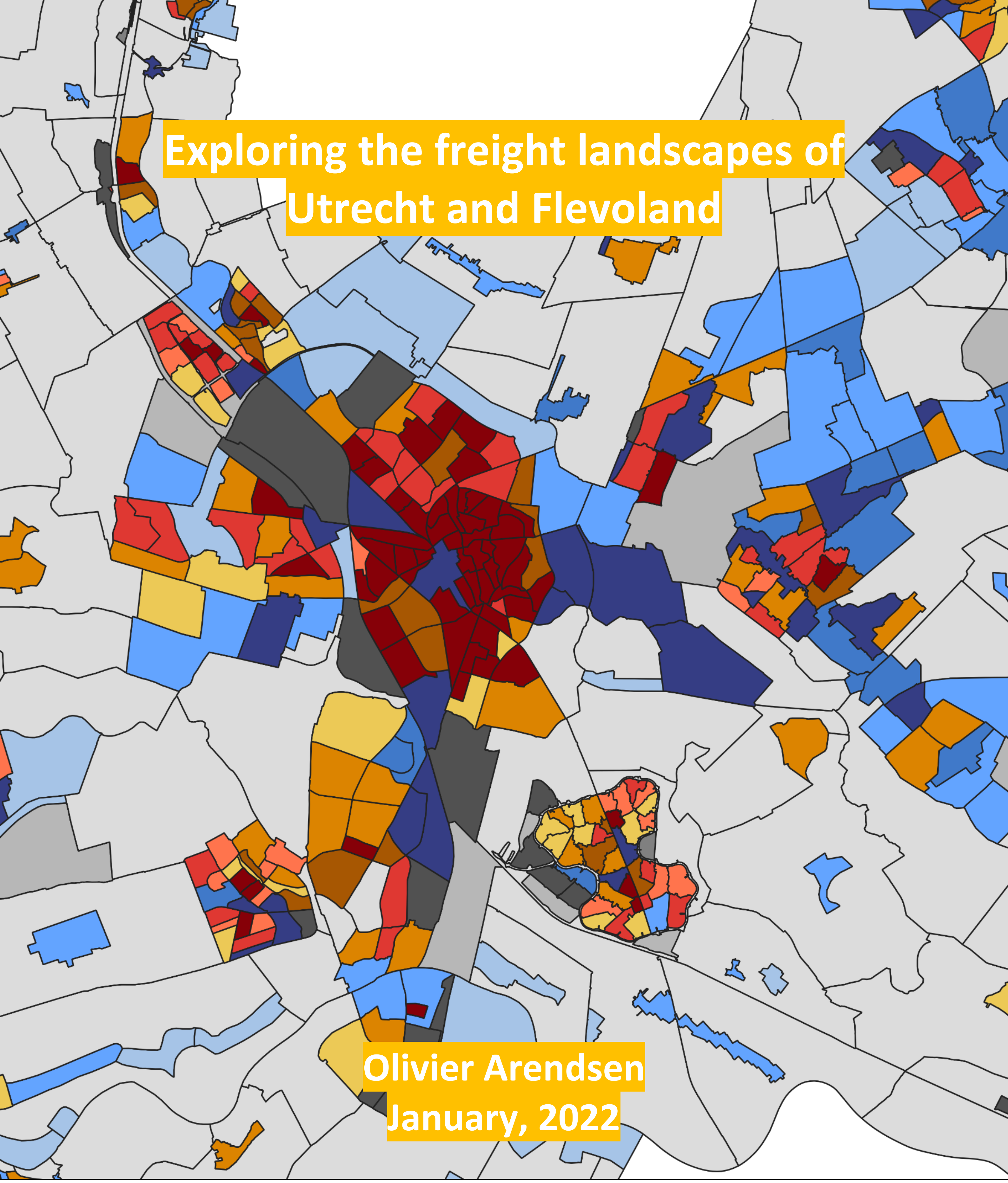
Exploring the freight landscapes of Utrecht and Flevoland



Olivier Arendsen

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Master's Thesis for the Spatial Planning programme,
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Radboud University

Exploring the freight landscapes of Utrecht and Flevoland

A research into the concept of the freight landscape as a representative of the spatial distribution of freight activities.

This thesis was written during an internship at Rijkswaterstaat

Colophon

Submission date:	20-01-2022
Student:	O. Arendsen
Student number	s1060028
University:	Radboud University
Supervisor:	Dr. S. Lenferink
2nd reviewer:	Dr. F. Verhees

Radboud University

IN·DEI·NOMINE·FELICITER

Internship organisation:	Rijkswaterstaat
Internship supervisor:	L. Aarts

Rijkswaterstaat
Ministry of Infrastructure and Water Management

Preface

I hereby present my master thesis in which I explore the freight landscape of Utrecht and Flevoland, which has been conducted for my Master in Spatial Planning, with a specialization of Urban and Regional Mobility. Finalising this thesis marks the end of an extensive research period.

The thesis started with questions on how freight transportation was being dealt with in both the literature and in the field of spatial planning. Throughout writing the thesis I gained a lot of insight into the different aspects that together make up the complex topic of freight transportation, and how it is linked to spatial (planning) issues. While the thesis gave answer to a lot of questions, I also found many new questions, which I discussed in the conclusion and recommendation chapters.

Writing the thesis was both enjoyable, but at moments also stressful, and I would like to thank my supervisor Sander Lenferink for his support by giving feedback on different elements of the thesis, thinking along with me on planning issues and organising group sessions with other thesis writers. These group sessions were a really nice platform to interact with other thesis students and to both give and receive feedback from one another, especially in these times of COVID-19.

Next to learning much about the academic side of freight transportation, an internship at Rijkswaterstaat was also part of the thesis process. I would like to thank Loes Aarts not only for thinking along with me on different aspects of the thesis, but also introducing me to the work of Rijkswaterstaat and involving me in different projects currently being worked on at Rijkswaterstaat, which has been very interesting, and a really nice addition to the thesis process.

And last but not least, I would like to thank the people at Rijkswaterstaat who participated in the focus group. This really helped in better understanding what the freight landscape concept could mean for Rijkswaterstaat.

All that remains me to say is that I hope you enjoy reading the thesis!

Olivier Arendsen
January 2022

Summary

Freight transportation is essential to any economy. This is also true in the Netherlands. Much of the freight moved in the Netherlands will use the infrastructure that is managed by Rijkswaterstaat. Rijkswaterstaat, as an executive agency within the Dutch Ministry of Infrastructure and Water Management, is tasked with the management of the highway and waterway network of the Netherlands. They are currently facing a serious challenge in renovating and replacing much of their infrastructure, of which large parts have been built in the 60s and 70s (Rijkswaterstaat, 2021). A better understanding on the movement and spatial distribution of freight activities could help in better managing assets and assist in such a challenge, especially considering that freight transportation has a serious impact on the wear and tear of road infrastructure (IFT, 2018, p. 15). Despite this importance there is relatively little attention from spatial planners and policy makers towards freight transportation. Most attention is focussed on passenger transportation (Cui, Dodson, & Hall, 2015). Different reasons point towards the cause of such a lack of focus on freight transportation. Among which is the complexity of freight transportation, which is in contrast to passenger transportation very heterogenous: coal, for example, is transported in a different way compared to vaccines. This complexity is also expressed in the spatial distribution of freight transportation activities. A concept that could help in better understanding this spatial distribution of freight transportation is the freight landscape, or landscapes. The freight landscape consists of four different, but interrelated landscapes:

- The political landscape: this landscape is about the rules and laws that could influence freight flows, such as parking restrictions or noise restriction.
- The socioeconomic landscape: this is about land uses that are used in most zoning plans of cities, such as residential, industrial, or office areas. Every land use, as already discussed in the land-use transport interaction (LUTI) literature, has its own impact on freight flows.
- Infrastructure landscape: this refers to all the infrastructure that supports freight flows, such as highways, bridges, freight terminals, airports, railyards, etc.
- Mobility landscape: this is about the way freight is moved around. What modes of transport are used, the route, the schedule, etc.

This research explored the concept of the freight landscape and did so for the provinces of Utrecht and Flevoland. This was done by conducting a mixed methods approach that combined elements of GIS, a focus group and a content analysis. Previous research primarily focussed on the socioeconomic landscape (Giuliano, Kang, & Yuan, 2017; Sakai, Beziat, Heitz, & Dablanc, 2018). This research also included a more detailed analysis of the political landscape. The main findings show that both provinces have a transport system dominated by road freight transportation, and that any model shift away from this road based system will not be occurring in the short to medium term based in the infrastructure currently available for other transport modes. This means that any growth in freight transportation will mainly be achieved through a growth in road transportation, which will affect the network of Rijkswaterstaat. The landscape further revealed that especially Flevoland, of these two provinces, is a favourable location for future logistical developments. Lastly, the freight landscape concept in the form of a mobility landscape, could potentially be useful for more operational tasks of Rijkswaterstaat, but is currently hampered due to a lack of data.

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1. Introduction

Freight transportation is essential to any economy. Without it, economies would grind to a halt. The stranding of the Ever Given in the Suez Canal illustrated that disruptions in the transportation of freight can have far reaching consequences (NOS, 2021). Cui, Dodson and Hall (2015) note that the efficient movement of goods is essential to the competitiveness of an economy. One of the main ways to improve the efficiency of freight transportation is by investing in infrastructure. Banister and Berechman (2001) do, however, note that the return on investment of infrastructure decreases if there is already a high quality infrastructure network present. Such as in the case of the Netherlands.

The Netherlands has one of the most dense highway networks in in the world. The whole highway and waterway network, together with other public works (such as water locks) is managed by Rijkswaterstaat, which is an executive agency that is part of the Dutch Ministry of Infrastructure and Water Management. As most of the highway infrastructure has already been built in the previous decades in the Netherlands, the role of Rijkswaterstaat around infrastructure is more and more moving from a developer of infrastructure to a manager of infrastructure assets (van der Velde, Klatter & Bakker, 2013). Parlikad and Jafari (2016) state that the management of such infrastructure assets comes with its own set of challenges. Most infrastructure is aging and is reaching the end of its life cycle. The usage of the infrastructure is also in a lot of cases more intense than was expected beforehand, which means that usage of the infrastructure often exceeds what it was actually designed for (Stroosma, 2021). Next to aging infrastructure and extra usage new regulations, on safety for instance, also create challenges in the management of assets. Adding to the challenge is the more than often tight (or even insufficient) budget under which maintenance, renovation or replacement of assets has to take place (Van der Velde, Klatter & Bakker, 2013; Stroosma, 2021).

Such challenges mean that the planning for infrastructure is a careful balancing act in which a complex set of factors, such as safety, performance and cost, have to be taken into account. In order to make more sound plans a lot of knowledge is required on all sorts of factors, such as its current state and usage that influence the assets. An important factor in developing such plans, or even visions, is freight transportation, in particular that of freight transportation on the road. According to a study of the International Transport Forum truck usage of the roads could cause as much as seventy to eighty percent of the road deterioration caused by motorized vehicles, while only being a minor road user in absolute numbers (ITF, 2018, p. 15). Another problem is that roads are becoming more and more congested, which fuels the debate on modal shift (Blauwens, et al., 2006).

Furthermore, freight transport planning becomes more important as a global shift towards more sustainable forms of transport is taking place, which includes the low-emission zones that a growing number of municipalities is implementing, which can cause rerouting (Dablanc & Montenon, 2015). One solution to the difficulty to reach the (dense) city centre, in part created through low emission zones, is the creation of dedicated freight hubs, also referred to as urban consolidation centres (van Heeswijk, Larsen, & Larsen, 2019). A concept different municipalities in the Netherlands are investigating. These developments also relate to the broader trend of logistical sprawl, in which warehouses and distribution centres (DCs) relocate further away from the city centre. On the other side of the spectrum are the international freight flows (through international freight corridors) that flow through so called 'gateways' such as (large) sea ports, which handle increasing numbers of goods as the process of globalization continues (Rodrigue, 2013). This eventually puts pressure on existing infrastructure as they become more congested. In order to better maintain and plan for future infrastructure, knowledge about freight transportation is necessary.

This, however, is were part of the problem comes in. While freight transport is an important factor in developing sound visions for future usage of the infrastructure most policies and spatial planning research is currently focussed on public transport, and little on freight (Hesse & Rodrigue, 2004;

Dablanc, 2007; Arts, van der Werf & Linssen, 2018). This is in part due to the heterogenous and complex nature of freight transportation (Holguín-Veras, Amaya Leal, & Seruya, 2017). For instance, different concepts, such as modal shift, consider a freight (or logistical) hub to be a key part in achieving a system that support modal shift, but no clear definition of the freight hub is given. Moreover, data about freight transportation and methods to measure it, especially when it comes to trucking, is scarce (Giuliano, Kang, Yuan, 2017). Also problematic is the lack of research connecting both ends of the freight transport spectrum (global and urban) towards one another. It is exactly this interface between the global and urban scale at which Rijkswaterstaat operates.

In order to fill this gap some policy initiatives on a European level have already been undertaken. For instance, to fill this knowledge gap between international corridors and urban nodes on the European level the Vital Nodes organisation (funded by the EU) has been called into life. Its objective is to remove barriers for freight on all levels and to bring about more integration of European networks (Vital Nodes, 2020). In order to better assess the interplay between an urban node and its hinterlands Vital Nodes introduced the concept of the functional urban area (Van der Linden & Linssen, 2019). One of the main ideas behind it is to be able to look beyond administrative boundaries when planning for freight and logistics, as such activities rarely stop at a municipal border, or, since the introduction of the Schengen area, even at the national border.

Another concept that tries to better understand the distribution of freight activities is the so called 'freight landscape', in this research also referred to as freight landscapes (Giuliano, Kang, & Yuan, 2017; Rodrigue, Dablanc, & Giuliano, 2017). This concept is meant to be a representation of the spatial distribution of freight activity and intensity in large urban areas (metropoles). The main part of the concept is the relation between urban density (of employment and population) and truck intensity. Meaning that more dense urban areas, such as the city centre, have more intense truck activity than more rural areas. While this socioeconomic part is has been de focus point of previous freight landscape studies, the landscape itself consists of four interrelated landscapes (Rodrigue, et al., 2017):

- The political landscape: this landscape is about the rules and laws that could influence freight flows, such as parking restrictions or noise restriction.
- The socioeconomic landscape: this is about land uses that are used in most zoning plans of cities, such as residential, industrial, or office areas. Every land use, as already discussed in the land-use transport interaction (LUTI) literature, has its own impact on freight flows.
- Infrastructure landscape: this refers to all the infrastructure that supports freight flows, such as highways, bridges, freight terminals, airports, railyards, etc.
- Mobility landscape: this is about the way freight is moved around. What modes of transport are used, the route, the schedule, etc.

The literature on the freight landscape has put an emphasis on research into the socioeconomic landscape of the freight landscape. It has been hypothesized and tested that there is a correlation between the amount of density and the intensity of freight movement (Giuliano, Kang, & Yuan, 2017; Rodrigue et al., 2017; Sakai, Beziat, Heitz, & Dablanc, 2018). Densely populated areas with high employment (city centres) generate a lot of intense freight movement as a broad spectrum of goods are offered consumed in such areas, which are delivered in small quantities. On the other side are the locations with very low population densities but high employment densities (industrial areas) through which a lot of freight is moved as well, but in larger quantities.

Research aim (goal)

The aim of this research is to gain an better understanding on how freight transportation is spatially organised. Especially how it is structured on the regional scale, since this scale is underrepresented in the literature (Rodrigue, 2006). For this research, the regional context is centred around the provincial scale. Provinces are regional government entities in the Netherlands situated between the municipality and the national government. The freight landscapes seems to offer a framework that can help assess the different spatial dimensions (socioeconomic, political, infrastructure and mobility) that have an effect freight transportation. However, the freight landscapes are also a novel concept that has not been tested and analysed in the Netherlands. This research therefore aims to explore a freight landscape in the Netherlands, by constructing and analysing it, and to assess whether it can actually help Rijkswaterstaat better manage their infrastructure assets.

Research questions

This aim is expressed in the following research question:

What can the freight landscapes of Utrecht and Flevoland indicate about the spatial distribution of freight transportation activities and what does this mean for the network of Rijkswaterstaat?

To answer this question, a set of sub questions have been formulated:

- How are freight transportation activities spatially organised? And how are freight transport activities spatially organised in the provinces of Utrecht and Flevoland?
- What does the socioeconomic landscape mean for Rijkswaterstaat as an infrastructure asset manager?
- What do the political landscapes of Utrecht and Flevoland mean for Rijkswaterstaat as an infrastructure asset manager?

Scientific relevance

As mentioned earlier, freight transport is scarcely researched by urban planners (Woudsma, 2001; Hesse & Rodrigue, 2004; Lindholm, & Behrends, 2012). Most focus is put on passenger transportation. The research that does focus on freight transportation is either concentrated around the large scale of global freight flows and the gateways through which they flow, or on the local (urban) scale, which is often referred to as the last mile problem. The regional scale, on which the global and local scales converge, has received little attention (Rodrigue, 2006).

Doing research into freight is also difficult because of a lack of data. As freight is operated by private companies, most data is simply not publicly shared. This is especially apparent on road freight transportation, in which even basic data is not available (Giuliano, Kang, & Yuan, 2017). The freight landscape (through the socioeconomic landscape) helps in obtaining useful data without a need to collect data from private companies (Sakai, Beziat, Heitz, & Dablanc, 2018). Furthermore, most research on the freight landscape has focussed on the socioeconomic landscape. This research will also further investigate the other landscapes, thereby expanding the knowledge on it.

Societal relevance

Just as in academic research, policymakers pay little attention of freight transportation (Dablanc, 2007). One of the main reasons for this lack of attention is the lack of knowledge on the side of the urban planner on the subject. They also considered freight transportation to be a private activity in which the government has no role to play. However, freight transportation does impact its surroundings, in negative and positive ways, and therefore cannot be ignored. For instance, freight transportation (although less than passenger transport) adds to congestion problems, creates noise and air pollution and also plays a serious role in fatal accidents in the urban environment (Lindholm, & Behrends, 2012). Furthermore, planning for passenger transportation automatically means planning for freight transportation, as most infrastructure is used by both. For instance, trying to move more freight flows to trains instead of trucks can only be done if the capacity on the rail network is not already completely utilized by passenger transportation. Planning for both passenger and freight transport can therefore help create synergies.

Apart from lack of capacity, freight also has a serious impact on the wear and tear of infrastructure (IFT, 2018, p. 15). This is especially relevant in the Dutch context as most road infrastructure under management of Rijkswaterstaat has already been built in the previous decades, and are therefore in need of big repairs or even replacement (Del Grosso, Inaudi, & Pardi, 2002). Understanding freight transportation can help develop more effective policies what is needed to deal with the challenge of repairing or replacing infrastructure assets. In this context the freight landscape could serve as a tool to better understand freight on a more regional scale. Especially the regional scale can be relevant since freight transportation does not stop at municipal boundaries, more understanding of the regional effects could help create regional freight strategies that could enhance the effectiveness of policies (Dablanc & Ross, 2012).

Outline of this research

This research consist of nine chapters. Chapter two will review relevant literature on freight transportation, asset management and the freight landscape. It will end by presenting a conceptual modal based on the reviewed literature in which elements of the freight landscape are presented schematically. Chapter three presents the methods that were used to gather and analyse the data needed to research the different elements presented in the conceptual model. These methods are a content analysis, GIS and a focus group. The results of these methods are presented in chapter four, which is structured around the four different freight landscapes. Chapter five used these results to answer the sub questions outlined in this chapter to build up to the conclusion. The conclusion itself is presented and discussed and critically reflected in chapter six. Chapter seven presents both recommendations for future research and some main takeaways for Rijkswaterstaat. The literature can be found in chapter eight, and chapter nine contains the different appendices referred to throughout this research.

2. Literature review

To better understand the role of an organisation such as Rijkswaterstaat on freight transportation, this literature review will start by asking the question what asset management exactly is. It will then proceed to the subject of freight transportation and review theories that relate freight transportation activities, often referred to as logistical activities, to space. First by embedding it in larger global processes that have shaped the freight transportation, or distribution, system to what it is now from a geographic perspective. The second part of this chapter will review relevant theories on the different landscapes that combined make up the freight landscape. The final part of the literature review summarises the literature into a conceptual framework.

2.1 Asset management

As transport agencies in the developed world have seen their focus shifting from constructing transport infrastructure towards the maintenance of it, this also brought a change in thinking on how to manage the infrastructure assets they constructed. This shift in thinking also brought with it the term of asset management (Arif, & Bayraktar, 2012). The more exact definition of asset management varies from place to place, as the term is also used by other organisations . Arif and Bayraktar (2012, p. 2351) define it as:

"… the process of maximizing value to a property or portfolio of properties from acquisition to disposition within the objectives defined by the owner."

Such a definition leaves in a lot of room for interpretation, as maximizing the property (asset) value based on the objectives of an owner can strongly differ from place to place. A private company will probably have very different objectives than a government agency. Van der Velde, Klatter, & Bakker, (2013, p. 340) use a definition that define it from the perspective of Rijkswaterstaat. They define it as the management of assets by balancing costs, performance and risk over the life cycle of an asset. Which in case the of Rijkswaterstaat is infrastructure surrounding roadways and waterways. Balancing these factors is complex. Not in the least because of all the challenges that asset managers have to face (Spatari & Aktan, 2013). In the case of Rijkswaterstaat one can think about challenges such as aging assets, which are due for renovation or replacement, limited budgets that do not cover the expected expenses of such replacements, but also rising expenses as more performance is expected from society: more vehicles have to be able to safely and comfortably use the infrastructure. This is in part also required by higher regulatory standards (van der Velde, Klatter, & Bakker, 2013). As becomes clear from these challenges, there is not one way to do it. Different organisations have different methods to manage their assets based on the (local) context they have to deal with (Emmanouilidis, Komonen, 2013).

One problem that is common in asset management is putting single objects in relation towards others, or put differently: seeing them from a network perspective (van der Velde, Klatter, & Bakker, 2013; Parlikad, & Jafari, 2016). One of the challenges here is that there is simply a lack of data on usage of the network to be able to put usage of single assets into such a perspective (Giuliano, Kang, & Yuan, 2017).

2.2 Geography of the new logistical system

Transportation is about overcoming space (Rodrigue, 2013). Once a product has been produced, whether that is corn or a video game console, it has to move from the place of production to the place of consumption. Therefore, transport is often considered to be a derived demand. Once demand for a certain product is made, the product will be transported along a transportation network (Rodrigue, 2013, p. 8). Based on multiple variables, such as type of good and distance that needs to be covered, a mode of transport will be chose to accommodate the transportation. A large variety of transport modes exist, Rodrigue (2013, pp. 89-126) discusses a large variety of transport modes such as maritime, rail and pipeline transport systems. All these different modes of transport compete and complement each other. They complement each other under three conditions:

- *Different geographical markets*: which is about products that are, for instance, shipped from the United States to (inland) Europe, different modes of transport are required which are linked through 'gateways'.
- *Different transport markets:* which is about the nature of what is being transported. Bulk goods are commonly shipped in large quantities, which is done by rail or by (inland) maritime transportation. This still leaves room for road transportation to transport other goods.
- *Different levels of service*: this is mainly about cost versus time. Some goods, such as vaccines often require fast transportation (by air cargo for example) which makes transportation more expensive.

As stated earlier, freight transportation is traditionally considered to be a derived demand that is part of logistics. Hesse & Rodrigue (2004, p. 172) define logistics as 'the wide set of activities dedicated to the transformation and circulation of goods'. This definition of logistics consists of two different parts:

- Physical distribution, which is about the whole range of activities related to distributing the goods (transportation, but also retailing) and;
- Materials management, which is about all activities related to the manufacturing of commodities (from raw recourse to final product).

Material management activities are assumed to be inducing demand for physical distribution. However, it is argued that the assumption of such a relation can no longer be made as a consequence of the changes that have taken place in logistics. Hesse and Rodrigue (2004) argue that there are two structural forces that have led to a reconsidering of the relation between physical distribution and materials management. First is specialization and division of labour and the 'spheres of circulation' (increased) specialization created. Within these spheres of circulation production and distribution are no longer a single-firm activity, but involve a range of different companies that execute different activities which are bundled together through the supply chain (Bowersox, Closs, & Stank, 2000). The second structural force is globalisation. Globalisation here implies the expansion of the spatial framework into a global one that involves complex networks and flows linked through hubs (Mccarthy, Agnew, & Knox, 2014). Such structural forces would not have been possible without being accompanied by technological advancements in relevant fields, such as ICT, containerization and the introduction of concepts such as lean management (Harrison, 1997).

Hesse and Rodrigue (2004) also describe geographical dimensions through which the contemporary logistical system can be observed. This geographical dimension of the logistical system (or distribution system) can be observed through flows, nodes and networks. These three elements interact with one another through space and time.

