FACULTY OF SCIENCE AND TECHNOLOGY

MASTER THESIS

Study programme / specialisation: City and Regional Planning. Mobility and Sustainable Development

The spring semester, 20.22.

Open / ~~Confidential~~

Author: Maria Ruiz Planelles

.....
(signature author)

Course coordinator: Daniela Müller-Eie

Supervisor(s): Daniela Müller-Eie

Thesis title: Evaluation of the accessibility and car dependency in the business area of Forus, Stavanger

Credits (ECTS): 30

Keywords:

Accessibility; mobility; urban planning; car dependency; transport development; travel times; catchment areas; GIS; parking

Pages: 71

+ appendix: -

Stavanger, 15/06/2022
date/year

Approved by the Dean 30 Sep 21
Faculty of Science and Technology

ACKNOWLEDGMENT

I would like to thank all my family and friends that have helped me through my entire academic career, showing me always their support even when I moved to Norway. Especially, to my supervisor Daniela Müller-Eie for all the time spent helping me in the process of writing the thesis and also her guidance during the semester.
Thanks to all the external collaborations for the data gathering and especially, Renate Aradi for helping me to solve multiple doubts with the digital programs in the analysis of this thesis.

Thanks to all the people that have been around me during these two years and for showing me their support and believing in me, even in the rough times. Thanks.

ABSTRACT

The aim of this thesis consists of a descriptive evaluation of the existing transport infrastructure in the area of Næringspark, the business area of Forus, Stavanger. The study outlines the built environment of Forus, the accessibility and connectivity for the different modes of transport within the transport infrastructure and the challenges that the area is experiencing in relation to land destined for parking. With the goal to answer the follow research questions, the analysis evaluates the travel times, the population covered by the transport infrastructure, the parking coverage of the area and the evaluation of the existing inter-municipal plans for future developments. *How many people are car dependent when travelling to/from Forus? Which areas? Which workplaces are car-promoting through parking? How will parking restrictions impact on the area to reduce the use of the car?*

The results for this analysis come from a technical geographic information system (GIS) to describe the travel times with isochrones for each mode of transport and catchment areas, literature review for a theoretical description of the concepts of this thesis and visits to the area to understand the built environment and the existing challenges.

TABLE OF CONTENTS

ACKNOWLEDGMENT I

ABSTRACT II

1. INTRODUCTION 1

1.1 LOCATION: NÆRINGSPARK, FORUS 1

1.2 TRANSPORT INFRASTRUCTURE 4

1.3 CHALLENGE DESCRIPTION 5

1.4 REGIONAL AND MUNICIPAL PLANS 7

1.5 RESEARCH QUESTIONS 7

2. LITERATURE REVIEW 8

2.1 ACCESSIBILITY AND MOBILITY 8

2.2 LAND USE AND TRANSPORT 10

2.3 ELEMENTS RELATED TO ACCESSIBILITY 11

2.3.1 Connectivity 11

2.3.2 Travel times 12

2.3.4 Car dependency 13

2.4 EFFECTIVE MEASURES TO IMPULSE PUBLIC TRANSPORT AND ACTIVE TRANSPORT 13

3. METHODOLOGY 16

3.1 FIELD WORK: SPATIAL ANALYSIS 16

3.2 GIS: TRAVEL TIMES AND CATCHMENT AREAS. 17

3.3 DATA REGISTRATION 19

4. ANALYSIS 20

4.1 SPATIAL ANALYSIS 20

4.1.1 Land use and built environment 20

4.1.2 Accessible Facilities 28

4.1.3 Infrastructure 29

4.1.4 Transport modal split 35

4.1.5 Traffic Volumes 37

4.2 ANALYSIS OF ACCESSIBILITY AND CAR DEPENDENCY 40

4.2.1 Comparative analysis of modes of transport 40

4.2.2 Catchment areas 48

4.2.3 Parking coverage 50

4.3 SCENARIO BASED ON THE PARKING RESTRICTION 53

5. DISCUSSION 55

6. CONCLUSION 57

LIST OF FIGURES 58

LIST OF TABLES 60

REFERENCES 61

1. INTRODUCTION

A sustainable transition towards walkable cities and an increase on the collective transport usage is essential to reduce climate change and the levels of pollution particularly created by the massive use of private cars and other commuter ways of transport in Nord-Jæren region.

Transportation is a fundamental factor for the development and growth of cities. The transport connections produce benefits to people, the national and local economy and help to shape greener and healthier places to live, work and interact. The effects of the city projections, plans and policies interfere in people's behavior and habits affecting the huge car dependency that exists in the area studied of Næringspark, Forus, due to the existing challenges related to the land destinated to parking.

Stavanger has a "high" dependency on the car, where a high majority of the population choose the car before other modes of transport, contributing to a significant part of the CO_2 emissions (Stavanger Municipality, 2018, p. 13).

The importance of a change in commuter accessibility and travel patterns is crucial to provide a better public transport service and improve access to workplaces, medical care, education, or recreational activities. The reliance on public and active transport together with land use planning helps a community to expand, having more job opportunities and creating the sense of community with transit-orientated developments. It also reduces road congestion and travel times, important towards the projections that Stavanger, Sandnes and Sola have for the community.

In this thesis all the primary transport modes will be taken into account, the car, the bus, cycling and walking, evaluating the accessibility of Næringspark and the importance of the evaluation of the area in terms of land designated for parking. The analysis evaluates the travel times, catchment areas and parking coverage together with the evaluation of the IKDP plan restrictions in terms of parking and other cities interventions to reduce the use of the car.

1.1 Location: Næringspark, Forus

Forus is located in the southwestern part of the municipality of Stavanger, in Rogaland County. In contact with Sandnes in the south part, and Sola in the western side, ideal location for the connection with the belt Sandnes-Stavanger or the airport in Sola.

Figure 1. Stavanger location in a national and regional perspective. Own figure.

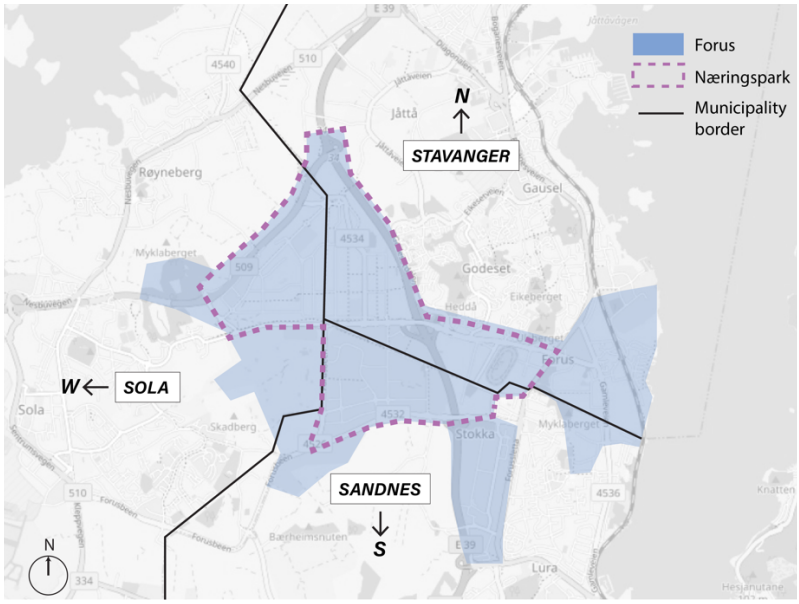

Figure 2. Area under study, Forus and Næringspark. Own figure.

Back in time, Forus was called Stokkavatnet. A lake with shallow water along Gandsfjorden and orientated towards Hafrsfjord, dividing the three municipalities formed by several old farms (Røyneberg, 2020). The water had qualities for fishing, but the ground conditions formed by soft clay made it difficult to access some areas. With the purpose of getting land to cultivate, even knowing that the land properties were poor, the plans continue their way to drain the lake. In 1906, the drainage of the lake gave new land to the nearby farms, until 1940, when the start of the World War II, made the Germans build the airport of Forus. After that, the area has been developed mainly for industrial purposes in relation to the oil industry, as it is nowadays (Røyneberg, 2020).

Currently, Forus is considered as a central urban place with proximity where most of the leading companies and multinational groups have their headquarters in Norway. A unique business area combined with multiple services and activities, but constantly under new developments (Forus Næringspark, 2022).

Being a great business potential area for the region, Forus has special challenges of how it is presented for the region Nord-Jæren. Due to its location, Forus has been led by the three municipalities with their own particular interests and presenting some challenges that need to be addressed to interact and develop as a part of an urban area for Nord-Jæren. There should not be a competition between Forus and other municipalities but complement and support each other to produce benefits (Rogaland Fylkeskommune, 2018, p. 8).

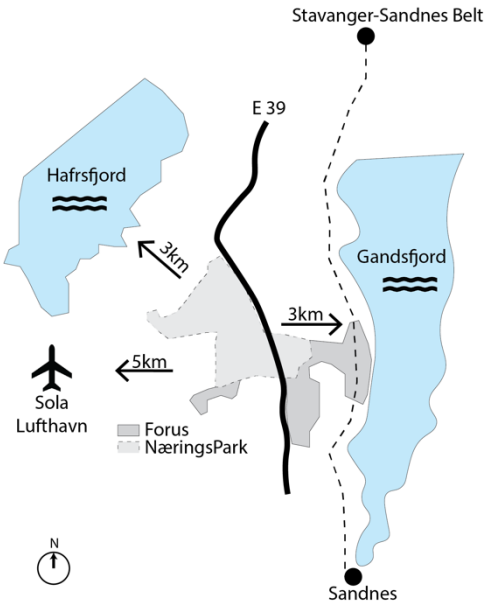

Figure 3. Graph of the areas surrounding Forus. Own figure.

Forus Næringspark works to create the best framework conditions for businesses in the area, owned by the three municipalities of Stavanger, Sandnes and Sola. Today, Næringspark AS is the principal company of the group of several associated companies, with the objective of preparing available land for the process of regulated sales of the plots for business activities and future densification (Forus Næringspark, 2022).

Almost all the companies located in Forus are in the Næringspark area, as the figure (4) shows. For this reason, the thesis is narrowed down to the analysis in this business park instead of all the area of Forus to achieve a more efficient result of the evaluation.

Figure 4. Significant companies related to the oil industry in the area. Modified figure from Forus Næringspark.

1.2 Transport infrastructure

Centrally located in the region, Forus has good transport accessibility for its building environment as a business area (Rogaland Fylkeskommune, 2018). Its transport infrastructure is formed by multiple bus lines passing the area with several stops, city bikes with stations in the main avenues, and possibilities to go walking or with your own bike. Currently, the travel in and out of Forus is mainly car-based, even though the National transport plans stipulates the need to cover most of the trips by public transport, cycling or walking. The change in the distribution of modes of transport is key to achieve the targets adopted by the region's agreement for the urban growth and zero emissions (Rogaland Fylkeskommune, 2019, p. 22).

The development of new bus routes surrounding the area and the cycling route definitely provides new opportunities to change people's habits in the way of travel. The importance of this change lays on the public transportation, the bus infrastructure plan needs to connect the different types of activities with the business area, linked to bus stops and short frequencies. This can reduce the travel times and contribute to the use of collective transport and reduce the car.

In this term, the major concern comes with the high amount of land used as parking spaces. This situation affects negatively to the balanced distribution of transport, promoting people to use even more the car due to the availability of parking spaces just next to the destination. Indeed, the area is connected with the highway directly from Sandnes or Stavanger providing a less time-consuming daily trip.

The active transport, referred to cycling and walking is under development with one of the highest investments in a cycle line for Rogaland, with the new "Sykkelstamvegen". It is a complex project with the purpose of building a "highway" for cyclists to connect Stavanger-Forus-Sandnes. While road E39 is mainly flat, the cycle line will have some steep areas that create doubts over the efficiency of the project. Aimed at reducing the use of the car providing more accessibility to cycling or walking, this project has helped to have a minor increase on the use of the bike from home to work in the last year (Nesvik, 2021). Together with other public bicycle sharing systems in Nord-Jæren, the projections show that it is possible a stimulation of cycling, for example with electric bicycles ownership, that can increase the share in a short term, according to a survey for Nord-Jæren (Pritchard & Lovelace, 2022). Indeed, more than half of the inhabitants having less than 7km to go to work agree with having good cycle paths. A change that can impact on the travel share in favor of active travel through transport policies and high costs for the use the private cars (Pritchard & Lovelace, 2022).

1.3 Challenge description

Some of the qualities that the area poses can be considered as benefits, while others are difficult challenges that the municipalities need to work to integrate Forus in the region with the rest of the municipalities (Rogaland Fylkeskommune, 2018).

The large distances between the workplaces and the rest of destinations, the large plots with large building footprints, retreated building lines and open areas around buildings have increase the dominance of the cars over the years, making it not suitable for people without a car. Walking or cycling in the area gives you the feeling of losing orientation, making it difficult to reach your destiny using the active transport. Most of the area of Forus and mostly, Næringpark, is characterized by the large surfaces of asphalt and industrial buildings, degrading the qualities of the urban areas that surround Forus. As other cases have shown, industrial land is difficult to transform in dense urban developments, but some parts of Forus are close to bus routes and commerce, having the possibility for a transformation of new denser areas with an efficient use of land (Rogaland Fylkeskommune, 2018, p. 9). The plans confirm that there are areas suitable for that transformation, but the challenge of how to achieve the efficiency in the utilization of the land still in place due to the high use of land destinated to parking in each plot of land with businesses purposes.

As an urban planner, land use and transport planning are essential for the steering of new development activities. The spatial optimization of land uses helps sustainable travel patterns to grow, avoiding the increased-on car use (Cao, 2018). In the location under study, the plans include parking as one of the topics to approach and solve, nevertheless these measures need to be analyzed in order to study their validity. This is the main reason why in this thesis the analysis only includes parking as a studied measure, not taking into account densification or the importance of blue-green elements as other measures for the development of the area.

As shown in the follow figures, the area has a big amount of land with parking uses in proportion with the total land and BRA. This challenge reduces the opportunities for new changes in transport in the area, contributing to promote the use of the car and making it easy to find parking spaces just right next to the destination.

Figure 5. Large parking area in Næringspark, Equinor. Source: Google maps.

The use of the car occupies a large part of the road network capacity. In the peak hours of business activities, the queues and delays are a common phenomenon in daily life. Concentrated in the hours after work, around 15:00 p.m. where a trip to Sandnes from Stavanger can take up to 30 min instead of 18 min in travel time (TomTom, 2022). Figure (6) shows the rush hour in the highway E-39.

Figure 6. Traffic congestion in the highway E-39 connecting with Næringspark, Forus. Own figure.

Another quality that has an impact on the travel choices is the climate conditions in Stavanger and the region. Known for the strong winds and continues rainfalls, the inhabitants of Nord Jæren could be more attractive to use the car rather than other modes of transport. In the early morning, most of the people are in a hurry to go to work and the climate conditions might have an important role for the use of public transport and active transport.

According to the plans, the aim of development is to focus on the transformation of Forus into a pleasant place to work, live and interact in the local area. Its proximity to the fjords and the sight lines to the mountain areas, is an opportunity to change the landscape and create new green structure for the area, reducing the large grey pavements of parking (Rogaland Fylkeskommune, 2018, p. 9). Currently, it can be seen as a developed area but still being poorly integrated into the municipalities

adjacent. Forus has qualities to be developed, with a unique location next to Stokkavanet, playing an important role in having natural resources (Rogaland Fylkeskommune, 2018, pp. 8–10).

1.4 Regional and municipal plans

Forus is an area under development exposed to several changes to become a better place. The analysis will be supported by the main plans that interfere in the development of the area together with the transport changes to reduce car dependency and the strategies to achieve it. These are the municipal plans used for the evaluation of the area:

- *IKDP Interkommunal plan for Forus (Sola, Sandnes and Stavanger)*

IKDP Forus is the main plan for the development of Forus in order to contribute with the urban development with solutions that protect the value creation, reducing the transport work and ensure natural and cultural values for a high quality of life for the business park. A project that aims the business development, attractiveness in the area, to ensure green alternatives of transport and adaption of the land use to achieve no growth in passenger car traffic with good walking and cycling connections (Rogaland Fylkeskommune, 2018).

This plan shows the alternatives to improve the accessibility to the area increasing the cycle lines accessing Forus, prioritizing the bus lines that cross the area and a strategy to implement restrictions for the parking between other measures (Rogaland Fylkeskommune, 2018).

- Regional Plan – Bymiljøpakken 2021/2024.
- 2050 Nord Jæren Strategy.
- Regional Plan for Jæren og Søre Ryfylke.

1.5 Research questions

The objective of this thesis lays on the comparative description of the existing transport infrastructure in terms of accessibility and the parking coverage contributing to the car dependency in Nærinsgpark, Forus. The conclusion will give an answer to the following questions.

1. *How many people in the business park are car dependent when travelling to/from Forus? And which areas?*
2. *Which workplaces are car-promoting through parking?*
3. *How will parking restrictions impact on the area to reduce the use of the car?*

2. LITERATURE REVIEW

This section gives a theorical description through the consultation of literature to provide knowledge about accessibility, the relation between land use and transport, and some of the concepts that measure how accessible a specific place is. Both, the theoretical background, and the data registrations are the base for the development of the analysis.

2.1 Accessibility and mobility

Accessibility is a concept often used in different fields, such as urban planning or transport. Defined as a complex and difficult theoretical concept, it has multiples meanings in different perspectives (Geurs & Wee, 2004).

In this thesis, the definition used to evaluate the present accessibility measures in Forus will relate to Hansen in 1959 "the potential of opportunities for interaction" (Geurs & Wee, 2004). It refers to people's ability to travel from one zone to another using the different modes of public transport and allows individuals to participate in daily activities (Geurs & Wee, 2004, p. 128). It is influenced by the locations of the stops and the performance of the transport network, but mostly what is seen as the supply-side of the public transport infrastructure, directly related to land-use. According to the different definitions, there are several components identified in the practical measures of accessibility. These are the components of land-use, transportation, temporal and individual (Geurs & Van Wee, 2004).

The first component is land-use, reflecting the spatial distribution of opportunities in destinations such as offices, shops, health, or recreational facilities. The connection between the origin location, where individuals live and availability of opportunities. Competition between the demand and supply of different activities with limited capacity, in the case of jobs, hospitals or the education sector (Geurs & Wee, 2004, p. 128).

The second component and the aim of this thesis is the transportation component. It describes the transport system, measuring the alternatives and possibilities for an individual to cover a certain distance between origin and destination using the different modes of transport. It includes the amount of time used between locations, for example the waiting time and frequencies, the costs of the trip, the level of effort and comfort and the location characteristics or the built environment (Geurs & Wee, 2004, p. 128).

The temporal component reflects the availability of opportunities in time, while the individual component consists of the main characteristics that influence people's access to different modes of transport. This component interacts with the rest and has a significant role depending on people's needs engaging times, activities, cost and effort. The definition of accessibility ideally combines all

components, but in practice, accessibility measure is often more dependent on a dominant component, depending on perspective taken (Geurs & Wee, 2004, p. 128).

When it comes to the indicators that measure accessibility in the transport context, Geurs and Van Wee confirmed the complexity of its definition and components, being impractical to just focus on one single indicator (Geurs & Wee, 2004). As Venter (2016) mentions, accessibility appears to be used as a measure of quality in mobility, access to transport and access to opportunities. In this case, Venter (2016) points out cumulative opportunity and gravity-type measures as the most popular measures in descriptive studies. Gravity-type measures reflect the attractiveness decreased in distant destinations by making the opportunities at destination a function of distance, time, or costs (Venter, 2016, p. 10).

In relation to the case of Næringspark, Forus, the explanatory applications of accessibility, travel activity, Venter mentions that "trip distances tend to increase with increasing accessibility, especially in work trips… and the overall vehicle miles traveled strongly increase with regional accessibility" (Venter, 2016, p. 11). This statement helps to understand the role that cars have in the trips to Forus, providing a form of accessibility for those working there, where long distances are predominant, and where residence is mainly in the outskirts of Forus.

Indeed, what Venter points out is that "There are ample evidence that accessibility by car and public transport affects car ownership" and "while greater neighborhood accessibility is associated with reduced car ownership due to the proximity to more opportunities within walking distances, regional car accessibility has been found to be positively correlated with car ownership" (Venter, 2016, p. 11). In fact, walking distances to access public transport opportunities have a direct impact on mode of choice, helping to expand the use of public transport (Venter, 2016).

In this concept and from the traveler's perspective the evaluation of the public transport is often explained with the pyramid of Maslow. Depending on the attributes of experience and comfort, people rely more on a mode of transport compared with the attributes to convenience, speed, safety and reliability (Currie, 2021, p. 252).

Urban mobility

While accessibility has been seen as the ease to reach destinations (interactions), mobility is considered as the ease of traveling along a network (movement). Urban mobility is the physical movement from one place to another, normally measured by distances or trips. Indeed, it is enclosed within the concept of accessibility as many studies have shown (Venter, 2016).

