing demand in this way. However, the increase in demand is not expected to be very large and could be potentially reduced by the minor threats for this port activity. Therefore, this port activity is only considered to create a marginal opportunity.

Narrative #7. Opportunity to introduce renewable energy production activities

Present energy production in the inland port

There is no energy production activity present in the inland port of Wageningen.

Projected future demand for energy production according to the narrative

For the inland port of Wageningen, it is only relevant to take the trends with opportunities into account for the identification of the impacts for this trend-based narrative, because this could lead to the introduction of new port activities with relevance to energy production. As there is no energy production activity in the current inland port, the inland port cannot be threatened by the negative impacts of these trends.

The energy transition from the conventional fossil fuels into renewable energy sources is considered to be the main trend for this port activity. The renewable energy production may therefore be introduced in the inland port in order to take advantage of the energy transition.

Impact on the inland port of Wageningen

The facilities for renewable energy production activities are not yet facilitated in the inland port of Wageningen, because there is no energy production in the inland port. It is therefore required to construct this new terminal on the free areas in the inland port of Wageningen. However, it is more likely that these renewable inland port activities will be located in current energy producing facilities. In these facilities, infrastructure of the energy network can then be used for renewable energy production. It is not likely that the renewable energy production activities will be introduced in the inland port, because of the absence of this infrastructure. It is therefore considered to be a minimal opportunity.

Narrative #8. Opportunity to introduce recycling activities

Present recycling activities in the inland port

The inland port of Wageningen does not have any facilities for recycling activities along the port basin.

Projected future demand for recycling activities according to the narrative

For this inland port, it is not relevant to take the threats into account, because the inland port does not include any recycling activities. It is only relevant to take the trends with opportunities into account for the identification of the trend-based narrative, because this could lead to the introduction of recycling activities. As there is no recycling activity in the current inland port, the inland port cannot be threatened by the expected negative impacts of these long-term developments. The transition from the conventional raw materials to more sustainable and recycled materials is considered to be the main trend for this port activity, resulting in a significant increase in recycled materials. The introduction of recycling activities is therefore considered to become an opportunity for the inland port.

Impact on the inland port of Wageningen

There are no facilities for recycling activities in the inland port of Wageningen. It is therefore required to construct a new recycling terminal on a free area in the inland port, but there is not a lot of free area left in this inland port. Overall, this port activity is considered to create a marginal opportunity, because the throughput volumes are expected to increase significantly.

Narrative #9. Opportunity to introduce new production activities

Present industrial production of other products types in the inland port

The inland port of Wageningen does not have any terminals for other production processes.

Projected future demand for the production of other products to the narrative

For this inland port, it is only relevant to take the trends with opportunities into account for the identification of the trend-based narrative, because this could lead to the introduction of the industrial production of other goods. As there is no such a production process present in the current inland port, the inland port cannot be threatened by the expected negative impacts of these long-term developments.

The transition towards sustainable and local products may increase the demand for local production of goods from sustainable raw materials. For the inland port, this could result in attracting these types of inland port activities towards the inland port of Wageningen. The introduction of this port activity can be therefore considered as a minimal opportunity for the inland port.

Impact on the inland port of Wageningen

The facilities for other production activities are not yet located in the inland port of Wageningen. It is therefore required to construct a new terminal on the free areas in the inland port of Wageningen in order to meet the potential demand for this type of activities. However, the fact that the increase in the demand for this type of port activities is rather small makes it unlikely that this new port activity will be introduced in the inland port, resulting in a minimal opportunity for the inland port of Wageningen.

Projected impacts of the narratives

In Table 27, an overview of the trend-based narratives and their projected impacts is presented per activity for the inland port of Wageningen. For all but one port activity, it is projected that these activities create opportunities for this inland port. The only threatened port activity is the liquid bulk transfer and storage activity. According to these results, it is likely that the inland port can be considered as future-proof for the inland port, because the number of threatened port activities is very small.