- *Flows*: Flows through the supply chain have changed due to the increased integration of all the different parts of the supply chain. This has reduced stock and moved part of it to one centralized distribution centre, which has become the core component of the contemporary supply chain.
- *Nodes*: Concentration of distribution activities have shifted from places of production to gateway locations such as large sea-ports. However, due to the increasing demand for logistical space, some gateways have no space left. Therefore, new inland hubs are developing, mainly along highways or near airports. While high land prices, due to lack of space, do push logistical activities further away from gateways or city centres, they do tend to be as close to consumer locations as possible, and therefore concentrate at the fringe of metropolitan regions (Verhetsel et al., 2015).
- *Networks*: The type of network that is used to distribute a product depends on the type of product that is being shipped. A general trend is the reconfiguration of networks into a more

centralised hubs-and-spoke network, but not all types of freight allow for such a reconfiguration.

According to Rodrigue (2004) the best scale for which to observe these elements is the regional scale. As this is the scale where global and local flows converge, explained in the distribution paradigm.

The distribution paradigm argues that according the structural processes of globalization and specialization economies have been more regionalised through spheres of distribution. This means that flows organise themselves through a complex network of nodes, as can be observed in figure 2.1.

Figure 2.1. Paradigms of geographical theory related to transport corridors

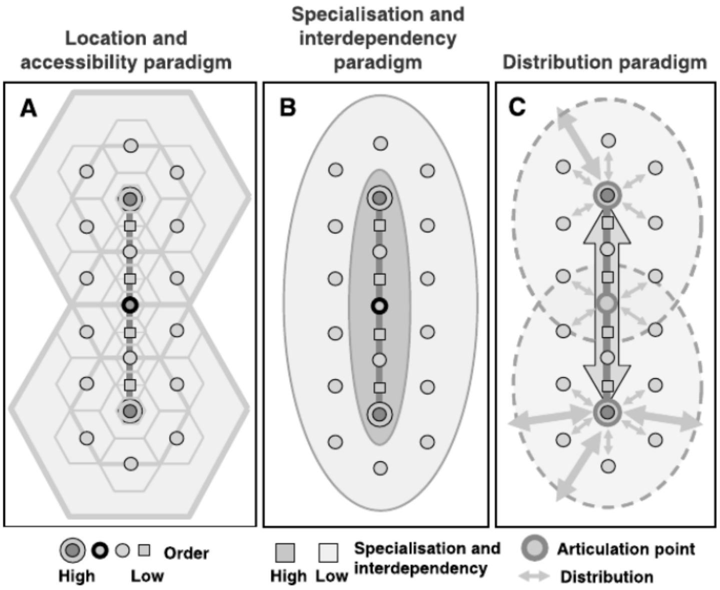
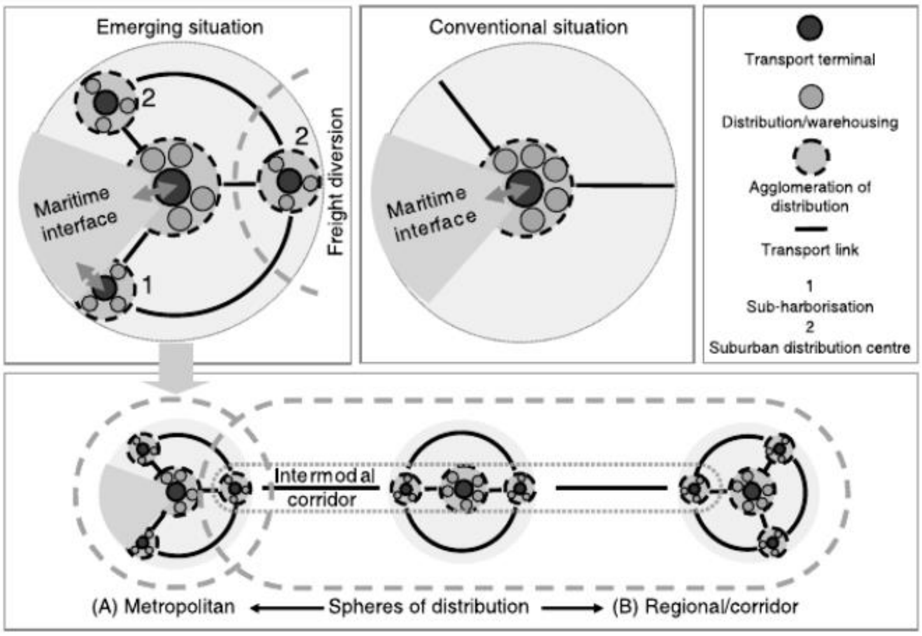


Figure 1. *Paradigms in the representation of transport corridors.*

Source: Rodrigue 2004, p. 149

Within this distribution paradigm, Rodrigue (2004) identifies three main elements. First are the articulation points, which regulate the distribution of freight through an accumulation of freight terminals and distribution centers. Second are the freight corridors. Which, as stated before, are the dynamic entities linked to economical, infrastructural and technological process and are embodied through accumulations of flows and infrastructure. Third are freight distribution flows that show how freight moves around within a corridor. This is subject to a changing pattern, as more and more freight activities are relocated to suburban areas. As a consequence of de relocation of distribution centers the sphere of regional freight circulation is expanded, which is schematically shown in figure 2.2.

Figure 2.2. The changing freight distribution spheres.



Source: Rodrigue, 2004, p. 153

This relocation of distribution centers and other logistical facilities from metro areas towards more peripheral regions is also referred to as logistical sprawl (Dablanc & Ross, 2012, p. 432).

This change in freight distribution can linked to a number of developments. Kang (2020) names a list of factors that added to this change: changing consumption patterns, the rise of just-in-time deliveries, containerization of freight, and also advancements in ICT, logistics and transport technology. Kang (2020), notes that the main focus of this new freight distribution system was on throughput: keeping products constantly on the move reduces shelf time. The constant movement of goods required a rearrangement of the storage system, in which storage was centralized into larger distribution centres and local storage (at the factory or at the store) would be minimized (Allen, Browne & Cherrett, 2012) This focus on throughput eventually led to an increase in economies of scale, but could not have been achieved without the construction of modern infrastructure such as highways, terminals and airports.

Next to a reduction of large inventories (at factories), this change in freight distribution also led to a growth of (hub) distribution centers. The location of these new DCs was also less dependent on transport cost. This is largely due to the fall in transport costs which led to these costs to be of marginal influence on the total product costs. Furthermore, these new DCs require more space, which is cheaper on the outskirts of a city than closer to the city center. In the new supply chain system sub-urban areas are also more attractive locations as they are often better connected to regional and national freight flows through the construction of an extensive highway network (Dablanc & Ross, 2012).

The development of logistical sprawl is mainly considered to be a negative one. A problem related to the logistical sprawl, but more to the underlying changes in the supply system, is that smaller and older DCs are at risk of becoming vacant, as demand is shifting to larger DCs further away from the city center. According to Kang (2020) the biggest problem with logistical sprawl is that it can cause a higher vehicle-miles-traveled (VMT). Extra VMTs cause more noise and air pollution and also costs more energy through the extra fuel that is required for the longer distances that are travelled (Dablanc & Rakotonarivo, 2010). However, it is uncertain whether extra VMT actually is that negative (Kang, 2020). Kohn and Brodin (2008) suggest that more VMTs do not necessarily lead to an increase in negative environmental impacts. Besides green initiatives that exist on a more operational level, such as teaching drivers to drive more eco-proof or better route planning, centralizing a distribution system could also be better for the environment. They explain this through three characteristics of logistics: consolidation, modal shift, and emergency deliveries. The main argument here is that centralizing your distribution activity does not have to lead to a less flexible logistical system, which is required to stay competitive. It does help reduce the amount of emergency deliveries that have to be made, which could help offset the extra VMTs. Though this is dependent on the type of company and freight that is being shipped. Global companies that ship low weight products of high value use more expensive emergency delivery options, such as airplanes, and therefore stand to make more environmental gain by centralizing their distribution activities.

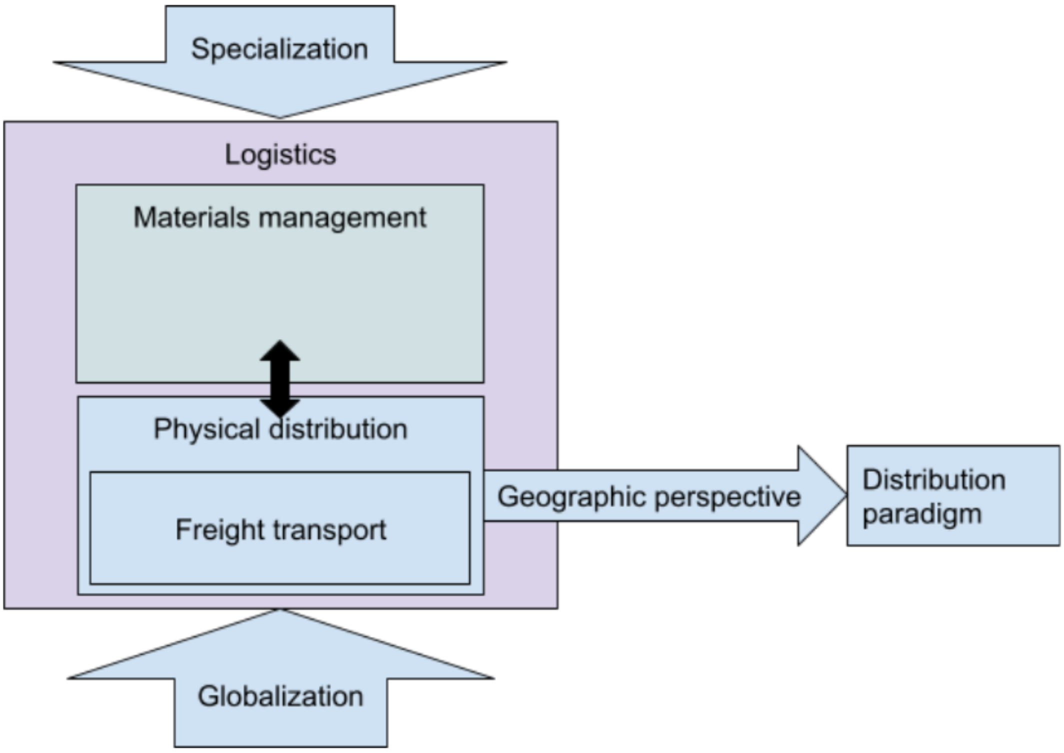
Another concept that is central to the geographical dimension of the logistical system is the so called '*logistical friction'* (Hesse & Rodrigue, 2004, pp. 179-181). What is argued here, is that the changes in de logistical system also brought a change in the impendence factors. Impendence consist of four non-independent elements.

- *Transport/logistics costs*: this element relates to the cost one has to make to overcome time and space. It is mainly focussed on time, as this has become the decisive cost factor, in contrast to overcoming space. Transhipment costs are also related to this element.
- *Complexity of the supply chain*: The more complex a supply chain becomes, the harder is becomes to manage it. Ways to reduce this friction are found by consolidating distribution activities in central warehouses or by outsourcing management of the supply chain to third-party logistics providers.
- *Transactional environment*: This friction is twofold. The first part involves the power relationships within the supply chain, in which the more powerful companies delegate the risks to those less powerful. The second part involves government interference, which vary from incentives to locate somewhere to regulations on the driving hours of truckers.
- *Physical environment*: This is about the hard barriers that exist and influence flows. For example: not every city is located near a river that is linked to a large gateways.

The concept of logistical friction helps in understanding differences in freight flows from one place to another. It, for example, helps explaining why congestion, due to lack of space to expand infrastructure, can help alter freight flows.

Figure 2.3 gives an overview of what has been explained until now. It shows how freight transportation is embedded in the definition of logistics, and how to structural forces influence the concept (Hesse & Rodrigue, 2004; Dablanc & Ross, 2012; Kang, 2020). These forces also influence the physical distribution component of logistics. Viewing these changes in physical distribution through a (transport) geographic perspective of flows, nodes and networks, a certain spatial pattern can be observed. This pattern is described in de distribution paradigm (Rodrigue, 2004). In this paradigm distribution is organised along a network of articulation points and most flows are situated along (major) corridors between large regional articulation points. It should be noted here that the spatial structure of de distribution paradigm is on an aggregate scale. On the scale of single (transport) companies the spatial distribution layout can vary from a number of different network layouts, such as a hub-and-spoke network (Onstein et al., 2019).

Figure 2.3. Overview of theoretical framework in which freight transport is embedded.



2.3 The freight landscapes

Now that the broader, global, processes that shape the distribution of logistical activities have been explored, this second part of the literature review will focus on the freight landscape and theories behind it. As already mentioned in the introduction, the freight landscape consists of four landscapes: the political, socioeconomic, infrastructure and mobility landscape (Rodrigue, et al., 2017). All the research on the freight landscape until now has been done on the socioeconomic landscape in which a relation between land use and freight traffic intensity is hypothesized. This however, does not mean that no research on the other landscapes has been done. This second part will therefore review theories related to each of the four freight landscapes.

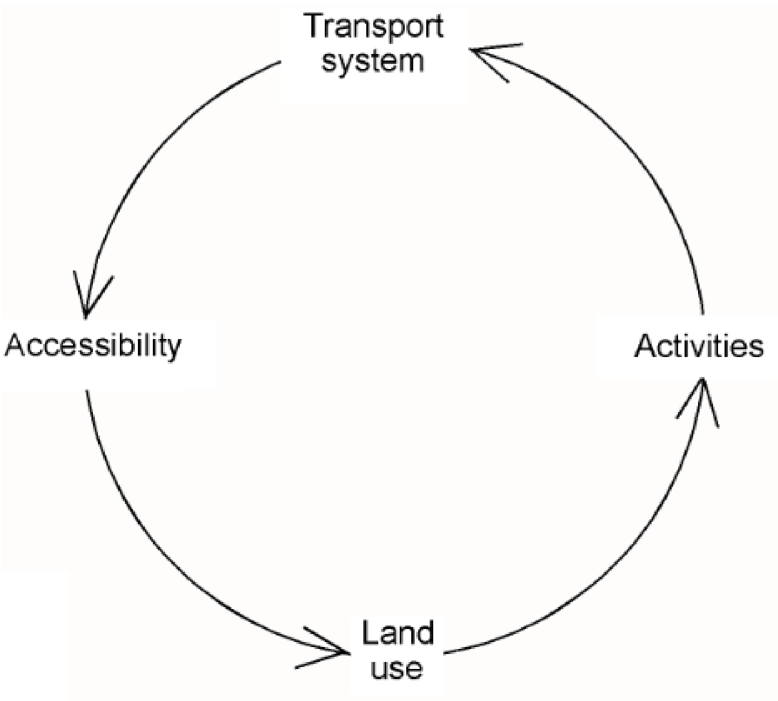
2.3.1 The socioeconomic landscape: land use and freight transportation *and urban form*

Central to the socioeconomic landscape is the relation between land use, in the form of population and employment density, on the one side, and freight intensity on the other side (Giuliano, Kang, & Yuan, 2017). The relation between freight transport and land-use is hard to determine, this is in part due to the lack of literature on this relationship. Most literature focusses on the more general relation between transport and land-use, although this is in a lot of cases implicitly focussed on transportation of people.

Theories that research the relationship between land use and transportation are so called land use transport interaction theories (LUTI theories). The theories behind LUTI are very eclectic (Acheampong, & Silva, 2015). Wegener and Fuerst (2004) categorizes the theories around LUTI in three broad themes. First are the technical theories, which consider cities to be established on the crossroads of trade routes, such as river crossings and sea ports. From this paradigm, the transport feedback cycle emerged (figure 2.4), which shows the relation between land use on the one side, and transport on the other. Wegener and Fuerst (2004, p. 5) describe this relation, starting at land-use, as follows: Land uses (such as industrial or commercial) determines the location of activities. The distribution of activities through space requires a transport system to overcome this space. The infrastructure that facilitates a transport system creates opportunities for spatial interaction which are measured through accessibility. The accessibility of a place co-determines a location decision, and thus influences the land-use of a certain location.

In other words, based on this model one could argue that improving the transport system will increase accessibility, which in turn will alter land-use, which will change the activities pattern, which will then requires changes in the transport system. It should be noted here that, as is the case with every model, there is more to it than can be observed via this model. Land uses and transport systems are also influenced by a range of factors that are not included here, such as institutional factors and market forces.

Figure 2.4. The transport feedback cycle

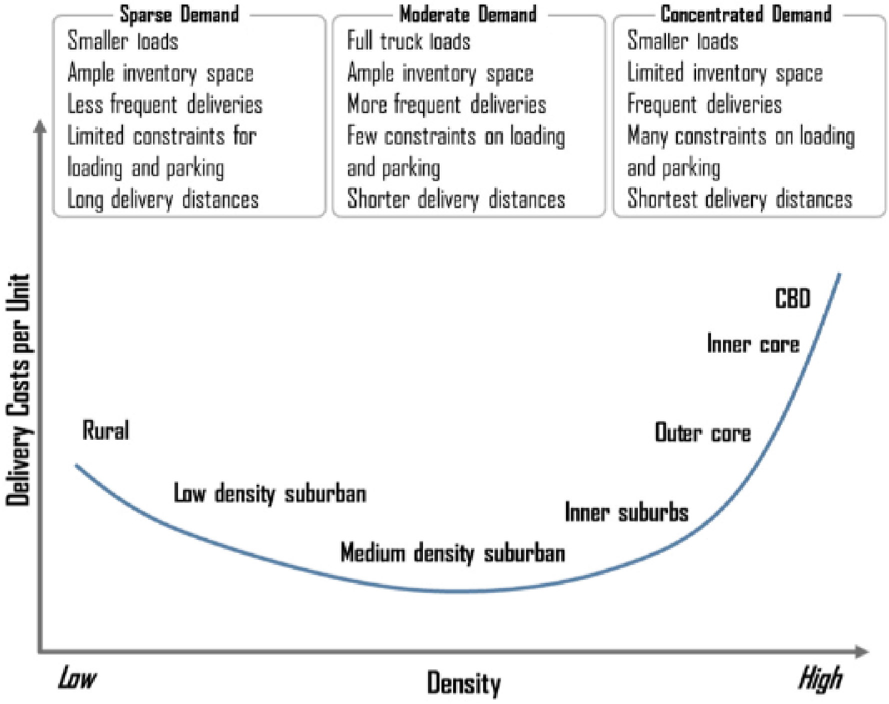


Source: Wegener and Fuerst, 2004, p. 6

Second to the technical theories are the economic theories, which view city growth through an economic perspective. Within the economic theories, theories such as the central place theory of Christaller (1933) and the bid rent theory by Alonso (1964) can be found. Third, and last, are the social theories, which consider spatial development as a result of individual or collective appropriation of space. One of the more prominent works of social theories is that of Hägerstrand (1970) and his theory of time geography. His theory allowed for a more detailed research into different groups in society and place attention on their more restricted mobility, such as the mobility of women. Based on the theory of Hägerstrand, Zahavi (1974) hypothesized that individuals may not actually try to minimize their travel time, as is assumed by conventional theories, but actually have a certain budget allocated to the time spend traveling, disregarding travel distance. Based on this, an explanation can be found for the trend of suburbanization. Based on these theories Wegener and Fuerst (2004) created an overview of the impacts of certain factors of land-use and transport. For example, it is expected that high residential density alone will not make for shorter trips. This requires the location to also have workplaces.

One problem with these theories is that there is an implicit focus of passenger transportation. This is also stated by Wegener and Fuerst (2004, p. 2) as they suggest that transport does not have to imply an inclusion of freight transportation in the context of their paper about LUTI. Which can also be observed when analyzing the expected impacts summarized the paper, none of which are about transportation of freight, just transportation of people. In general, when it comes to urban planning and density, it is assumed that higher densities are preferable as they allow for certain thresholds to be reached, which allows for the provision of better public transport, save energy, make cities more walkable and improve liveability (Rodrigue, Dablanc, & Giuliano, 2017). However, for freight transportation, this is not always the case. Very dense urban areas do not offer a lot of space for loading and unloading activities, or parking in general. The shortage of space also means that stores are smaller and have less storage capacity, which means they have to be supplied more often. On the other side, low density is also not preferable for freight transport, as the average amount of kilometres that have to be travelled increases. This relation to density and freight is shown in figure 2.5.

Figure 2.5. Relation between urban densities and commercial freight deliveries



Source: Rodrigue, Dablanc, and Giuliano, 2017

Allen, Browne and Cherrett (2012) also noted a lack of research on the relation between freight transportation. In their study they found that there are a number of spatial (geographical) factors that influence the freight activity in urban areas. For instance, commercial and industrial land use patterns have different influences on quantity of the freight that is being transported. Furthermore, in large urban areas freight is more often lifted by heavy goods vehicles. This is probably due to the polycentric nature of such urban areas, in which they have multiple city centres. Finally, transportation within urban areas are less efficient (in terms of tonne-to-kilometer) than those outside. Such a relation is also noted by Dablanc (2007), whom states that each activity in the urban environment (such as commercial and industrial ones) can be related to a freight generation profile.

The relation between space and transport is also hypothesized in the concept of the freight landscape. By combining spatial data on employment density and population density, different logistical landscapes can be identified. Rodrigue, Dablanc, and Giuliano (2017) describes four main logistical landscapes that can be constructed using this data.

- High density convergence of employment and population density. These places are in general assumed to be the city centres with office zones and commercial districts. Since there is a high density here, it is expected that last mile problems are most occurrent here, and these are the focus areas for urban freight planning initiatives (Navarro, Roca-Riu, Furió, & Estrada, 2016).
- Employment density divergence: These locations are assumed to be business parks mainly filled with manufacturing and warehousing activities. This is assumed since the negative externalities of such economic activities avert residents from living there, often stipulated in zoning laws and ordinances, hence relatively lower population densities. Based on figure one, these places attract the most heavy trucks. First, because there are little constraints on transportation and these places are often designed to facilitate larger trucks, or at least no constraints are put on them (Muñuzuri et al., 2012; Cui, Dodson & Hall, 2015). Second, because the high (employment) density attracts more freight to one place than lower densities.
- Population density divergence: these are the residential districts. Where it was previously assumed that such areas attract little freight traffic outside of retail deliveries, the rise of e-commerce have made parcel freight traffic more intense in such areas (McLeod, Schapper, Curtis, & Graham, 2019).
- Low density convergence: these are the places where no specific logistical activity takes place. According to Rodrigue, Dablanc, and Giuliano (2017) such places can house large distribution centres and fulfilment centres.

One of the main parts of the socioeconomic freight landscape concept is the relation between urban density (of employment and population) and truck intensity. Meaning that more dense urban areas, such as the city centre, have more intense truck activity than more rural areas. This hypothesis has been successfully tested in Los Angeles and Paris (Giuliano, Kang, & Yuan, 2017; Sakai, Beziat, Heitz, & Dablanc, 2018). This means that density of population and employment could serve as a proxy to estimate the intensity of truck activity. Sakai et al. (2018) also found that proximity to intermodal facilities (rail-road facilities) has an significant effect on truck traffic demand. Giuliano et al. (2017) could not find such a relation in Los Angeles for trucks and intermodal facilities, but did find the overall traffic effect (cars and trucks) to be correlated to such facilities. Though intermodal facilities have a significant role in predicting truck traffic demand, distance to highways is the most important accessibility variable in predicting truck traffic demand. Such results suggest that the impact of hubs on the overall network may be significant, but not as significant as the vicinity of highways.

It should be stated that the socioeconomic freight landscape serves as a proxy for the actual freight flows. Meaning that estimations can never be completely accurate. This is especially true when using employment density as an estimator of freight flow. A high density of employment could also imply the presence of a large office building. While such an office building will attract some freight flows as the building needs to be supplied, this would be in the form of smaller freight vehicles and more intense flows and not in the form of larger freight vehicles that can be found in logistical cluster or industrial sites. Furthermore, new technologies and automation of distribution centres also makes the link between employment and freight transportation less obvious. The problem with employment density was also noted by McLeod et al. (2019). They argue that using a classification of economic activity (whether employment comes from office jobs or logistical jobs) would help in making estimation more accurate. Another way of making the data more accurate is to include data on the size of a facility, as logistical facilities are known for their increasing spatial claim (Holguín-Vera et al., 2012, pp. 35-36).

2.3.2 The infrastructure landscape: freight transport and accessibility

The infrastructure landscape consists of all the infrastructure that enables the movement of freight: highways, ports, distribution centres, etc (Rodrigue, 2004). Infrastructure is mainly about accessibility. This is because it is the main goal of transport enabling infrastructure: to have better transport access to the market. As such, this landscape will be discussed in terms of accessibility. The topic of accessibility is widely debated on in the literature (Banister & Berechman, 2001; Handy, 2002; Geurs & van Wee, 2004; Verhetsel et al., 2015). This also makes it hard to determine what the concept of accessibility exactly encompasses. Different definition are used, such as the 'potential for interaction opportunities', or the 'ease through which land use activities can be reached from a location using a particular transport system' (Geurs & van Wee, 2004). What complicates the matter even more is that many discussions explicitly or implicitly focus on accessibility for people, not freight (Thomas, Hermia, Vanelslander, & Verhetsel, 2003). Since ease of access is central to accessibility, the concept of logistical friction (discussed in paragraph 2.2) as described by Hesse and Rodrigue (2004) is also relevant for understanding which places have high accessibility and which places do not.