Travelers try to minimize costs, using less time and money spent on travelling, with more to be used for other purposes, connected to the spatial distribution of places and location of activities. Transport problems have been based on "low speeds" according to Venter, because of the ineffective network or insufficient infrastructure capacity (Venter, 2016). The transport view of "traffic-based" has been based on the concerns of motorized vehicles instead of the point of view of all transport users, leading to traffic congestion, as the case of Forus in the peak hours.

In some cases, and as already mentioned, planning can evaluate the quality of the transport systems based on mobility, having as indicator average traffic speed or congestion delay. However, efforts focusing on vehicle traffic speeds and volumes can reduce other forms of accessibility, creating more disperse travel patterns (Litman, 2022a, p. 9). Improving the occupancy in public transport can reduce many of the current issues in terms of transport, avoiding congestion and increasing personal mobility. Each mode of transport has its own speed and different scales of accessibility (Litman, 2022a).
In this perspective and as a broader concept, mobility also includes a multimodal perspective where make visible the people that rely on public transport, walking or cycling with measures such as door to door travel time and travel time reliability. But if the aim consists of moving as many people as possible efficiently, transport interventions still prioritizing reducing travel times and increasing travel speeds (Venter, 2016). Mobility and accessibility are connected concepts, influencing each other in the reduction of distances and time for people to reach more destinations (Litman, 2022a).

2.2 Land use and transport

Land use patterns are defined as the uses of land, for example agriculture, urban or natural areas, between others. It includes the location, the type and the design of the infrastructure that will take place (Litman, 2022b, p. 8). All transportation planning decisions affect directly the land use, by considering which land is devoted to transport plans such as roads or parking lots. Nevertheless, it also has an indirect influence affecting the accessibility level and the costs of the development. In general, policies that involve a reduction in costs in diverse sectors (financial costs, travel times, risks) tend to alter the impacts encouraging the sprawl and the total traffic. However, policies investing and improving nonmotorized transit will then support smart growth (Litman, 2022b).
In planning decisions there are often trade-offs between motility and accessibility. The increase in road infrastructure and parking contributes to dispersed land use patterns, increasing the travel distances and creating long distances between destinations (Litman, 2022b, p. 11).

In the last century, many of the transportation plans and land use exercises have supported automobile dependency and sprawl, reflecting the absence of impacts of the decisions. It can be difficult to determine the land use impacts, in particular indirect impacts in transport planning a long term, depending on the demand, the improvement degree in accessibility or the integration of transport policies. A more representative example can be the case of an urban fringe development with the expansion of roadway capacity. This plan could significantly stimulate the sprawl for the area, but if there is a sufficient demand for transit orientated development with the improvement of transit services and supportive land policies, it will probably benefit the smart growth. This will arrange the parking lots efficiently, create compact developments or the improvement of walking path conditions (Litman, 2022b).

As shown, activities interfere in the dynamic interaction between transport and land use, adjusting the accessibility level. The importance of growth in relation to future land use plans is key to determining transport demand (Rodrigue, 2020).

2.3 Elements related to accessibility

2.3.1 Connectivity

Transport is fundamental for the connection between people, workplaces and services. Transport connections are present in almost everything we do, giving us access to new opportunities and creating connections with other modes of transport. It is part of the economic development, being effective and successful depending on the quality and conditions of the transport system, necessarily well connected, attractive and integrated. If so, people's decisions will adapt to those places where travel is ensured in an efficient way, pleasant and with good quality (Wigan Council, 2015).

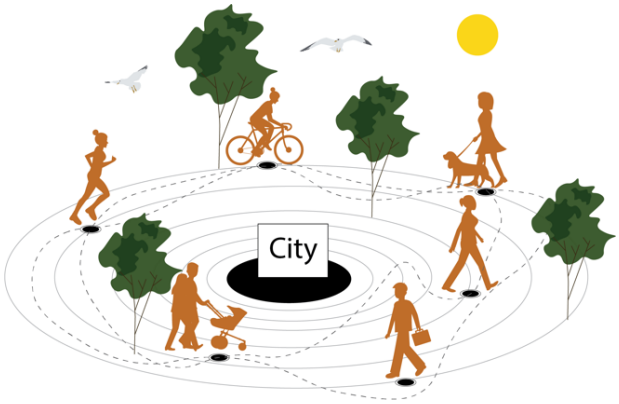

Figure 7. Illustration of connectivity. Own figure.

In relation to businesses, the number of travel opportunities and connections is essential for the growth of cities. Road and rail logistics, access to new markets for goods and services or the improvement in productivity is key for the development and growth of cities. Transport connectivity also affects health and well-being of the inhabitants, promotes active travel, better air quality and sustainable communities, contributing to the reduction of emissions to achieve the climate goals (OECD, 2018).
The increase in population and the demand for mobility creates an urge for the enhance of transport connectivity with both quality and quantity, mainly in the main corridors of the network, giving special attention to the areas lacking in connectivity or where connectivity in prioritized for motorized vehicles, like in the case of Forus.

2.3.2 Travel times

Shorter travel times constitutes to the benefits to the cost-benefit analysis of transport projects. It is an important value for travel demands models and the management of the transport investment decisions, but it is also key in the transportation component of accessibility. Travel time is the time used when a traveler displaces from one place to another in the network, a variable that differentiates route-choice behavior (Harder et al., 2005, p. 23). It is not a single value, it depends on multiple factors in relation to the travel context such as, the trip purpose, travel mode or the time of the day, and the characteristics of the traveler (Flugel et al., 2020).
In this case, the travel times studied for this analysis will be used for public transport, the bus and the train, walking, cycling and the private vehicle, with the purpose to compare them having the origin in the center of Forus and Næringspark.

2.3.3 Catchment areas

Catchment areas are often used in public transport planning, defined as the "vicinity of a stop or a station of a public transport line" (Lohmann Elkjær & Landex, 2009, p. 2). This area is where most of the passengers are transferred from, being the base for travelers in public transport. Depending on the desired, there are different approaches, which are the circular buffer and the service area (Lohmann Elkjær & Landex, 2009).
Based on walking distances, the area under influence of public transportation stops or stations are often used to estimate the potential number of travelers in the public transportation system with accessible services (Lohmann Elkjær & Landex, 2009). The analysis of catchment area can be used for different purposes and it can differ on the type of business, how visited the area is or the densification of workplaces. A larger catchment area involves a denser population and workplaces with a higher potential for travel (Brebbia, 2008, p. 175).

The execution of this analysis is done by the geographic information system (GIS), providing geographical approaches in the catchment areas used for the optimization of the stop locations of railways or bus lines. The detail of analysis can increase by dividing the catchment area in buffer rings. (Lohmann Elkjær & Landex, 2009).

2.3.4 Car dependency

Emerging in the late 1980s, car dependency in cities has become more present and relevant through intense debates on car traffic effects, highlighting climate change, air pollution or road safety. Early literature started with the scarcity of fossil fuels during the oil crisis, while nowadays and especially private transport, is threating our climate and contributing to global warming (Saeidizand et al., 2022).

The car is often in the regular travel patterns of the citizens, becoming the primary choice in every developed country. The growth in the transport sector has contributed to an increase in CO_2 emissions over the years, increasing over 74% and representing a quarter of the global emissions (slocat, 2020).
Car travel and its externalities is present in many of the recent literature, interpreted in diverse ways. For Litman (2002), for example, the term car dependency is related with the high rate of car travel per capita with car-orientated land use patterns, lacking in alternative ways of transport (Litman & Laube, 2002). On the other hand, Merom et al. (2018) defines the term as permanent dependence of the car as main mode of transport (Merom et al., 2018).
In relation to this thesis, the definition of car dependency will be associated to Litman, where the car dependency is connected to car-oriented land uses, such as parking. With the aim to reduce the use of the car in Næringspark, this thesis gives some references of cities where the implementation of restrictions has directly affected the car dependency and promote the public infrastructure.

2.4 Effective measures to impulse public transport and active transport

Oslo car-free Livability Program

For decades, cities have been designed and built for the use of the cars, until recent years with the need to bring the urban spaces back to their citizens. The urge for a change is on all the cities' agenda with the objective of reducing emissions, mostly in the transport sector. Rewarded as the European Green Capital in 2019, Oslo city has ambitious plans in terms of transport, environment, and climate. Aimed on multiple targets, this reference focuses on the importance of meeting places and the room for city life "From parking spaces to city life" (Fig, 2021).

The car-free livability program for Oslo was explicitly designed to impose vehicle restrictions in some parts of the city. Divided in different phases, the city was divided in rings, starting from the central area with higher concentration on activities and workplaces. The first phase was aimed on the removal of

on-streets parking spaces in the central area withing the ring 1, keeping the car parks in the zone and keeping other on-street parking but for other uses. After this measure, the second phase included more severe actions, with the closing of traffic routes through the city center with some exceptions in terms of deliveries. This aggressive measure was able to be applied due to the combination of the extension of the pedestrian and cycling network. In total 800 parking spaces were removed, together with some street renovations (Oslo Kommune, 2019).

The plan is a long-term plan with multiple similarities to the case studies in Forus, despite the difference in built environment, but focus on the improvement of the accessibility for cyclists, pedestrians, and public transport to facilitate a "car-free city life".

After the implementation of the different measures, Oslo car traffic was reduced by 11% between 2016 and 2018, and 19% in 2018-2019 without negative impact on the travel patterns within city center destinations. Indeed, the city has also included other measures in the outsider areas with ring tolls that differ between time and environment with different tariffs with the same purpose (Fig, 2021).

Figure 8. Illustration of city life and active transport. Own figure.

Other cities interventions

The study of the different measures appliable for car use reduction has several classifications and categorization depending on the city where it is applied. In this regard, the interventions in European cities have been differentiated as charging and pricing, increasing prices in the congestion's areas and workplace parking's, the access limitations in traffic zones, parking and traffic control, as the example explained in Oslo or mobility services to impulse the public transport and car sharing plans (Kuss & Nicholas, 2022).

In the first type of intervention the example of London or Gothenburg has shown effective results reducing the car use by 33% and 12 % respectively. Introduced in 2003 and in 2013, in both cases the charging revenues for the car use has been used for public transport investments, applied in congested zones with fixed daily charges according to the timings (Kuss & Nicholas, 2022, p. 16). Reflexing the analyzed case, this measure could constrain employees in Næringspark from using other modes of transport, implementing charges in the peak hours to avoid road congestion and reducing the car use mostly in working hours.

In the area under study in this analysis, the access limitation is already implemented in the street Lagersveien, restricted to cars, and only used by public transport. This restriction has reduced 10% the car use in Rome, with exceptions of access in special hours of the day and limiting the access to residents or workplaces paying the entry fee in the area (Kuss & Nicholas, 2022, p. 16).

As described in the beginning of this chapter, literature review, the essential changes aim on the mobility services, which means the improvement and enforcement of the public transport infrastructure. Some examples are the case of Mälmo in Sweden, Utrecht in the Netherlands, or Bremen in Germany, with the investment on new cycling paths to promote the active transport, new metro lines to connect more places within the city and the possibility to low the prices for the employees in working areas or even free usage in the case of Utrecht (Kuss & Nicholas, 2022, p. 21).

When it comes to parking and parking restrictions to reduce the car, the example of Rotterdam is quite representative in relation to the strict measures and ratios per housing units. Known by the levels of cyclist in the city, Rotterdam is pioneer in Europe for taking seriously this topic. Following the ABC land use policy in the early years, the parking standards abandoned this pattern to be changed by maximum and minimum parameters and become more independent for the local authorities. With the latest trends to promote low parking provisions, the parking ratios changed in the suburban areas from a minimum of 1.6 parking spaces per residential unit and a maximum of 2.5, to less than 1 space per unit and 0.2-0.3 spaces per unit in the inner center areas of the city. Aggressive measures to lower parking prompted by the traffic congestion, as figure (9) shows, costs, and the rapid response to the challenge to build more housing and services (Barter, 2022).

Figure 9. Afternoon traffic in the A4 to Rotterdam. Source: NL Times.

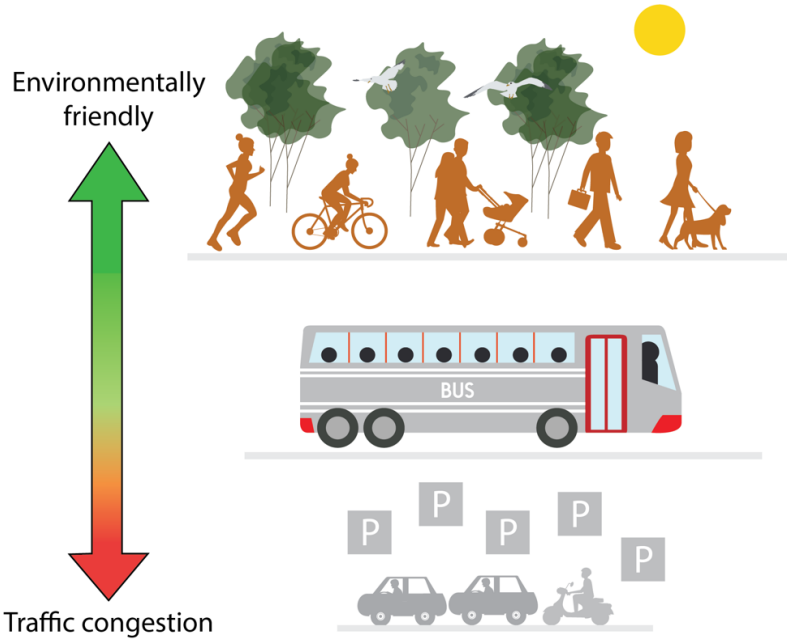

Figure 10. Illustration to transform congested cities into environmentally-friendly cities. Own graph.

3. METHODOLOGY

This thesis consists of an evaluation through a descriptive comparison of the different modes of transport using field work as one of the methods to collect data for the analysis and GIS network to model the travel times from Forus. The thesis explores the comparison between public transport, private car, and active transport from a perspective of land use, accessible facilities, traffic volumes, travel times and infrastructure.

3.1 Field work: Spatial Analysis

The visits to the area are essential to understand the built environment of Forus. The registration of data and the photos taken show the current situation to contribute for the following comparative analysis. The visual conception of the public transport stops, frequencies, and the experience of using the public transport from different locations to Forus provide a better understanding of the accessibility to the area by bus and walking and cycling.

In relation to the use of the car, the easy access to parking, the rush hours on the highway and the high congestion have shown the relevance of this study through the experience of visiting the area. Indeed, the visits have contributed to the registration of data in relation to parking densities, what areas are more densify with parking and also the type of use, being destinated barely for the employees or available for visitors.

Through this approach the research questions "*Which workplaces are car-promoting through parking?" and "How will parking restrictions impact on the area to reduce the use of the car?"* will be answered through the calculations of the exiting parking density and ratios, and the areas where companies tend

to promote parking. The spatial data obtained in the field has been essential for the calculations and for the built environment of the business park, directly connected to the land use and the transport infrastructure, as mentioned in the literature, chapter 2.

3.2 GIS: Travel times and catchment areas.

Travel time isochrones

In addition to the field work, the approach by QGIS Desktop shows how to build maps with the open-source Geographic Information System (GIS).

The increased interest in the ease of reaching valuable destinations leads today to the assessment of optimal ways of measuring accessibility. The diversity in mobility and the changes in socioeconomic life become a challenge to find universal and comparable measures of accessibility. It is a fact that time, costs and effort are essential attributes in transportation accessibility and depending on them people's behavior becomes affected, as mentioned in chapter 2 (Śleszyński et al., 2022).

The time used to connect two points in space involves different obstacles and barriers, being physical, as well as political or economic. Depending on their nature the trips can be longer or shorter, reason why it becomes interesting here to find a measurable way to compare the different times for each mode of transport and the conditions and characteristics of each of them (Śleszyński et al., 2022).

One of the most useful and known ways to aim comparability in transport is to use a measure in trip duration. Travel time isochrones are developed indicators for the assessment of spatial and temporal efficiency in the different transport modes. The isochrones are imperfect circles in geographical space centered in the origin of the trip, with radius the time needed to reach it (Śleszyński et al., 2022). The comparison of individual isochrones in different times and different transport systems provides a better understanding of the reachable destinations from the center of Næringspark, Forus.

Travel times vary between 5-20 minutes in most of the daily trips, according to the national surveys in 2020 (Statens vegvesen & RVU gruppa, 2020). Divided into separate groups, 29% of the daily trips range between 10-19 minutes and 26% in trips of 4-9 minutes. These intervals are references to the travel times used for this analysis, considering that small portions of the trips exceed these travel times in 20-29 minutes or 30-40minutes (Statens vegvesen & RVU gruppa, 2020).

This tool creates isochrones for the different modes of transport in 5,10- or 20-min catchment area, for example. The isochrones show the areas that are reachable from a starting point in a given amount of time for the different modes of transport, public transport, cycling, walking and by car. The travel time plugins in QGIS also differentiate the different hours of the day, allowing to see how the catchment areas in a certain amount of time change along the day (van Rees, 2020).

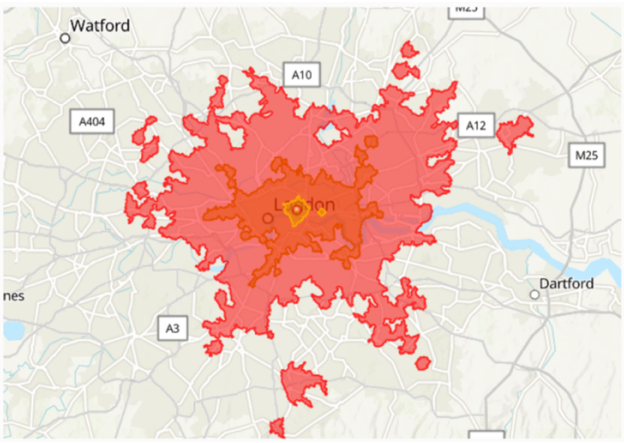

Figure 11. Example of public transport isochrone map for the London bank station showing different travel times. Source: gislounge.

The selection of these digital tools comes with the task for the evaluation of the accessibility in the area and the importance of travel times for the analysis. The travel time mapping provides information of what areas can be reached depending on the mode of transport choose for the trip to Forus and what areas are dependent in the intersection with other layers, contributing to the answer of the stablish research question in this thesis, "*How many people are car dependent when travelling to/ from Forus? Which areas? ".*

Catchment areas

In this case the approach chosen is the circular buffer approach. This method is fundamental and direct, for investigations of whole public transport lines and the alignment of stops (Brebbia, 2008). This method is used to understand the areas that are isolated or car dependent in the business park, with an analysis that starts with the design of the circular buffer around each stop of the public transport, defining more in detail the areas the car dependent areas in Næringspark.

Differing from the regional plan, the inter municipal plan establishes 400 m as the buffer zone for combined industries and industrial operations outside of 400m, from the main public transport lines (Rogaland Fylkeskommune, 2018). The difference in parameters between regional and municipal plans can be misleading, but in this case, and considering the public transport service low, the buffer zone analyzed will be 300m. The effective public transport service often uses 400m buffer zones for the bus, 800m for the train infrastructure and 500m for tram (Mladenović et al., 2021, p. 32). The regional plan suggests the use of 250m buffer zone for working places (Rogaland Fylkeskommune, 2019).

The relation of this approach connects with the travel time approach through GIS analysis. The catchment areas in the public transport will determine the areas car dependent in the business park, contributing to a more detailed answer to the primary research question, but more specify for "Which

areas?" inside Næringspark. This means how the possibility of restricting the car will impact those areas where the public transport does not reach or has long frequencies.

3.3 Data registration

Population

The population of the three municipalities, Stavanger, Sandnes, and Sola have increased in the last year 2021 (Stavanger Statistiken, 2022). The three municipalities, including others, are the residence for many of the visitors and employees traveling to Forus. As shown in figure (12), there are no settlements in the area under study, all the travelers in Næringspark live nearby or in other municipalities.

The highest concentration of population is located in the coastline and Stavanger- Sandnes belt. In 2021, Stavanger had a population of 144.147 inhabitants (0,4 % increased compare with the last years), Sandnes 80.450 inhabitants (increased of 1,15%) and Sola with 27.457 inhabitants (increased of 1,12 %) (Stavanger Statistiken, 2022).

For this thesis, the population data analyzed in GIS is the data from 2019, being the most updated population data available in the specific format. Indeed, the thesis will consider only three municipalities, without including Randaberg or Nord-Jæren due to the relevance with the area under study explained in the beginning of this thesis, Næringspark.