	Port activity	Trend-based narrative	Projected impact
1	Container transfer and storage	Opportunity to introduce container transfer and storage activities	Marginal opportunity
2	Dry bulk transfer and storage	Opportunity to increase the sand & gravel throughput	Marginal opportunity
3	Liquid bulk transfer and storage	Threat of decline of mineral oil products	Major threat
4	Transfer and storage of remaining cargo types	Opportunity to create a terminal for break-bulk, neo-bulk or special goods	Minimal opportunity
5	Agro-bulk production	Opportunity to create an agro-bulk hub	Major opportunity
6	Construction materials production	Opportunity to increase the construction materials production throughput	Marginal opportunity
7	Energy production	Opportunity to introduce renewable energy production activities	Minimal opportunity
8	Recycling activities	Opportunity to introduce recycling activities	Marginal opportunity
9	Remaining industrial production activities	Opportunity to introduce new production activities	Minimal opportunity

Table 27: Overview of the identified narratives and the projected impact per port activity for the inland port of Wageningen

The number of port activities with projected opportunities in relation to the number of threats does not give a good representation of the actual projected impacts on the inland port. Similar to the previous case studies, additional insights have been obtained to understand the impacts for the inland port of Wageningen. The projected impacts can be presented in relation to the total inland port, by calculating the share of threatened port activities in relation to the total port area, quay length and bulk throughput volumes. For the inland port of Wageningen, this has been presented in Figure 51. The green colours represent the port activities with opportunities, while the red colours represent the port activities, which are projected to be threatened. The darker the red and green parts, the larger the projected impacts of the threats and opportunities respectively.

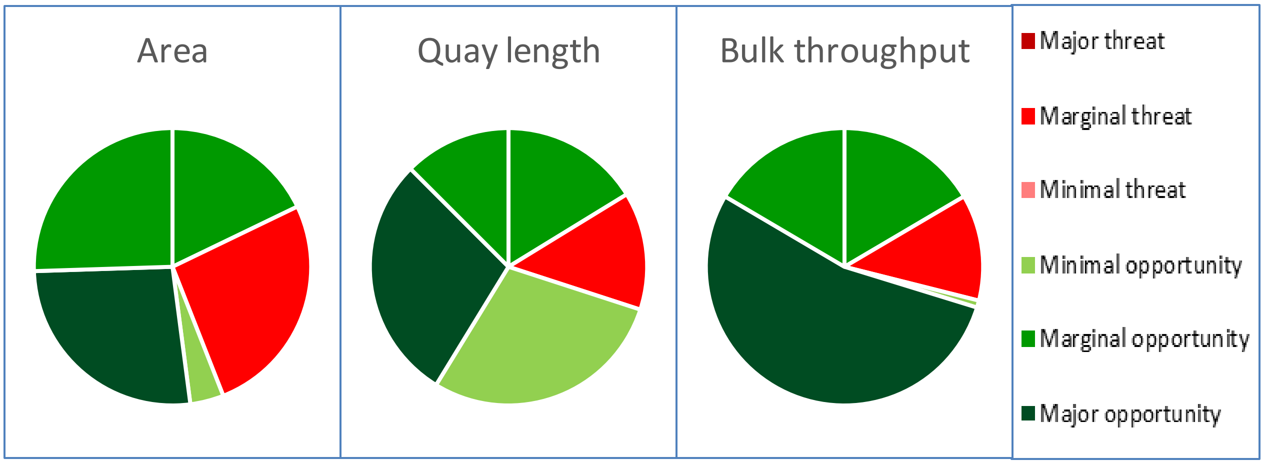


Figure 51: The share of port activities with opportunities (green) or threats (red) in the inland port of Wageningen with relation to the total port area, total quay length and total throughput volumes in the port

The impacts of the trend-based narratives showed that the demand for only one of the port activities was projected to decrease: the liquid bulk terminal for the transfer and storage of mineral oil products. In this way, it looked like the inland port of Wageningen was almost entirely operated by port activities with opportunities. Figure 51 shows a slightly different outcome as around 25% of the total port area along the inland port basin is occupied by these threatened port activities. It can also be seen that around 25% of the port includes a port activity with a major opportunity (agro-bulk production).

The share of the quay length of these threatened activities is relatively small (15%) compared to the share for the port area, because the liquid bulk has a relatively small quay length compared to the other inland port activities. The share of throughput volumes of the threatened port activity is equal to the share of the quay length: also around 15% of the total bulk throughput. This 15% of the total bulk throughput may disappear because of the future threats.

Overall, the share of threatened port activities is relatively low in relation to the total port. In order to become a future-proof inland port, the inland port of Wageningen has to reduce the negative impacts on the port activities related to the liquid bulk terminal. On the other hand, the inland port has attracted new port activities and retain the port activities with future prospects in the inland port. In this way, the inland port may remain future-proof. For this inland port, this seems not a very big problem, especially when the opportunities for agro-bulk activities will be converted into new port activities.