Thomas et al. (2003) adapted accessibility measures from general studies on accessibility into measures that would fit freight transportation. They suggested four ways through which accessibility can be measured: topological, geographical, economical and multimodal measures. Each measurement introduced another factor relevant towards accessibility. The topological measurement of accessibility is centred around connectivity, how many transport links does a certain place contain? The links are weighted by the distance a certain place is towards another. The geographical measure introduces population as a key factor. Meaning that being closer to large population centres would create a higher accessibility score. Population here is assumed to be a proxy for the amount of consumption at location and therefore the need for goods to be transported towards it. Economic measurement is centred around proximity towards economic activities. The last measurement, multimodal accessibility, integrates the separate modalities of road, rail and water into one map. Verhetsel et al. (2015) also explored accessibility factors when doing a stated preference study om logistical locations in Belgium. The authors found that while the location of a logistical facility is mainly determined by the land rent, factors such as distance to a port or road accessibility do play a role in whether or not a firm decides to build a logistical facility at a certain location. They also found that firms that deal with the transportation are, while still being the most important factor, relatively less concerned with land rent than logistical firms in general. Studies on accessibility all point towards the importance of distance to highways as one of the main factors of accessibility in freight transportation (Thomas et al., 2003; McKinnon, 2009; Holl & Mariotti, 2018). This confirms the strong competitive value of road transportation towards other modes of transport, which is especially true in many western countries as there has been a strong focus on constructing highways in the past decades (Del Grosso, Inaudi, & Pardi, 2002; Rijkswaterstaat, 2021). Only Verhetsel et al. (2015) could not find a strong preference of distance to highways compared to other infrastructure, but they argued that the extensive highway network of Belgium (in which the research took place) could have influenced the results. Highways could be considered less important if they are always nearby.

2.3.3 The mobility landscape: location policies of logistical companies

The mobility landscape is the landscape that maps how freight is actually moved around cities (Rodrigue, 2004). To map the actual movement of freight would go beyond the scope of this thesis and deserves research on its own. Not in the least because of the already identified lack of data on freight movement, and trucks in particular (Giuliano, Kang, & Yuan, 2017). As such, this review will not be going into the technical details such as optimal routing, truck usage or any other operational considerations that go into the freight distribution networks. However, a rough estimation of the mobility landscape can already be made by combining the knowledge of the other three landscapes, as these landscape play a role in the operational decisions on where to use what type of vehicle and route. Something that has already been noted in the first part of this literature review on logistical sprawl (Kang, 2020). Furthermore, the mobility landscape can also be further approximated by taking into consideration the location choice of individual logistical facilities. While such information does not give exact data on the individual freight trips, locational choices of logistical facilities do give an indication on the type of freight operations that will be performed at certain locations. Research on the causes (logistical sprawl) of the choice of logistical facilities has already been discussed (Kohn & Brodin 2008; Dablanc & Rakotonarivo, 2010; Dablanc & Ross, 2012; Kang, 2020). There are a some common factors that logistical operators take into consideration when planning a new logistical facilities, these factors are related to the changes in the freight distribution system (Aljohani, & Thompson, 2016). The common factors are land use, plot size, accessibility of the location, which are all interrelated. Land use refers to the zoning laws that preclude logistical facilities from certain locations, in many cases close to the city centre. This related the plot size, as it is argued that due to changes in how supply chains are organised, larger distribution centres are required, which require larger plots (Allen, Browne, & Cherrett, 2012). This is especially true for distribution centres that are meant to serve a larger area (from regional to international distribution centres).

Accessibility is also a key factor when it comes to deciding where to locate new facilities. According McKinnon (2009, p. S295) the development of the highway network has been the central catalyst for DCs to relocate to locations where they had to space to centralise their distribution system. However, as already noted the large heterogeneity of logistical activities makes it difficult for approximating a more refined mobility landscape. Different types of freight and logistical facilities have different modus operandi. As such McKinnon (2009) noted that not all new DCs that are build are larger boxes, smaller DCs are also still being build, fuelling the argument that there is no one size fits all when it comes to freight transportation. Heitz, Launay and Beziat (2019) also noted this heterogeneity in logistical activities. In their research they hypnotised that different logistical activities have different spatial patterns for the city of Paris. They found that different types of logistical activities have different spatial patterns. Specialized transport such as specialized e-commerce DCs and food wholesalers are generally located closer to dense urban areas than other types of logistical activities. This was also concluded by Mcleod et al. (2019). They argue that the disadvantage of being located further away from the highway has to be compensated by differentiating into more specialized transport. Sakai, Beziat and Heitz (2020) build further upon the work of Heitz, Launay and Beziat (2019) and research locational factors of logistics through the perspective of (individual) logistical facilities. They found that land use regulations and clustering play a significant role in the location of new logistical facilities.

2.3.4 The political landscape: government freight transportation policy

The political landscape is about the governmental factors that influence the way freight moves around a city. Freight transportation receives relatively little attention form urban planners and other policy makers compared to passenger transportation (Cui, Dodson, & Hall, 2015). In the urban context, this mainly involves issuing restrictions on freight transportation in order to have the area fit within the liveability plans of the municipality (Lindholm & Blinge, 2014). According to Lindholm and Blinge (2014) such restrictions could actually be counterproductive when planning for sustainable urban areas, as such restrictions could hamper the efficiency of freight distribution. The literature points towards different reasons as to why freight transportation receives less attention and from urban planners compared to public transport. Dablanc (2007) states that there is a lack of knowledge on freight transportation among urban planners. One of the main reasons for this lack of knowledge is that freight transportation is considered to be a private activity, and not something that the government has to provide. Another reasons is that urban freight transportation is a very complex topic (Cui, Dodson, & Hall, 2015). As already observed in the first part of this literature review, freight distribution networks are a complex networks of articulation points each with its own unique type of freight is serves (Rodrigue, 2004). The setup of the network and how freight is distributed also means that freight distribution systems have a large number of stakeholders that have to be accounted for (McLeod, & Curtis, 2020). Different stakeholders, from public to private ones, can have conflicting interest. Public parties, such as local municipalities, have different views on objectives such as stimulating the economy, infrastructure asset management, and the environment, than a private transport company (Woudsma, 2001). Gathering knowledge for robust policies is also complicated by the vague definitions freight transportation has to deal with (McLeod, & Curtis, 2020). What types of freight transportation are to be included in a policy? Can the distribution of construction materials and consumer packages be fitted in the same policy? A last problem is the geographical influence on freight distribution (McLeod, & Curtis, 2020). Freight is distributed in very different ways when comparing American cities with European cities. This makes it difficult to take lessons from other places and apply them to another local context.

Despite these reasons, the literature also identified multiple ways through which government policies can measure and influence freight transportation. The main policies that directly influence freight transportation are discussed by Muñuzuri, Cortés, Guadix, & Onieva, (2012). These policies involve various regulations, such as traffic ordinances, access restrictions, load zones, access time windows and noise regulations. However, one problem with these regulations is that they can sometimes be difficult to enforce (McLeod, & Curtis, 2020). For instance, when there is a lack of public acceptance on certain regulations.

Another way to influence freight distribution is through more indirect policies. Such as financial incentives to locate somewhere, or by through zoning logistical land-use, such as distribution centres (McLeod, & Curtis, 2020). McLeod, Schapper, Curtis, & Graham (2019) also point to ways through which a government can influence freight transportation. These range from very broad influence factors to very specific and more direct measures. On the broad (strategic) level are nationwide conditions that can enhance freight transportation, namely improving international trade by removing (legal) barriers. Other indirect measures are policies that invest in 'soft' public goods such as education (Lindsey et al., 2014).

Multi-level governance

The political freight landscape also brings another concept: multi-level governance. To understand why multi-level governance is relevant in the context of freight transport planning a brief overview of the concept will be provided.

The concept of multi-level governance (MLG) came into discourse with the creation of the European Union, in which it offered a fairly easy paradigm for understanding the policy-making process in the EU (Stephenson, 2013). Multi-level governance is a divers concept. It could potentially refer to either a process or a situation (Piattoni, 2009). The levels, in multi-level governance can either refer to 'terrestrial levels (going from local to national governments)' or 'jurisdictional levels' in which regards to functions and those that are interested in the performance of such functions (Piattoni, 2009). This distinction closely resembles the definition two different types of multi-level governance described by Hooghe and Marks (2002). They suggest that there are two types of multi-level governance. Type I and type II. Type one fits with the terrestrial interpretation of MLG levels and is about different layers of government that focus on a diverse range of tasks, such as improving accessibility and liveability. Type two governance is much more focussed on one specific task and can come in a wide variety of structures. Type II can mainly be found in the 'niches' of type I governance. This type of governance can assume a wider and often less clear structure than type I governance. They can be (semi) public-private partnerships, such as the privatisation of the Dutch rail network, which is still regulated by the national government, but also cooperation between different local governments and organisations committed to achieving certain goals, such as safer roads. Scholten, Engbersen, Ostaijen and Snel, (2017) operationalise the MLG concept by setting it off to other types of governance processes that lead to policy. First is the centralist type of governance, in which a central government hierarchy is present. The highest (often national) government decides the policy agenda of all lower government levels. The second is the localist government type. Here policy is formed through a bottom-up process, often as the result of strong local leadership. Policies are aimed at local problems that require 'local solutions'. When the problems of different levels converge, a multi-level governance type is most likely to occur. Scholten et al. (2017) also mention a fourth governance type: governance decoupling. In this situation, policies are formed independent of all other levels and are likely to overlap or even contradict one another.

Taking this definition of multi-level governance in consideration, it becomes clear planning for freight transportation, and transport policies in general, fits within this paradigm as a type II governance (Marsden & Rye, 2010). While developing freight transportation policies is a task specific process, it overlaps with a lot of other related subjects, such as economic development, safety and climate change. Furthermore, the fragmented nature of freight transportation in which different actors all hold certain assets that together make up how freight transportation is, and can be, organised (Kin, Verlinde, Mommens, & Macharis, 2017). The municipality decides on which land logistical companies can be established, the national government is responsible for the main infrastructure network and the transport companies are responsible for their vehicle fleet, which impacts aspects such as noise pollution. Moreover, movement of freight does not stop at the municipal border. Marsden and Rye (2010) argue that acknowledging that the policy making progress fits better in type II multi-level governance helps in understanding how freight transport policies are developed. Since type II governance encompasses a broad range of groupings, the ways on how freight transport policies are developed are potentially endless. Multi-level governance should not be confused with an optimal way of governance. Marsden and Rye (2010) argue that too much devolution of the government could lead to a strong influence of lobby groups that potentially result in less optimal policies.

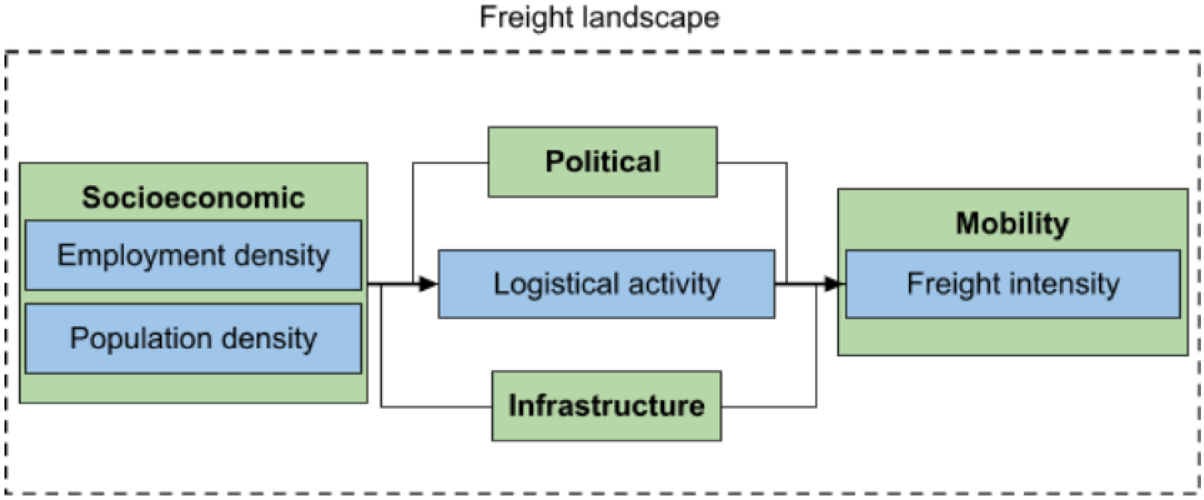
2.4 Conceptual framework

Despite its limited attention from the side of policy makers and urban planners, freight transportation has received a fair amount of attention in other related fields of research such as transport geography (Rodrigue, 2004). The conceptual framework that can be observed in figure 2.6 tries to capture the different strands of research on freight transportation using the freight landscapes as the overarching framework with which to categorize it. It should be noted that the model does not include all the links between the different landscapes. This is because the main objective of this research is to explore the spatial distribution of freight activities, and not how different landscapes influence one another. The model shows the freight landscape as composing of the four landscapes that have been discussed in the review: the political, socioeconomic, infrastructure and mobility landscapes. Combining these landscapes and using the framework on the geographic perspective of Rodrigue (2004) an insight can be gained on the spatial distribution of freight transport activities.

In the middle of the freight landscape are the logistical activities. These are the four types of logistical activities that have been described by Rodrigue, Dablanc, and Giuliano (2017): high density convergence (city logistics), high employment divergence (logistical and manufacturing districs), high population divergence (residential zones such as suburbs), low density convergence (rural areas with little logistical impendence). It is assumed that the type of logistical activity is most directly influenced by variations in employment and population density. Based on the transport feedback cycle an influence on the type of logistical activity is also expected from both the political and infrastructure landscape (Verhetsel, 2015; McLeod, & Curtis, 2020). For the political landscape this is expressed in the indirect measures that a local government can take to influence freight transportation, such as zoning laws that prohibit certain activities from taking place at a particular location. For the infrastructure landscape this is expressed in the indirect and slow influence of good accessibility on a location. Better accessible locations are more attractive to (logistical) companies, and are therefore more likely to settle at such locations (McKinnon, 2009).

The different logistical activities on their turn are assumed to influence the intensity of freight flows, which is part of the mobility landscape. Freight transportation will be most intense in the high density convergence, and gradually reduce when densities are lower. The divergence of employment and population density mean that the share of type of freight vehicle also changes. Backed up by access restrictions in city centres and residential neighbourhoods to mitigate negative externalities, heavy freight vehicles are less likely to be observed in these locations (Muñuzuri, et al., 2012; Lindholm & Blinge, 2014). Locations with high employment divergence are expected to have a, relatively, higher share of heavy freight vehicles because such locations lack restrictions on them and, especially with higher density, attract more freight (Verhetsel, 2015; Giuliano, Kang, & Yuan, 2017). The infrastructure landscape is also expected to influence freight traffic intensity as it also directly enables the movement of freight (which on the long term will influence the location of logistical activities).

Figure 2.6. Concept conceptual modal.



3. Methodology

This chapter outlines the methodology that was used to construct and analyse the freight landscape. The chapter starts with embedding the research into the ontological and epistemological paradigms. It will then proceed to elaborate on the research strategy, for which a mixed-methods approach is used. After setting out the strategy, and discussing the selection of the cases, the choices on the operationalisation of the freight landscapes are elaborated upon. The last part of the methods explains how the freight landscape is assessed from the perspective of Rijkswaterstaat.

3.1 Ontological and epistemological foundations

A research methodology is always based on a guiding paradigm. Guba and Lincoln (1994) classified four main paradigms based on their ontological, epistemological and methodological perspectives. It should be noted that the boundaries between the different classes are not as clear as may be presented here. This research is trying to understand how freight is spatially distributed. Since it acknowledges that capturing freight transportation in one framework would not do justice to the complexity and heterogeneity of the topic, it understands that fully capturing reality is not possible. It is believed though that this research helps in better understanding the spatial dimension of freight transportation, however imperfect observations of reality truly are. The research can, taking this into consideration, be located somewhere within the post-positivist paradigm. It is assumed in this research that a reality can, although imperfectly, be observed. This research uses the theories that have been reviewed in the literature review to set up hypotheses on the spatial distribution of freight transportation and also uses this framework to analyse it. This approach is also called the empirical-analytical approach (Van Thiel, 2014). This would mean that when this research is placed in the empirical cycle that is described by Scheepers, Tobi and Boeije (2016, p. 84), theory will be used to deduct hypotheses on the influence of land-use one freight flow. Although a complete empirical-analytical approach would be criticized for its faith in objectivity, this research acknowledges that identifying the relation between land-use and freight flows is only part of a complex puzzle.

3.2 Strategy

According to Van Thiel (2014, p. 58) there are several research strategies a researcher can use to approach its research. To choose the research strategy it would be good to review the main research question again:

What can the freight landscapes of Utrecht and Flevoland indicate about the spatial distribution of freight transportation activities and what does this mean for the network of Rijkswaterstaat?

Based on the literature review a conceptual framework was constructed (see figure 2.6) in the previous chapter. Here it is stated that the four different landscapes of the freight landscape combined give information on how freight is spatially organised. This spatial organisation can be analysed using the geographical dimensions (nodes, flows and networks) described by Rodrigue (2004). Since the concept of the freight landscape is both complex and relatively novel, the choice was made to do a case study. To answer the first part of the research question (the spatial distribution of freight transportation) the four parts of the freight landscape will be operationalised into researchable elements and then analysed using GIS and a content analysis. Second part of the research question is to understand the relevance of the results of the freight landscape for an infrastructure asset management organisation, in this case Rijkswaterstaat. In order to answer this part of the question a focus group will be organised with experts from Rijkswaterstaat.

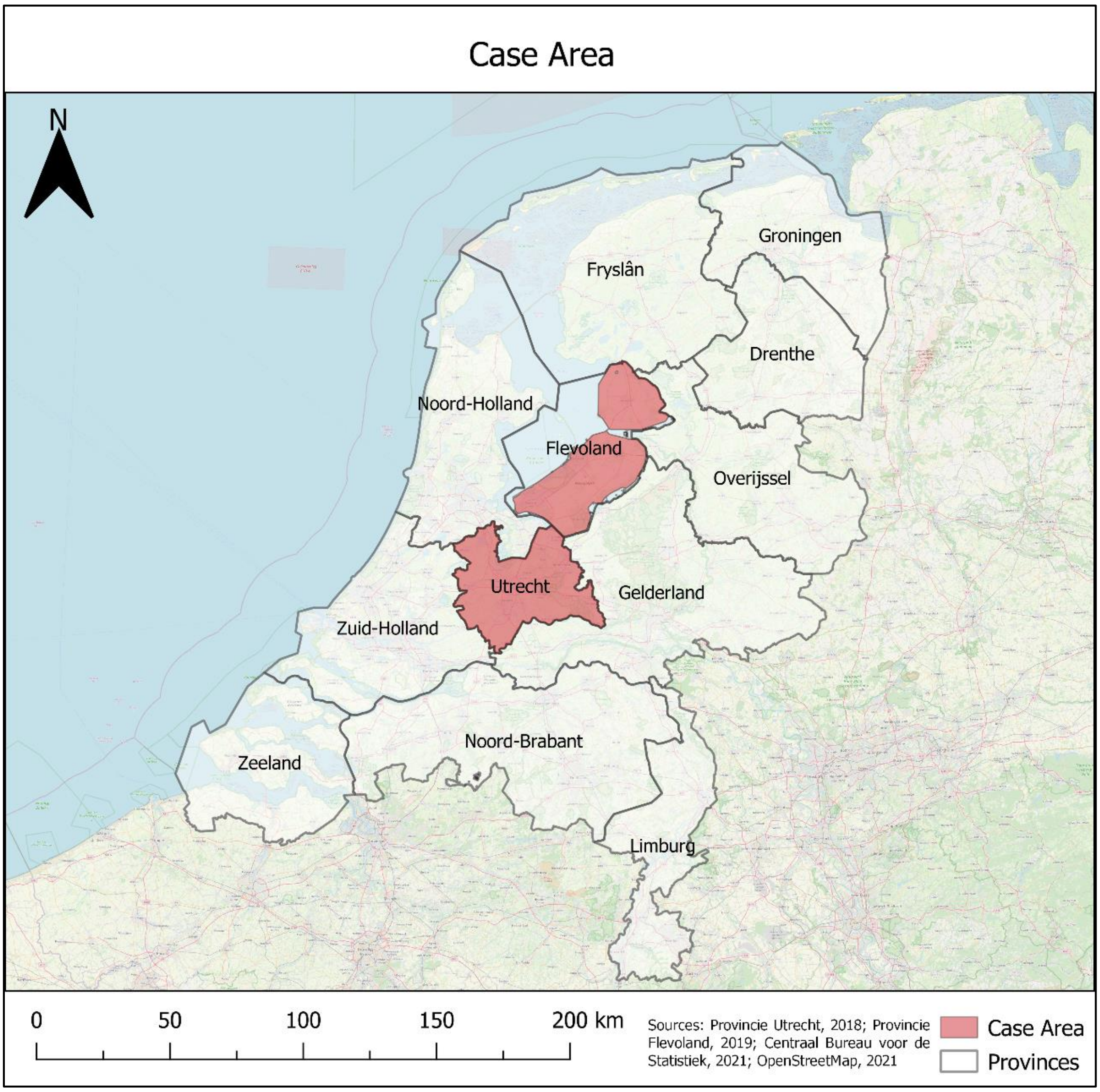
3.3 The case: Provincie Utrecht and Flevoland as part of Rijkswaterstaat MN

3.3.1 Selection of the cases

In order to construct the freight landscape some operational choices have been made to create a researchable object. The first choice, as already explained in the strategy, was to do a case study. When selecting a case area three things have been considered: the scale, importance of the area to freight transportation, and availability of the data.

From an operational stance, the relevance of the scale of the area is mainly important to prevent the area from being too big, which would take too much time to analyse. Theoretically, the area should also not be too small (on municipal level for example), because most freight transportation is not bound to one city. A regional scale would be best suited for research into freight transportation and distribution (Rodrigue, 2004). As this research is being done for in cooperation with Rijkswaterstaat, a Dutch regional case would be best suited for the research. One way to regionally divide the Netherlands is through provinces (of which there are 12 in total). In the Netherlands provinces are the regional government layer situated between the national government (the Rijksoverheid) and the municipal government. The importance to freight transportation of those twelve is not equal. The provinces of Zuid-Holland and Noord-Holland contain large population centres and important freight infrastructure (the port of Rotterdam and Amsterdam and Schiphol Airport). The province of Noord-Brabant, Limburg and Gelderland contain important freight corridors that connect the port of Rotterdam with its, mainly German, hinterlands (Topcorridors, 2018). The northern provinces (Friesland, Groningen and Drenthe) also facilitate freight transportation flows, but to a lesser extent than other provinces. The northern provinces are also less populated than those in in the western part of the Netherlands. The provinces that has eventually been selected are Utrecht and Flevoland, as these are the only province for which all the required data is available. For the analysis, each case will first be analysed apart from one another. This is because both provinces have a very different history.

Figure 3.1 Map of both case areas



3.4 Operationalising the landscapes

In this part, the four landscapes that are part of the freight landscape will be operationalised.

3.4.1 Infrastructure: a GIS analysis

The landscape of infrastructure is considered to be about relevant accessibility of freight transportation. It was found that accessibility is a complex topic and many factors go into the concept. In order to get an indication on the accessibility two factors will be considered. First is connectivity, simply how well the area is connected (Thomas et al., 2003; Verhetsel et al. 2015). To this end, three datasets will be collected: data on waterways, railways and highways. Second is proximity/vicinity. Vicinity means being near the place where transport comes from and goes to. For this research population density can serve as a proxy for the amount of consumption at a certain place (Thomas et al., 2003). Banister and Berechman (2001) are critical on the role of proximity. On the one hand they consider it closely related to accessibility, on the other hand they suggest that proximity is, just like accessibility itself, a relative concept: it is not always import to accessibility. When it comes to logistical companies, there is a certain balancing factor going on. On the one hand logistical companies want to be located close to customers to reduce the amount driving distance to customers. On the other hand, land rent is an important factor for deciding where to develop new large distribution centres. Being located near population centres generally increases the cost of land and that would mean that being located too close to population centres creates an unprofitable situation. As such, this will be accounted for in the analysis. Data on the proximity is essentially already collected through the socioeconomic landscape: population density and employment density.

3.4.2 Socioeconomic: a GIS analysis

Based on the literature it is assumed that this landscape can give an indication on the intensity of freight transport in large urban areas (Rodrigue, Dablanc, & Giuliano, 2017). This is based on the hypothesis that a higher density of population and employment are related to more intense freight flows. In order to investigate this landscape a map with the population and employment density will be constructed. This map will only contain the matrix of employment and population density.

In order to make the GIS analyses two datasets are required:

1. **Population density**
   Population density has been identified in the literature as a variable that has a relation to freight flow (Sakai et al., 2020). In this research, population density is defined as the amount of people that live in a defined area per square kilometre.
2. **Employment density**
   Just as population density, employment density has also been identified as variable that has a relation to freight flows. In order to investigate the variable it has been defined as the amount of jobs in a defined area per square kilometre.