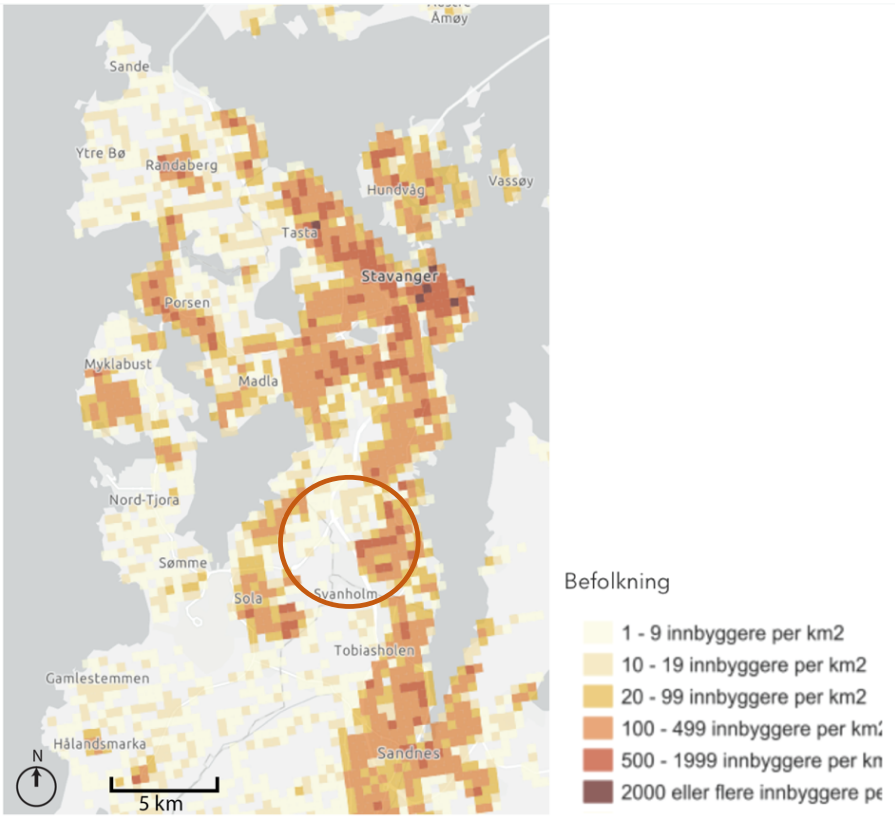

Figure 12. Population in Stavanger, Sandnes and Sola municipality. Source SSB.

Working places

When it comes to the concentration of workplaces and employees, Forus/Lura, Stavanger center, Sandnes center and some areas in the belt such as Hillevåg, have the highest workplaces concentration, as shown in figure (13).

The population growth has brought new workplaces and more employees to the region in the recent years. Rogaland counts with a total of 50.371 businesses in the beginning of 2022. Divided into the municipalities for this thesis, Stavanger has a total of 14.142 businesses, Sandnes 7.417, and Sola 2.804 (SSB, 2022). Shared by the three municipalities, Næringspark has approximately a total of 2.500 companies working in different fields and no residence buildings in the area (Forus Næringspark, 2022). Most of the employees working in the business park depend on the transport infrastructure to connect with the rest of the municipalities and their residence.

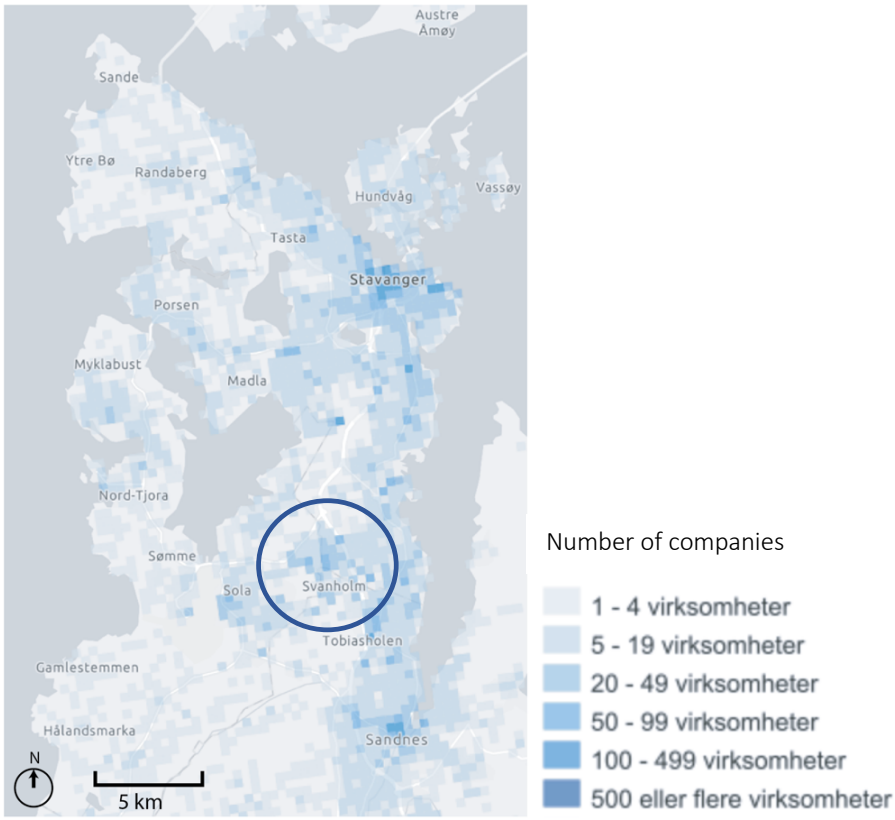

Figure 13. Concentration of workplaces in Stavanger, Sandnes and Sola. Source SSB.

4. ANALYSIS

4.1 SPATIAL ANALYSIS

4.1.1 Land use and built environment

Forus was built over large parts of land occupied by lakes, having poor ground qualities. A lot of work has been done over the years for the stabilization of the ground with piling and groundwork to become an area to be developed (Røyneberg, 2020). Aimed at industrial purposes, Forus is nowadays formed

by a variety of uses mostly located in the main axes, leaving most of the land for businesses and warehouses.

The business park, Næringspark, offers different services depending on which zone. According to the plans, Forus is divided into different areas. Forus kanal, Forus øst, Forus sør, Forus Vest, Forus stasjon and Forus Golfbaue, characterized with its own services and uses (Forusvisjonen, 2022). In this thesis, the areas under analysis are Forus kanal, Forus vest and small part of Forus sør. Area where the majority of the businesses and industrial areas are allocated in Nord-Jæren.

Forus has a total area of over 6.500 acres, 6.5 km2 with Næringspark taking over 3.2 km2. Founded in 1968, Forus Næringspark has been the location for 40.000 daily employees, growing over the years to the number of 46.000 and possible 90.000 employees in the future (Forus Næringspark, 2022).

Based on the data provided from the regional plans, the highest concentration of businesses in Nord-Jæren is located in Forus/Lura, Stavanger and Hillevåg. Both have decreased in the period from 2016 but the projections show an increase from now on with a change in businesses, mostly in Forus (Rogaland Fylkeskommune, 2018, p. 6). The decrease of traditional jobs in the oil industry, mostly oil platforms will steadily decrease with a shift in the direction of development, administration and management in the energy sector (Rogaland Fylkeskommune, 2018). This means that Forus and specially Næringspark is essential for the economic growth of the city and the region Nord-Jæren. With the increased in population over the years, Forus has become the workplace for many in the region with the need of transport alternatives to travel to work daily or for leisure activities.

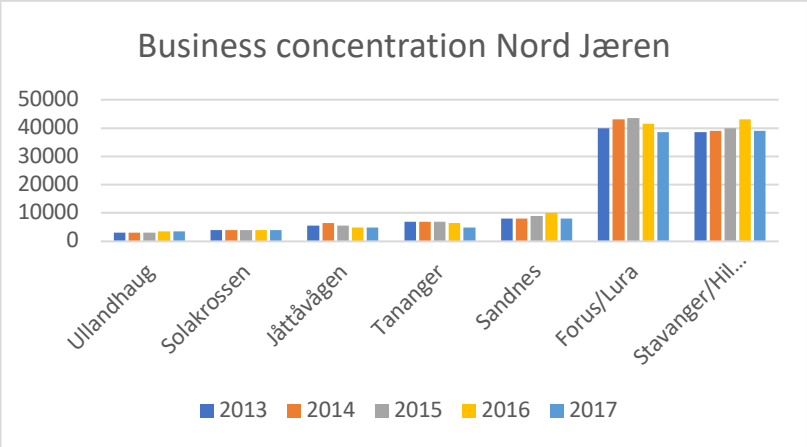

Figure 14. Data from the IKDP plan. Own figure.

Mix of uses

Næringspark has a little mixture of uses, being a business park with companies in different sectors. Many of them are companies related to the oil industry but also automobile industry, logistics and warehouses.

In addition to the businesses, one of the main arteries in transport in Forus and NæringsPark is Forusbeen. Street with multiple commerce and restaurants, essential for the mixture of uses to create interaction between land and mobility (Forusvisjonen, 2022). In general, the services in NæringsPark are divided between businesses, rock and oil extraction, commerce, industry or construction being the most predominant. The following figure (15) shows the different functions in the area.

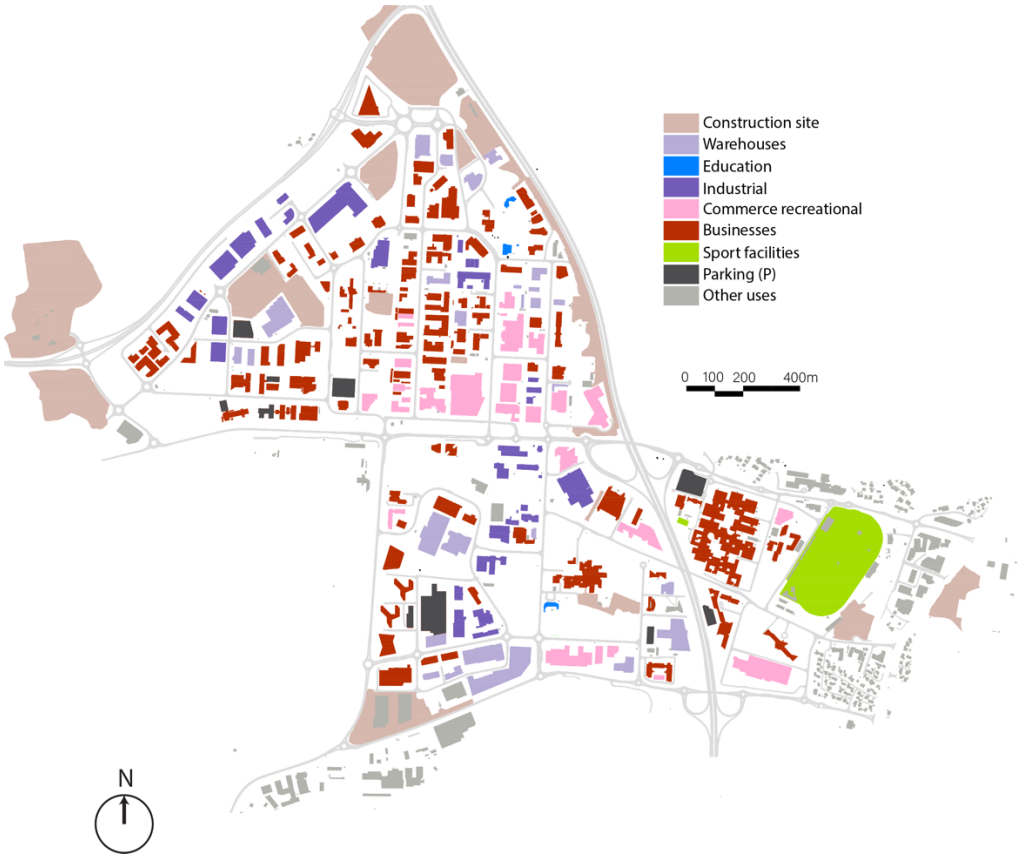

Figure 15. Mixture of uses in the area. Own figure.

The fact that the area is mainly industrial makes it difficult to interact with a mixture of uses. The concentration of services in the Forusbeen tends to increase the public infrastructure around it leaving behind the rest of the area where a high number of employees need to travel daily. Indeed, the commercial recreations are usually warehouse stores such as IKEA, Biltema or other technological stores where people need or often use a car to bring their belongings. Combined with the lack of sport facilities, greenery, only a few educational buildings and no residence buildings, it is a challenge to fight against car dependency with the high number of parking spaces and the lack of mixture of uses.

The business park presents itself as a monofunctional area for the region, which according to Carmona (2010) tends to increase car dependency and reduce transport choice (Carmona et al., 2010, p. 222).

Building typology

The building typology in the area is like many other industrial parks, with concrete blocks, glass facades or retreated building lines. The lack of greenery makes the area asphalt and concrete based with poor

architecture value and predominant large and compact buildings of 3-6 storeys per average and warehouses of 1-2 storeys. It is not an attractive location for visitors, with large distances between buildings, open spaces without a use and with a lack of compactness. The business park was built in a simple and cheap way, just considering the plot boundaries and creating massive buildings for offices. Currently, the area has available plots for new uses or to be occupied by new companies, empty spaces breaking the built environment with limited access to services.

Parking

As part of the regional plans, parking is an important part of the policies applied for land use and the mobility infrastructure. According to a study made by Asplan Viak in 2013, there is a total of 27.500 parking spaces and 19.000 parking spaces in used (IKDP Forus, 2018). A parking occupancy of approximately 70% and 1.2 parking spaces per 100 m2 BRA. The parking ranges from 0.35 spaces per 100m2 to up to 3.08 spaces per 100 m2 BRA (IKDP Forus, 2018). One year after, KAP and Brandsberg-Dahls Arkitekter made an estimation of 31.500 of total parking spaces (IKDP Forus, 2018).

These registrations show the high overcapacity of parking in the area a few years ago, with the uncertainty if the parameters continue the same way or increasing even more nowadays. For this reason and due to the lack of recent data from parking in this area and its variation, the analysis in this thesis will evaluate and estimate the number of parking spaces and ratios.

Nowadays, the figure (16) shows the parking facilities in the area, considering the parking in private plots and customer parking available for visitors. In total, there are 2.000 parking spaces for visitors in the area, not related to businesses (Statens vegvesen, 2022).

- Maskinveien: 170 parking places.
- Kanalsetta 3: 149 parking places.
- Forus Parkering: 1450 parking places.
- Kanalsetta 2: 37 parking places.
- Frabrikkveien 12-14: 28 parking places.
- Petroleumsveien 6: 149 parking places.
- Travbaneveien 1: 18 parking places.

Figure 16. Parking facilities in Næringspark. Own figure.

Figure 17. Different types of parking in Næringspark. Own figure.

Næringspark has a parking coverage spread in different ways along the area, being private for most of the existing plots. There are several types of parking such as surface parking, parking in blocks, underground parking, and roof parking, as figure (17) shows. The identification of the parking spaces has been quite challenging due to the large area with hidden parking, reason why the calculation made in the analysis of this thesis is conservative, considering a small margin of error due to the complexity of this issue.

Not only does each plot provide spaces to park, but also some of the land has been devoted to parking blocks with 2-3 floors or even 6 floors, increasing even more the car capacity to the point where it became a challenge for the area. The long distances between buildings and the availability of parking spaces slows down the possibility for a new change in the area, in terms of transport, urban qualities and new densities (Rogaland Fylkeskommune, 2018).

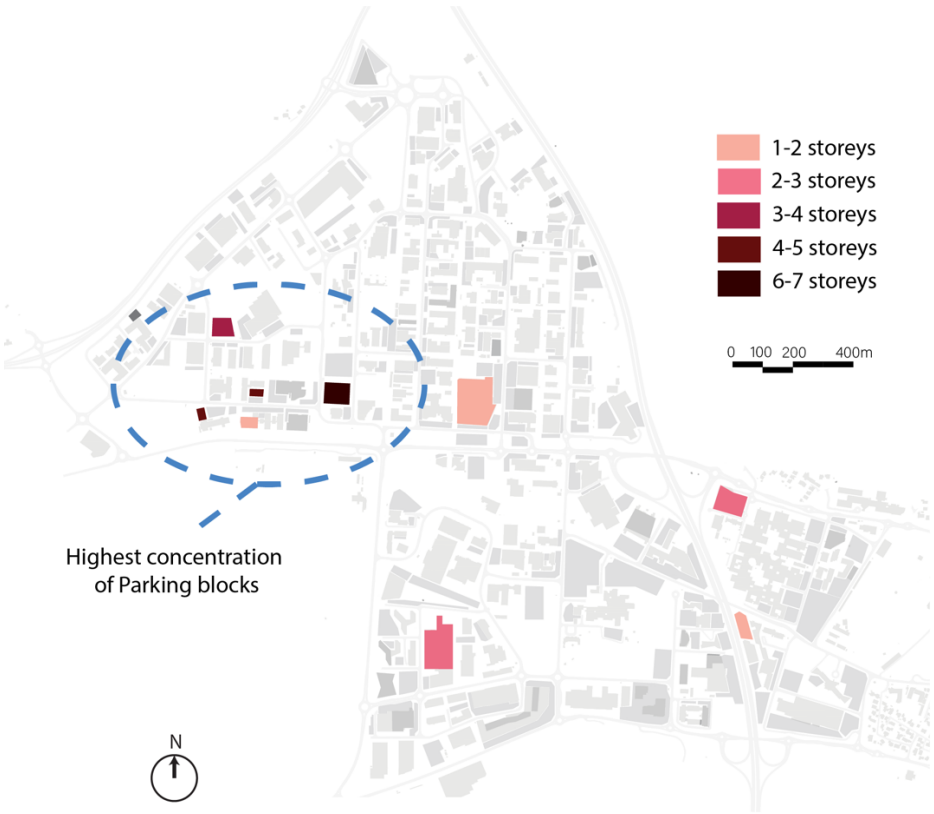

Figure 18. Height of buildings destinated for parking. Own figure.

During the collection of data in the visits to the area, on a regular weekday at 11 a.m., most of the parking was occupied in each of the plots, but in the case of companies like Equinor, the parking was close to half of its capacity with free parking spaces. This parking is restricted only to employees in Equinor and parking is not allowed with another purpose.

The area also has underground parking with restricted access only for employees, having in some cases underground parking for bikes. The registration of the location of these parking has been difficult, hidden in many occasions and difficult to estimate their area and the parking capacity and occupancy.
In general, all companies have parking spaces specially for the use of visitors, with an average of 4-6 parking spaces. As an exception, Equinor has between 25-30parking spaces designated for visitors in different locations. All of them in used the day of the visit to the area.
Equinor has an approximately total of 6.000 employees in the corporate offices in Forus, located in Forus been and Svanholmen (Vervik Salte, 2021). The availability of parking even when you are a visitor is an advantage for those who want to travel to Forus or Næringspark. The commodity to park next to your destination is an important element to make people not change their travel habits. Indeed, the availability of free parking spaces shows that the parking capacity is higher than the parking in used. Næringspark also offers the possibility to park for long periods of time. The parking block located in Næringspark vest has 6 storeys with a capacity of approximately 1.500 parking spaces.

Together with the use of the car, biking is becoming more often a mode of transport chosen by many. The cycling infrastructure in the area connects all the internal paths and having the cycling highway connecting from Stavanger or Sandnes is essential for the transition of many to use the bike. The figure (19) shows the high number of bikes located in the parking accommodated for the bikes in each company. Most of the buildings have parking for bikes and city bike stations located close by.

Figure 19. Parking for bikes in Næringspark, Forus Nord and Sør. Own figures.

The need to reduce the traffic levels and the dependency in the car is well known and present in other Scandinavian cities such as Trondheim, Oslo or Kristiansand, where restriction on parking has had effect in terms of reducing the use of the car and promoting other modes of transport (IKDP Forus, 2018). Following this strategy, the three municipalities agreed on establishing some parameters to reduce the land used for parking, represented in the IKDP plan (Rogaland Fylkeskommune, 2018).
Some of the restrictions can be the establishment of maximum and minimum parameters. The use of minimum restrictions can lead to even more parking spaces than required and for this reason the

municipalities establish a maximum restriction for the number of car parking spaces per 100 m2 for industry and per housing.

Today's parking restriction plan is based on the "ABC plan" depending on the area. Depending on the level of accessibility in public and active transport, the areas are defined as A for high accessibility, B medium and C low. This level goes together with the requirements for parking being low for A, slightly higher in B and parking requirement for employees and visitors in C (IKDP Forus, 2018).

The regional and municipal plans differ in the definition of zoning for parking restriction being categorized differently depending on the utilization of land and the proximity in and out of the principal transport axis. The table (1) shows the values depending on the regional plan and the municipality (IKDP Forus, 2018).

	PARKING SPACES PER 100M2 BRA		
	High utilization Local centers, city centers.	*Business area 1 By main transport axis*	*Business area 2-3 Out of the main transport axis*
REGIONAL JÆREN PLAN	-	Max 0.75-1	-
STAVANGER (FORUS ZONE)	0.5-0.9	0.9-1.2 Max 0.75-1	Min 1
SANDNES	Max 1	Max 1.2	Min 1
SOLA (FORUS)	-	Max 1.2 Max 0.75-1	-
PROPOSAL IKDP PARKING FORUS/LURA	-	Max 1.2	Max 0.4

Table 1. Parking restrictions in the different plans. Source: Parking restrictions for Forus.

In this case, the IKDP proposes three alternatives for the restrictions on the parking for Forus. These depend on the area and the transport axis, according to the municipal plans while the other alternatives refer to the areas with industrial purposes and businesses (IKDP Forus, 2018, pp. 3–4).

Alternative 1

- Core areas (A): Min 0.5- Max 0.9
- Collective axis (B): Min 0.4- Max 1
- Other (C): Max 0.4

Alternative 2

- Industry/ Warehouse: Max 0.4
- Businesses: Min 0.5- Max 1

Alternative 3

- General rule of Max 0.3 parking spaces per 100 m2.