Part 3: Determination of the future-proofness of the inland ports

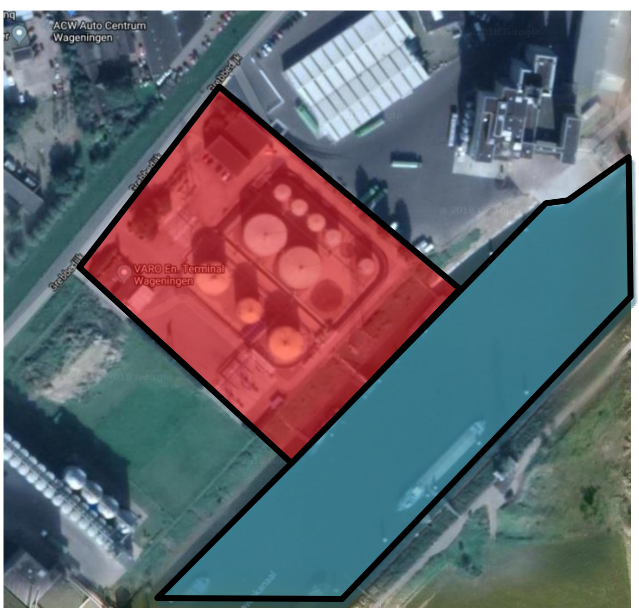
The third part of the method is used to determine the flexibility of the inland port. The flexibility of the inland port represents the degree in which the inland port can adapt to the future demand for port activities. This adaptability cannot be measured directly, but two different aspects will be determined: the potential reduction of negative impacts by replacing them with new port activities and the potential to increase the capacities of current activities (by converting the opportunities into new port activities at new terminal areas). The higher the potential to reduce its negative impacts and the more likely that the capacity of new activities can be increased, the more flexible the inland port may be. These two aspects of the inland port of Wageningen are determined in this section.

Analysis of the current port infrastructure of the threatened port activities for new port activities

The current infrastructure of the projected threatened port activities is analysed in order to determine whether this infrastructure can be used for the new port activities. In this way, it can be determined whether the inland port could reduce its threats (and thus remain useful and successful in the future).

Argos Energy Terminal Wageningen

The Argos Energy Terminal Wageningen is the only existing terminal in Wageningen, which is projected to be threatened. This terminal is located on the northern bank of the inland port and has one jetty, at which the liquid bulk inland vessels can be (un)loaded (see left figure in Figure 52**Fout! Verwijzingsbron niet gevonden.**) by using a system of pumps and pipelines. With help from these pipelines, the liquid bulk can be transported between the storage areas and the jetty. The terminal area itself has multiple silos, in which the oil products are stored until they are further transported to the final destinations by trucks. The main characteristics of this terminal are presented on the right in Figure 52.



Argos Energy Terminal Wageningen	
Area	15,400 m^2
Quay length	110 m
Current throughput	150,000 tonnage
Current activities	Liquid bulk transfer & storage
Current cargo type	Liquid oil products
Quay equipment	Pumping system
Terminal equipment	Pipelines
Storage equipment	Storage tanks

Figure 52: Location of Argos Energy Terminal Wageningen and its terminal characteristics

The infrastructure on this specific inland terminal is specified for liquid bulk activities (both transfer and storage). Fortunately, a few trend-based narratives project an increase in demand for some of the other liquid bulk transfer and storage activities. These trend-narratives are:

- Opportunity to create an agro-bulk hub
- Opportunity to introduce renewable energy production activities
- Opportunity to convert the current liquid bulk terminal into a sustainable fuel terminal

Trend-based narratives project that the demand for some of the liquid bulk transfer and storage activities may increase for this specific inland port, which may result in the fact that the threatened port activity will be replaced by a new liquid bulk terminal. The main reason for this replacement is based on the already present liquid bulk infrastructure in the inland port. Therefore it is likely that this projected threatened port terminal attracts an agro-bulk producer or a sustainable fuel distributor, because only minor adjustments to the current infrastructure are required for these type of terminals.

It is expected that the negative impacts of the threatened liquid bulk terminal will be reduced, because the current port infrastructure may be reused by new port activities, which are projected to create opportunities for this specific inland port.

Analysis of the potential to expand the capacities of the port activities

The capacity of the port activities in Wageningen can be further increased in two different ways: increasing the internal terminal capacity and/or constructing new terminal areas for new port activities. This section looks at these two aspects to determine whether there are opportunities to increase the capacity for port activities in the inland port of Wageningen.