3.4.3 Mobility: a GIS analysis

As already mentioned in the literature review, the mobility landscape encompasses a wide range of factors that determine how freight is actually moved around. Since such data is not publicly available, as it is owned by private companies, one of the only ways to approximate this landscape is through freight flow data (Giuliano, Kang & Yuan, 2017). Data on freight flows is operationalized as the freight flow intensity that is documented in the INWEVA (Dutch acronym for Intensiteit Wegvlakken) database. Reason for this operationalization is twofold. First, as stated in the literature there is a lack of accurate data on freight movement, this is also the case in The Netherlands (Giuliano, Kang & Yuan, 2017). Second, this research is focussed on the networks of Rijkswaterstaat, which are covered in this database. In this research, the mobility landscape will be part of the broader socioeconomic landscape analysis. Using the freight flow data of INWEVA, a set of maps will be created that visualizes the data of freight intensity on the network of Rijkswaterstaat. A detailed explanation on the creation of these maps is given in in the ‘working with GIS’ paragraph (3.6.3).

3.4.4 Political: a content analysis

In the literature review the political landscape is understood to be the influence of the government into all aspects that have to do with freight transportation. Since such measures would also, in theory, include factors such as trade agreements, some simplification towards the political landscape concept has to be made (McLeod et al., 2019).

Based on the literature review of the political landscape it is expected that most municipalities and regional governments only marginally deal with freight transportation by only viewing it as a disturber of the liveability of a location (Lindholm & Blinge, 2014). By operationalizing the political landscape into municipal and regional freight plans this research will analyse whether freight is treated marginally by regional governments, and try to analyse through which ways plans (if any at all) influence freight transportation. The documents will be analysed through a content analysis (Boréus, & Bergström, 2017). The document that will be analysed are mobility plans (mobiliteitsvisies) and vision documents (structuurvisies or omgevingsvisies). Such plans do not have to specifically applicable to the year 2019, the year on which the socioeconomic and mobility landscape data is based. The reason for also including plans that where not yet enacted (such as visions for 2020-2030) is because they are commonly the result of a process that was already in motion in 2019, and therefore more accurately represent the stance of a local government on freight transportation. These documents are, partly, meant for envisioning and laying out plans on the road infrastructure and land use regulations, and therefore are relevant to the political landscape. While there are many other policy documents that set out rules that also apply, in part, to freight transportation this research is mainly interested whether or not freight transportation is considered within the overarching policies of a local government, and not just ad-hoc when, for example, creating an actual zoning plan (bestemmingsplan in Dutch).

For analysing the documents a code scheme was constructed (see appendix 1). As the analysed documents are written in Dutch, the coding scheme uses Dutch words. First the document is scanned for the usage of the words such as freight (vracht) or goods (goederen) to check whether it is considered at all. If these words are found in the document the next part of the coding scheme analyses in what context freight (transportation) is used. Based on the literature on the political landscape it is expected that local governments only pay marginal attention the freight transportation (Muñuzuri et al., 2012). Meaning that they probably consider it to be a cost factor they have to act on (minimizing externalities). The scaling (marginal to high influence) is adapted from the research of Kiba-Janiak (2017, pp. 7-9), who set up a scaling on the maturity of freight transport policy development for urban freight transportation. The literature identified different interventions a local government can take by which it can handle freight transportation. The types of intervention (direct or indirect) are mainly based on the interventions that have been identified by Akgün, Monios, Rye and Fonzone (2019) and Mcleod et al., (2019). The types of regulations have been subdivided into two categories: direct regulations and indirect regulations. Direct regulations are the types of regulations that directly impact the movement of freight, which mainly involve the traditional access regulations such as time windows and weight restrictions. Indirect regulations are comprised of a broader range of policies that local governments (can) use to regulate freight transportation, such as participating on projects such as urban consolidation centres. Such regulations influence the type of logistical activity taking place at a particular place. Lastly, an assessment is made on the extent to which certain policy documents discuss the expected impact of their plans, from local to regional/nationwide. This relates to the multi-level governance aspect of freight transportation. This last assessment is interesting because planning activities that generate a lot of freight activity not only impact one municipality, but a broader region, since freight movement (generally) not stops at a municipal border. Something that makes planning for freight also more complicated (Marsden & Rye, 2010; Lindholm & Behrends, 2012).

3.5 Data collection

Table 3.1 gives an overview of the data that was used for this research. While most data is readily available, data on employment is less so. The only data set that is detailed enough to research the socioeconomic landscape is from the Province of Utrecht (Provincie Utrecht, 2018). Their dataset contains detailed information on employment and also on economic classifications. Employment figures for the province of Flevoland were acquired by contacting the province. The other datasets were be found on the PDOK[1] website, which shares all publicly available geo datasets of the Dutch governments. Since covid-19 has had a serious impact on traffic, and therefore may not be representable for regular traffic figures, this research will use data from 2019 to construct the socioeconomic landscape. Table 3.1 gives an overview of the required data and the source from which the data will be extracted.

[1] https://www.pdok.nl/

Table 3.1. Data sources

Required data	Source
Population density	CBS – Wijk- en buurtstatistieken
Employment	Provincie Utrecht - Provinciaal Arbeidsplaatsen Register (PAR)
Freight flows	Rijkswaterstaat – INWEVA
Highway infrastructure	Rijkswaterstaat – INEWVA
Waterways	Rijkswaterstaat – Vaarweginformatie Nederland (VIN)
Railways	ProRail – Spoorwegen
Policy documents	Various municipal and provincial websites and www.ruimtelijkeplannen.nl*

* The Google Search engine was also used to obtain policy documents using key words such as 'mobiliteit [municipal name]' and 'goederenvervoer [municipal name]'.

3.6 Validity, reliability and working with GIS

3.6.1 Validity and reliability

As Van Thiel (2014, pp. 48-52) argues, validity and reliability are of great importance of sound scientific research. When it comes to reliability, two things are important: accuracy and consistency. Put differently: reliability is extent to which random errors can be ruled out (Scheepers et al., 2016). When it comes to validity, there are also two things are important: internal and external validity. Internal validity is about the question whether the research has measured what it intended to measure. This is done through operationalising the concepts as has been done in 3.4. A critical note can be made here on the political landscape and its code scheme (see appendix 1). Especially on the 'ranking' of the role of the local/regional government (from marginal to high) as there is no exact boundary that determines whether or not a regional government considers their role to be high or medium. However, this vagueness of boundaries will be addressed in the results by giving insight in the considerations that have gone into deciding why a local/region government got a certain rank. External validity is about the extent to which results can be generalised, and will be addressed in the discussion (chapter 6.1).

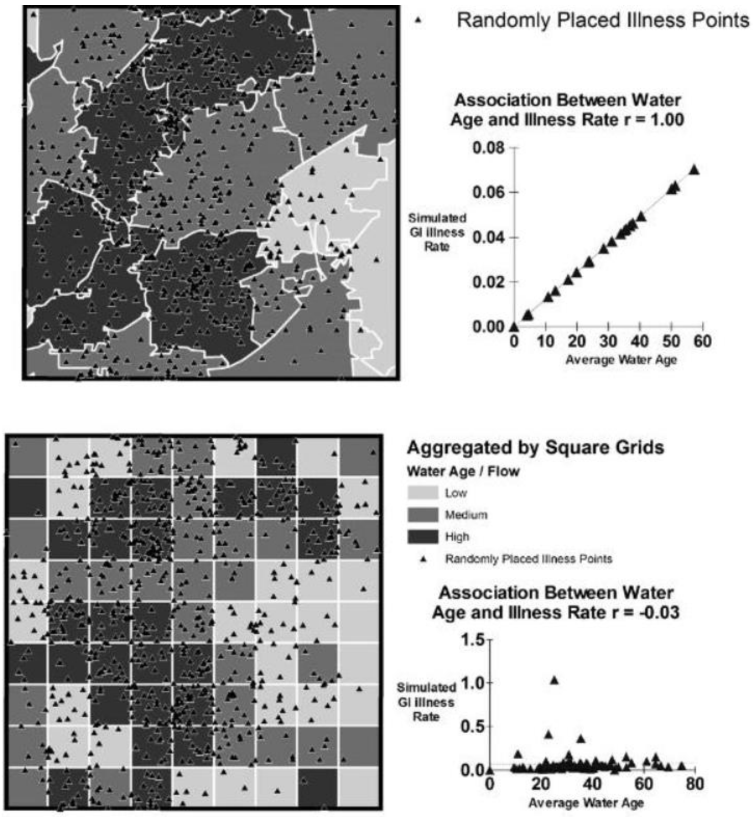
3.6.2 Known issues when working with GIS

Problems with validity and reliability also arise when working with GIS analysis. Heywood, Cornelius and Carver (2011, p. 197) note three problems that arise when working with GIS.

1. The modifiable areal unit problem (MAUP)

The MAUP can be a result of using arbitrarily drawn borders (spatial units) to investigate and research geographical phenomena . This means that the choice of the spatial unit that is being investigated can have a serious impact on the statistical results of the research. For example, this research uses the spatial unit of 'buurten' (neighbourhoods) to create the freight landscape, and also to incorporate data on employment (which is point data, instead of areas), but using 'wijken' (city district) instead of buurten will yield different statistical results. Another example can be seen in figure 3.2.

Figure 3.2. Example of MAUP



Source: Swift, Liu, & Uber, 2008

According to Xu, Huang, Dong, & Abdel-Aty (2014, p. 111) one way to reduce the problem is to use small spatial units. The neighbourhoods units that are being used in this research are small in city centres, but somewhat bigger in rural areas. Using visual inspections of large neighbourhoods that report unusual high densities (extreme values), and correcting if necessary, should help reduce the MAUP.

2. Ecological fallacy

A problem related to the MAUP is ecological fallacy. This problem occurs when one assumes that observations aggregated at the spatial unit level are evenly distributed throughout the spatial unit (Heywood, Cornelius & Carver, 2011). An example within the spatial unit of the neighbourhood would be the density of population. It could occur that a certain neighbourhood would include one very large apartment block and no other housing around it. It would be wrong to assume in such a case that the density is the same in the whole neighbourhoods. Using smaller spatial units also helps reduce the risk of ecological fallacy, though it can never be completely prevented unless one works with completely homogenous data. Recognizing this problem helps prevent false assumptions about the data one works with.

3. Threshold values

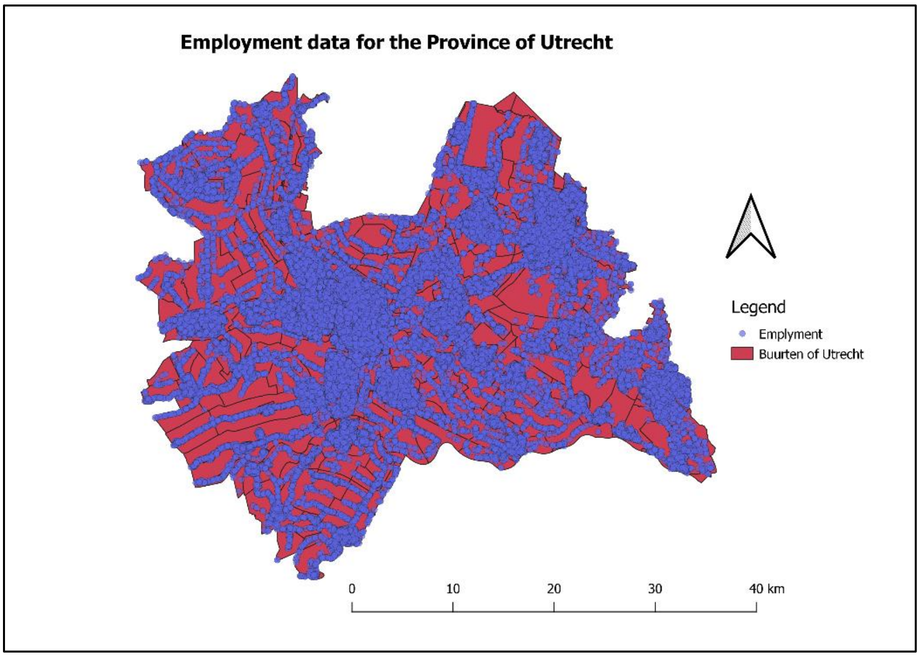
A final problem that can occur when working doing GIS-analyses is choosing wrong threshold values. Choosing threshold for certain analyses, such as a buffer zone, is a somewhat arbitrary activity (Heywood, Cornelius & Carver, 2011). For most variables no clear definition of what is perceived as 'good' thresholds exists. One way to deal with this problem is to do sensitivity analysis for each analysis to check whether smaller or bigger buffer zones yield very different results.

3.6.3 Creating and analysing the (socioeconomic) freight landscape using GIS

Constructing the freight landscape for Utrecht and Flevoland
Now that all the required data has been identified and collected and the most common fallacies of working with GIS have been identified, the next step is construct the socioeconomic freight landscape for both provinces. The method for constructing it will follow the same line as previous research (Giuliano, Kang, & Yuan, 2017; Rodrigue, Dablanc, & Giuliano, 2017; Sakai, Beziat, Heitz, & Dablanc, 2018).

This first step to create the landscape was to format the data on employment and population into the neighbourhood polygons. For population data on both provinces and employment data for the province of Flevoland this was already done. However, employment data from the province of Utrecht required some reworking as data was only available in the form of point data with categorical attributes. This can be seen in figure 3.3. Each employment point in the map was given an categorical value on the amount of employment it represented. The full list of categories can be found in appendix 3. As eventually this data has to be translated in the amount of employment per square kilometre for each neighbourhoods to make the data comparable with the other datasets, a reclassification was required. Two methods of reclassification were considered, one in which the bottom value of each class was considered. So for example, if an employment point was represented by a class ranging from 1-5 jobs, it would be reclassified into 1. This would make for a conservative estimation of the actual employment. The other method that was considered was to take the average of each class. Using the same example, an employment point would represent 3 jobs. The averaging approach was eventually chosen, but the other reclassification was also used to test whether the different classifications would yield different (statistical) results.

Figure 3.3 Spatial employment data of the Province of Utrecht



Source: Provincie Utrecht, 2018; Centraal Bureau voor de Statistiek, 2021

The next step was to calculate the average density per square kilometre for each neighbourhood in both provinces and then divide them into 4 quantiles. Another classification method for the density units was also reviewed to test for choosing different threshold values. The results of this analysis can be found in appendix 3. The landscape that eventually resulted from this method can be found in figure 4.3.

3.6.4 Creating the mobility landscape freight intensity maps

In this research the mobility landscape will be represented through a set of maps that visualize the intensity of freight trucks using the INWEVA database. This database makes a distinction between heavy (larger) and medium (smaller) trucks on the Rijkswaterstaat highway network. This distinction is used to analyse whether assumptions made in the literature on the socioeconomic landscape, namely that converting density units generate more small freight movements and diverging density units more large freight movements (Rodrigue, Dablanc, and Giuliano, 2017). Since a serious share of the freight movements along the highways in both case areas is probably not destined for either of the regions, the maps will represent the freight that is observed at the on and off ramps of the highways.

3.7 Assessing the landscapes

In order to understand what the freight landscape means for Rijkswaterstaat two methods were applied. First, for the socioeconomic landscape, a focus group was organised with Rijkswaterstaat employees to assess what the results of this landscape could mean for their work in managing the RWS assets. Second, an overview of relevant national and international policies is created to better understand the role policy context under which Rijkswaterstaat operates. This in turn helps to better assess the political landscape.

3.7.1 The focus group

To help answer the last two sub questions a focus group was organised with experts from Rijkswaterstaat. The reason for not conducting individual interviews but instead organise a focus group with multiple respondent was based on the expectation that organising a group discussion would yield extra insight from the freight landscape. Since the freight landscape is a novel concept and therefore unknown to the experts at Rijkswaterstaat, they might have different interpretations on the usefulness of such a concept to their day-to-day work. When doing individual interview, it was expected, there would be a greater risk that respondents would misunderstand the concept. Through a group discussion different interpretations could be shared, which could lead to more insight for all participants into the concept and therefore to less misinterpretation. Furthermore, it reduces the risk of relying too much on a limited number of key informants (Scheepers, Tobi & Boeije, 2016).

According to Silverman (2013) there are a couple of things that require extra attention when organising a focus group. The first is trying not to lead a discussion, input on the subject should primarily come from the respondents. Second is deciding who will actually be in the discussion. The respondents should all have something in common to talk about. This was taken into consideration on the setup of the focus group.

Selection of respondents

The choice of the respondents within Rijkswaterstaat is mainly based on the case area. Rijkswaterstaat has several regional departments that are tasked with managing RWS assets within their borders. Close to all of the case area is located within the boundaries of Rijkswaterstaat Midden Nederland (RWS MN). Hence, respondents were selected based on the criteria on whether or not they work for RWS MN. While these respondents can give an indication on the meaning of the freight landscape to Rijkswaterstaat, some things should be noted. First, Rijkswaterstaat is a large organisation (with about 8.000 employees) with several regional departments such as MN. While there is a lot of overlap in the type of work of such departments do, each regional department has a different regional context under which they operate. Therefore, employees from other regions may have different views on what the freight landscape could mean for their work, and therefore yield other results. This means no strong generalising conclusions can be made.

Setup of the focus group: the presentation
For the organisation of the focus group it was decided first give a short presentation on the context of the research and the freight landscape concept. In order to minimize the presentation time and maximise the time for discussion some choices had to be made on what parts of the research would be presented and which parts would not be presented. Since the central part of the research was focussed on constructing the socioeconomic landscape and testing it, it was decided to focus the presentation on this part of the freight landscape, and only briefly mention the other three landscapes. Furthermore, statistical results would also not be included as the main aim is the gain an insight in their perspective on the usefulness of the concept regardless of whether it actually can help predicting freight intensities.

Setup of the focus group: discussion on network impacts
In order to ask more focussed questions on the insights the freight landscape could give on the impact on the network, some specifications have to be made. Impact on a network, such as the network under management of Rijkswaterstaat, can have a variety of different interpretations. Since the freight landscape is aimed at estimating freight traffic intensity at certain locations, the impact discussion was focussed on three elements:

- **Impact on asset management**: freight vehicles are one of the main causes for the deterioration of roads (Del Grosso, Inaudi & Pardi, 2002). In order to create a better balance costs, performance and risks the additional knowledge of where to expect a relative higher share of freight vehicles and what potential causes could give input to a rise of it might help in such a complex balancing act (Spatari & Aktan, 2013).
- **Impact on traffic management:** while heavy freight vehicles may not have a large impact on congestion, smaller freight vehicles (such as vans) can already have a more serious impact on it as the appear in larger numbers. Since facilitating efficient (e.g. no congestion) traffic flows is one of the main aims of Rijkswaterstaat, such information could be valuable to the organisation (Ministerie van Infrastructuur en Waterstaat, 2021)
- **New perspective on the network:** combined with the first two elements, this element is aimed at a more strategic level.

The discussion was guided by using a set of maps that were accompanied by three polls in which respondents were asked to react on a statement. Each map would first be explained, then the a poll was inserted, based on one of the three elements, to stimulate the discussion.

4. Results

This chapter presents the results of the research that was described in the previous chapter. It will start with a brief introduction on both provinces and analyse the infrastructure landscape that is present in both areas. Then the other landscapes are analysed using a map of the socioeconomic landscape. More insight into the usefulness of the freight landscape will be gives based on the results of the focus group. For most of the results a separate map for both provinces is presented as this helps better to give a more detailed analysis. This also helps better compare both landscapes.

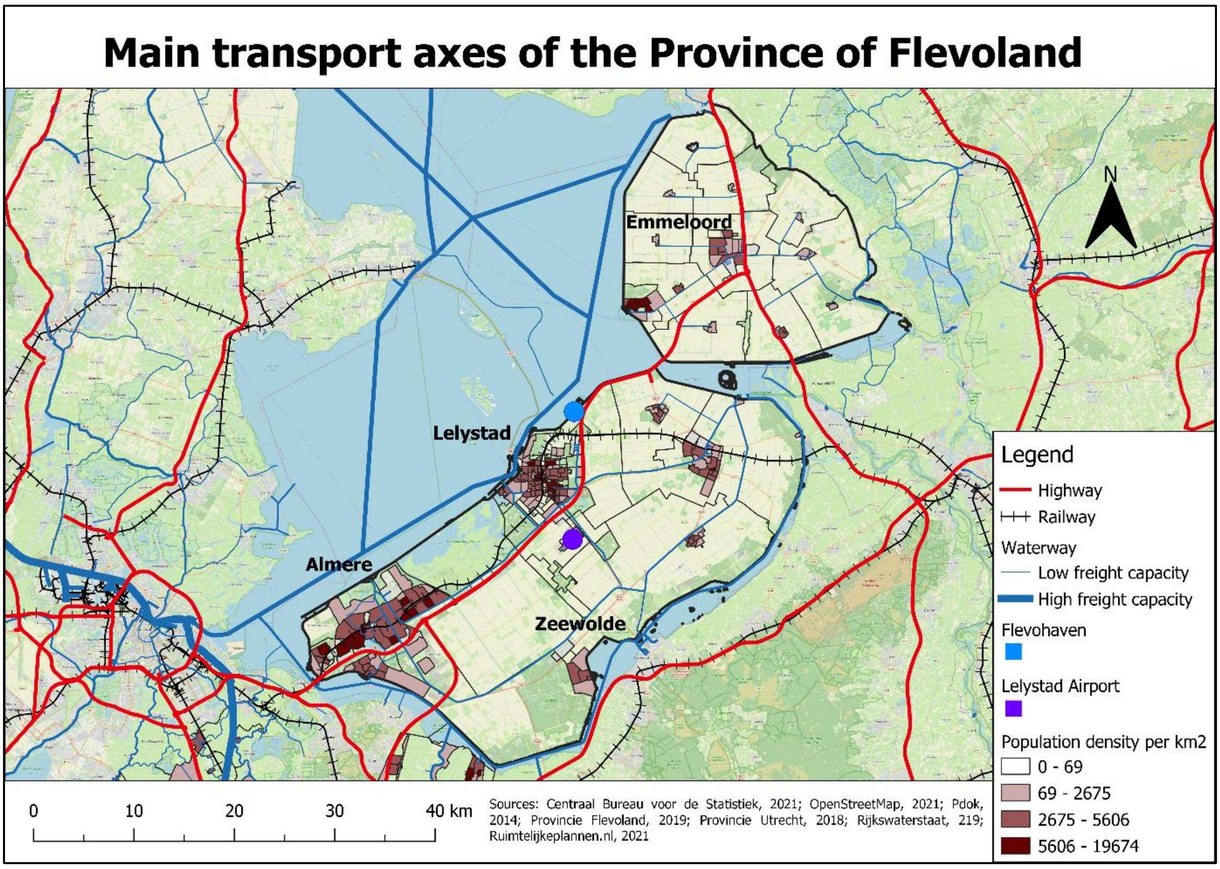
4.1 The infrastructure landscape

Flevoland and the infrastructure landscape

The province of Flevoland is the newest province of the Netherlands. It was created by reclaiming land of what was formerly known as the Zuiderzee, which turned into the Markermeer and the IJsselmeer. The reclaiming of the land of the Zuiderzee started in 1939 and finished in 1968. The province of Flevoland was created in 1986. Nowadays the province is home to 428.226 people (CBS, 2021). In 2019 this number was 416.546. The province of Flevoland consists of 6 municipalities. The capital city of the province is Lelystad. The largest municipalities in the province are Lelystad (77.893) and Almere (207.904).

Figure 4.1 shows the main infrastructure networks present in the province of Flevoland. As can be seen on the map, there is one highway (main road) that runs along the most important population centres of the province (the A6) and one highway that bypasses Amsterdam when traveling from Almere to Utrecht (the A27). The only two urban centres that are not in the vicinity of the A6 are Dronten and Zeewolde. Furthermore, Almere and Lelystad are located along an major shipping route from Amsterdam to the hinterlands (such as cities in the provinces of Overijssel and Friesland). The recent addition of the Flevohaven was partly due to this location along a shipping corridor (Provincie Flevoland, 2019). Almost all (95%) of the freight to and from the province is moved by road transportation (Provincie Flevoland, 2019). The remaining 5% is moved over water. Lastly, while there are rail lines crossing the province, these are dedicated to passenger transportation and there is no rail terminal in the province that can connect freight transportation towards rail lines. The same is true for air transportation. While the province does possess an airport (Lelystad Airport), its runway is currently too short to accommodate any serious freight activity (Provincie Flevoland, 2019).