The three alternatives have been studied in the plans ending up in the final recommendation to use alternative 3 for the IKDP plan. This will increase and strength the accessibility for the area in terms of collective modes of transport, according to the plan.

Having a general picture of the parking and the restrictions applied in each municipality, the business park depends on the intermunicipal collaboration and agreements, where each municipality has its own interests. This means that it will be difficult to reach a political agreement when each municipality applies different parameters, and in this case considering that the plots are privately owned.

4.1.2 Accessible Facilities

The existing facilities in NæringsPark define the mixture of uses in the area to attract visitors and the settlement of new companies. The majority of the facilities are located in the core area with the street "Forusbeen" where the shopping mall "Tvedtsenteret" is located together with several other shops and restaurants.

In general, the area has three educational buildings, all of them kindergarden, a medical care center "Mosaic Medical", four hotels and two open sport facilities. The diverse groups of facilities are defined according to the data collected from statistics of Norway for the area of Forus/Lura (Stavanger Statistiken, 2021).

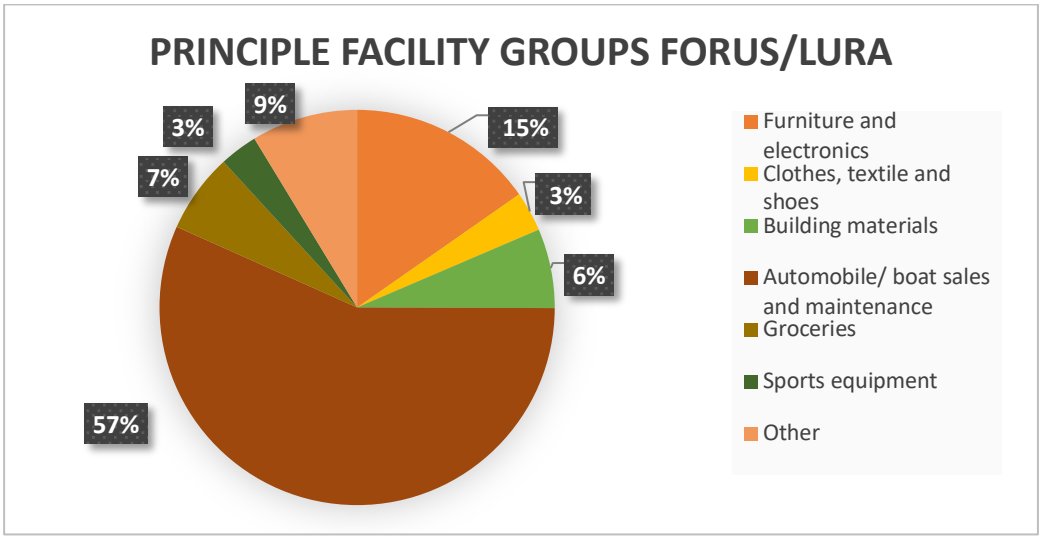

Figure 20. Facilities in Forus and Lura. Source: Stavanger statistiken.

Inside the facility groups, the statistics of Stavanger provide a number of businesses and employees according to the post numbers in each kommune. The postal numbers that include the area under analysis are 4033, 4313 and 4031. Due to the big coverage of this registration, this thesis will only use the data from 4033 post number together with an overview of the main facilities in Sola and Sandnes that affect Nærinsgpark.

GROUP	NUMBER OF BUSINESSES
Groceries	3
Clothing and textile	4
Sports equipment	2
Automobile workshop/sales	31
Furniture and electronics	10
Building materials	4
Restaurants and services	9
Education	4
Sports	2
Health	1
TOTAL	70

Table 2. Number of businesses differentiated by group in Næringspark. Source: Stavanger statistiken.

The shopping mall Tvedtsenteret opened in 1982 was first providing only interior and furniture facilities but in order to be adapted to new development, new stores opened nowadays including grocery stores, sports, clothing etc. (Tvedtsenteret, n.d.).

GROUP	NUMBER OF BUSINESSES
Groceries	2
Clothing and textile	5
Sports equipment	2
Furniture and electronics	7
Training	2
Restaurants	4
Personal services	3
TOTAL	25

Table 3. Number of businesses differentiated by group in the shopping mall, Tvedtsenteret, Næringspark Forus.

As the figure (20) shows, 57% of the facilities in the area are warehouses destined for automobile/ boat maintenance or repair. In relation to the entire area of Næringspark, the number of facilities is quite low to contribute for people interaction. The area is barely a working place, without housing and just a small percentage of interaction, mainly in the shopping mall in Forusbeen.

4.1.3 Infrastructure

The transport infrastructure in Næringspark and Forus offers facilities to choose different modes of transport. The regional plans establish a target of zero traffic growth in the use of private vehicles, which means that all trips must be done walking, cycling or by public transport (Rogaland Fylkeskommune, 2019). For this, the accessibility and connectivity in these modes of transport needs to attract more people than it does nowadays. The existing transport infrastructure evaluation shows the main axis of the public transport, the routes and lines connecting the area and the main bus stops. In terms of cycling and walking the paths are represented through maps.

Roads

The area is defined by the main roads in the area, which are the highway EV-39, connecting Stavanger and Sandnes, the road 509 with direction to Sola and the secondary road Forusletta (Fv-44), see figure (21). With access to the core of Næringspark, the roads considered as principles are Forusbeen in the exit (Forus) from highway E39 and the exit (RV 509) to solasplitten, connecting with Næringsveien and Lagersveien.

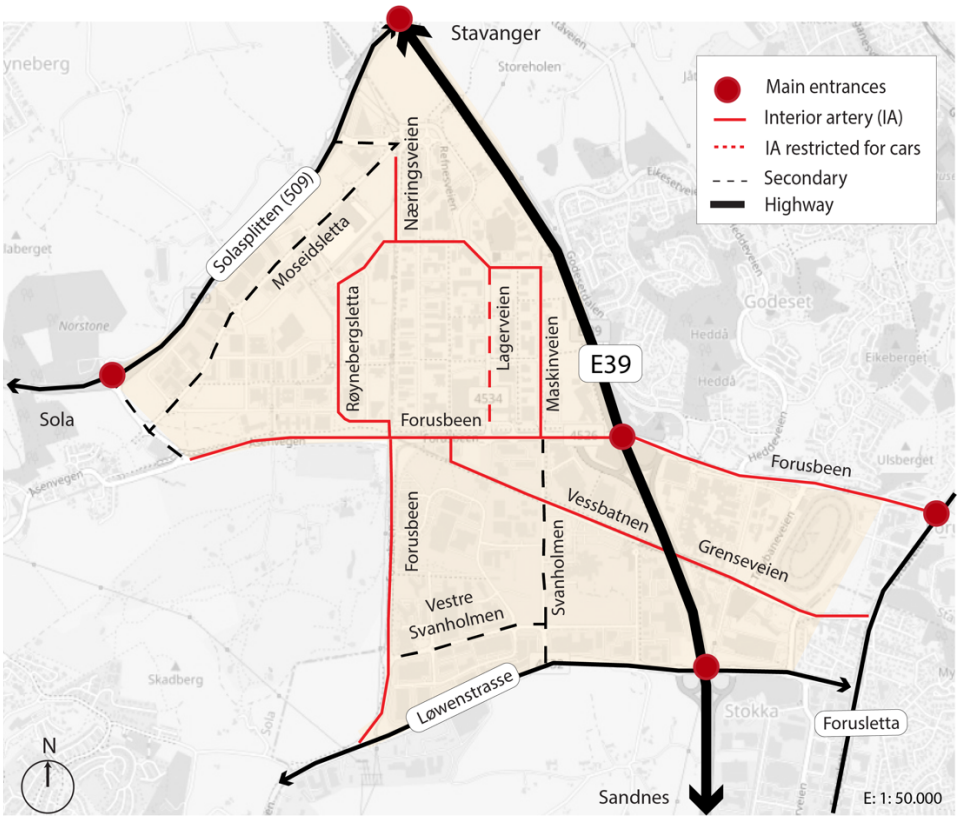

Figure 21. Graph of the main roads in Næringspark. Own graph.

Public transport

The bus infrastructure has two main arteries that cross the area, in connection with Forusletta (fv-44), the principal line of connection between Stavanger-Forus-Sandnes belt. Currently, the road Lagerveien is only open for buses, having the traffic restricted for private cars, see figure (22).

The new concept for the development of the bus infrastructure comes with the project Bussveien, defined us precise, comfortable and comparable to the modern trams. This project includes the area of Forus (Forus vest and Forus nord) and in its totality is 50 km length. Currently the section of Forus still under development in the regulation plans (Rogaland Fylkeskommune, 2022a).

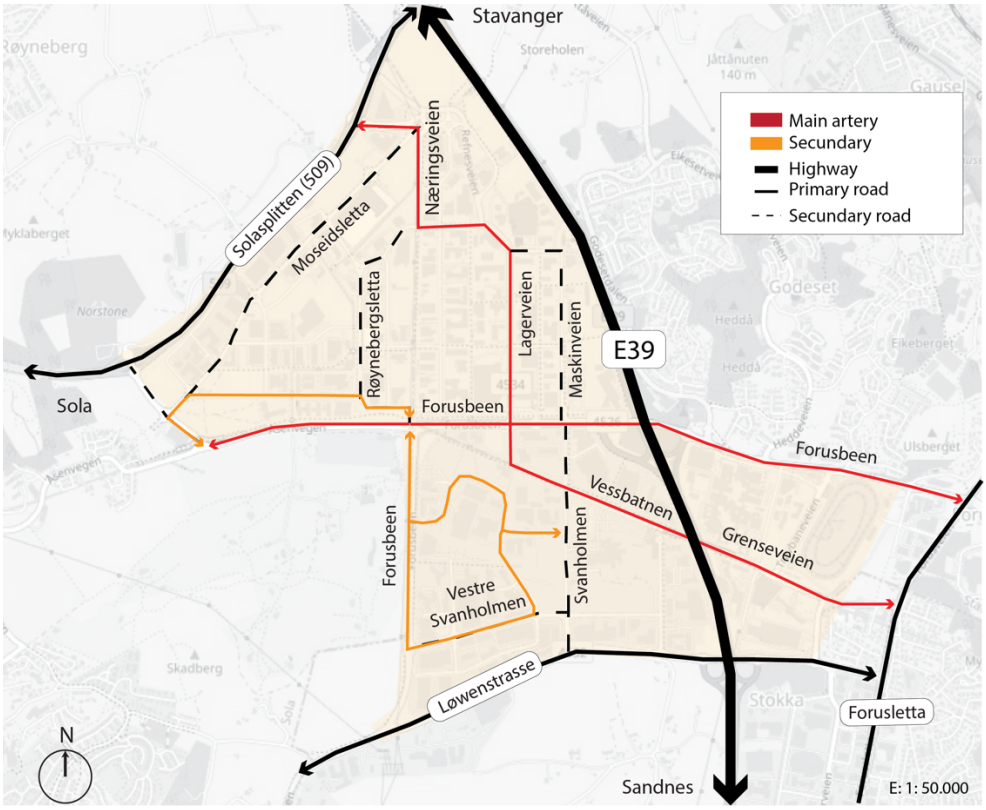

Figure 22. Graph of the main and secondary arteries of the public transport. Own graph.

Today, the area has six main stops covering Næringspark. These are Forus Nord, Tvedtsenteret, Foruskanalen, Equinor øst and Forus øst, and the last connection with FV 44, Forusbeen. The following figure (23) shows the shapes of the public transport, referring to the transit of the buses. The lines covering the area under study are line 6, line 42, line 67, line 3 and 2, lines X60, X71, X44, X40, X77, X39 and the special line SK0302, only a few days per week from Tananger. The frequency in most of the lines rounds about 8-15 min except for the line 67 that covers Forus Sør with a frequency of 30 min or SK0302 with 48 min (Kolumbus, 2022). The frequencies are shorter mostly in the peak hours, working days, and longer in the rest of the day.

Figure (24) represents more in detail the bus stops in Næringspark, showing the main stops where most of the passengers end their trip (Kolumbus, 2022).

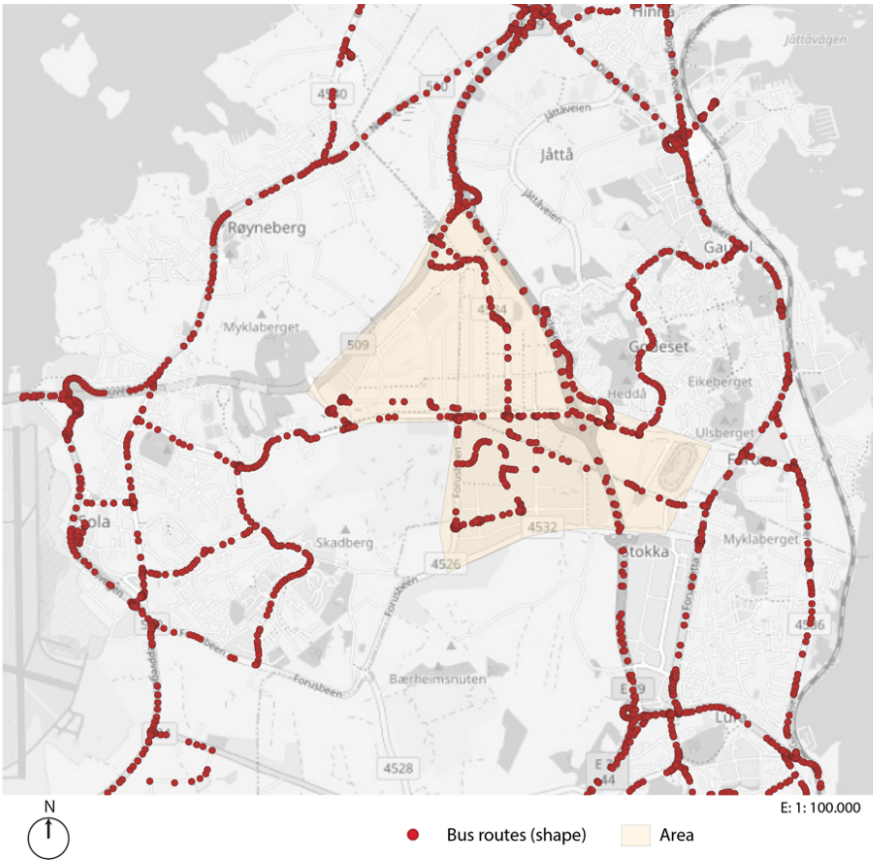

Figure 23. Public transport shapes. Own figure by GIS.

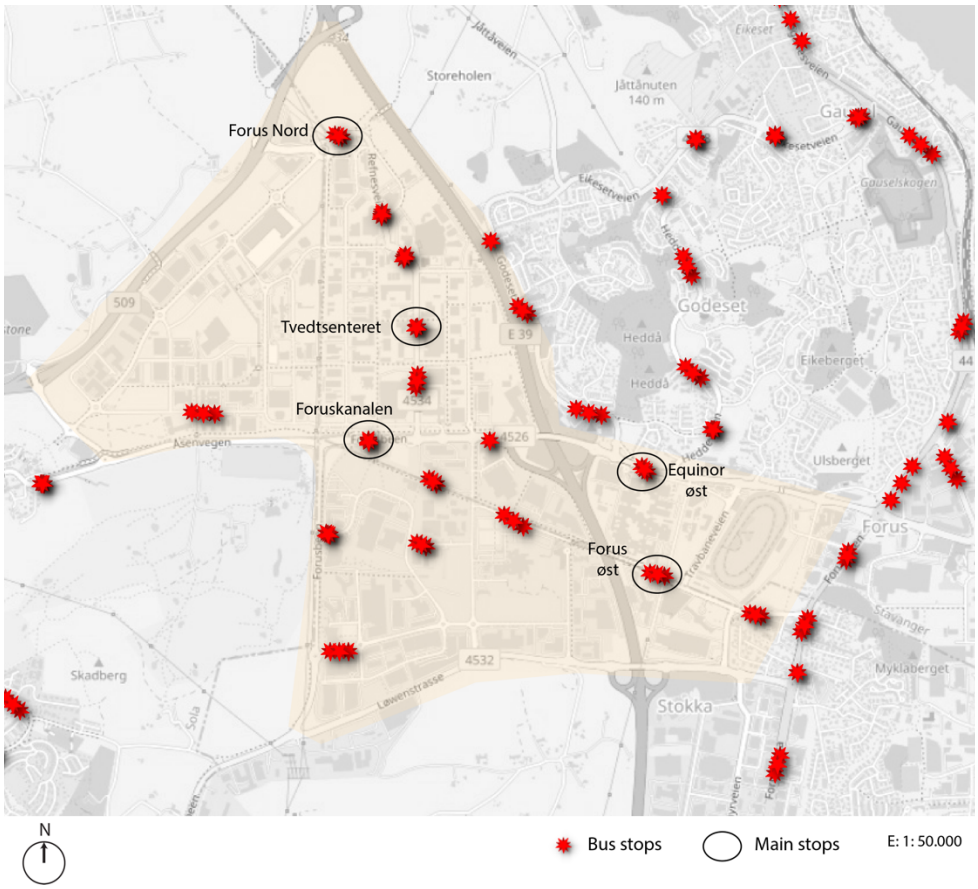

Figure 24. Public transport stops in Næringspark. Own figure by GIS.

Cycling highway

With the same value as public transport, cycling is the second mode of transport used to go to work in the area of Stavanger. The cycling infrastructure is also under an important development for the region. The E39 sykkelstamveg Nord Jæren is beside the highway E39, main entrance to Forus and NæringsPark. The cycling line is a traffic safe road for cyclists that covers the entire Stavanger-Sandnes belt with the objective to impulse the use of the bike in work travel. It is a well-constructed cycle line where cyclists can enjoy the trip and also feel safe and comfortable. The infrastructure counts with traffic and directional signs to easily find your destination (Statens vegvesen, 2020).

Figure 25. Cycling highway. Source: Statens Vegvesen.

Today, the project is only finished in one of its sections from Asser Jåttens vei to Sandnes grensen. Opened in 2020 the cycling line is now available for cyclists in Næringspark, Forus (Statens vegvesen, 2020) offering also the possibility to rent city bikes with the location of bike stations in strategic locations in the main axis of Næringspark.

The existing cycling infrastructure is comfortable to cycle in and made of quality building materials. The connectivity of the infrastructure is wide and makes it possible to cycle from Stavanger to Sandnes away from the driving roads. The path connects with Kvadrat, Stokka, Forus, Jåttå, Ullandhaug and Madlaveien from Sandnes to Stavanger, see figure (26).

In general, the cycling infrastructure is growing over the years, providing quality cycling paths due to important economic investments and connections to persuade drivers to choose the bike instead of the car, avoiding congestions and enjoying a bike trip with less travel time.

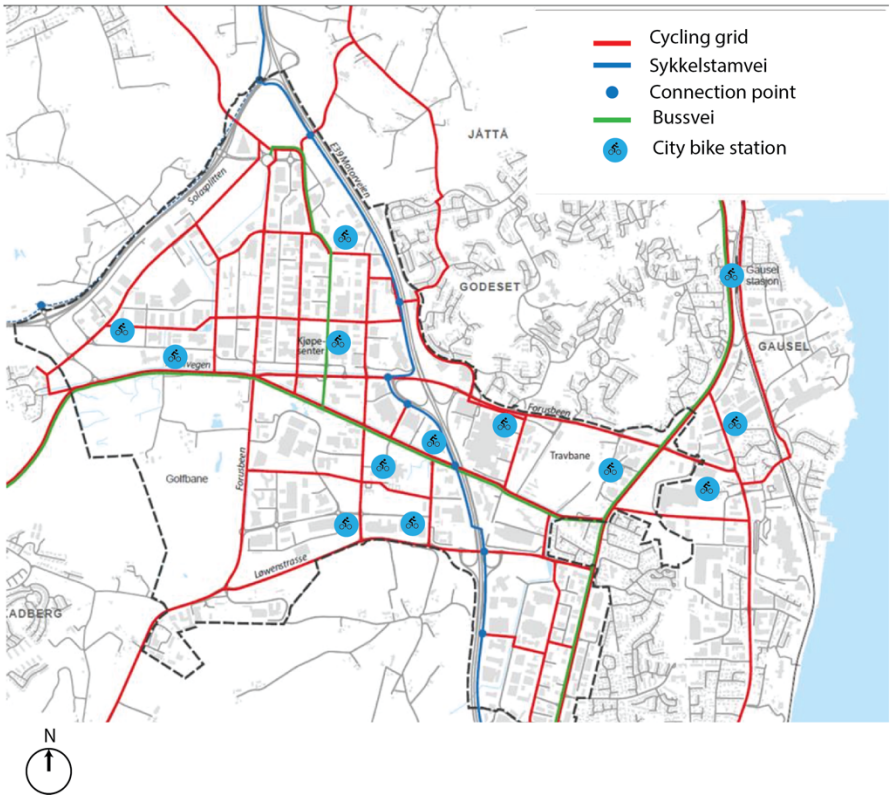

Figure 26. Cycling paths in the area based on the IKDP plan and example of parking for bikes. Modified map from IKDP plan and own figure.