Internal terminal capacity

Most terminals within the inland port of Wageningen use advanced terminal and quay equipment for carrying out the port activities. The transfer capacities at these terminals can therefore not be optimised significantly. At the two public quays, mobile cranes (on the quay and on the inland vessels) have been used to (un)load the cargo, but these quays are not used frequently for the transfer of cargo. The quay capacity for these terminals can therefore be improved by using more advanced quay equipment on these quays.

At the other terminals, an efficient and effective system is in place for the transfer and storage of the cargo. Some examples of this system includes the use of cranes with grabs for the sand/gravel terminal, the use of conveyor belts for the agro bulk transport and pipelines in the liquid bulk terminal (see Figure 53). The use of these efficient and effective methods and equipment for both storage and (internal) transport in the terminals ensures that the internal capacity of the current terminals cannot be increased significantly, unless the terminal configuration will be changed.

Figure 53: Quay equipment at the agro-bulk terminal (left) and the concrete plant (right)

Possibility to increase the area for port activities

The other possibility to increase the capacities of the inland port can be reached by expanding the area with port activities. A distinction has been made between free areas and areas, which are currently used by companies without any port-related activities. These free areas can be bought and then be used to construct terminal facilities. The existing company has to be relocated to another location when the port wants to use the areas with companies without port activities, which may take a long time. Free area along the port basin is therefore preferred over the other potential areas in order to increase the terminal capacity.

The free areas and areas with non-port activities in the inland port of Wageningen have been identified (Google Maps, 2018; Kok, 2018), which is presented in Figure 54. The brown areas represent the port area along the port basin without any port activities, while the free areas are presented in a black colour. The blue areas present the current port terminals.

Figure 54: Location of the free areas (black) and the areas without port activities (brown) in the port of Wageningen

In order to expand the current port terminals or to attract new activities in the inland port area, free areas have to be used in the inland port area of Wageningen. Along the southern bank of the inland port of Wageningen, there is plenty of free area, which can be used to construct new port terminals. In addition, the free areas on the northern bank can be used to expand the current port activities, when needed. There is also a lot of potential port area present, which is currently occupied by companies without any port activities. In order to use this inland port area, a process of relocation for the current company has to be started, which can take a long time. The fact that there is a lot of free area available in the inland port may avoid these relocation processes, which is preferred for a good flexibility of the inland port.

In order to present the overall potential to expand the port area, the share of the potential port areas is presented in relation to the total port area along the port basin and the total quay length (see Figure 55). This gives a better insight in the potential port area compared with the current inland port. The blue colour represents the area or quay length, which is currently used for the port activities. The grey parts represents the share of free area and its quay length in the inland port, while the brown parts represents the area and quay length along the port basin that is currently used by companies without any port activities.

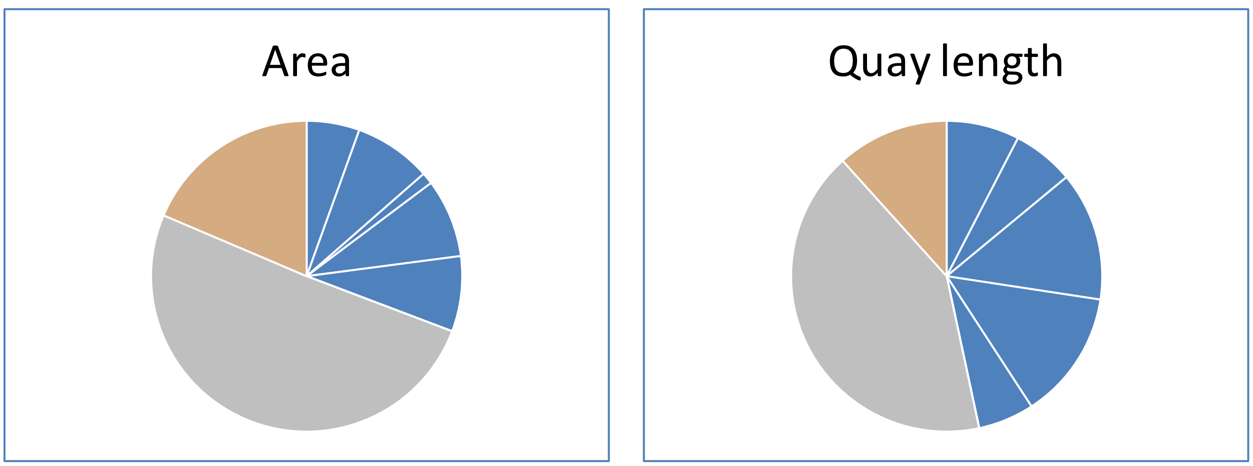


Figure 55: Potential area and quay length in Wageningen (blue = current use, grey = free area, brown = currently used by non-port activities)