Figure 4.1. Transport infrastructure in Flevoland



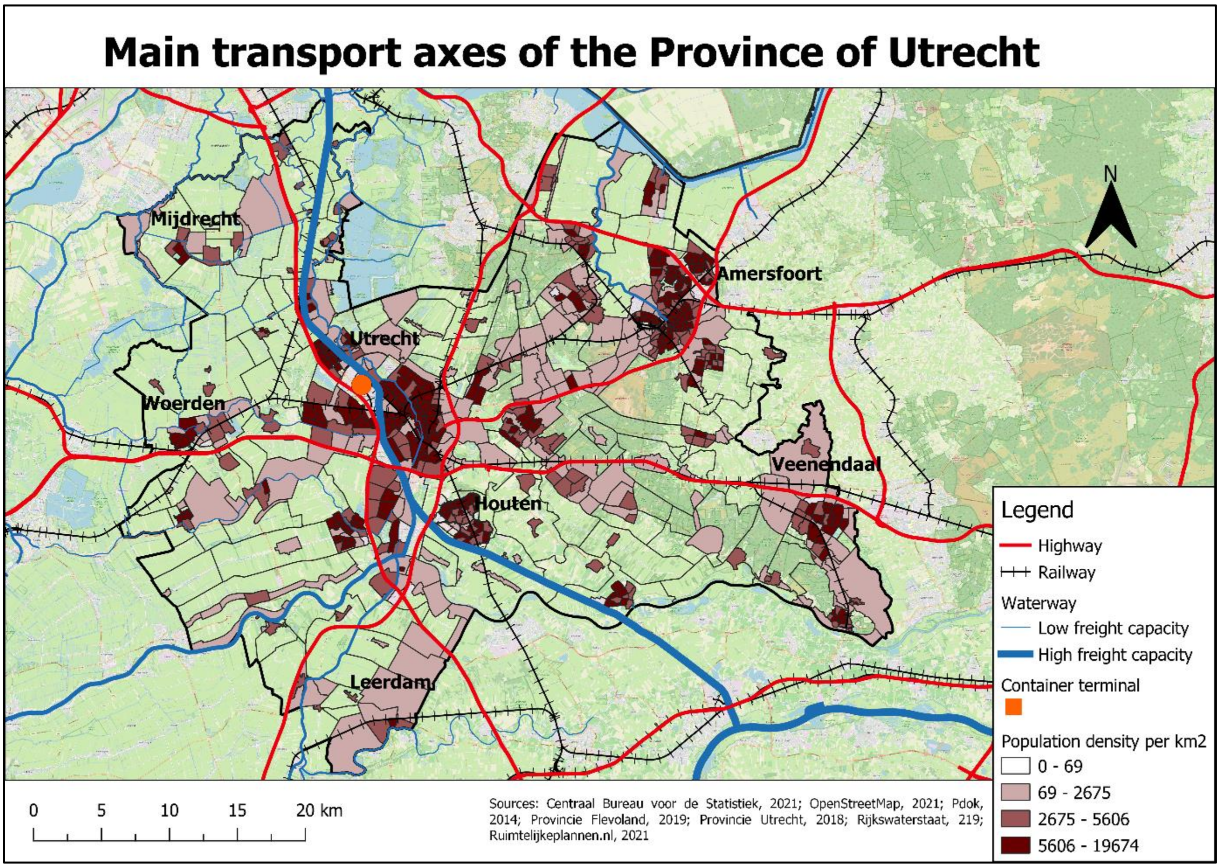
Utrecht and the infrastructure landscape

The province of Utrecht is the most centrally located province in the Netherlands. The capital and biggest city/municipality of the province has carries the same name: Utrecht. The province is home to 1.356.822 people and is thereby the 5th most populated province in the Netherlands (CBS, 2021). The main railways, waterways and roads (the highways) fall under the responsibility of the national government. Of these main networks Rijkswaterstaat is responsible for the management of the highways and the waterways and Prorail, a semi-private company, is responsible for the railway infrastructure. About 70% of the freight movement in the province is through traffic (Provincie Utrecht, 2018).

Figure 4.2 shows the main transport infrastructure of province of Utrecht. The city of Utrecht, in terms of transportation, is often referred to as the 'draaischijf van Nederland' (turntable of the Netherlands), which refers to the fact that you will often pass the city when traveling between different places in the Netherlands since a lot of infrastructure (mainly rail and road) comes together at this city (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2020). This can also be observed on the map as mainly highways come together at the ring road of Utrecht: the A2 and the A27 going from south to north (towards Amsterdam and Almere respectively). And the A12 going from Rotterdam and Den Haag (west), two major population centres, to the Arnhem and the German hinterlands (east). The same is true for railways, as Utrecht is a central point from which different rail lines converge. Yet, despite its central location, not much freight is transported along its railways. About 2,5% of all freight is transported along rail, of which most (99%) is through traffic destined for Germany (Provincie Utrecht, 2018). Most of the freight transported to the province along rail lines is destined for a car distributor located south of Amersfoort (PON). Three, closely related, reasons can be given for this lack of freight of rail freight in the province. The first, and most prominent, reason is that passenger transportation is given a priority on most rail lines in the Netherlands, with the province of Utrecht not being an exception (Provincie Utrecht, 2018). Most of the rail capacity is already filled by passenger transportation, leaving little room for any freight to be transported along the same rail lines. The second reason relates to the comparative advantages of the different modes of transport (Rodrigue, 2004). Rail transportation is most competitive on middle to long range distances with large volumes of freight that can be consolidated and transported, which can also be observed in the fact that most rail freight that flows through the province is coal destined for Germany. Most transport distances within the Netherlands, and especially within the province itself, are relatively short. This makes rail transportation less attractive. Add to that the changes that have taken place in the (global) distribution system in which a larger emphasis on just-in-time deliveries: transport is required to be more reliable and with the emergence of e-commerce also more flexible (Kang, 2020). Such requirements can best be met by road transportation, which has become even more attractive with the construction of extensive highway networks (Del Grosso, Inaudi, & Pardi, 2002; McKinnon, 2009). Such an extensive highway network can also be observed in the Province of Utrecht. A final reason for lack of rail transportation is the construction of a dedicated railway called the 'Betuweroute'. This railway connects the port of Rotterdam with the German hinterlands in one direct connection and bypasses the Province of Utrecht.

Moving to water infrastructure, two important waterways cross the province of Utrecht. First is the Amsterdam-Rijnkanaal, which connects Amsterdam to the Waal river and flows past the city of Utrecht. It is one of the busiest canals by amount of ships that pass through it in the world (Rijkswaterstaat, 2020). The other important waterway is the Lek, which runs parallel with the larger Waal river that connects the port of Rotterdam to German hinterlands, and forms most of the southern border of the province. Despite the presence of these waterways freight transportation over water is destined for the Province of Utrecht is also, even with the presence of a container terminal, relatively low (Provincie Utrecht, 2018). Mainly for the same reason as rail transportation: the comparative advantages of road freight transportation.

Figure 4.2. Transport infrastructure in Utrecht



Synthesis of the infrastructure landscape
Based on the analysis of both infrastructure landscapes it has become clear that most freight destined for both provinces is transported by road. Even with the presence of waterways and railways it is not expected that these transport modes will, in the short to medium term, gain a larger share in the modal split of the provinces. This expectation is based on the literature of the infrastructure landscape, and the general distribution paradigm. First, as already mentioned when discussing the province of Utrecht, each transport mode has its own competitive advantages. While there are possibilities in both provinces to use other modes of transport than road, they cannot compete with flexibility and speed that road freight offers, largely thanks to the extensive highway network (McKinnon, 2009). Secondly, as there are so many highways, going to different large markets (Amsterdam, Rotterdam, Den Haag, Utrecht, Almere, etc.) the accessibility road transportation offers is also higher than those of other transport modes. Accessibility is one of the key factors through which logistical companies determine their location (Holl & Mariotti, 2018).

4.2 The socioeconomic landscape

Figure 4.3 presents the freight landscape of both provinces, the frequency of each density unit is presented in figure 4.4. To gain a better insight in the organisation of the freight landscape for both provinces individually two separate maps have also been constructed (figure 4.5 and 4.7). The three maps show the different density units that have been constructed by combining both the employment density and population density data. E stands for employment and P stands for population. To give some examples, 1E/1P means that there is both a relatively low density of employment and population. These are rural areas with little to no (freight) activities taking place. 4E/1P means that there is a high density of employment compared to a low density of population. These areas are assumed to be industry zones or logistical zones that are unattractive for housing, hence the low population density (Rodrigue, Dablanc & Giuliano, 2017). The prevailing logistical activity is distribution of larger quantities of goods being hauled over longer distances, or consolidations of so called 'less-than-truck loads': smaller quantities of goods. 4E/4P is the density unit that represents a high density of both employment and population. These are in general the dense city centres. These are the places that need to be supplied with a large variety of different goods and services (food, specialized items for local retailers, garbage collection, etc.). Since space is relatively scarce and expensive due to the large amount of people and activities using the same space, there is also less storage space available. Meaning that stores also need to be supplied more often. Adding to these challenges is the fact that many city centres also have set constraints on movement of freight in city centres to combat the negative externalities freight causes in these places. To accommodate such complex circumstances most freight is moved in smaller quantities (and smaller vehicles), but more frequently. Together these density units can give some insight in the types of freight distribution activity being conducted in a certain area.

When inspecting figure 4.4 and the legend of figure 4.3, one of the first things that can be noted is that there are two density units missing from the legend: 1E/3P and 1E/4P. Meaning that there are no neighbourhoods in the province of Flevoland that have a relatively low amount of employment compared to relatively higher amounts of population. A possible reason for the missing of these two density matrixes is the influence of freelancers on statistics. Freelancers who own a company may register their business on their home address. Higher population densities may proportionally bring in a higher amount of freelancers with their business registered at home. Another thing that can be noted in the graph presented in figure 4.4 is the high amount of, relative, low density units in both provinces.

Figure 4.3. The freight landscape of Flevoland and Utrecht

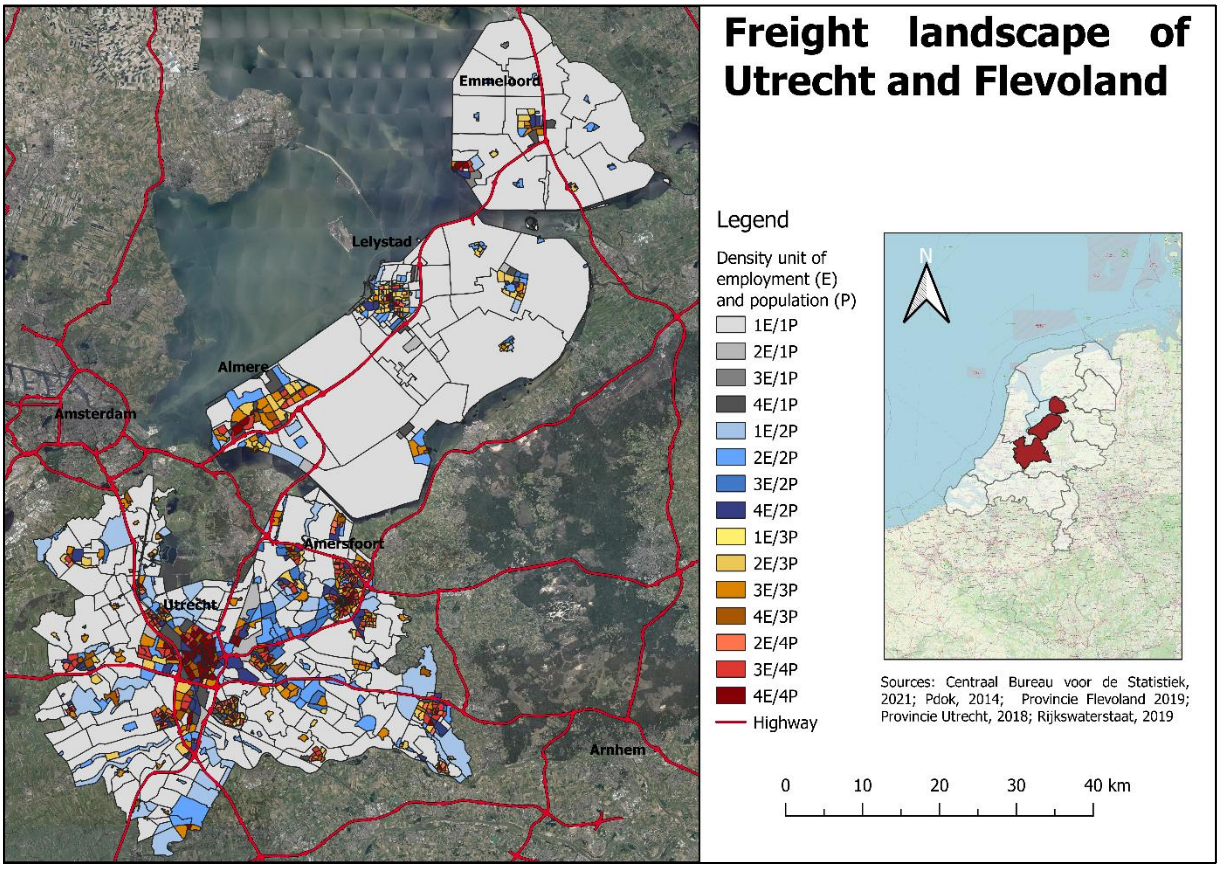
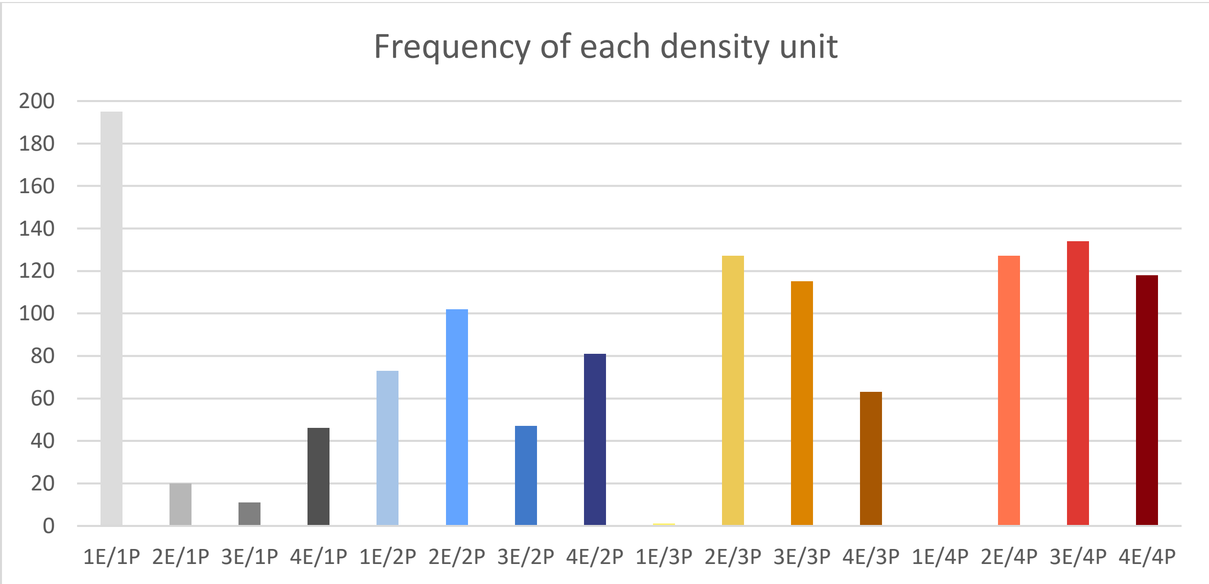


Figure 4.4 Frequency of each density unit for the freight landscape of Flevoland and Utrecht



4.2.1 Flevoland

At first glance, for both for Utrecht and Flevoland, it can be stated that a familiar pattern comes forward when examining the freight landscapes. Something that was also noted by participants of the focus group. High density units such as 4E/4P can be found in the larger urban areas (such as the city of Almere) and smaller density units such as 1E/1P can be observed in the rural areas that mainly consists of farmland. This was also noted by the participants in the focus group. Interestingly the only small municipality in Flevoland that contains the highest density unit is Urk. Though this can be explained through the fact that Urk is the only settlement that has a dense historic village centre that already existed before the rest of Flevoland was constructed. As it was an fishing village located on an island before it was incorporated into what is now the Noordoostpolder. Even though Urk has some high density units, in general it can be observed that there are not many combined very high density units in the province. Both Almere and Lelystad do also contain some 4E/4P. These observations can also be seen figure 4.6, which shows the frequency graph of the density units for Flevoland. The relative low amount of high density units seem to suggest that there are relatively few barriers for freight transportation in province as there are not that many neighborhoods in which freight has to deal with complex city centre logistics.

Figure 4.5. The freight landscape of Flevoland

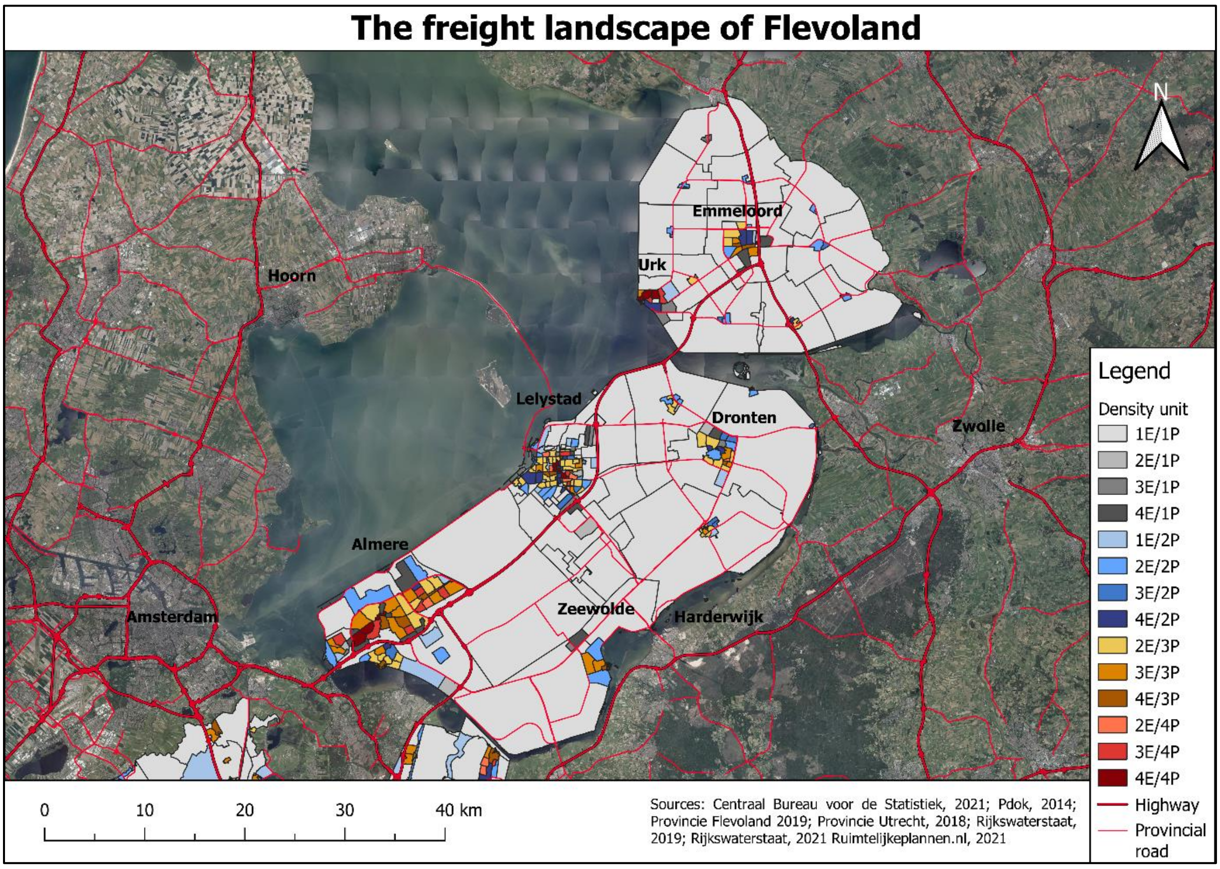
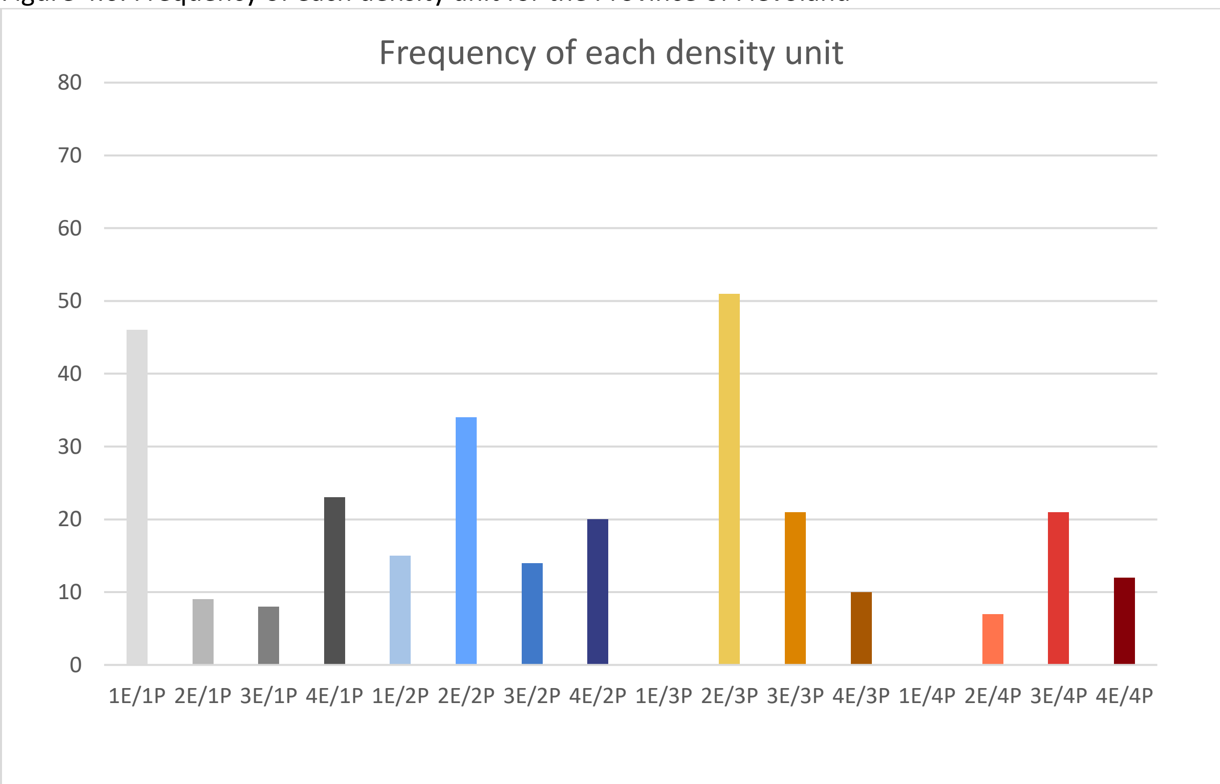


Figure 4.6. Frequency of each density unit for the Province of Flevoland



4.2.2 Utrecht

Just as with Flevoland, at first glance a familiar pattern can be observed in which the contours of the larger urban areas in the province, with the cities of Utrecht and Amersfoort being the most prominent examples, are quickly observed. The high presence of high density units indicate that both the city centre of Utrecht and Amersfoort have little room for freight transportation and freight flows to and from these places takes place in large flows of small freight delivery vehicles. Another thing that can be noted is the cumulation of blue density units along the A28 corridor between Utrecht and Amersfoort. This would, based on the literature indicate a diverging pattern (especially with the dark blue) towards high employment density. This would in turn mean that more heavy freight vehicles could be expected between the two cities. This however, is probably not the case, since most of the employment in the region does not come from logistical companies or companies that generate a lot of (heavy) freight traffic, but from the location of large (military) government facilities and the University of Utrecht. This also points towards a critique point of the socioeconomic landscape that previous research also identified (Sakai et al., 2018). Namely that adding economic classification towards the different employment groups would create more accurate maps.