Pedestrian paths

In daily basis the majority of the trips are done by motorized modes of transport, finished with a small walk from the bus stop or the parking lot to the final destination (Statens vegvesen & RVU gruppa, 2020). An essential concept for the development of well-connected grid of pedestrian paths. Not only to allow connections with other modes of transport but also to allow people to choose walking as their daily transport.

As previously mentioned in the current situation of the area, Næringspark has a complex-built environment with no housing in the business area and large distances between buildings. This difficulty affects directly to this mode of transport even though the infrastructure counts with multiple pedestrian paths in all direction in the area, see figure (27). Næringspark is not considered as a walkable area, with long distances and long travel times, considering that the business park is not a compact area. This means that the urban issue in the area cannot be solved through enhancing walkability unless the urban environment changes with a more lively and sociable environment where people can live, work and interact (Forsyth, 2015).

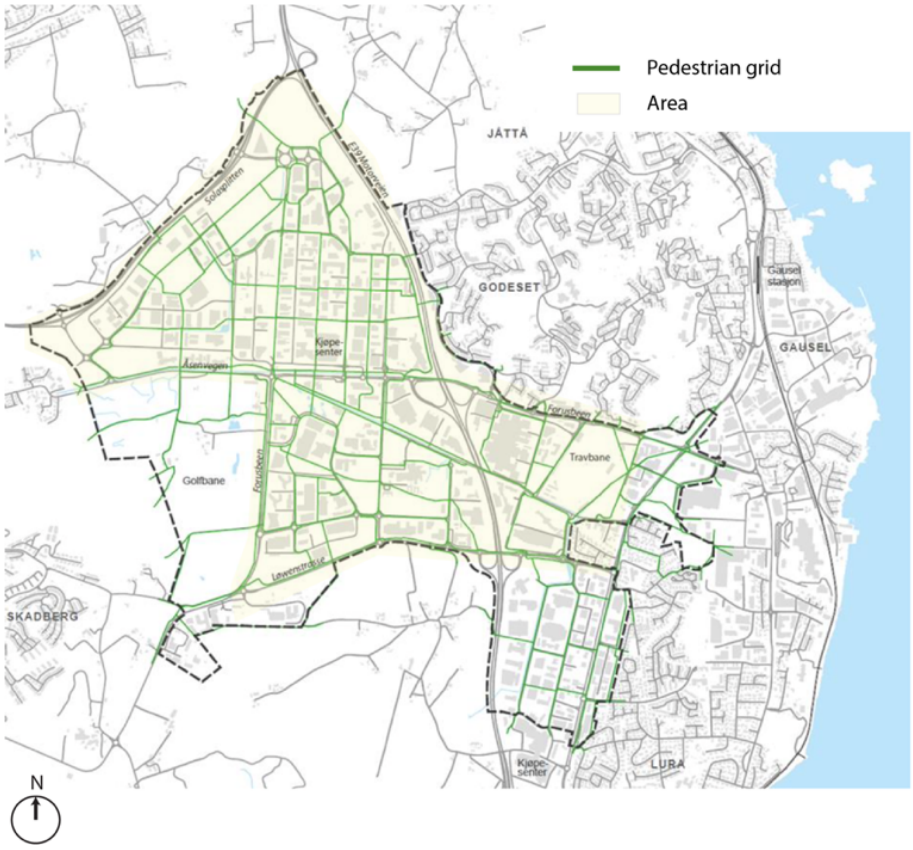

Figure 27. Pedestrian grid in the area based on the IKDP plan. Modified map from IKDP plan.

Not only walkability is important in the area but also outside of the business park. The location of Forus makes it difficult for pedestrians to connect with Godeset, Gausel, Lura or Jåttå walking, due to the highway barrier and the long distances. The urban design is built for other modes of transport rather than for pedestrians.

4.1.4 Transport modal split

Targeting the zero growth in passenger car transport, the priority in all the regional plans is given to other modes of transport such as public transport and active transport (walking and cycling).

Currently, many of the daily trips at a national level are taken by car 54% and followed by walking trips 23%. In a minority public transport accounts 8% together with trips as a passenger 10% and cycling 4% (Statens vegvesen & RVU gruppa, 2020).

This data has been obtained from “The nasjonal reisevaneundersøkelse (RVU)” in 2019 and 2020, and the recent survey “Sykkelundersøkelsen 2021” by Stavanger Kommune. The national travel habits surveys are key for the analysis of populations travel activity and travel patterns, used as a basis for the development and planning within the transport sector (Statens vegvesen & RVU gruppa, 2020).

Nord-Jæren

The division in modes of transport from the regional perspective is similar to the patterns follow in the national context. The car, as predominant mode of transport (53%), walking trips (20%), public transport (11%) and cycling (5%)(Statens vegvesen, 2019).

The public transport needs to be prioritized mostly in areas where the road network presents capacity challenges, like the case studied in this thesis. The grid in public transport in Nord Jæren is quite developed, offering service along the entire Stavanger-Sandnes belt but also with Sola or Randaberg. Indeed, the new plans focus on the belt in order to improve the accessibility of the bus, building a new bus road with prioritized access for the buses, reducing the waiting times when there is high congestion (Rogaland Fylkeskommune, 2022b).

As the second mode of transport, walking is included in most of the region's journeys (80%), meaning that every journey starts and finishes with a walk. The facilitation of pedestrian accessibility is essential, together with a mix of uses, compact development and infrastructure in order to choose walking as your mode of transport. Nowadays, the region counts on a wide network of walking paths (Statens vegvesen & RVU gruppa, 2020).

In terms of cycling, the bike accounts for over 11% of the journeys. The new development of Sykkelstamvegen is an important investment for the region with the purpose of increasing the accessibility by bike from Sandnes to Stavanger passing through Forus. Only one section of the project has been completed out of 6 sections. The cycle lane makes sure that the cyclist can feel safe during its journey and away from the road traffic (Statens vegvesen, 2020).

Stavanger and Forus

The transport modal splits follow the same patterns as the regional data. 50% of the trips are made by car, being the principal modes of transport followed by walking trips with 25%. In terms of public transport and the use of the bike the results from the surveys are quite surprising, mostly referring to the use of the bus. Only 7% of the trips are made by bus and 8% by bike (Statens vegvesen & RVU gruppa, 2020, p. 62).

The data registration in travels to work sightly differs with higher use of public transport (17%), nevertheless the car still dominating the area with 49% of the share. In relation to the use of the car 93% of the people interviewed in the national surveys, agreed on having a parking garage at home and 95% of the people have a driver license (Statens vegvesen & RVU gruppa, 2020).

The walking share traveling to work is 12 % and 17% by bikes. Cycling is increasing over the years in comparison with 2015 or 2017 and also with higher usage in the summer months. Out of the national surveys 64% agree on having a good system of public transport while 17% think that is good, 5% slightly

good, 2% bad and 12% does not have access to the infrastructure (Statens vegvesen & RVU gruppa, 2020).

Regarding to the specific share in modes of transport for Forus, the data from Rogaland Fylkeskommune has not been shared and therefore, not possible to be obtained. However, the transport share in Stavanger can be as reference to have an overview of the possible share in Forus, following the same car tendency as the dominant transport mode, but with some differences in terms of built environment, unique for Næringspark, Forus. In this case, and with a higher share, the dominance of the car is even more predominant, and probably less walking trips. Information that could not be collected.

4.1.5 Traffic Volumes

Traffic congestion happen due to an over capacity of the traffic network, when exceeding the regular traffic volumes. Normally this phenomenon happens in the peak hours going to work in the early mornings or in the afternoon when people come back from work, commonly every weekday. To prevent this issue, the area of Næringspark is surrounded by tolls as a measure to reduce the use of the car and generate an economic reserve to the conservation of the roads, public transport or cycling paths, see figure (28). People passing these tolls need to pay extra taxes to use them, mainly located in the highway and the exists to enter the business park. In addition to paying the toll, the choice to use the car increases up to 12 minutes or even more in the rush hour per every 30 min trip (TomTom, 2022).

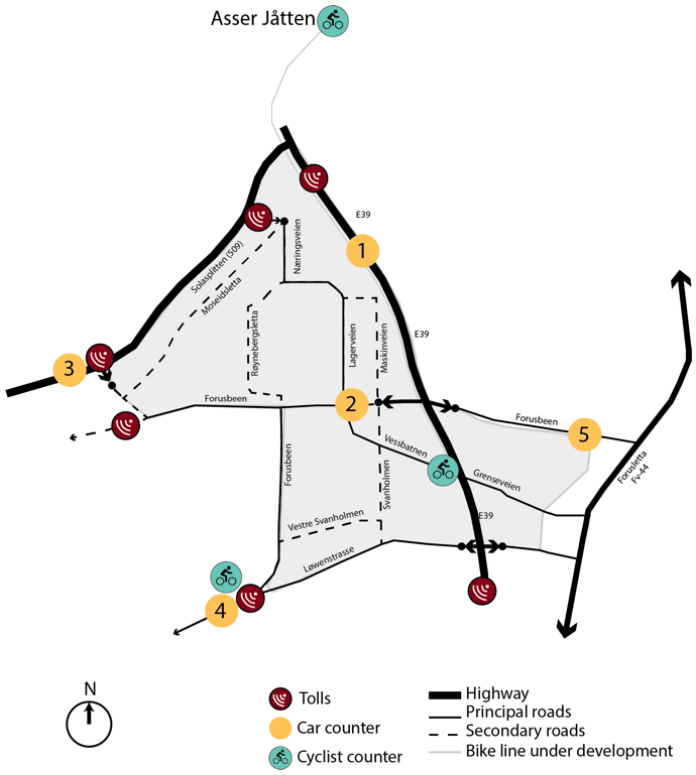

Figure 28. Traffic counters in the accesses to the business park. Own graph.

In addition to the tolls, the Norwegian public road administration has located different counters in the area to get an estimation of the traffic volumes. In this case, the data gathered represents the traffic volumes per hour in the location shown in table (4) during 2018, 2019 and 2020.

	Traffic Volumen/hour		
Location	*2018*	*2019*	*2020*
Forusbeen (2)	11337	11355	11884
Solasplitten (3)	7587	7866	6282
Forusbeen RV 44 (5)	9932	9698	9010
Forusbeen/Løwenstrasse (4)	6732	6432	5994
Jåtten E39 (1)	57221	56338	54573

Table 4. Traffic volumes of car per vehicle per hour. Source: Statens Vegvesen.

In a regular day the traffic volumes show a sharp increase in the peak hours, as the figure (29) shows, in the counter registered in Forusbeen day 06.04.2022 considering both direction to Sola and Forus øst.

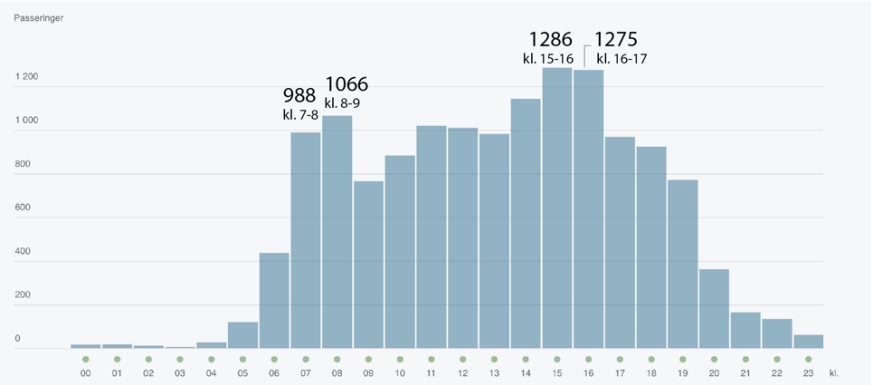

Figure 29. Graph showing the increase of traffic in the peak hours in the area. Source: Statens Vegvesen.

Mainly transited by car, Stavanger and Næringspark still have an average of 12% congestion level, with 19% of morning rush and 36% of evening rush. This means that travel times are 12 % longer than in regular traffic, making 4 minutes longer each 30-minute trip in regular flow traffic increasing to 12 min or even higher. In live congestion the diagrams can show even 70 % congestion with the highway completely blocked (TomTom, 2022).

Compared with 2020, this value has decreased by 1 minute, showing low changes in the traffic. An example of the rush hour in Forus at 15.00 pm shows the importance of recent changes in travel habits. The average congestion can increase up to 52% at this time, creating long traffic jams in the highway. As the figure shows the main congestion appears in the section connecting Næringspark, Forus (TomTom, 2022).

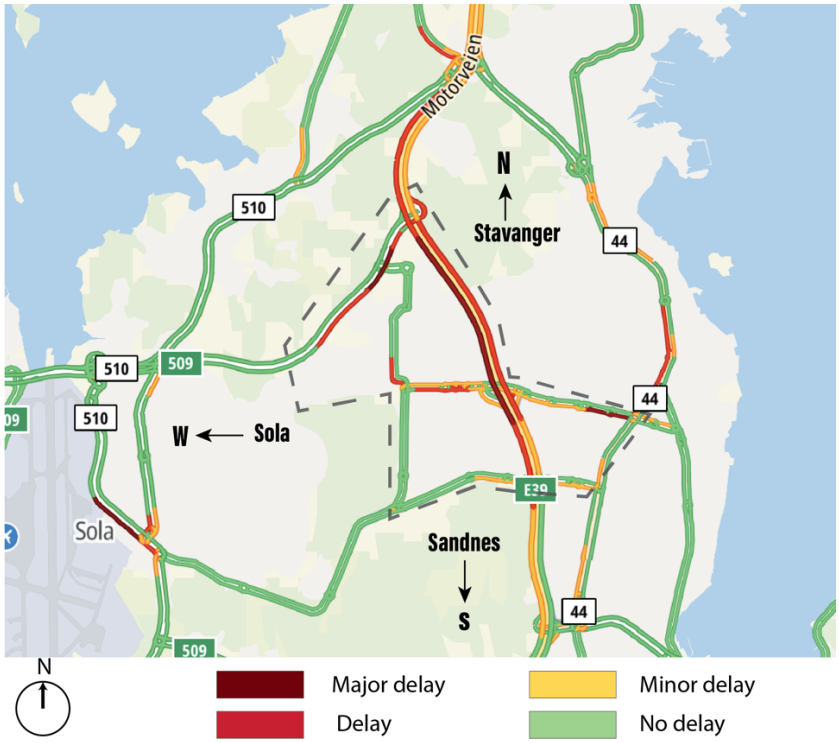

Figure 30. Congestion in the rush hour in the E39 at 15.00 pm, weekday. Modified figure from Stavanger traffic.

The data collected also provides the traffic volumes of cyclists in the counters located in Assen Jåtten (first section open in 2020 next to the highway), in Vassbotnen and Løwestrasse connecting with Forusbeen. In this regard, there is not much data available, the cycling highway is project recently started and approved.

	Traffic Volumen/hour		
Location	*2019*	*2020*	*2021*
Vassbotnen	333	276	250
Forusbeen/Løwenstrasse	-	191	147

Table 5. Cycling traffic volumes per vehicle per hour. Source: Statens Vegvesen.

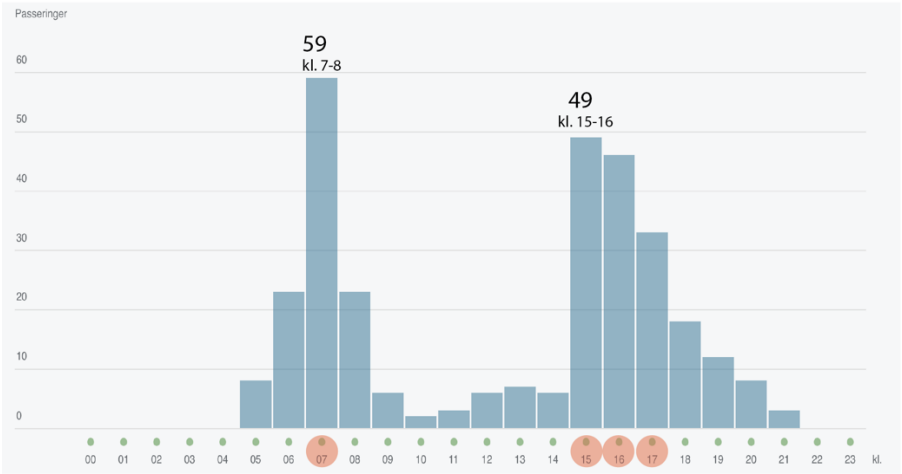

Figure 31. Graph showing the increase of cyclists in the working hours in the area. Data from the counter in Jåtten. Source: Statens Vegvesen.

This means that the existing transport measures are not interfering that much in the exits from the business park or Forus in the peak hours after or going to work. If the congestions level still show the same results as 2020 or 2019, it means that new measures need to be imposed, maybe stricter or applied in a different way. Nowadays, the traffic delay is quite high with major congestion in the main arteries of exit from Næringspark, being an issue that repeats daily after work.

4.2 ANALYSIS OF ACCESSIBILITY AND CAR DEPENDENCY

Based on the data gathered from the area, the analysis of this thesis consists of a comparative description of the different modes of transport previously mentioned. Being the core of the thesis, this part of the analysis evaluates the travel times through isochrones for the average times mentioned in the national survey for each mode of transport, and the comparison between them. Indeed, the analysis also evaluates the area used for parking and the parking ratios depending on the different areas of Næringspark.

The relation between land use and accessibility is described through the comparison between the population, the number of workplaces and employees that work in Næringspark and the areas that are basically car dependent with low public transport coverage. The possibility of a parking reduction, according to the plans, will directly affect those areas car based.

4.2.1 Comparative analysis of modes of transport

Travel times isochrones

In this analysis, the travel times evaluated as average are 5,10 and 20 minutes for the different modes of transport, such as driving, cycling, by public transport and walking. These travel times has been considered due to the average travel time given in the national survey, with the average between 5-19 min (Statens vegvesen & RVU gruppa, 2020). The area under study has no center of development and for this thesis, the center for this evaluation has been considered as the main axis of public transport for the area. The street Lagerveien connecting with Forusbeen is the center for the development of the travel times isochrones.

The following figures represent the travel times isochrones showing how the isochrones expand with the increase of travel times depending on the mode of transport and how the car has the highest coverage in relation to other modes, as figure (32) shows.

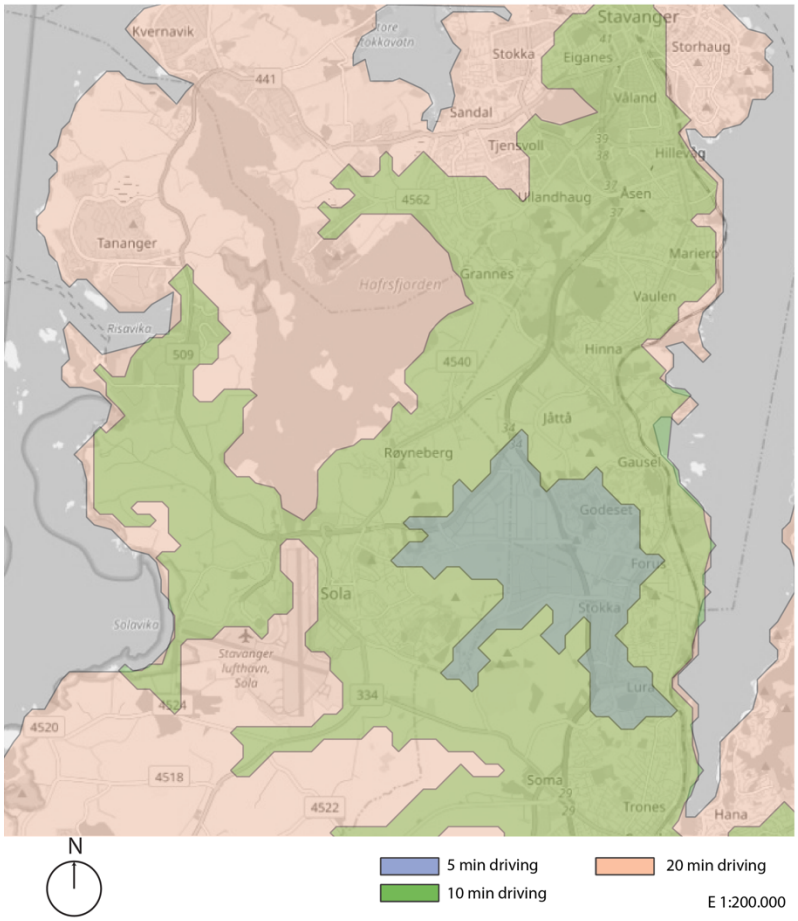

Figure 32. Travel times isochrones in 5,10- and 20-min driving. Own figure from GIS.