Figure 55 shows that almost 70% of the total inland port area is not used for inland port activities. This area (around 132,350 m^2) could be potentially used to increase the capacity of the various inland port activities. Around 75% of this port area is free area, which can be directly used to construct a port terminal or to expand a current port terminal. The other 25% is occupied by companies which are not bound to a location along the port basin, which have to be relocated in order to use this port area. Overall, the relatively high free area can be considered as a good sign for the flexibility of the inland port of Wageningen.

The potential increase in quay length could be increased by 915 meters, which is larger than the current quay length in the inland port. 715 meters of this quay length are located at the free areas, while the other 200 meters are located at the already occupied port areas. This high potential quay length is also considered a good sign for the flexibility of the inland port, as the inland port can 'easily' increase its transfer capacity.

Overall flexibility of the inland port of Wageningen

The overall flexibility of the inland port of Wageningen is considered to be very good. In the first place, the port characteristics show that the diversity of the inland port is quite evenly distributed, although the agro-bulk activities are dominating (see results of part 1). Furthermore, it is not expected that the climate change would reduce the operational time of the inland port, because the inland waterway and port basin have a sufficient depth and the terminals are constructed with a sufficient safety level.

Moreover, the threatened port activities (the transfer and storage of oil products) are likely to be replaced by other inland port activities (e.g. sustainable fuels), because the current port infrastructure matches the port activities with opportunities. In addition, there is plenty of free area to expand the port capacity. In this way, the port may convert these opportunities in new port activities and further increase its successfulness.

Part 4: Assessment of the future-proofness of the inland port of Wageningen

The strengths, weaknesses, opportunities and threats for the inland port of Wageningen are known, which are included in a SWOT-analysis. In addition, the flexibility for the inland port is included in the SWOT-analysis to present whether the inland port can convert these opportunities into more port activities. The combination of the strengths, weaknesses, opportunities and threats is used to present a first insight whether it is likely that the inland port remains successful and useful in the changing conditions up to 2050.

SWOT-analysis

The SWOT-analysis in Figure 56 presents an overview of the identified strengths, weaknesses, opportunities and threats of the inland port of Wageningen. This gives a first impression of the future-proofness of this inland port.

Strengths	**Weaknesses**
• CEMT-class Va • Good inland navigation accessibility • Large hinterland area • Many free area for expanding port activities • Mainly port-related activities in the port area	• Bad rail and road accessibility • Limited diversity in port activities • Small throughput volumes • Small total port areas • Restricted operational time • Very dependent on agro-bulk terminal (AgruniekRijnvallei)
Opportunities	**Threats**
• Many potential area available for new activities Activities concerning: • Sand and gravel transfer and storage (*marginal*) • Transfer of remaining types of cargo (*minimal*) • Agro-bulk transfer and processing (*major*) • Production of concrete (*marginal*) • New port activities (minimal or marginal)	• Max. internal terminal capacities may be reached due to use of advanced equipment Activities concerning: • Mineral oil transfer and storage (*major*)

Figure 56: SWOT-analysis for inland port of Wageningen

The port specific information about the port characteristics, the projected impacts and the flexibility are included in the SWOT-analysis from above. This means that it is possible to assess the future-proofness of the inland port of Wageningen.

The inland port can be considered as future-proof when the inland port remains useful and successful for the transfer of goods, the storage of goods and the industrial production of goods in the future, while being flexible enough in port services and infrastructure to deal with potential changes (see the definition in chapter 2). Similar to the previous case studies, the projected usefulness and successfulness of the inland port needs to be determined first. Thereafter, the general result of the future-proofness of the case study port will be determined according to the combination of answers on the three questions (which is categorised in Table 4).

Usefulness

The port of Wageningen can be considered as useful when there are sufficient port activities to use the port area and infrastructure in a useful way in order to perform the primary functions of the inland port. This can only be achieved when the inland port provides sufficient services and infrastructure to perform these main functions.