Figure 4.7. The freight landscape of Utrecht

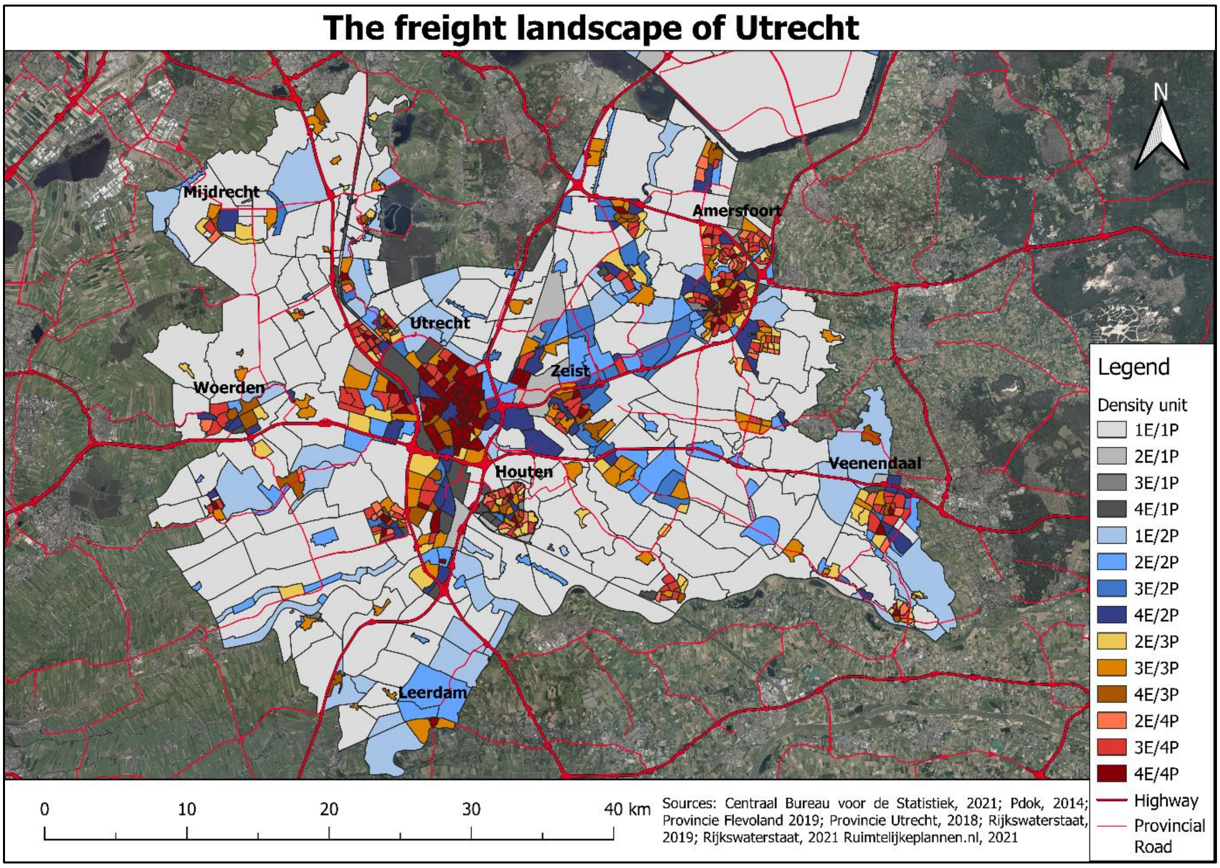
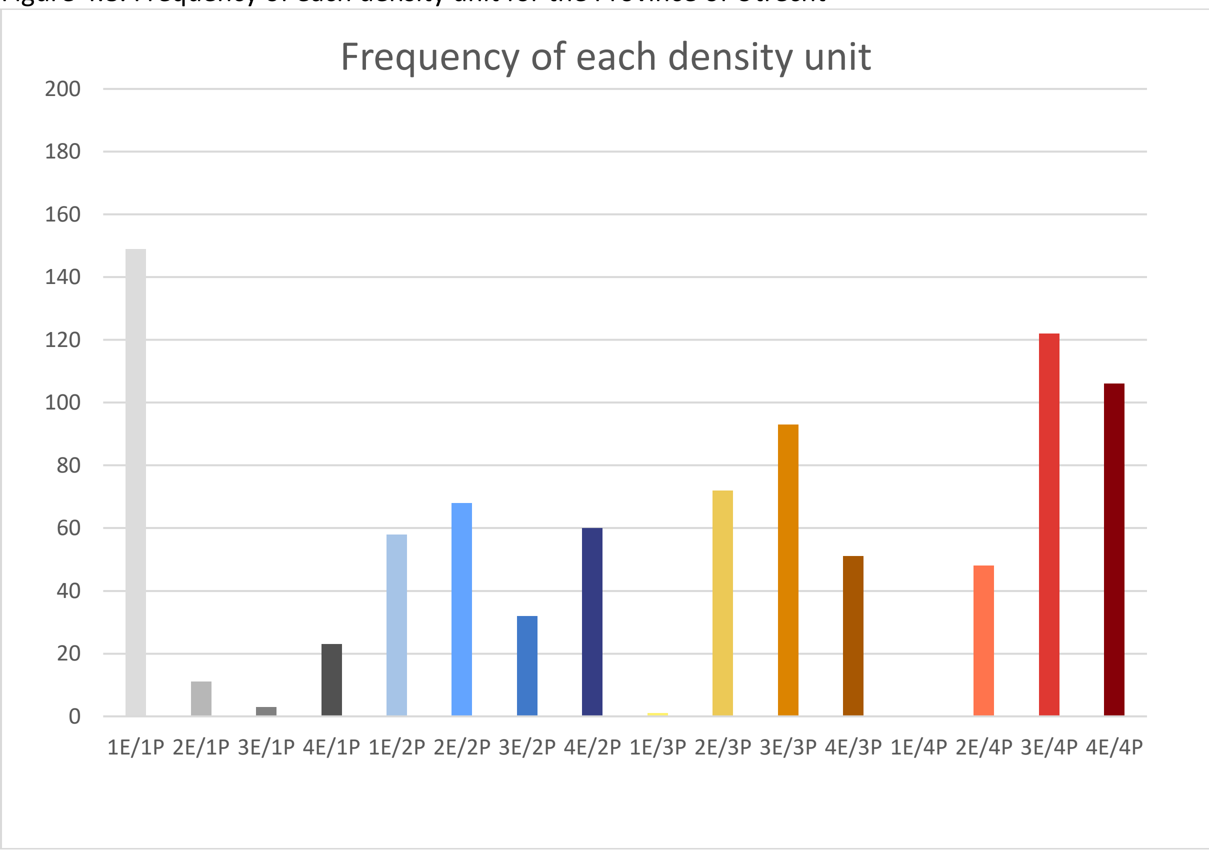


Figure 4.8. Frequency of each density unit for the Province of Utrecht



4.2.3 The socioeconomic landscape and freight intensity: plotting a mobility landscape

One of the main assumptions of in this research, based on the conceptual model (figure 2.6) is that freight landscape can give some indication on the intensity of freight traffic and also indicate where more heavy freight vehicles, and where more light vehicles can be found. In order to investigate this assumption data that contained all the highway on and off ramps and its traffic intensity in the case area was collected using INWEVA data (see paragraph 3.6.3) for details on how the map was created). Based on the data of INWEVA, it can be noted that the share of all freight traffic is small compared to passenger (small vehicle) traffic. The average share of freight traffic on the ramps is about 8%. The highest share can be found at the ramps serving Utrecht Lage Weide with a share of 19%. The lowest share can also be found near Utrecht, which are the ramps that serve the business park Papendorp.

Plotting this data on a map creates that map that can be observed in figure 4.9. The diagrams in the map show the share of heavy freight vehicles and light freight vehicles compared to the total amount of freight vehicles passing through the ramps. The total amount of freight vehicles is shown by the size of the diagram. Since this map is somewhat hard to read, some basic statistics will be given. In order to compare these statistics on a map, multiple maps where created to give additional insight into the spatial dimension of these statistics, and to compare it with the freight landscape and the patterns that where observed in the previous section. These maps can be found in figure 4.10 and in appendix 2.

When observing these maps a pattern emerges that seems to be in line with what was expected from the literature (Rodrigue, Dablanc & Giuliano, 2017). Not only are highway ramps (access points) more numerous at locations at locations with a large share of high density (4E/4P) units, but they also appear to handle more freight traffic than their low density rural counterparts. This seems to make sense, since such locations not only are expected to generate more freight, but also require such freight to be transported in smaller quantities due to vehicle restrictions in such areas (Lindholm, & Blinge, 2014). The expected pattern of heavier vehicles at locations with less high density units is most clearly observed in the province of Flevoland, in which locations that have little to no high density units, such as Lelystad and Emmeloord have relatively high shares of heavy freight vehicles compared to those of Utrecht and Amersfoort. Exceptions to the pattern can also be explained. For example, the ramp that sees most heavy freight vehicles in the case area (and also has a larger share of freight vehicles) is located at the northwest of the city of Utrecht. While it is located near many high density units, it is also located near the largest neighbourhood (Bedrijventerrein Lage Weide) of the city of Utrecht that has a high density of employment, but a low population density. This neighbourhood also hosts the largest inland port of the case area. Combining both accessibility features (located next to a highway access point, inland port and proximity to high density units) and the fact that it is a high employment density divergence neighbourhood explains both why the share of heavy freight vehicles is relatively high and why it is the most intensely used ramp in terms of heavy freight vehicles.

Interestingly, one of the top 10 locations is located near Vinkeveen (in the northwest of the Province of Utrecht). Based on the map, on would not immediately expect this to be a location reaching the top 10. A possible explanation is the large business park near Mijdrecht (west of Vinkeveen) which houses a large household chemicals factory.

Figure 4.9. On and off ramps of the case area. Legend is to be added later

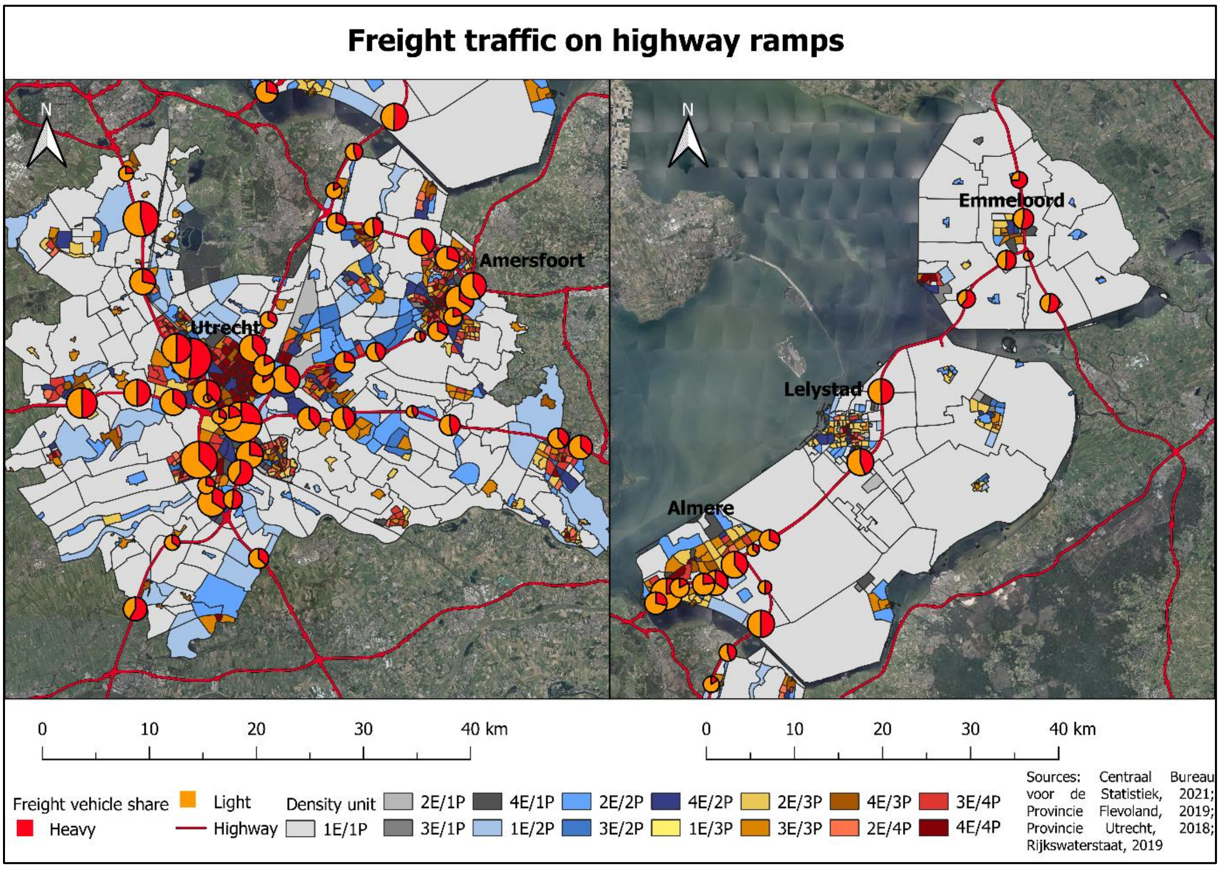
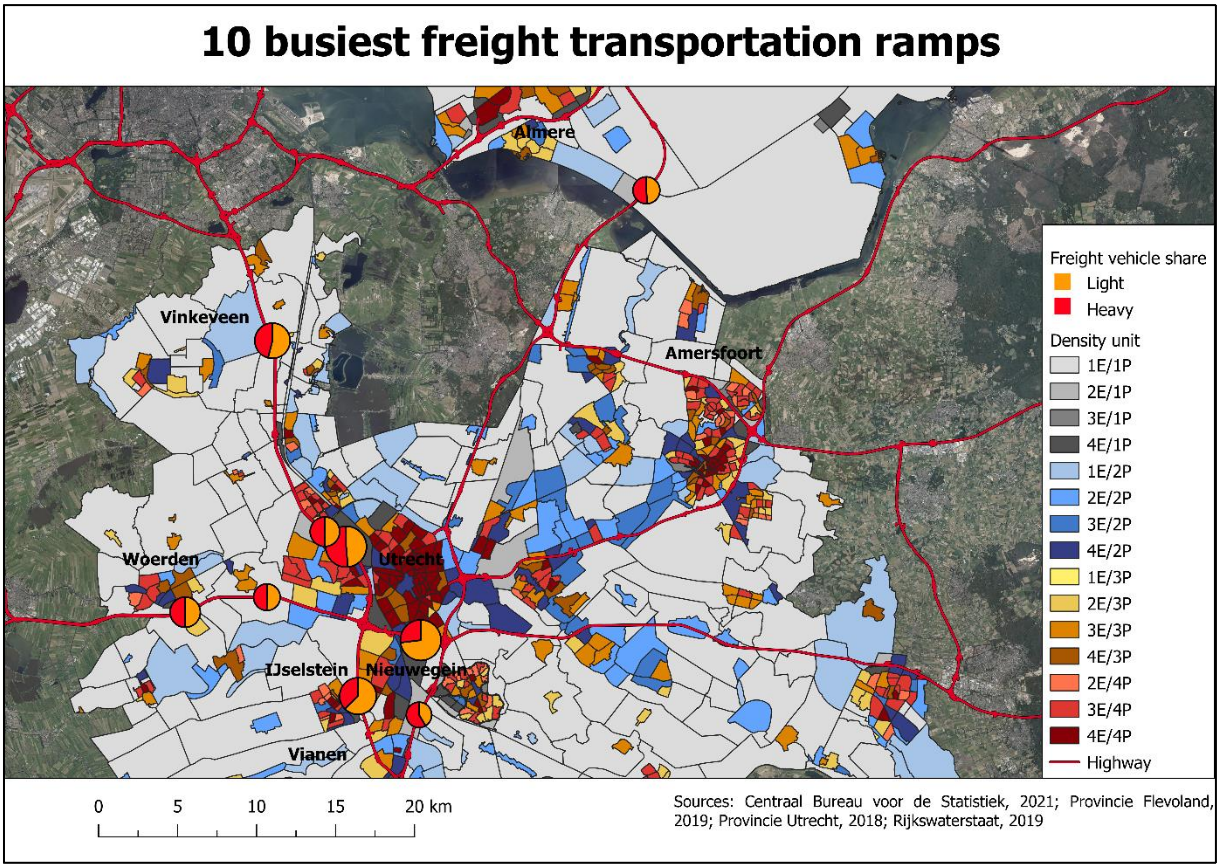


Figure 4.10. Top 10 busiest freight on and off ramps in the case area



4.2.4 The socioeconomic landscape and the focus group

The main part of the focus group, which was conducted with employees of Rijkswaterstaat Midden Nederland (RWS MN), was centred around the question to what extend the socioeconomic landscape maps could assist asset management and traffic management. This was done under the assumption that more data on the location patterns of freight transportation could help make better decisions on how factors such as cost, performance and risk could be balanced (van der Velde, Klatter, & Bakker, 2013). Such a map would especially be helpful in adding a network perspective (Parlikad, & Jafari, 2016). From the focus group it became clear that maps on the socioeconomic landscape could certainly be interesting for Rijkswaterstaat. However, for traffic management, asset management, and a network perspective more information is necessary for it to make it more useful.

For traffic management more detailed information on the origin and destination of freight movement is required. While this map gives an indication on where more, or less, freight traffic can be observed. It does not indicate the direction in which it is flowing, which would be useful information when planning for detours during maintenance or construction work. Furthermore, as one respondent noted, traffic management involves more than just freight traffic. The same is true for asset management. The maps currently give too much of an abstract insight in freight movement for it to be incorporated into the asset management of RWS MN. For questions such as the usage of certain asphalt types at certain places on the highway more detailed information is required on the location, route and weight of freight vehicles. A map that only indicates the estimated location and weight of freight vehicles is not enough to base asset management decisions on.

Moving from a more operational (asset and traffic) management perspective towards a more strategic (network) perspective, it became clear that the freight landscape could play a more prominent role. RWS MN employees are looking for ways to couple city logistics with the wider network implications, while single objects may not have a serious impact on the RWS network, a cumulation of single objects does. Especially when it comes to optimizing the location of new logistical hubs and clusters. The socioeconomic map can give some insight in demand for certain types of logistical activities, and where certain types of could be located. For instance, city hubs or urban consolidation centres are expected to be most feasible near Utrecht, Amersfoort, and to a lesser extend Almere, since these locations host a large amount of neighbourhoods with high density convergence. Cities such as Lelystad and Veenendaal, despite being reasonable sized cities, are less feasible for such hubs, since they contain less high density convergence neighbourhoods. However, despite its potential, some questions about the maps remain that could hamper its potential. Respondents are critical at the current version of the socioeconomic map in which high employment divergence could also mean office zones without any residential areas. Such locations do not necessarily attract heavy freight vehicles, as expected in the literature (Rodrigue, Dablanc & Giuliano, 2017). Furthermore, interpretation of the map was also difficult due to the large amount of colour shades used to represent the different density units. Questions were also raised about the choice of threshold values for the different density units, which could influence the look of the map. This issue has also been addressed in the methodology (paragraph 3.6.1) and the results can be observed in appendix 3.

4.2.5 Literature perspective on the socioeconomic landscape

Comparing the freight landscape to previous research shows some differences and similarities. In the research of Rodrigue et al. (2017) four different landscape patterns where identified while comparing the metropolitan areas of New York, Los Angeles, Paris and Seoul. Paris was characterised as having a high level of convergence, creating a relatively uniform landscape when it comes to operational constrains. Los Angeles on the other hand was characterised by a relatively high level of divergence, which would imply less comprehensive city logistics strategies as a result of the functional variation. New York had a somewhat similar pattern with Paris, but had a larger share of diverging density units surrounding the core urban areas. The pattern of divergence/convergence for Seoul seemed to be fitted somewhere between New York and Paris, though it was harder to grasp since the spatial units were larger compared to those of the other urban areas. Comparing the freight landscape of Utrecht and Flevoland next to these landscapes it becomes clear that the freight landscape of the case areas are very distinct of those in the research of Rodrigue et al. (2017). Both are more characterised by concentrated pockets of convergence and low density in between them. This is, in part, the result of national policies of the Dutch government that focussed around the efficient usage of the available space in which concepts such as the compact city where widely used (Spit, Zoete, & Beek, 2016). This means that, in contrast to a highly convergent city such as Paris, no one city logistics plan could comprehend all the different urban areas. Each would require its own city logistics plan.

Comparing the landscape of Flevoland to that of Utrecht also gives some insight in another geographic concept that was discussed in the literature: logistical sprawl. There are different factors that attribute to logistical sprawl. Once such factors are met, one can expect more incentive for logistical sprawl. An emphasis should be placed on incentive, as meeting such conditions does not directly mean more sprawl will actually occur. Dablanc, Ogilvie and Goodchild (2014) suggest that the population size of the metropolitan area and legislative power of lower governments, in that they have a high level of autonomy in deciding where to put what type of land use, also have a serious impact on the extent to which sprawl will occur. Furthermore, land prices and accessibility can have a strong impact on the amount of sprawl. The socioeconomic map can give some indication on the potential of logistical sprawl by estimating the attractiveness of certain locations to logistical companies, which have been identified in the mobility landscape literature. Based on this literature it can be argued that, not taking the political landscape factors into consideration, both Flevoland and Utrecht are interesting in their own respects for logistical companies. Utrecht is mainly interesting for its central location in the Netherlands and its relatively large population and employment concentration, which mainly make it interesting from an accessibility standpoint (Verhetsel et al., 2015). Flevoland and its urban centres are somewhat less centrally located and do not have such a high degree of both highways and densities converging in its provinces. However, especially Almere and Lelystad are well connected to both the large urban centres of Utrecht and Amsterdam and the province has more, and mainly larger, plots available. Especially when the distribution paradigm is taken into consideration, in which physical proximity is becoming less relevant with the development of extensive (highway) infrastructure, it can be argued that Flevoland is more interesting for future development of logistical facilities, such as distribution centres (Hesse & Rodrigue, 2004; Rodrigue, 2004; Dablanc & Ross, 2012; Aljohani, & Thompson, 2016). However, as already argued by Heitz, Launay and Beziat (2019), these are not all the factors that determine the favourability of a locations. Land use regulations also play a significant role in the location of new logistical facilities.

4.3 The political landscape

For the political landscape a content analysis and a policy review on infrastructure planning in the Netherlands was performed. The results of the content analysis have been summarised in table 4.1. First the results of the content analysis, in which municipal and provincial vision documents where asset will be discussed. The second part provides an overview of Dutch infrastructure planning policies, which are the policies under which Rijkswaterstaat operates. These are then compared to the results of the content analysis and the literature on the political landscape.

4.3.1 The content analysis

Municipal findings

Despite the expectation that a freight transport discussion would be non-existent in many municipalities, all municipalities did mention freight transportation in one or more of their (vision) policy documents. The extent to which they mention it did, however, varies. Based on the content analysis the expectation that especially municipalities with higher density convergence pay attention to city distribution activities, and therefore freight transportation, seems to hold true. The smallest two municipalities (Veenendaal and Noordoostpolder) consider their role to be marginal, mainly because they barely mention freight transportation, and if so only in a more generalised line on motorized vehicles and safety issues. On the other hand, municipalities with high density convergence do focus more on freight transportation in their policy documents. In many cases this is not only related to efficient city logistics, but also coupled with sustainability goals of the municipality. This is also reflected in the fact that most municipalities not only plan to enact direct freight transport regulations, mainly aimed at reducing negative impacts of freight transportation, but also plan to enact more indirect policies, such as incentives to move to a electric vehicles fleet. This goes beyond what was expected in the literature, in which freight transportation would mainly be considered from a classical perspective by municipalities as a disturber of the liveability (Lindholm & Blinge, 2014). The municipality of Utrecht even goes one step beyond such actions acknowledges that current trends in logistics can lead to large spatial claims in the form of distribution centres (Gemeente Utrecht, 2007).

Interestingly, the municipality with most focus on freight transportation is not the municipality with the highest convergence levels (Utrecht or Amersfoort), but the municipality of Lelystad. Lelystad considers the logistical industry (and freight transportation) as a key policy objective (Gemeente Lelystad, 2020). Their focus on logistics is, however, different from those of municipalities with a higher density convergence. Cities such as Utrecht and Amersfoort are mainly aimed at facilitating efficient freight distribution in their cities and also investigate to what extent freight transportation can assist in their sustainability goals. Lelystad is more focused on the economic aspect of freight transportation and attracting economic activity. Such activities would preferably be logistical activities. This fits well with what was expected in the socioeconomic and infrastructure landscapes on the location of new logistical facilities, in which Lelystad has located near large urban centres of Amsterdam and Utrecht, located near a large body of water in which a port has recently been developed, and has a relative abundance of large plots of land available.

Provincial findings

Where focus on freight transportation varies between the different municipalities, the provincial government of both Flevoland and Utrecht are more strongly involved in freight transportation. Both provinces have separate policy documents specifically focussed on freight transportation. Moreover, both consider it a relevant part of their general mobility policy. Despite this, there are some differences between both provinces that explain why the role of Flevoland can be considered as high, and the role of Utrecht as medium. This is the result of a difference in how freight transportation is planned to be worked on by both provinces. Both provinces mainly deal with freight transportation to help achieve sustainability goals and reduce the negative effects of it. However, while both discuss mitigation efforts on the negative effects of freight transportation, Flevoland also explicitly focusses on growing and facilitating growth of freight transportation through the co-developments of transport facilities such as the Flevohaven (Provincie Flevoland, 2019).

Table 4.1 Summary of the content analysis

			Regulation type		
Local goverment	**Mentions freight Y/N**	**Role**	**Direct**	**Indirect**	**Expected impact**
Prov. Flevoland	Y	High	No	Yes	Regional
Almere	Y	Marignal	Yes	Yes	Municipal
Lelystad	Y	High	Yes	Yes	Municipal
Noordoostpolder	Y	Marginal	No	No	*Unknown**
Prov. Utrecht	Y	Medium	No	Yes	Regional
Amersfoort	Y	Medium	Yes	Yes	Municipal
Utrecht	Y	Medium	Yes	Yes	Regional
Veenendaal	Y	Marginal	Yes	No	Local

* The expected impact of freight transportation for Noordoostpolder is unknown, because there is too little information available to base the expected impact on.

4.3.2 Context on infrastructure planning in the Netherlands

In order to better understand how Rijkswaterstaat is positioned and why choices certain choices in the setup of the focus group were made, it is good to give a brief overview of the (policy) context from which Rijkswaterstaat operates. The policies discussed are mainly focussed on those policies that discus freight transportation.