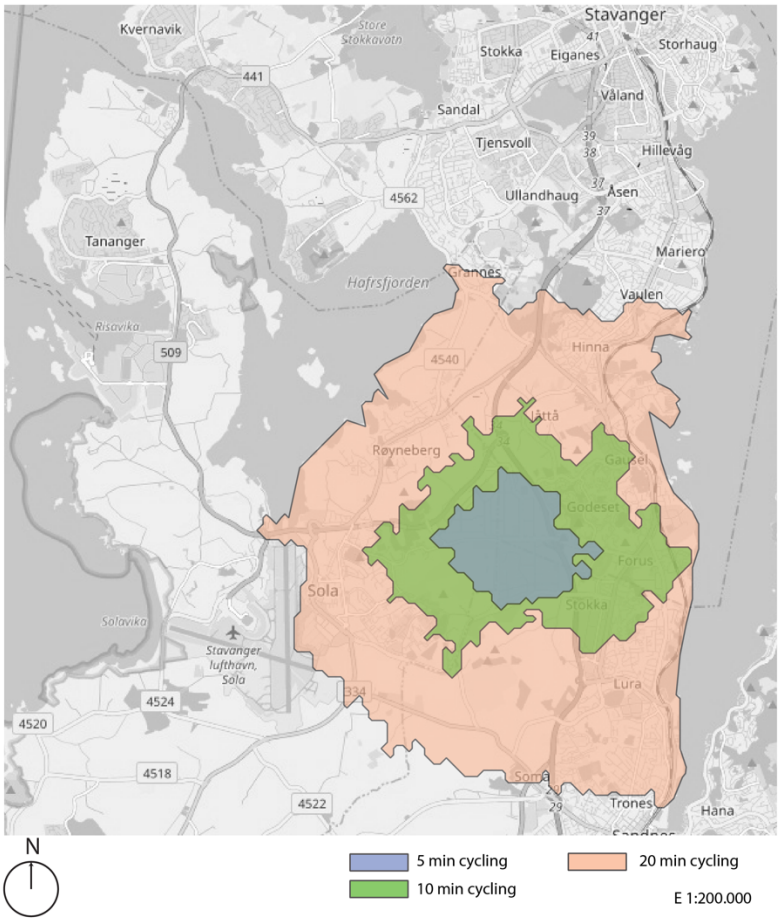

Figure 33. Travel times isochrones in 5,10- and 20-min cycling. Own figure from GIS.

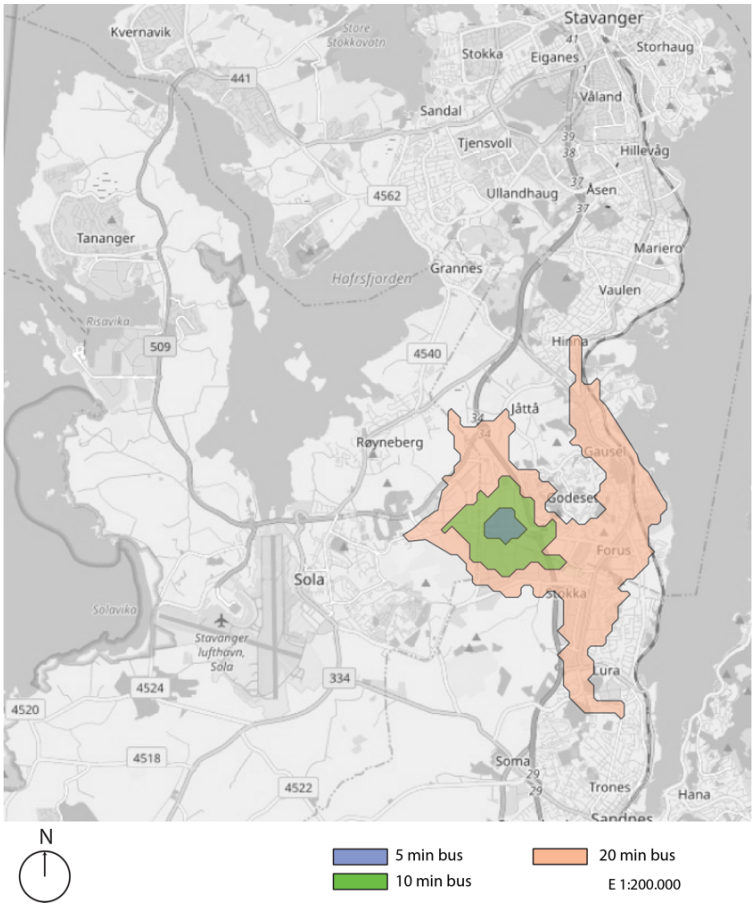

Figure 34. Travel times isochrones in 5,10- and 20-min by bus, public transport. Own figure from GIS.

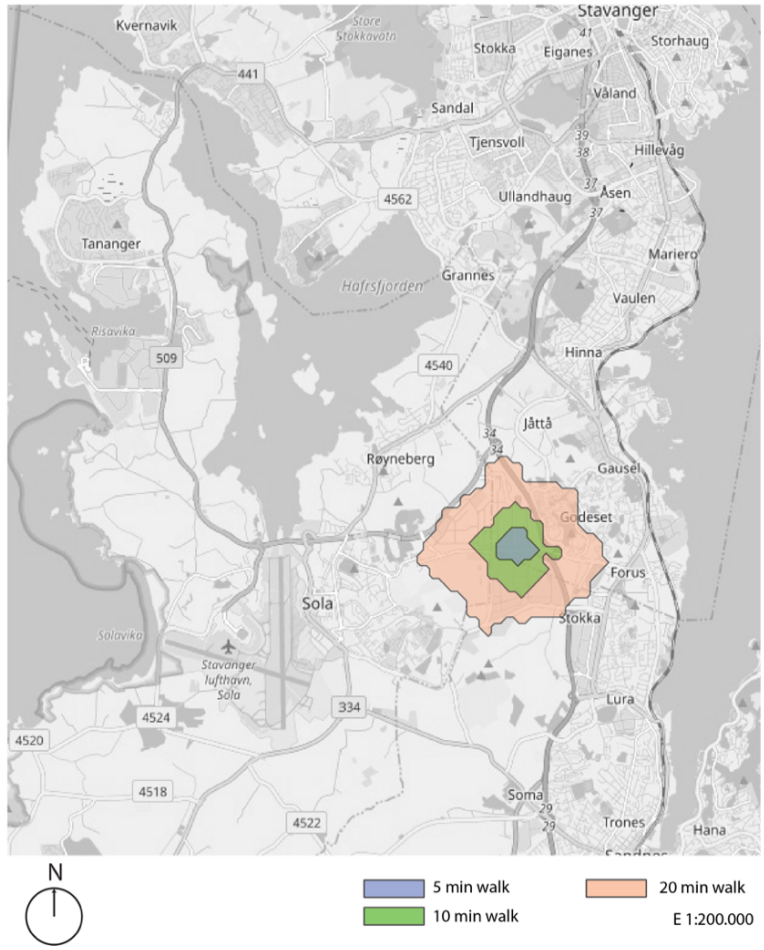

Figure 35. Travel times isochrones in 5,10- and 20-min walking. Own figure from GIS.

The results show the difference between the car and the rest of the modes of transport. The use of the car covers longer distances in less travel times in comparison with the rest of modes, where the coverage is quite low mostly in the case of public transport. Followed by the use of the car, cycling covers the entire area and even further, presenting good results in terms of accessibility while the bus, surprisingly does not expand out of Næringspark after 10min travel times, see figure (33 and 34). The bus infrastructure in 10 minutes shows similar results as walking in the same travel time, see figure (35).

Aimed on the comparison between modes of transport, the isochrones are represented comparing all the modes in 5, 10 and 20 min. In figure (36) the comparison between modes shows 5-minute travel time.

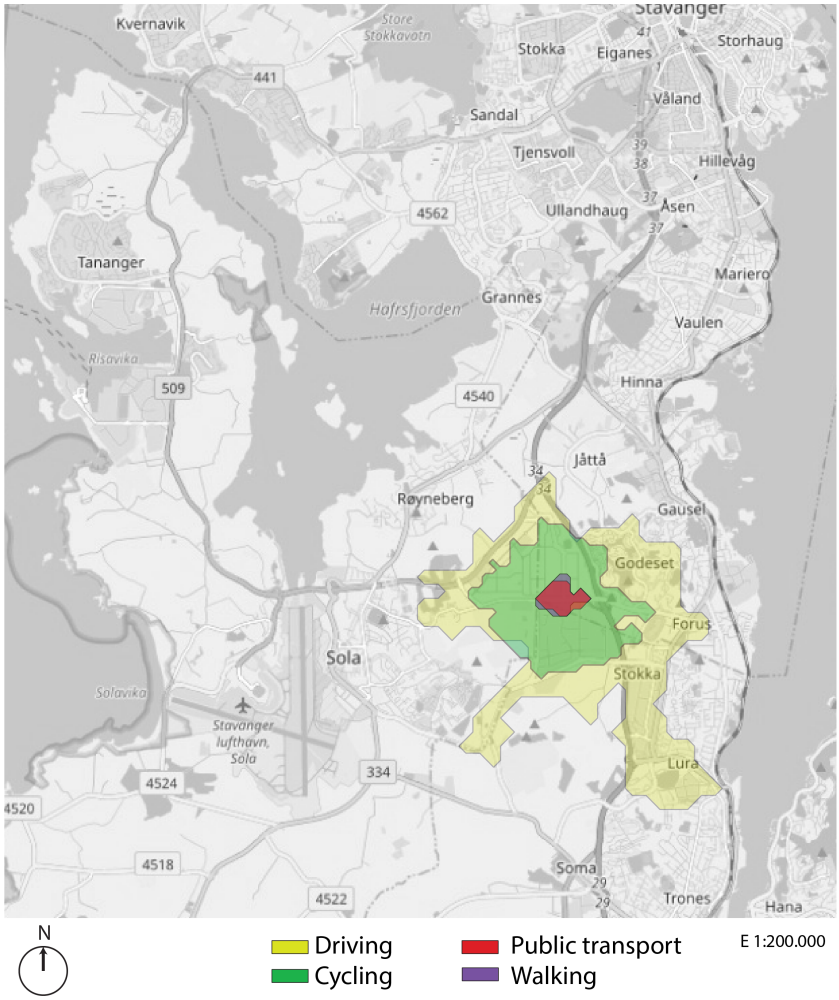

Figure 36. Travel time isochrones in 5 min from Lagerveien. Own figure from GIS.

In the 5 minutes graph, the public transport coverage is quite low, reaching almost the same destinations as walking, approximately 900m in the diameter of the isochrone. However, the cycling coverage shows a good result covering almost the entire area of Næringspark, meaning that the possibility to use the bike from the Lagersveien to reach workplaces is viable. In a wide range, driving covers the small neighborhoods surrounding Næringspark in the areas of Lura, Stokka or Godeset, increasing the accessibility for the cars.

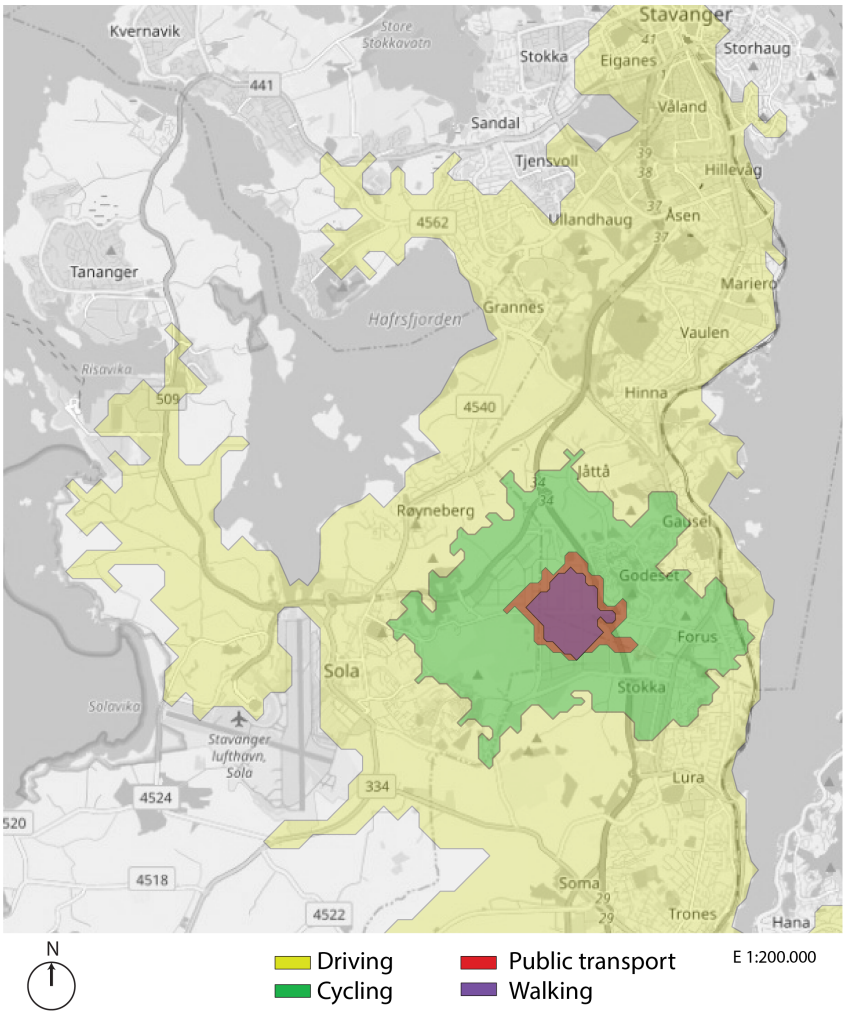

Figure 37. Travel times isochrones in 10 min from Lagersveien. Own figure from GIS.

In 10 minutes, the results show the same patterns, increasing even more the accessibility for the car. Just in 10 minutes' drive, the entire belt Sandnes -Stavanger is covered, including Sola and a small part of Tananger, as figure (37) shows. The road infrastructure connecting Forus with Stavanger and Sandnes makes this possible, otherwise on secondary roads the travel times would show different timings.

It is difficult to compare it with the accessibility of the public transport, which is poor even in 10 minutes trip. The bus only covers the main axis of public transport with around 2 km length from north to south and 1 km wide in Forusbeen, with a similar coverage as walking.

Cycling covers the entire Forus in a 10-minute trip, opening new connections with the belt Sandnes-Stavanger. This means that a trip to Gausel or Jåttå with the train or bus can be connected to Næringspark by bike in a short trip. Indeed, the train stops in these areas have city bikes stations to rent, as the figure (26).

Figure (38) shows the isochrones in 20 minutes travel time for the different modes of transport.

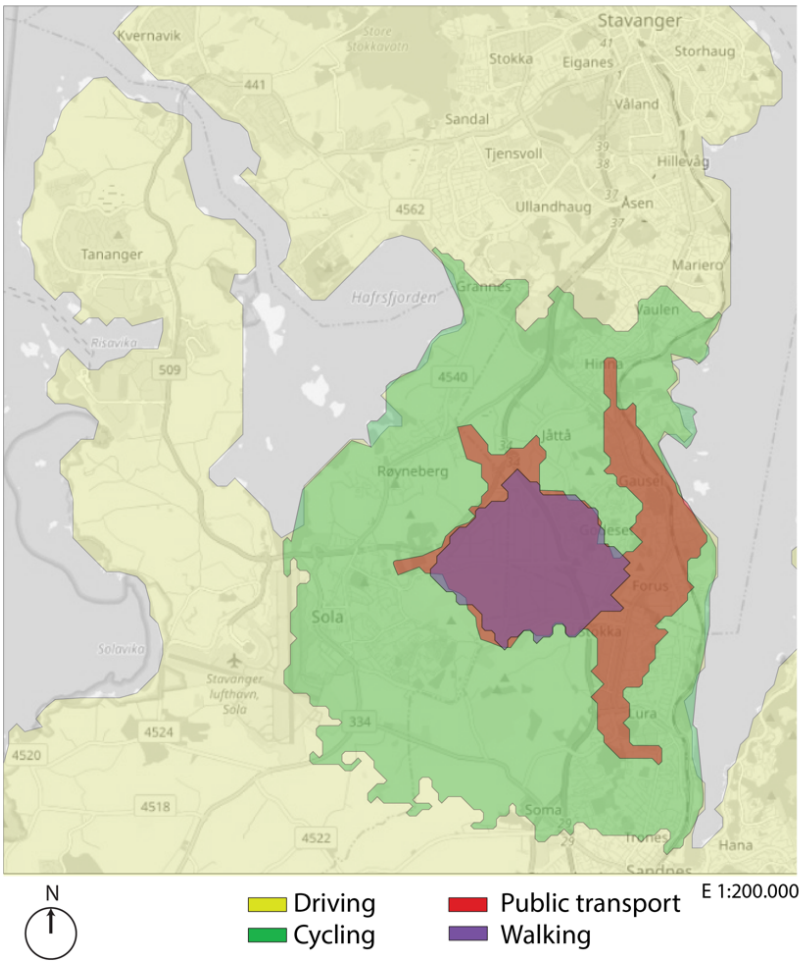

Figure 38. Travel times isochrones in 20 min from Lagersveien. Own figure from GIS.

In the last travel time analyzed, the 20-minute isochrones cover the entire area of Næringspark and Forus for all the modes of transport evaluated despite for walking, with some gaps in the area of Forus. The bus covers the entire business park connecting to Gausel, Jåttå, Stokka, or Hinna. The cycling isochrone also expanded into the university area and Sola, with a wide range of connections. As the most accessible mode of transport, driving covers even the islands in the north, Randaberg, Buøy and Hunvåg where part of the population has residence. In the south it also covers Ganddal, Bryne, Klepp or Ålgård.

As a result, this methodology has shown the relative attractiveness between modes of transport. The bus entails more travel time and more walks in comparison with the car, where you can directly drive to your destiny in less time and with free parking spaces next to your destination.

Following the description of accessibility in chapter 2, the daily trips to Forus have their origin in areas located out of Nærignspark, where people have their residence and travel to Forus to go to work. To integrate the registrations of transport and land use and population, first the evaluation of the travel times has been described to know what areas are accessible by the different modes of transport. The

connection of this analysis with the population of the area shows what areas are mainly car dependent and not covered by the public transport infrastructure, as shown in the following figures.

To evaluate which locations and number of inhabitants that are car dependent, the analysis uses the 20 min travel time isochrones as a limit time for the public transport, according to the average travel times described in the national survey (Statens vegvesen & RVU gruppa, 2020). The areas out of the 20 min isochrones are considered as car based.

The population data used in this analysis comes from SSB Statistiks, providing a more detail analysis than the grunnkrets for each kommune, previously used in the analysis but dismissed. The overlapping of the population and the public transport isochrone provides the exact number of the inhabitants that are covered by the public transport, showing the population that are car dependent in the three municipalities.

In this regard, the population under the public transport coverage is a total of 19.772 inhabitants, mostly concentrated in the area of Jåttå, Forus, Stokka, Lura and a little bit of Røyneberg.

With a total of approximately 250.000 inhabitants between the three municipalities, the population able to use the public transport from Forus is under 8%, according to the results obtained in this analysis and shown in figure (39). This means that people living in Randaberg, Tananger, Sola, Vaulen, Sandal or even Stavanger sentrum are car dependent because of the long travel times to travel to Forus. Travel times that can be higher than 30 min or in some cases, without direct line to Forus.

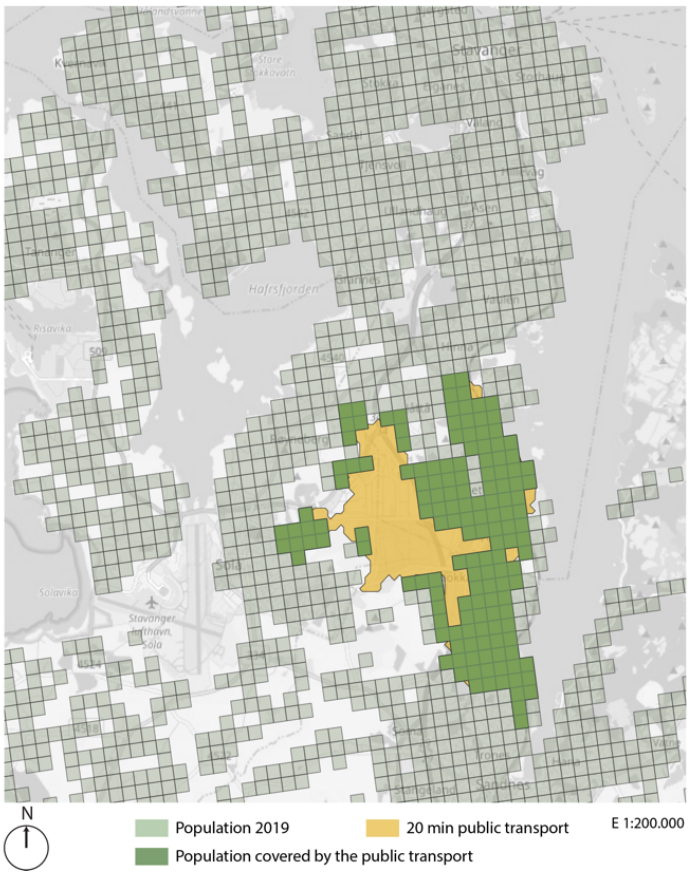

Figure 39. Correlation of the travel time isochrone (20min) and the population layer. Own figure from GIS.