The inland port has five different inland port activities. For the majority of these inland port activities, it is projected that the demand increases until 2050 and therefore the inland port remains useful for the port activities. It is found that the demand for the activities in the sand and gravel terminals, the agro-bulk terminal and the concrete plant will increase significantly (port activities with a marginal or major opportunity). These terminals therefore require an increase in the terminal capacity in order to meet the demand, which can only be achieved by increasing the internal capacity or by expanding the terminal area. For all these terminals, improving the internal capacity may not be sufficient to meet this future demand, because these terminals already use advanced equipment for the transfer and storage activities. It is therefore required to expand the terminal area in order to meet the future demand for these port activities and to remain useful for these inland port activities.

Furthermore, a small increase in demand is expected for the transfer activities of the remaining cargo types (e.g. break-bulk, special bulk), but the capacity of the two quays may be sufficient to meet these small increases in demand for these port activities. It is therefore not required to increase the terminal areas for these port activities in order to meet the future demand.

However, the demand for the liquid bulk terminal is projected to decrease substantially. There is a risk that this port activity may leave the port area, which makes the inland port less useful (and thus less future-proof). Fortunately, there are several port activities with the same port infrastructure, which can be attracted to replace these threatened port activity (such as the transfer and storage of bio-based fuels or liquid agro-bulk cargo).

Overall, the usefulness of the inland port of Wageningen faces a minor challenge, which is mainly based on the risk of the departure of the production of liquid bulk transfer and storage.

Successfulness

The inland port of Wageningen is successful when the inland port activities remain effective and efficient on the long-term, so that the port activity can continue to exist in the inland port area (on condition that it remains useful). For the inland port activities, the effectiveness can be defined as the state at which the inland port is able to address a certain demand, while the efficiency is the extent at which the activities can be conducted with a minimum wasted effort.

The successfulness of the inland port of Wageningen seems not to be under big threat. The only contributor to this threat is the expected reduced demand for oil products, but this port activity is relatively small in the inland port (covering around 25% of the total port area and the throughput is around 15% of the total bulk throughput). The projected decrease in demand may result in a decrease in total cargo throughput volumes in the inland port. This port activity is therefore not likely to remain successful as the inland port company may not sustain in the inland port.

In addition, the efficiency and effectiveness of the inland port of Wageningen also presents the successfulness of the inland port. This can be improved by increasing the port capacity of several port terminals. The terminals already use advanced types of storage and transfer equipment, resulting in an efficient an effective port activity. This may result in a more attractive port area for companies for their inland waterway transport.
Overall, it is considered that the inland port remains successful, because the majority of the port activities are projected to result in an opportunity. On the other hand, there is a risk that some port activities leave the inland port, but these are expected to be replaced by the port activities with opportunities. Furthermore, the successfulness can be improved by attracting new port activities to the inland port, because there is plenty of free area available at the inland port.

Future-proofness

In this last step, the future-proofness of the inland port of Wageningen is determined. The following questions have to be answered in order to determine future-proofness of the inland port according to the general guideline from Table 4:

1. Is it projected that the inland port activities in the inland port are hardly threatened?
2. Are there sufficient opportunities to compensate for the anticipated threats?
3. Does the existing infrastructure match the infrastructure needed for these identified opportunities?

The first question can be answered positively, because only one port activities is anticipated to be threatened. This port activity (transfer and storage of oil products) is performed at only terminal and is not considered to be a dominant port activity for the inland port. This makes this inland port not very vulnerable for a decline in demand for this port activity. The risks of becoming less useful and successful are therefore relatively small.
The second question can also be answered positively. The port activities with opportunities are likely to replace the threatened port activity. In addition, there is a large potential to increase the port area, because there is a lot of free area around the port basin. It is therefore also possible to attract a lot of new port activities to this inland port.
The third and final question can also be answered positively. For this inland port, the threatened port activity is related to liquid bulk transfer and storage. This activity is likely to be replaced by the transfer of bio-based fuels or liquid agro-bulk, which can both use the current port infrastructure of the threatened port activity.

According to the general guideline in Table 4, the inland port can be categorised as a very future-proof inland port (see Table 28). This excellent score tells us that this inland port is expected to remain useful and successful for performing future port activities and it is also flexible enough to deal with potential changes in the demand for the various port activities.

Question 1	Question 2	Question 3	Total
+	+	+	**Very Future-proof**

Table 28: Overview of the future-proofness of the inland port of Wageningen