There are many different policies that directly or indirectly influence infrastructure planning in the Netherlands, and thereby influence Rijkswaterstaat. Most policy for Rijkswaterstaat is set by the Dutch Ministry of Infrastructure and Water Management (IenW). Policies can range from international, to national policies. International policies are made by the European Commission and are often (just as national and local policies) influenced by international treaties such as the Paris Agreement from 2015.

On a European level (EU level) the policy on transport infrastructure is mainly aimed at creating an efficient, multi-modal network that stretches the entirety of the EU (European Commission, 2011). TEN-T formulates this objective into active EU policy. TEN-T comprises nine corridors, three of which cross the Netherlands (North Sea – Baltic, Baltic Adriatic, Rhine – Alpine). EU transport infrastructure funding is meant to be focussed on the corridors.

On the national level there are three main policy documents that guide how freight transport (infrastructure) is planned for. First is the Nationale Omgevingsvisie (NOVI), which sets out the long term vision of the Dutch government on spatial developments in the Netherlands (Rijksoverheid. (2020, September). The NOVI replaces different policy sectoral policy documents, such as the policy document on infrastructure and mobility (Structuurvisie Infrastructuur en Ruimte). The NOVI acknowledges the importance of freight transportation to the competitiveness of the national economy. Furthermore, it also states that large scale distribution centres should be concentrated near the (main) ports, such as the port of Rotterdam, or on the main freight corridors that connect these ports to the (German) hinterlands (Topcorridors, 2018). On the urban logistics side, the NOVI states that distribution centres should be located on the fringes of the city in order to prevent negative externalities effecting residential neighbourhoods. It further stresses the need to achieve a more optimal balance of transport modes, meaning a focus on the development of multi-modal nodes that support the usage of transport modes other than road. This concentration is thought the be necessary both to enhance the competitiveness of the transport sectors, and to prevent the impact of logistical facilities on the landscape. Much of the input on mobility in the NOVI came from the 'schets mobiliteit naar 2040', which represents the direction of the Dutch government on how to think about and handle mobility (Ministerie van Infrastructuur en Waterstaat, 2019b). Just as with the NOVI, this document stresses the need more integration of different sectors (such as housing and environment) into mobility planning. The final policy document, goederenvervoer agenda (freight transport agenda), specifically addresses freight transportation (Ministerie van Infrastructuur en Waterstaat, 2019a). This document aims at integrating policy on the different transport modes. It also elaborates the role the Ministry of Infrastructure and Watermanagement consider themselves to have. Which is one of setting up the framework and conditions in which freight transportation can take place. The agenda distinguishes four main priorities that the ministry aims to work on when it comes to freight transportation: digitalization of transportation, improving sustainability of freight transportation, improving sustainability and efficiency of city logistics, creating integrated freight corridors. Cooperation between the different levels of government are considered essential in working on these priorities.

RWS position within the policy context of IenW

Since Rijkswaterstaat is part of the Ministry, the policies and visions of the ministry automatically apply to Rijkswaterstaat. However, the emphasis on the policies and visions of the Ministry can differ from policy to policy since Rijkswaterstaat, as an executive organisation of the ministry, has specific tasks it has to carry out. The mission of Rijkswaterstaat is stated as follows: *"Samen werken aan een veilig, leefbaar en bereikbaar Nederland. Dat is Rijkswaterstaat."* Which translates to: Working together on a safer, liveable and accessible Netherlands. That is Rijkswaterstaat[2]. The mission goes beyond efficient asset management, the ministry (and thereby RWS) is concerned with the efficiency of the freight transportation system as whole, which requires a cooperation of all (local) governments involved.

4.3.3 Comparing the policies of all different governments

Comparing the results of the content analysis to the analysis of the policies under which Rijkswaterstaat operates brings some new insights in the similarities and differences between the policies. Also when it comes to multi-level governance. As discussed in the literature, freight transportation fits mainly in the type II category of MLG as described by Hooghe and Marks (2002). This is mainly because freight transportation not only involves different local and regional governments because of its borderless (freight movement rarely stops at a municipal border) operations, but also because many important actors involved in freight transportation are private companies handling freight. As is clear from the analysis of the infrastructure planning context in the Netherlands, Rijkswaterstaat also has a stake in freight transportation. Not only through some of their core activities such as asset management, but also through the (freight) policy objectives of the ministry under which Rijkswaterstaat operates. In many ways the goals of local governments seem to align with those of Rijkswaterstaat. Both want to reduce negative externalities of freight transportation such as pollution, safety issues and reduce congestion. All governments also, if they mention freight transportation somewhat more extensively, consider efficient freight transportation essential for, sustainable, economic growth (Provincie Flevoland, 2016; Provincie Utrecht, 2017b**,** Gemeente Lelystad, 2020**,**). However, the extent to which the different governments take each other into consideration is somewhat unclear, especially when it comes to the involvement of Rijkswaterstaat. While the provincial governments do take the whole province (region) into consideration for the freight policies, most municipalities do not. Even if the region is taken into consideration, such impacts on the network of Rijkswaterstaat are not taken into consideration.

[2] https://www.rijkswaterstaat.nl/over-ons/onze-organisatie/onze-missie

5. Answering the sub-questions

This chapter will discuss the results and use them to answer the three sub-questions of this research and put the answers in perspective of the reviewed literature.

5.1 How are freight transportation activities spatially organised? And how are freight transport activities spatially organised in the provinces of Utrecht and Flevoland?

To answer this question this research first reviewed the literature on geography of transport geography and the freight landscape, and then produced different maps on the (socioeconomic and infrastructure) freight landscapes for both provinces using GIS software. Based on these maps it was found that freight in both provinces is primarily organised around road based transportation. While regional governments in both provinces are looking into ways to shift the modal split from the current domination of road transportation, it seems hard to achieve such a change in de short to medium-long term (1-5 years) since the competitive advantages of road based transportation are very strong (McKinnon, 2009). Such a domination of road based transport means that any growth in transportation of goods, as a result of economic growth for example, will primarily be facilitated through road based freight transportation. Thereby also increasing the usage on the road assets of Rijkswaterstaat.

Moreover, it also became clear that the socioeconomic landscape of Utrecht and Flevoland is very distinct from those from previous research into the freight landscape. The socioeconomic landscape is characterised by concentrated pockets of convergence and low density inbetween them. Which is expected to mainly be a result of national policies of the Dutch government focussed around urban clustering (Spit, Zoete, & Beek, 2016). It was also found that especially Flevoland, not considering the political landscape, is interesting for the development of future logistical facilities.

5.2 What does of the socioeconomic landscape mean for Rijkswaterstaat as an infrastructure asset manager?

The answer to this question is twofold. First, based on the answer of the previous sub-question it can be argued that both Utrecht and Flevoland are interesting to Rijkswaterstaat in terms of freight transportation. Both provinces show very different landscapes. Utrecht contains more converging high density units, suggesting a landscape characterised by city logistics and the complexities that come with it (Cui, Dodson, & Hall, 2015). Flevoland on the other hand is more characterised by a lower amount of high density units, which are also more divergent than in Utrecht. Such a landscape suggest less constrains on freight transportation, which would mean the share of heavy freight vehicles in such locations would be higher than those in Utrecht (Giuliano et al. 2017). Both landscapes have their own implications for Rijkswaterstaat. The city logistics landscape means not only that much freight is attracted towards such places, but also that it is transported in smaller quantities, leading to an increased amount of light freight vehicles on the roads. This can lead to congestion, but also to more pollution due to the less efficient way freight is transported. Such problems can also be re-enforced through policies of local governments (Lindholm, & Blinge, 2014). On the other hand, the less dense freight landscape means more room for larger (heavier) freight vehicles. Such freight vehicles, especially if they are heavily loaded, are responsible for much (more than half) of the deterioration of road assets caused by vehicle usage (ITF, 2018, p. 15).

Both landscapes put a different emphasis on themes that are related to Rijkswaterstaat. A landscape of city logistics impose more pressure on the capacity of roads and can cause congestion, which puts an emphasis on traffic management. A landscape with more diverging densities facilitate relatively more heavy freight vehicle movements, which puts an emphasis on maintenance of, in the case of both provinces, road assets (asset management). The results of the statistics on highway ramp usage does seem to support this. However, no statistical relation was researched. Despite these findings the actual meaning of the socioeconomic landscape for Rijkswaterstaat towards the traffic management and asset management perspectives remains questionable based on the results of the focus group. The focus group results indicated that more detailed data is necessary for it to be of a value to the management of these asset and traffic management aspects. However, when considering a strategic network wide perspective approach to asset management, the focus group did indicate that the freight landscape could potentially assist in such a manner. As found in the literature, participants of the focus group indicated that they lack a way of putting local city logistics into a wide national network perspective. This was also a problem found in the literature on asset management (van der Velde, Klatter, & Bakker, 2013; Parlikad, & Jafari, 2016). Especially the question on where new logistical hubs would, or could be sited was of interest the participants of the focus group. The freight landscape was found to give clear indications of such questions since it presents data a multitude of factors that determine the location choice of logistical companies, which were discussed in the literature on the mobility landscape (Allen, Browne, & Cherrett, 2012; Heitz, Launay, & Beziat, 2019; Sakai, Beziat, & Heitz, 2020).

5.3 What do the political landscapes of Utrecht and Flevoland mean for Rijkswaterstaat as an infrastructure asset manager?

The literature indicated that local policies and land-use regulations can have a serious impact on the movement of freight and the location of new logistical facilities (Sakai, Beziat, & Heitz, 2020). Despite this, it was also indicated that local governments are generally are not involved in freight transportation planning, or do so from a narrow perspective of reducing negative externalities, which could even be counter-productive (Lindholm, & Blinge, 2014; Cui, Dodson, & Hall, 2015). Based on the results of the content analysis it was found that, in contrast to what was expected based on the literature, freight is fairly well incorporated in most municipal policies. This difference can be explained through the results of the different landscapes. Rodrigue et al. (2017) suggests that municipalities with converging high density units will pay more attention towards freight transportation due to the larger potential of conflicts with other space users (such as passenger transportation) occur at such locations. This pattern partly holds true in the case area, as especially the municipality of Utrecht pays attention towards freight transportation. However, the municipality of Lelystad, with its relatively small size, seems to make an exception to this explanation as it was found to be the municipality most invested in freight transportation. The explanation for this exception can partly be found in the results of the different landscapes: Lelystad is well connected to the larger urban centres of Amsterdam and Utrecht through the highway connection. It recently constructed a new harbour and has relatively little convergence of high density zones. Based on the literature, this makes Lelystad an interesting location for the siting of new logistical developments (Kang, 2020; Sakai, Beziat, & Heitz, 2020). Such a favourable location can help in making logistical developments a valid policy option. Other reasons for why Lelystad is invested in logistical developments went beyond the scope of the content analysis.

Next to understanding where certain policies are most likely to occur, the content analysis also revealed that the interests of Rijkswaterstaat largely align with those of local governments. There were also some differences in what objectives (economy, asset management, liveability, etc.) are more important and questions about the involvement of RWS as the manager of the highway and waterway network onto municipal and provincial plans to. The content analysis could not find an indication that Rijkswaterstaat, or the ministry of Infrastructure and Water Management, was part of the strategic policy documents that were analysed. This is where part of the problem of freight transportation and Rijkswaterstaat comes in: single objects are not much of a problem in general, which is why RWS is often not involved in their development. However, adding all of the local developments up will eventually lead to a more serious impact on the network in the form of negative externalities, such as wear and tear on the roads, congestion or pollution (van der Velde, Klatter, & Bakker, 2013; Cui, Dodson, & Hall, 2015). This problem was also addressed in the focus group.

The freight landscape can help put such problems into perspective. Favourable locations for different logistical activities can be found through the infrastructure and socioeconomic landscape. The mobility landscapes gives some additional insight in where certain types of freight vehicles can be observed. The political landscape further expands knowledge on where certain landscapes are shaped through policies of local governments, which influence the RWS network.

6. Conclusion, discussion and reflection

With one of the densest highway networks in the world, and with some of the busiest waterways, both frequently used at full capacity, Rijkswaterstaat is tasked with a serious challenge in maintaining and developing the network under its management. A better understanding of freight transportation is necessary for such a job to be done more efficiently. Not only because freight transportation is a user of its networks, but also one of the main causes of wear and tear on its assets (ITF, 2018). Understanding freight transportation is, however, complex for the multitude of factors that make up freight transportation. Hesse and Rodrigue (2008) already stated that the boundary between the materials management and physical distribution are fading as a result of different global processes. Such changes cause freight to more and more be organised in a certain pattern. This pattern is described by Rodrigue (2004) in the distribution paradigm. In order to assess such spatial patterns, this research used the freight landscapes framework set out by (Rodrigue et al., 2017). The freight landscapes were researched in in two provinces of the Netherlands using the following research question:

What can the freight landscapes of Utrecht and Flevoland indicate about the spatial distribution of freight transportation activities and what does this mean for the network of Rijkswaterstaat.

Previous research focussed primarily on the socioeconomic aspect (Giuliano et al. 2017; Sakai et al., 2018). This research build further on the socioeconomic landscape and extended this by also reviewing the political, infrastructure, and to a lesser extent the mobility landscapes. The mobility landscape would involve the actual data of vehicle movement, type, route and schedule, but such data is owned by transport companies and not publicly available. Ways of acquiring such data would deserve a whole research on its own. This landscape was therefore only marginally researched.

Based on this research it was found that the spatial distribution of freight transportation activities is primarily organised around road based transport, and that a serious shift to other transport modes, such as rail or water based transport modes are not feasible on the short to medium term (1-5 years). The dominance of road freight is not surprising considering its competitive advantage on relatively short transport distances which have to be covered in both provinces (Rodrigue, 2013). Therefore, growth of freight transportation is expected to primarily be expressed through a growth of road freight transportation, and therefore adding to congestion and wear and tear on road infrastructure. The socioeconomic landscape also gave an indication of the type of logistical activity at certain locations. Based on the results of the socioeconomic landscape a pattern emerged in which the province of Utrecht was more characterised by a city logistics (converging density) landscape and Flevoland a more diverging density landscape. Combining this knowledge with literature on spatial preferences of logistical companies and the results of the political landscape, it becomes clear that especially Flevoland is favourable location for new large logistical developments (Kang, 2020, Sakai, Beziat & Heitz, 2020). This is not to say that no new developments and therefore growth of freight transport will take place around the Province of Utrecht. With its large population centres, which are expected to grow for the coming years, it will keep attracting more goods, and therefore more freight transport movements.

The findings of the freight landscape are especially meaningful for Rijkswaterstaat on a strategic level. This means putting local city logistics into a wider national network perspective (van der Velde, Klatter, & Bakker, 2013; Parlikad, & Jafari, 2016). In this way, the freight landscape can help understand what locations on the network are more likely to face a serious growth of freight transportation, and what type of freight vehicles (heavy or light) will come with this growth. It was found that asset management and traffic management on an operational level need more detailed and recent (live) data for it to be of value towards the challenges faced at an operational level.

6.1 Discussion

Despite this research having answered the questions set out in the introduction, there are also questions remaining with the finishing of this thesis. One of the first questions is relating the findings towards the broader theory described in the distribution paradigm. While the freight landscape can help identify elements from these more broader theories, such as logistical sprawl, no clear indicators in the research could be found on other elements of the distribution paradigm. For instance, Rodrigue (2004) states that the current distribution paradigm consists of three main elements, which are closely related to the geographical elements described by Hesse and Rodrigue (2004): articulation points, the freight corridors and the freight distribution flows. While the freight landscape helps in identifying elements of it, it still remains unclear in what perspective such results should be placed. For instance, locations for articulation points can be identified using the infrastructure and socioeconomic landscape, which show that both provinces contain some articulation points, mainly the largest urban centres in the provinces. The articulation point of Utrecht is the largest in this sense, as it serves most freight vehicles, based on the socioeconomic analyses done in this research. Furthermore, it also has become clear that the freight corridors in both provinces are structured around road based transport infrastructure. The final element could not clearly be answered as it would require investigating the mobility landscape, which as stated previously, would deserve a research on its own. Despite being able to identify these elements using the freight landscape, it still is unclear how these elements could be placed in broader national or international freight streams. How is Utrecht connected to Amsterdam or Rotterdam in terms of freight? Or to the Ruhr region?

Another question is about the extent to which this research can be generalised. A couple of arguments against it can be made based on the chosen methods. First is the more broad problem of generalising spatial research. Every location, even if they are geographically located close to one another, has its own unique local context. Such a local context could mean that results from this region may only partially be applicable to its own location. Second, the focus group only contained Rijkswaterstaat employees from the Midden Nederland department, which roughly covers the case area. Organising focus groups with employees from other regional departments may yield different results. In summary, while the results are certainly relevant within the case area, generalisation of the results should be met with caution. This is not to say that that nothing can be generalised, especially when it comes to the socioeconomic landscape and the pattern of freight intensity related to it. This pattern, of relatively more heavy freight vehicles in landscapes with diverging density units , is expected to hold true for the rest of the Netherlands. Mainly because the pattern was, though not statistically, also observed in the case areas and, statistically, also found in other studies.

Also important are questions about the chosen methods, which became most apparent during the focus group. A reflection on GIS and chosen approaches is described in the last paragraph. For the focus group most points have already been discussed in the methods chapter. One thing that could be done in future research is to organise more than one focus group, or also do additional interviews, as a follow up to interesting results from the focus group sessions for instance. This is mainly to reduce the risk of low attendance due to overlapping appointments. In this research, low attendance was partly compensated through reviewing the policy context in which Rijkswaterstaat operates (chapter 4).

Finally, during the research different questions came up that could not be answered within the scope of this research. These questions mainly had to do with the spatiality of freight transportation and the spatial claim the infrastructure it uses lays on the landscape. For instance, both the national and local governments suggest that it might be preferable to search for ways to stimulate a modal shift away from the road based dominance. However, as becomes clear from this research, such a shift would require development of other infrastructure to support such a shift. Would such a shift then result a net reduction of the spatial claims of freight transportation supporting infrastructure? Or would it increase the spatial claims? And if so, would such an increase in spatial claims outweigh the negative effects of the current road based system? Future research might give answer to such questions.

6.2 Reflection on working with GIS

During this research, as is with most research, different challenges were encountered that put up barriers towards the progression. Most of these barriers were related to working with GIS and GIS data. Collecting the data required to construct the freight landscape proved more difficult than initially was assumed. Most of that had to do with the aspired scale for which data was searched. In order to minimize known GIS issues such as MAUP the largest possible map scale was sought after. Yet this also means decreasing the chances of collecting all the data at the right scale. Besides this, not all data is directly available in the right format or geographical scale. For instance, the employment data of the province of Utrecht was provide in point data, and was also classified. In order to add these points and their respective values up towards the scale of neighborhoods, they first had to be ‘declassified’. The most crucial (GIS) barrier had to do with the intended statistical analysis. Contrasting to what was expected, in order to do valid statistical analysis with geographical data a different statistical method was required than those available to the researcher. Familiarising oneself with this other method also turned out not to be an options due to the complexity of it. This meant that an important part of the initial research plan (the statistical analysis of the socioeconomic landscape) could only be done in a more simplistic way. It was decided that the time that became available, since it would no longer be used for doing statistical analysis, would be used to extent research on the political landscape.

7. Recommendations

7.1 Recommendation for future research

While the research has given many new insights into the spatial distribution of freight activities in the provinces Flevoland and Utrecht, there are still some questions that remain and new questions that resulted from this research. Some have broadly been discussed in the previous chapter.

First recommendation is related to the reflection on the statistical (GIS) side of this research. This research did observe a visual pattern on the expected relation between the different density units and the type of freight vehicles (heavy or light) being related to it, which confirmed what was found in previous studies (Giuliano, Kang & Yuan, 2017; Sakai et al., 2018). Despite this, no statistical relation was researched. Therefore it remains unclear whether or not the patterns observed actually are related to the density units, and if so, to what extend this might be. Future research could also add a time dimension to the statistical research, to see how the observed density pattern has shifted over time and what implications such as shift have had on the type of freight vehicles observed in the area.

Furthermore, many questions remain about the mobility landscape. Because of a lack of data, this research sought to approach the mobility landscape through investigating literature on location policies of logistical companies and see to what extent this could be observed in the other landscape. It also was represented in the research on the freight intensity patterns at highway ramps. However, such approaches are only estimations of what the mobility landscape is actually about, namely the live movement of freight vehicles. Future research could investigate better ways of estimating this, or find methods for obtaining real live data.

Finally, this research has investigated the freight landscape through the perspective of Rijkswaterstaat, and the regional governments to a lesser extend through the content analysis. Other actors, of which there are many when it comes to freight transportation, have been out of the scope of this research. Research into such actors and there relation to both other actors and the freight landscape could also be an interesting since most freight transportation is eventually performed by private companies, and not the government. Research could look into cooperation between private companies and the government, or between different private companies that work together to consolidate freight for example.

7.2 Recommendations for Rijkswaterstaat

Next to recommendations for future academic research, this research also gained insights that could be useful for Rijkswaterstaat.

The freight landscapes can be useful for strategic considerations, not operational

During the focus group, the usefulness of the socioeconomic landscape for projects that Rijkswaterstaat employees are working on were discussed. Here it became clear that this landscape could certainly be interesting for Rijkswaterstaat, however, for day to day operations and operational asset management more detailed data is required. While information on the potentially more truck intensive locations is useful, it is not enough information to help with decisions on the quality of the asphalt needed or which bridges are expected to be more intensely used. However, just as discussed in the literature, the focus group participants also pointed out that they lacked a framework from which to investigate how freight streams could be influenced. What could be logical locations for logistical hubs, just as they (RWS) are doing with passenger transportation? Are there ways to achieve a modal shift for freight transportation? The freight landscape offers a framework to help answer such questions.

For example, it has become clear that changing the modal split from the current road based dominance is hard to achieve in the short to medium-long term. This is not only based on the infrastructure currently available, but also on trends going on in freight transportation which influence what modality logistical companies will use. Trends such as just-in-time deliveries and changing consumer patterns ask more flexible transportation (Kang, 2020). Road transportation is best at offering such flexibility. Such findings indicate that growth in freight transportation will mainly lead to a growth in road freight transportation, which adds to congestion and wear and tear on road infrastructure. This can influence goals of Rijkswaterstaat, such as better asset management and increasing mobility through reducing congestion.

Focussing on better asset management means a need to be more involved in local freight developments.
While the Netherlands knows a clear division of responsibilities between the local, regional and national government, freight transportation is not easily captured administrative boundaries. Rijkswaterstaat is not responsible for choosing where certain activities can take place, such as new business parks or large distribution centres, the effects of such developments do, however, effect how RWS assets are managed. Especially considering the large renovation and replacement task that Rijkswaterstaat is dealing with, in which no endless budgets exist, it is important to cooperate with municipalities that have plans that could potentially increase the amount of freight traffic. What Rijkswaterstaat can do is share information with other governments to help make more sound policy decisions.

In this respect, the freight landscapes can help in assessing where certain types of logistical activities can occur, and also what that could mean for Rijkswaterstaat. For instance, the political landscape showed that especially Flevoland, with Lelystad at the top, is encouraging a growth in freight transportation. Such growth will undoubtably find its way towards the highway infrastructure (owned by Rijkswaterstaat) located in the province, as much of the freight from new distribution centres will serve larger urban regions such as Amsterdam or Utrecht.