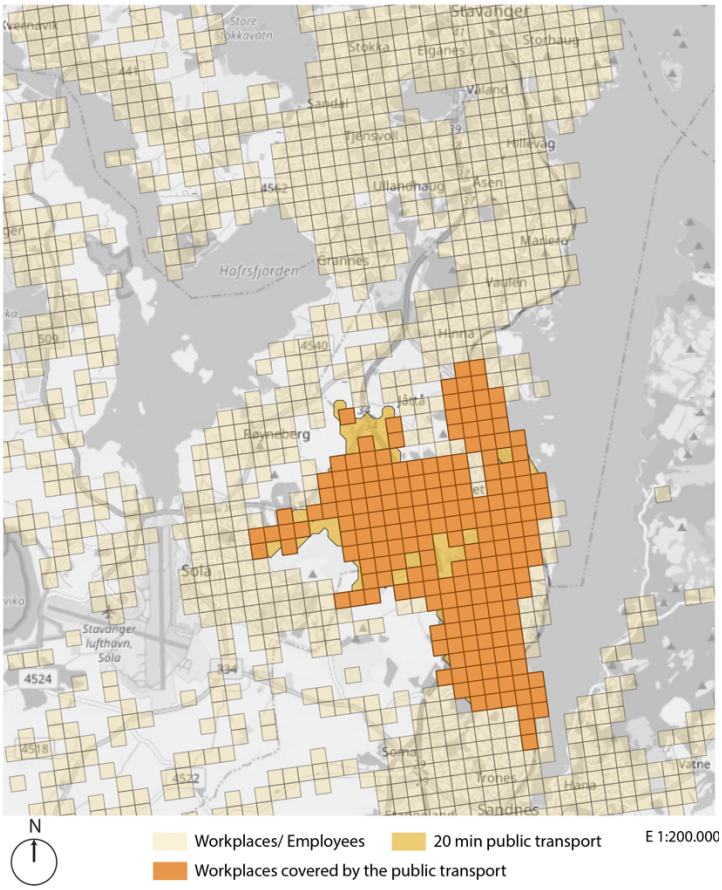

Figure 40. Correlation of the travel time isochrone (20min) and the workplaces layer. Own figure from GIS.

Running the same analysis in relation to the workplaces and employees, the total number of employees covered by the 20 min public transport is 39.777 employees and 3.208 workplaces, see figure (40). The results show how most of this employees and companies located in Forus are covered in 20 min travel time in connection with the FV-44. With a total of 42.654 workplaces and 230.952 employees in the entire Rogaland region, these results can be quite surprising, representing 7% of the total workplaces and giving answer to why people choose the car over other modes of transport. Probably there are different reasons together with commodity, but as shown in this analysis, is basically related to the poor service and coverage of the public transport.

To show an interesting part of this analysis, the evaluation of cycling in 15 min travel time shows even better results than the public transport, as figure (41 and 42) shows. The use of 15 min travel times was established to represent the comparison of modes, considering a less travel time in comparison with the bus.

The coverage in travel times is better, as mentioned in the first part of this analysis, but also the results in the correlation between workplaces and population layers. The population that is covered by 15 min cycling is 37.654 inhabitants, in addition to 4.674 workplaces and 50.382 employees.

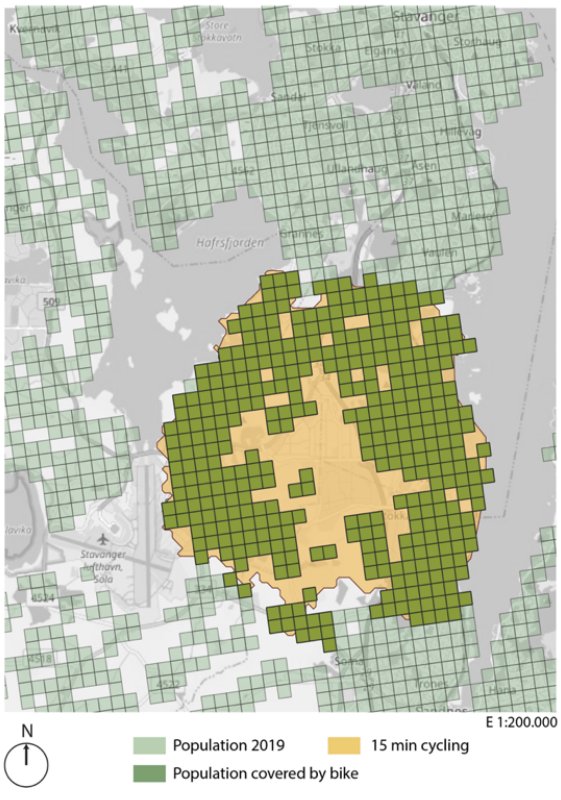

Figure 41. Correlation of the travel time isochrone cycling (20min) and the population layer. Own figure from GIS.

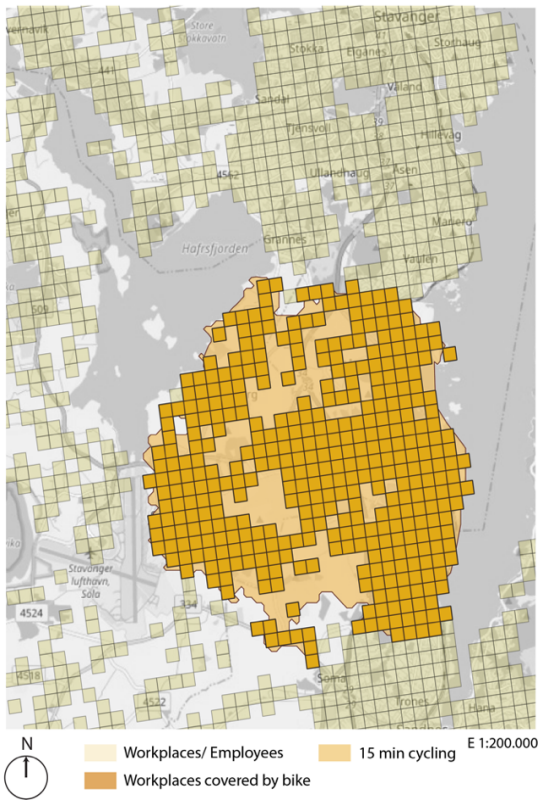

Figure 42. Correlation of the travel time isochrone cycling (20min) and the workplace layer. Own figure from GIS.

Reducing the travel times, the analysis shows better results in terms of accessibility for the use of the bike rather than the use of the public transport, which means that the infrastructure of Næringspark is increasing but aimed on cycling, to attract people to use the cycling lines and the highway instead of the car. The areas mainly car dependent from Næringspark are Tananger, Randaberg, Hana, Sandnes, Sola, Hillevåg, Mariero or Stavanger city center. These areas are dependent on the use of the car to go to the business park or Forus due to the high travel times, even having direct bus lines going to Forus, in some cases.

Inside Næringspark, it is difficult to identify which areas are car dependent, considering the complexity of this topic. However, the analysis of catchment areas for the bus stops will show which areas are likely to be out of the service area and become car dependent.

4.2.2 Catchment areas

Considered as a simple and suitable approach for the evaluation of catchment areas, the circular buffer approach examines the stop locations with catchment rings of 400m, as shown in the figure (43). Creating a radius of 400m in the center line of the bus stop, it is possible to appreciate the areas that would decrease in share when the distance increases. This shows what are the marginal areas that

should be destinated for industrial purposes, logistics or warehousing, where the parking densities could be higher than in the buffer areas. In this case, the analysis evaluated the 400m buffer zone according to the plan and also the 300m buffer zone, due to the low public transport service in the area, as shown in the travel times of the first part of the analysis.

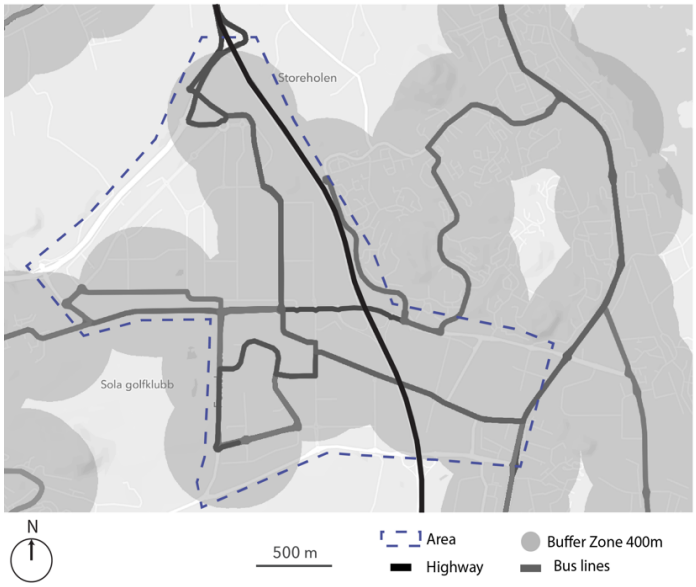

Figure 43. Buffer zone of 400m from each bus stop in the area. Modified figure from Kolumbus data.

With a 400 m zone, almost the entire business park is covered by public transport considering the numerous bus stops. However, and as analyzed, the public transport service is quite poor also in terms of travel times and frequencies, which is the reason why the buffer zone for this area should be lower than what the plans described. For this analysis, the buffer zone evaluated is 300m from each bus stop considering that a major part of the business park is designated to warehousing and industrial purposes, see figure (44).

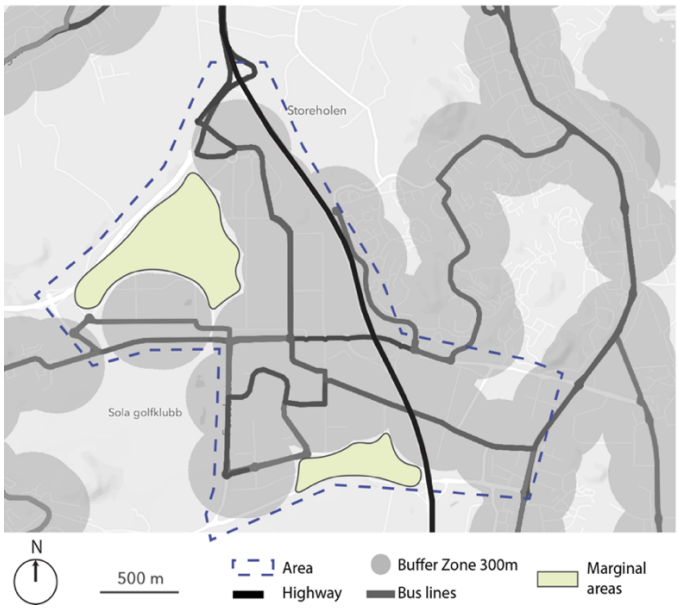

Figure 44. Buffer zones of 300m from each bus stops in Næringspark. Modified figure from Kolumbus data.

The results show the marginal areas that are car dependent in need of higher parking coverage. The only way of travel for the employees in these workplaces is by car or active transport, considering that the area is characterized by the long distances the only modes of transport are by car or by bike.

In relation to the connectivity with services, the catchment areas provide a very limited data, being representative only in the central area of Næringspark, where the variety of services could make people choose walking as a mode of transport. According to Denstadli, all destinations out of the 1 km zone tend people to depend on the car instead of using other active modes of transport such as walking (Denstadli et al., 2006, p. 30).

Figure 45. 1 km zone from the main Forusbeen in Næringspark, showing the covered walking area. Own figure.

4.2.3 Parking coverage

As part of the analysis, the parking coverage gives an estimation of the area used for parking, the parking spaces and the ratios per 100 m2 BRA. Several visits to Næringspark and the details of each type of parking have been used in the calculation of the densities and parking coverage.

The total area used in the analysis is 3,1 km2 and 1,6 km2 of BRA (Asplan Viak, 2019), dividing the business park into small areas for an easy data collection and calculation of the parking ratios per 100 m2 BRA.

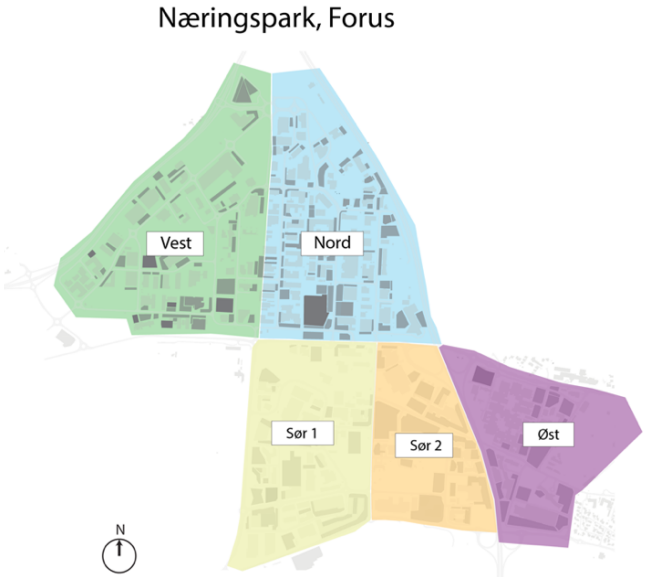

Figure 46. Area divided into zones for the calculation. Own figure.

The total area calculated of parking is 431.447m2 for surface parking, 16.592 m2 of roof parking only located in the shopping mall building in Tvedtsenteret, 30.992 m2 of underground parking mostly private for each company and 114.721m2 of parking in blocks. Figure (17) shows the location of each type of parking in the area.

With the area calculated and the total BRA, the number of parking lots can be obtained considering a stablish parameter of 25 m2 that includes the space for the car parking and also the area to maneuver. Nowadays, Næringspark has 38% of the total BRA designated to parking.

	Total Parking area (m2)	Total m2 BRA	Total area (m2)	% of parking	Parking spaces	Ratio per 100 m2 BRA
Vest	114 755	353 000	791 906	**33%**	4 591	**1,3**
Nord	130 299	330 000	758 082	**40%**	5 212	**1,6**
Sør	258 915	624 000	1 044 777	**42%**	10 357	**1,7**
Øst	89 783	260 000	498 813	**35%**	3 601	**1,4**
TOTAL	**593 752**	**1 567 000**	3 093 578	**38%**	**23 761**	**1,5**

Table 6. Total parking calculations. Own table.

As shown in the table, the total parking spaces is 23.761 in the entire area, with an average ratio of 1,5 parking spaces per 100 m2 BRA. The biggest amount of parking comes as a surface parking, present in every plot and often combined with underground parking for the employees. The utmost coverage in parking is located in the sør area of Næringspark, with a coverage of 42% in relation to the total sør part, and a ratio of 1,7 parking spaces per 100m2 BRA. This happens due to the presence of Equinor in that area and the building blocks for parking for Oceaneering and the companies nearby. Equinor has its base in Forusbeen, with a massive amount of land designated to parking, not only surface parking, but also building blocks built for parking purposes. Indeed, in the sør of Næringspark many automobile companies and warehouses are located.

Followed by 40% of the parking coverage, the nord and øst area of Næringspark are also considered with high occupancy of parking. It is not as high as in the sør area due to the availability of land that will be developed or that is available for new companies to move to the business park. The vest area has similar characteristics but with a higher percentage of land free of usage.

When it comes to underground parking, some companies have their own access to underground parking restricted to employees. The collection of data in this matter has been a challenge, most of this parking has restricted control in the entrance and could not be visited, so the area considered in the calculation has been considered as the building BRA.

This conservative measurement shows how the parking capacity in Næringspark is exceeding the limits according to the plans. To have an overview of the ratios in the entire area, the following figure (47) shows the different ratios per 100 m2 BRA depending on the area analyzed.

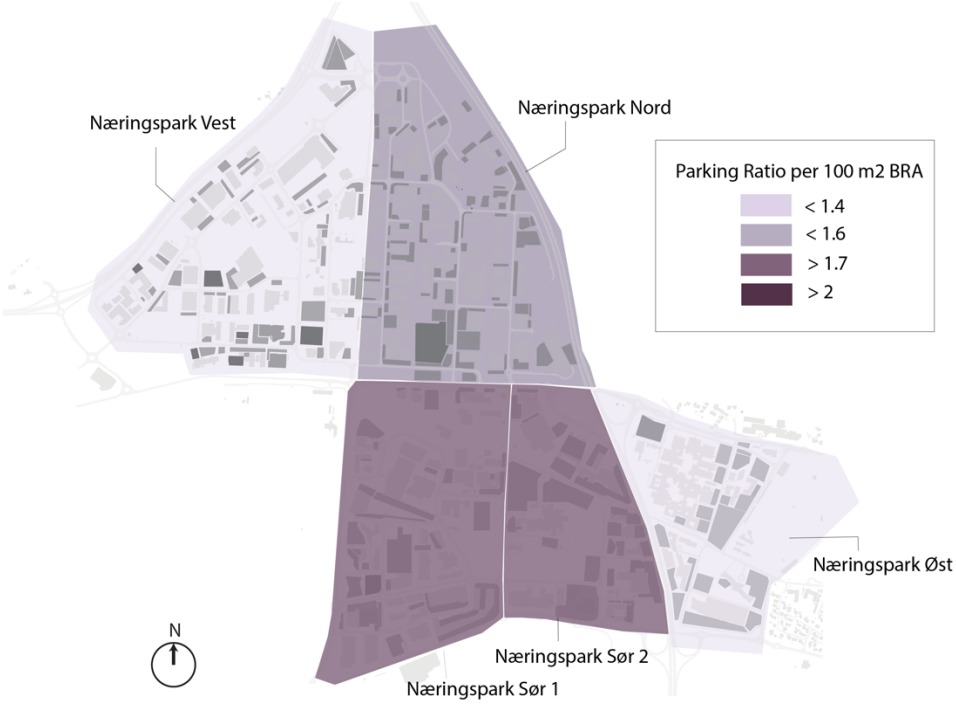

Figure 47. Parking ratios per 100 m2 BRA per zone. Own figure based on the calculations.

The overcapacity of parking spaces promotes the use of the car for the employees working in the area but also the visitors. Næringspark is monofunctional without walkable distances, making people to not considered other modes of transport.

Nowadays, and as explained, the area has a clear predominant mode of transport with difficulties to new changes. It presents high accessibility for cars, due to travel times and parking availability.

Indeed, to recognize the areas promoting the car are mainly the biggest companies in the oil industry. These companies provide many services for their employees, offering an ensuring parking space and probably many other commodities, as Equinor does.

The workplaces with the highest parking coverage promoting the use of the car are Equinor, having the highest plot area, Subsea7, Oceaneering, Biltema and Neptune Energy Norway. Most of these companies belong to the oil and gas industry and have a bus connection in the proximity.

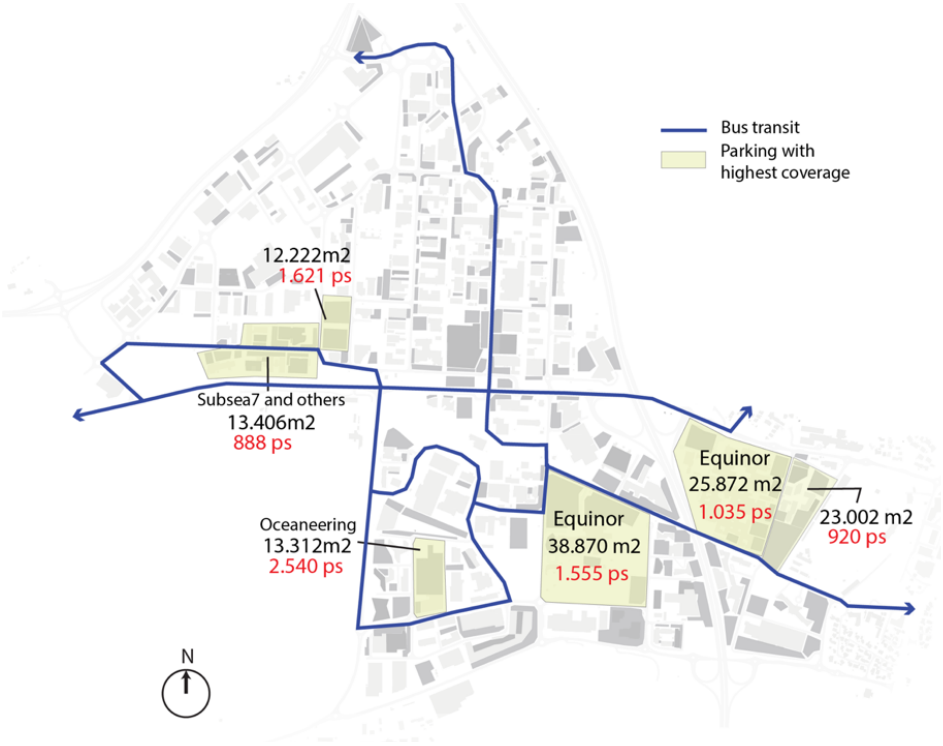

Figure 48. Areas promoting car dependence due to parking availability. Own figure.

Figure (48) shows the main companies that promote the use of the car for their employees, as mentioned. Privately owned, it is difficult to interfere in the parking restrictions to reduce the number of parking spaces, but as described in the spatial analysis, chapter 4, many of the parking spaces will never be used. In a regular working day, the parking of Equinor or Oceaneering still having multiple free spaces, meaning that the parking exceeds the parking spaces needed, ensuring a free space to park. People travelling to Næringspark or Forus will not reconsider choosing the car unless the public transport infrastructure improves or introduces economic charges for the cars.