8. Literature

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9. Appendix

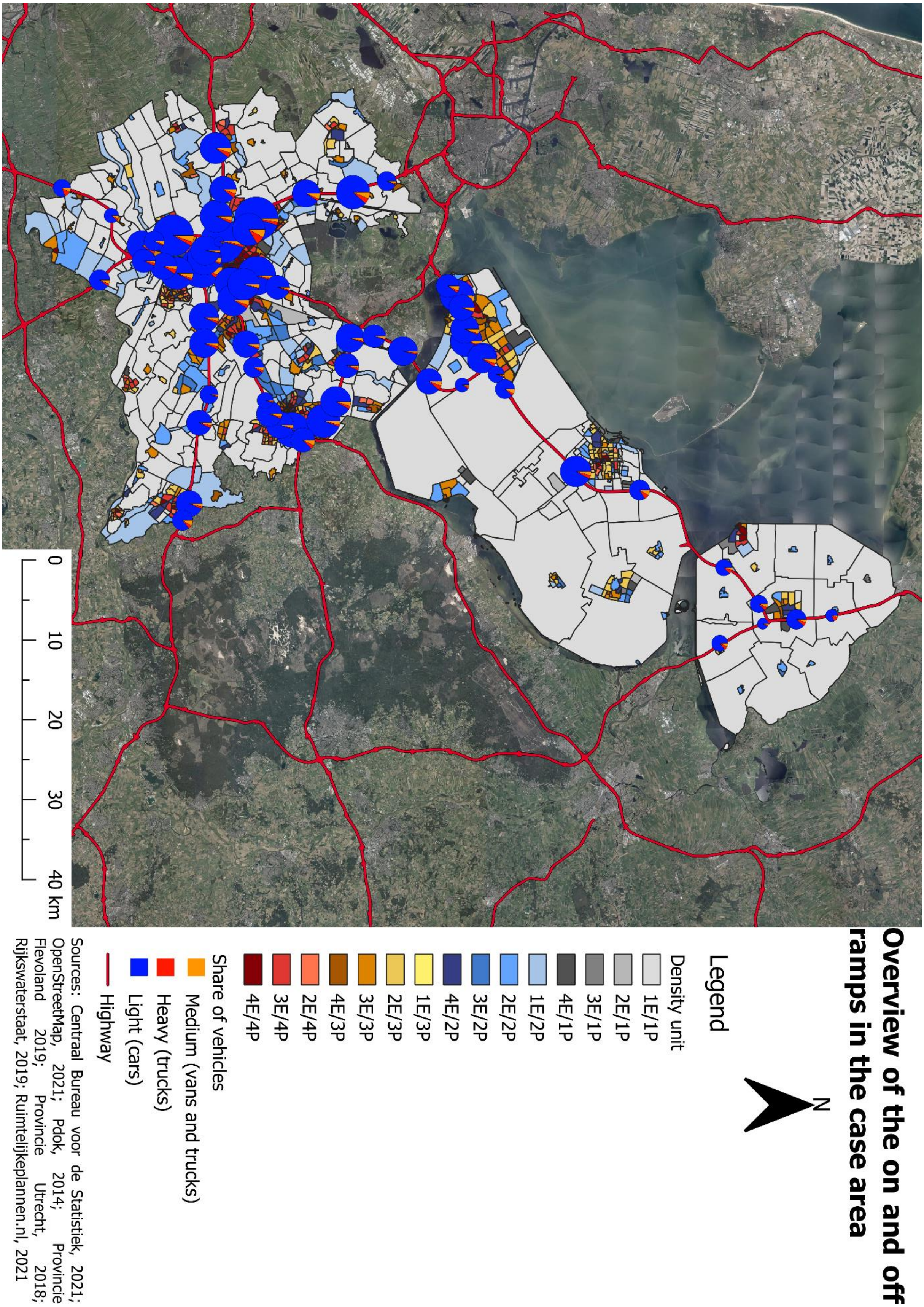
Appendix 1 – Code scheme of the content analysis

Coding scheme 2

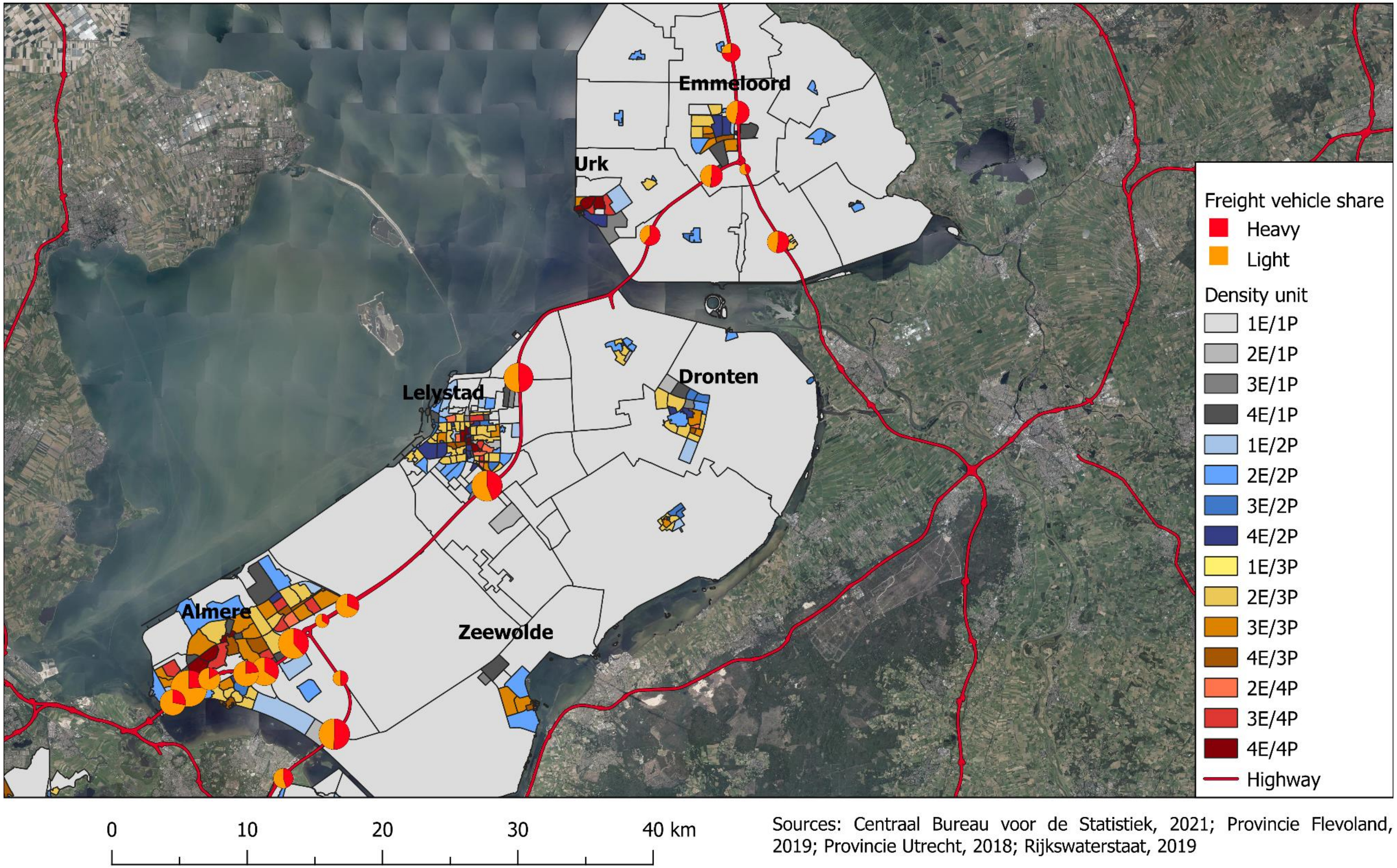
Document mentions: Vracht+verkeer, Goederen, Zwaar (vrachtverkeer), Logistiek, distributie

- Their expected role
    - Marginal → not mentioning their role or expecting other parties have a more serious impact.
    - Medium → they expect to have some serious influence over freight transportation through their policies, mainly by through usage of ‘tradition’ regulations, as described by (Dablanc, 2007, pp. 282-283)
    - High → The local government considers freight as a key objective for policy development.
- Type of regulation policy (yes or no)
    - Indirect regulations, such as:
        - Financial support (for example: subsidizing freight fleet greening or logistical facility development)
        - Road safety projects
        - Innovation support
    - Direct regulations, such as:
        - Access restrictions
            - Time windows
            - Parking restrictions
            - Weight limitations
            - Pollution regulations
- Freight impact assessment
    - Local (only very local issues, such as safety of a interchange is considered)
    - Municipal (freight issues are considered at a municipal level)
    - Regional/ nationwide (impact of their freight plans are considered on a regional level).

Appendix 2 – Maps of freight traffic on ramps

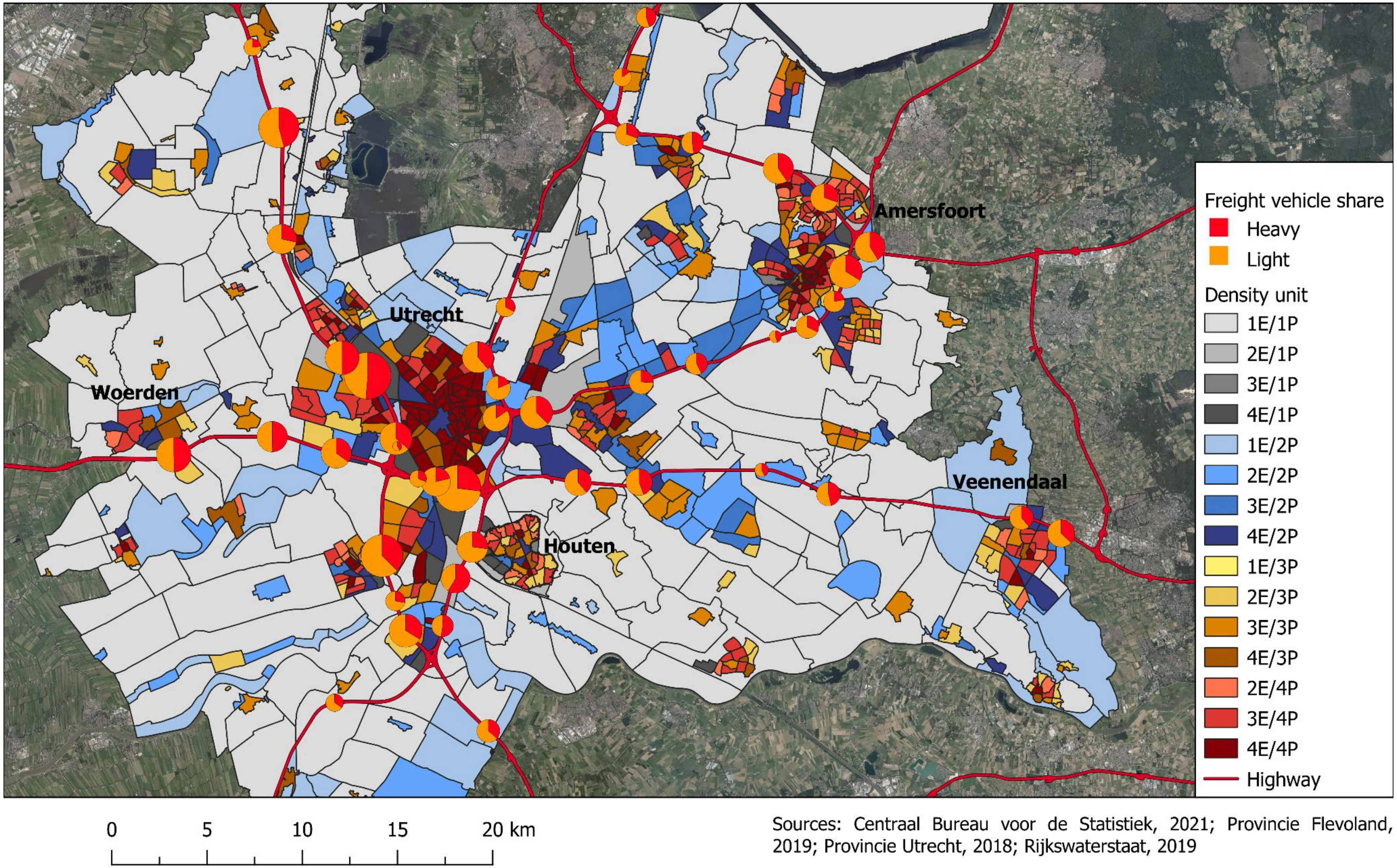


Freight traffic in Flevoland on highway ramps



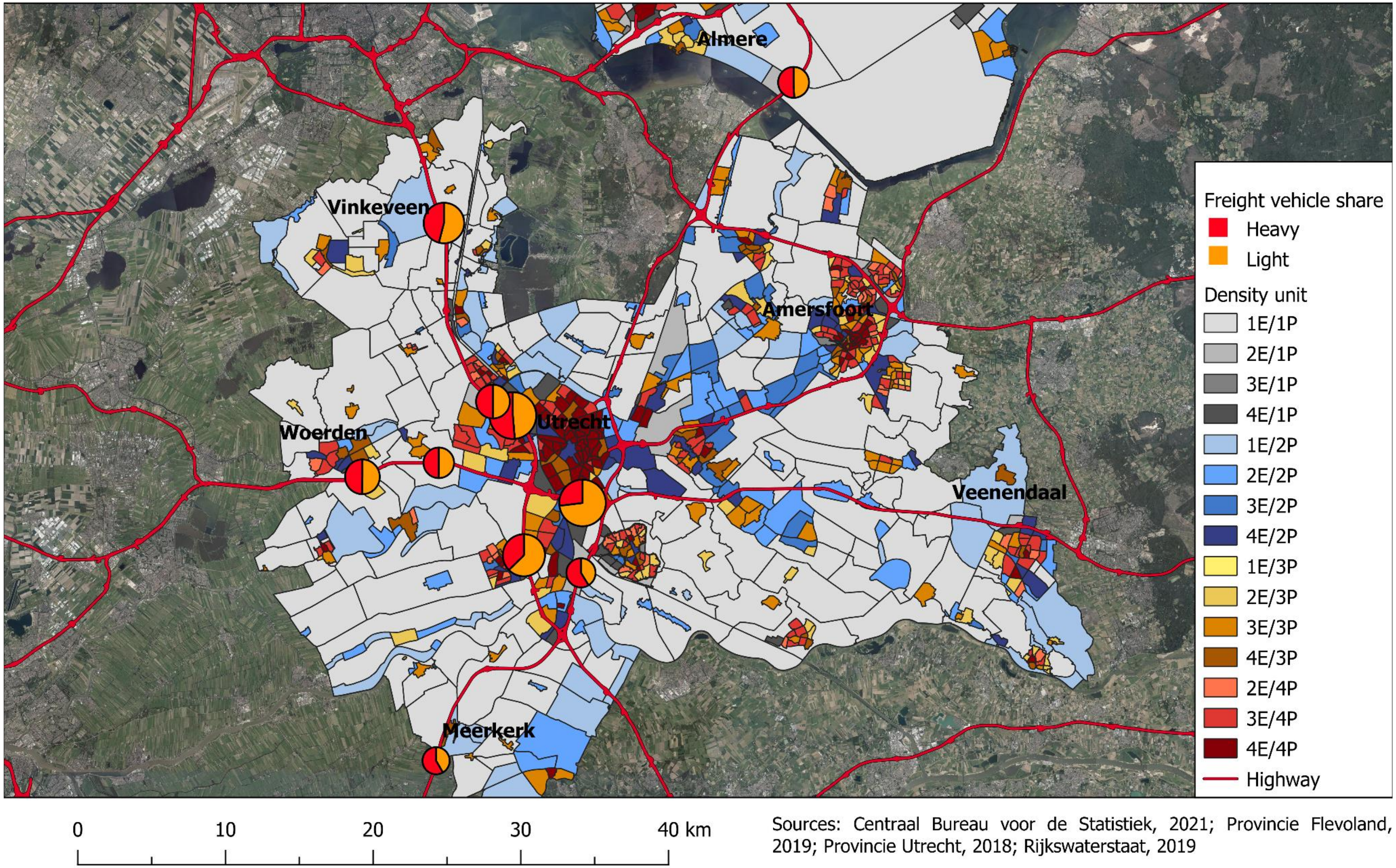
Sources: Centraal Bureau voor de Statistiek, 2021; Provincie Flevoland, 2019; Provincie Utrecht, 2018; Rijkswaterstaat, 2019

Freight traffic in Utrecht on highway ramps

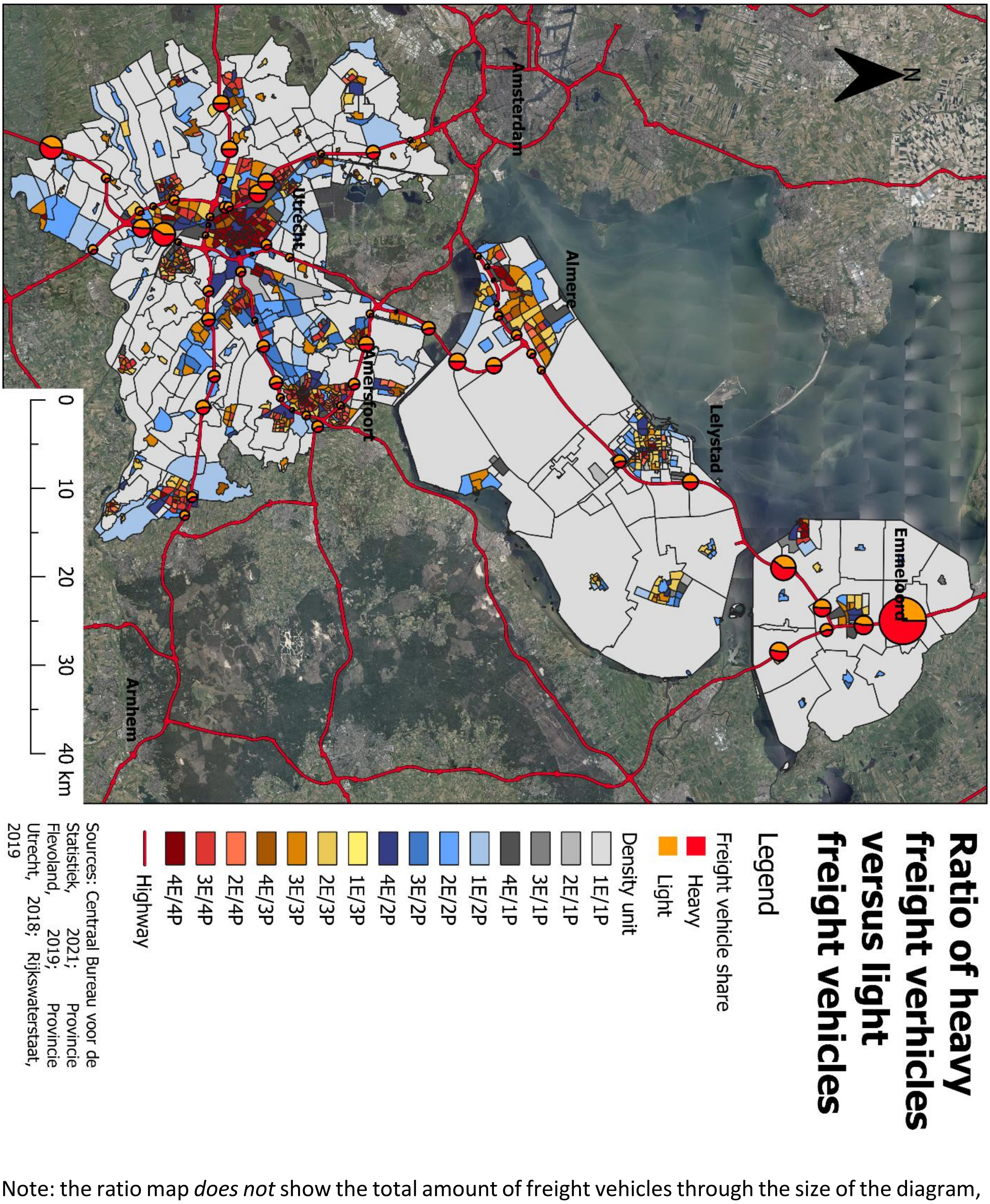


Sources: Centraal Bureau voor de Statistiek, 2021; Provincie Flevoland, 2019; Provincie Utrecht, 2018; Rijkswaterstaat, 2019

Top 10 ramps with most heavy freight traffic



Sources: Centraal Bureau voor de Statistiek, 2021; Provincie Flevoland, 2019; Provincie Utrecht, 2018; Rijkswaterstaat, 2019



Note: the ratio map *does not* show the total amount of freight vehicles through the size of the diagram, but instead shows the amount (ratio) of heavy freight vehicles compared to light freight vehicles.

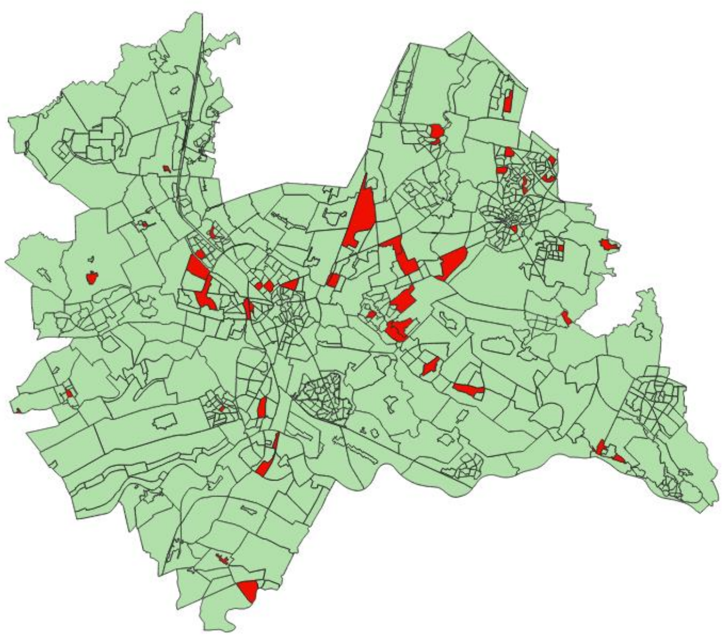
Appendix 3 – Reclassification of the Utrecht data and the results of the sensitivity analysis

Sensitivity of employment classification
In contrast to the data of the province of Flevoland, the data of the province of did not come in absolute numbers, but in classified ones (see table 7.1)

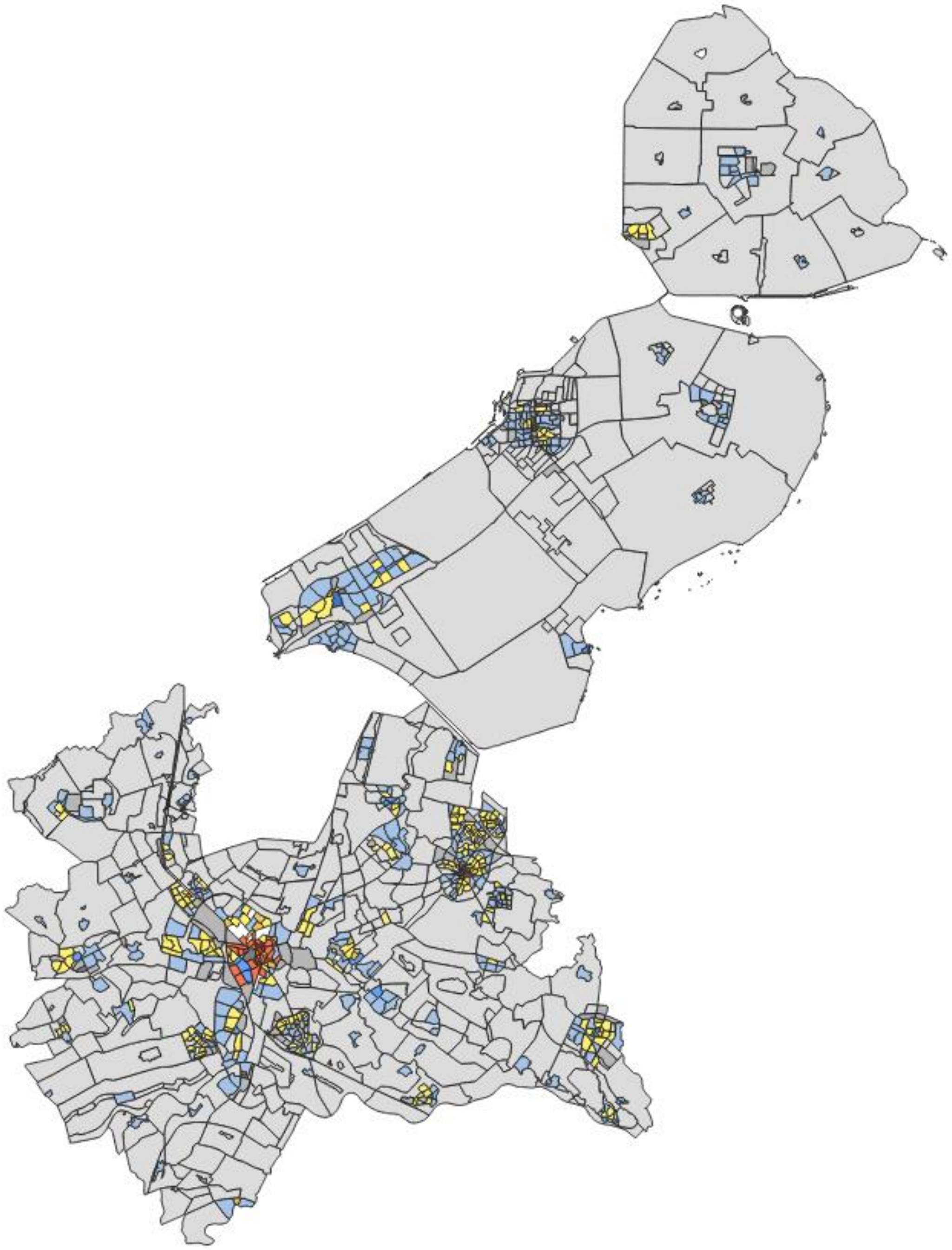
Table 4.1 Reclassification on the employment data of Utrecht

Original	Average	Lower boundary
1	1	1
2-4	3	2
5-9	7	5
10-19	14,5	10
20-49	34,5	20
50-99	74,5	50
100-199	149,5	100
200-499	349,5	200
500-799	649,5	500
800-999	899,5	800
1000 +	1000	1000

Figure 4.2 resulting difference in density code



Difference in classification of the density thresholds



The map shows the result of reclassifying the density units. Instead of using the quantiles method, this map was created using the natural breaks method.

This map clearly is different from the map used in the research. The higher density units have reduced in numbers, which means that the map is now overwhelmingly presented by low (mainly diverging) density units.

Statistically this difference is not relevant, the different classification methods are only used for mapping the landscape, and not analysing it statically (this is done using the absolute population and employment data).