4.3 Scenario based on the parking restriction

As a second part of the analysis and having the overview of the area designated to parking according to the calculations, the IKDP plan gives some alternatives and recommendations in relation to solve or mitigate this challenge. Previously mentioned in chapter 4, the final recommendation given by the intermunicipal plan is to set a restriction of maximum 0.3 parking spaces per 100 m2 of potential BRA (IKDP Forus, 2018). This setting will be applied for the central areas, the main public transport axis and the industrial areas in relation to the potential BRA described in the IKDP plan.

The application of this recommendation is now evaluated with the recalculation of the parking ratios considering the potential m2 of BRA. In this case, the percentage of parking reduces together with the ratio per 100m2 of BRA. The average ratio is 0,8 per 100m2 considering a total potential BRA of 2,8 km2.

	Total Parking area (m2)	Total m2 potential BRA	Total area (m2)	% of parking	Parking spaces	Ratio per 100 m2 BRA
Vest	114 755	737 000	791 906	**16%**	4 591	**0,6**
Nord	130 299	670 000	758 082	**19%**	5 212	**0,8**
Sør	258 915	1 066 000	1 044 777	**24%**	10 357	**1**
Øst	89 783	360 000	498 813	**25%**	3 601	**1**
TOTAL	**593 752**	**2 833 000**	3 093 578	**21%**	**23 761**	**0,8**

Table 7. Calculation of parking spaces and ratios according to the potential BRA proposed in the IKDP plan. Own figure.

The application of the 0.3 parking spaces per 100 m2 of BRA is still a low parameter compared with the results obtained in table (7), showing double or triple of what the plans described. The restriction gives the possibility to reuse the land for different purposes, but with the challenge that most of the parking is privately owned with only a few parking spaces for customers, depending on political agreements to make a possible transformation to the area. The parking spaces will be reduced to 8.499 spaces out of 23.761 parking spaces, reducing the car accessibility and leaving the area with poor service and marginal zones.

The recommendation is considered as a maximum of 0.3 parking spaces per 100 m2 BRA which is equivalent to a reduction of 15.262 parking spaces less than the current state. In addition to this, there are multiple warehouses in Næringspark and many of them are related to manufacture, maintenance of cars and cars for sales, reason why a general restriction will not fit for this companies, considering that they need parking buildings for the storage of the vehicles.

In general, the restriction on parking is quite aggressive and it will carry political decisions and important economic investments. Indeed, the possible appliable restrictions should be adapted to the characteristics of each area. The reduction in parking could only leave some areas of Næringspark disconnected with the urgent need to potentialize the public transport infrastructure and connectivity. Currently, the dependency on the car in Næringspark is high and the restrictions on parking will only have efficient and positive results if the measures are linked to the improvement of the public transport system.

There are examples where the restrictions in parking have had an impressive result in the reduction of cars and the promotion of other modes of transport, this are mentioned in chapter 2, as examples of efficient measures to impulse other modes of transport.

5. DISCUSSION

The transport infrastructure for Næringspark and Forus is a topic included in many of the existing plans to reduce car dependency in relation to the availability of parking and to promote public and active transport. Described in the analysis of this thesis and also present in the intermunicipal plans, it is a challenge to solve in order to promote other modes of transport due to the high number of daily trips to the area and to go to work.

The possibility of implementing parking restrictions in private plots is quite complex and it might carry economical compensations and political decisions to interfere in the private properties with intermunicipal collaborations (Stavanger, Sandnes and Sola). This case can be compared with other cities that have been successful in terms of implemented measures to reduce the use of the car, but the characteristics of Næringspark are totally different from central areas, as compared in the plans.

The main challenge is the built environment. The area was built to be dependent on the car, with the establishment of most of the industries from the adjacent municipalities in the location of Forus during the last decades. Currently, the new changes are difficult to impose and to produce benefits. As shown in the analysis, the results prove the low level of accessibility in public transport to the area and the lack of connectivity and quality in the public transport infrastructure.

Centrally located in the belt Stavanger-Sandnes, the focus for futures plans should include more alternatives to improve the service and reduce the travel times for the bus infrastructure, implementing more bus lines or increasing the frequencies for the area together with the train infrastructure, in case of longer distances. Probably the implementation of new uses and housing in Næringspark could have an impact on the travel patterns, but those actions could take long periods of time and also large economical investments.

For example, the cycling infrastructure for the region is under development and improving over time, with easy access to the business park from different locations. The investment in this mode of transport over the last years is getting good results showed in the shared (Stavanger Kommune, 2021). Nevertheless, the climate conditions and the large distances for some of the inhabitants, still choosing the car over the active transport, rather than choosing the public transport.

This thesis sets out different research questions that quantify the amount of people affected by each mode of transport when travelling from Forus, as well as the employees working in the area.

1. *How many people are car dependent when travelling to/from Forus? And which areas?* The number of inhabitants covered by the public transport traveling from Forus is 19.772 inhabitants, representing 8% of the total inhabitants between the three municipalities interfering in Næringspark. Mostly concentrated in the area of Jåttå, Forus, Stokka, Lura and a

little bit of Røyneberg. Considering that Næringspark is a business park, the total of workplaces and employees covered in 20 min are 3.208 companies and 39.777 employees in the entire Forus, representing a 7% of the total workplaces in the region.

This means that people living in Randaberg, Tananger, Sola, Vaulen, Sandal or even Stavanger city center depend on the car to go and leave Næringspark, Forus, because of the long travel times. Travel times that can increase up to 30-40 min or in some cases, without direct connection from Forus.

2. *Which workplaces are car-promoting through parking?* Surprisingly, Equinor is the workplace with the highest capacity in parking promoting car dependency for their employees. With a total of 2.590 parking spaces, Equinor uses 64.747 m2 of land for parking spaces, including two buildings of 3 storeys. Followed by Oceaneering, this oil company has 2.540 parking spaces and 13.312 m2 of land for parking. Of a total of 28.726m2 in the plot, 46% of the land is parking with a building of 6 storeys for parking. With approximately the same m2 for parking, Subsea7 and other companies in the Nord part of Næringspark have 888 parking spaces and 13.406 m2, also with private parking in buildings of 3 and 5 storeys.

The fact that the biggest companies with the highest number of employees in the oil and gas industry provide facilities for their employees to park, makes it a difficult obstacle. Being private companies or even partially government owned, the reduction of parking spaces is probably not a measure that they would implement or consider accepting. These companies try to provide the best facilities for their employees and even introducing measures to support the use of the bike or public transport, their employees continue using the car. This shows the complexity of this issue, where probably the effective reutilization of the land is not a suitable measure in this case, falling directly on the strengthening of the public transport infrastructure.

3. *How will parking restrictions impact on the area to reduce the use of the car?* The implementation of parking restrictions in the area without any improvement in the public infrastructure will reduce accessibility by car but also will create marginal areas with workplaces. Areas in need of other alternatives of transport to allow people to travel every day to work. The increase in frequencies or the implementation of new lines covering the entire area, in combination with parking restrictions, will allow the employees of Næringspark to change their travel habits and start using public or active transport.

The examples used as references in chapter 2 show how parking restrictions and the restriction of the car for the main streets has had effective results, but considering the environment in Næringspark, the

restriction in parking would only create marginal areas were employees will depend on the car to go to work and without possibilities of parking. Indeed, the cities used as reference could have a different share in modes of transport, being more walkable as the city of Oslo. Parking restrictions could only be applied if combined with incentives such as, reduction of prices for the use of the bus, mainly for employees, or creating internal lines increasing the connectivity with the main stops. This might persuade employees working in the area to use the public infrastructure in order to transform the business park into a location accessible to the entire region without the need to use the car. Then, the travel patterns could start showing results, otherwise, Forus and Næringspark would still be car dependent.

In general, this thesis has been based on a conservative measurement of the parking coverage, considering the hidden amount of parking in private land. Its complexity made it a challenge that has concluded giving a detailed answer to the research questions aiming at the car dependency in Næringspark, Forus.

6. CONCLUSION

To conclude, this thesis has shown how the challenge of parking is currently presented in Næringspark affecting the car dependency. To solve or mitigate this issue there needs to be a tremendous effort from policy makers, urban planners and also the companies established in the business park. Despite the clear car dominance in the area, the plans and current developments show how the cycling infrastructure is further developed than the public transport, showing better results in travel times when travelling from Forus. Due to its biggest challenge, the built environment, Næringspark is not a walkable place due to the large distances and its proximity to the highway barrier. Indeed, it has a lack of social interaction and livability, necessary in compacts areas to potentialized other modes of transport rather than the car.

With large private plots, Næringspark presents challenges to introduce restriction measures in terms of land destined for parking, measure considered as not viable and carrying a large restructure of land uses. Potentializing the public infrastructure is then the possible solution to mitigate the issue, being poor in this area. The bus infrastructure should be further developed in the plans to transform the business park that accommodates a high percentage of the employees in Nord-Jæren, into a more interconnected location. In this way, travel patterns will start changing and probably people will use other modes of transport instead of the car.

LIST OF FIGURES

Figure 1. Stavanger location in a national and regional perspective. Own figure.

Figure 2. Area under study, Forus and Næringspark. Own figure.

Figure 3. Graph of the areas surrounding Forus. Own figure.

Figure 4. Significant companies related to the oil industry in the area. Modified figure from Forus Næringspark. Source: https://www.forusnaeringspark.no

Figure 5. Large parking area in Næringspark, Equinor. Source: https://www.google.com/maps

Figure 6. Traffic congestion in the highway E-39 connecting with Næringspark, Forus. Own figure.

Figure 7. Illustration of connectivity. Own figure.

Figure 8. Illustration of city life and active transport. Own figure.

Figure 9. Afternoon traffic in the A4 to Rotterdam. Source: https://nltimes.nl/2020/02/14/traffic-jams-a4-highway-persist-2030

Figure 10. Illustration to transform congested cities into environmentally-friendly cities. Own graph.

Figure 11. Example of public transport isochrone map for the London bank station showing 15,30- and 45-min catchment area. Source: https://www.gislounge.com/how-to-create-public-transport-isochrones-in-arcgis-pro/

Figure 12. Population in Stavanger, Sandnes and Sola municipality. Source: https://kart.ssb.no

Figure 13. Concentration of workplaces in Stavanger, Sandnes and Sola municipality. Source: https://kart.ssb.no

Figure 14. Data from the IKDP plan. Own figure.

Figure 15. Mixture of uses in the area. Own figure.

Figure 16. Parking facilities in Næringspark. Own figure.

Figure 17. Different types of parking in Næringspark. Own figure.

Figure 18. Height of buildings destinated for parking. Own figure.

Figure 19. Parking for bikes in Næringspark, Forus Nord and Sør. Own figures.

Figure 20. Facilities in Forus and Lura. Source: https://public.tableau.com/app/profile/stavanger.statistikken

Figure 21. Graph of the main roads in Næringspark. Own graph.

Figure 22. Graph of the main and secondary arteries of the public transport. Own graph.

Figure 23. Public transport shapes. Own figure by GIS.

Figure 24. Public transport stops in Næringspark. Own figure by GIS.

Figure 25. Cycling highway. Source: https://www.vegvesen.no

Figure 26. Cycling paths in the area based on the IKDP plan and example of parking for bikes. Modified map from IKDP plan and own figure. Source: https://ikdpforus.com

Figure 27. Pedestrian grid in the area based on the IKDP plan. Modified map from IKDP plan. Source: https://ikdpforus.com

Figure 28. Traffic counters in the accesses to the business park. Own graph.

Figure 29. Graph showing the increase of traffic in the peak hours in the area. Source: https://www.vegvesen.no

Figure 30. Congestion in the rush hour in the E39 at 15.00 pm. Modified figure from Stavanger traffic. Source: https://www.tomtom.com/en_gb/traffic-index/stavanger-traffic/

Figure 31. Graph showing the increase of cyclists in the working hours in the area. Data from the counter in Jåtten. Source: https://www.vegvesen.no

Figure 32. Travel times isochrones in 5,10- and 20-min driving. Own figure from GIS.

Figure 33. Travel times isochrones in 5,10- and 20-min cycling. Own figure from GIS.

Figure 34. Travel times isochrones in 5,10- and 20-min by bus, public transport. Own figure from GIS.

Figure 35. Travel times isochrones in 5,10- and 20-min walking. Own figure from GIS.

Figure 36. Travel time isochrones in 5 min from Lagerveien. Own figure from GIS.

Figure 37. Travel times isochrones in 10 min from Lagersveien. Own figure from GIS.

Figure 38. Travel times isochrones in 20 min from Lagersveien. Own figure from GIS.

Figure 39. Correlation of the travel time isochrone (20min) and the population layer. Own figure from GIS.

Figure 40. Correlation of the travel time isochrone (20min) and the workplaces layer. Own figure from GIS.

Figure 41. Correlation of the travel time isochrone cycling (20min) and the population layer. Own figure from GIS.

Figure 42. Correlation of the travel time isochrone cycling (20min) and the workplace layer. Own figure from GIS.

Figure 43. Buffer zone of 400m from each bus stop in the area. Modified figure from Kolumbus data. Source: https://eu.remix.com/map/cceafc28?latlng=58.88265,5.73223,12.452

Figure 44. Buffer zones of 300m from each bus stops in Næringspark. Modified figure from Kolumbus data. Source: https://eu.remix.com/map/cceafc28?latlng=58.88265,5.73223,12.452

Figure 45. 1 km zone from the main Forusbeen in Næringspark, showing the covered walking area. Own figure.

Figure 46. Area divided into zones for the calculation. Own figure.

Figure 47. Parking ratios per 100 m2 BRA per zone. Own figure based on the calculations.

Figure 48. Areas promoting car dependence due to parking availability. Own figure.

LIST OF TABLES

Table 1. Parking restrictions in the different plans. Source: https://ikdpforusdotcom.files.wordpress.com/2019/06/05e-parkering-ikdp-forus-16.03.2018.pdf

Table 2. Number of businesses differentiated by group in Næringspark. Source: https://public.tableau.com/app/profile/stavanger.statistikken/viz/Detaljhandel1_havr-Rogaland/Terminvisendringfraforriger

Table 3. Number of businesses differenciated by group in the shopping mall, Tvedtsenteret, Næringspark Forus. Source: https://tvedtsenteret.no/butikker/

Table 4. Traffic volumes of car per vehicle per hour. Source: https://www.vegvesen.no/trafikkdata/start/kart?lat=61.298669327869405&lon=8.112101491894993&zoom=5

Table 5. Cycling traffic volumes per vehicle per hour. Source: https://www.vegvesen.no/trafikkdata/start/kart?lat=61.298669327869405&lon=8.112101491894993&zoom=5

Table 6. Total parking calculations. Own table.

Table 7. Calculation of parking spaces and ratios according to the potential BRA proposed in the IKDP plan. Own figure.

REFERENCES

Asplan Viak. (2019). *Beregning av realistisk utbyggingsareal og kostnadsbidrag per m2 bra- IKDP Forus*. Sandnes Kommune. https://ikdpforusdotcom.files.wordpress.com/2019/06/05b-beregning-av-realistisk-utbyggingsareal-og-kostnadsbidrag-14.03.2019.pdf

Barter, P. (2022). *How the Netherlands handles parking*. https://www.reinventingparking.org/2022/01/Netherlandsparking.html

Brebbia, C. A. (Ed.). (2008). *Urban transport XIV: Urban transport and the environment in the 21st century*. WIT.

Cao, K. (2018). 1.17—Spatial Optimization for Sustainable Land Use Planning. In B. Huang (Ed.), *Comprehensive Geographic Information Systems* (pp. 244–252). Elsevier. https://doi.org/10.1016/B978-0-12-409548-9.09603-2

Carmona, M., Tiesdell, S., Heath, T., & Oc, T. (Eds.). (2010). *Public places - urban spaces: The dimensions of urban design* (2nd ed). Architectural Press.

Currie, G. (Ed.). (2021). *Handbook of public transport research*. Edward Elgar Publishing.

Denstadli, J. M., Engebretsen, Ø., & Vågane, L. (2006). *Den nsjonale reisevaneundersøkelsen 2005-nøkkelrapport*. Transportøkonomisk institutt. https://www.toi.no/getfile.php?mmfileid=4186

Fig, H. (2021). *Oslo – Promoting Active Transport Modes | Eltis*. https://www.eltis.org/resources/case-studies/oslo-promoting-active-transport-modes

Flugel, S., Harkjerr Halse, A., Hulleberg, N., Natalie Jordbakke, G., Veisten, K., Beate Sundfør, H., & Kouwenhoven, M. (2020). *Verdsetting av reisetid og tidsavhengige faktorer. Dokumentasjonsrapport til Verdsettingsstudien 2018-2020.* nstitute of Transport Economics. https://www.toi.no/getfile.php/1353108-1622621396/Publikasjoner/TØI%20rapporter/2020/1762-2020/1762-2020-elektronisk.pdf

Forsyth, A. (2015). *What is a walkable place? The walkability debate in urban design*. https://dash.harvard.edu/bitstream/handle/1/29663388/Forsyth_walkablity_082415_final.pdf

Forus Næringspark. (2022). *Forus Næringspark*. https://www.forusnaeringspark.no/

Forusvisjonen. (2022). *Forusvisjonen*. http://forusvisjonen.no/

Geurs, K. T., & Wee, B. van. (2004). Accessibility evaluation of land-use and transport strategies: Review and research directions. *Journal of Transport Geography*, *12*(2), 127–140. https://doi.org/10.1016/j.jtrangeo.2003.10.005

Harder, K., Bloomfield, J., Levinson, D., & Zhang, L. (2005). *Route Preferences and the Value of Travel-Time Information for Motorists Driving Real-World Routes*. Minnesota Department Transportation. https://www.lrrb.org/pdf/200520.pdf

IKDP Forus. (2018). *Forslag til prinsipper og bestemmelse for parkering*. https://ikdpforusdotcom.files.wordpress.com/2019/06/05e-parkering-ikdp-forus-16.03.2018.pdf

Kolumbus. (2022). *Kolumbus service 2022*. https://eu.remix.com/map/cceafc28?latlng=58.88265,5.73223,12.452

Kuss, P., & Nicholas, K. A. (2022). A dozen effective interventions to reduce car use in European cities: Lessons learned from a meta-analysis and Transition Management. *Case Studies on Transport Policy*. https://doi.org/10.1016/j.cstp.2022.02.001

Litman, T. (2022a). *Evaluating Accessibility for transport planning. Measuring people's ability to reach desired services and activities*. Victoria Transport Policy Institute. https://www.vtpi.org/access.pdf

Litman, T. (2022b). *Evaluating Transportation Land Use Impacts. Considering the Impacts, Benefits and Costs of Different Land Use Development Patterns.* Victoria Transport Policy Institute. https://www.vtpi.org/landuse.pdf

Litman, T., & Laube, F. (2002). *Automobile Dependency and Economic Development*. Institute for Science and Technology Policy Murdoch University. https://www.vtpi.org/ecodev.pdf

Lohmann Elkjær, A. J., & Landex, A. (2009). *GIS-based Approaches to catchment area analyses for Mass Transit*. ESRI International User Conference.

https://backend.orbit.dtu.dk/ws/portalfiles/portal/3471512/GIS-based+Approaches+to+Catchment+Area+Analyses+of+Mass+Transit.pdf

Merom, D., Humphries, J., Ding, D., Corpuz, G., Bellew, W., & Bauman, A. (2018). From 'car-dependency' to 'desirable walking'–15 years trend in policy relevant public health indicators derived from Household Travel Surveys. *Journal of Transport & Health*, *9*, 56–63. https://doi.org/10.1016/j.jth.2018.01.008

Mladenović, M. N., Toivonen, T., Willberg, E., & Geurs, K. T. (Eds.). (2021). *Transport in human scale cities*. Edward Elgar Publishing.

Nesvik, M. (2021, Mai). *Mener «sykkel-motorvei» til 1,5 milliarder mellom Stavanger og Sandnes har for mange bakker – NRK Rogaland – Lokale nyheter, TV og radio*. https://www.nrk.no/rogaland/mener-_sykkel-motorvei_-til-1_5-milliarder-mellom-stavanger-og-sandnes-har-for-mange-bakker-1.15461555

OECD. (2018). *Enhancing Connectivity through Transport Infrastructure*. https://doi.org/10.1787/9789264304505-en

Oslo Kommune. (2019). *The Car-free Liavility Programme*. https://www.oslo.kommune.no/getfile.php/13319592-1553857948/Content/Politics%20and%20administration/City%20development/Car%20free%20city/The%20Car-free%20Livability%20Programme%202019.pdf

Pritchard, R., & Lovelace, R. (2022). *Sykkelpotensial og bysykler. En beregning av potensialet for økt hverdagssykling og evaluering av bysykkelordningene på Nord-Jæren, i Trondheim og i Bergen*. NORCE Helse and Samfunn. https://norceresearch.brage.unit.no/norceresearch-xmlui/bitstream/handle/11250/2994058/Sykkelpotensial%2bBysykkel%2bRapport%2bEndelig_korr.pdf?sequence=1&isAllowed=y

Rodrigue, J.-P. (2020). *The geography of transport systems* (Fifth edition). Routledge.

Rogaland Fylkeskommune. (2018). *Interkommunal plan for Forus 2019-2040*. https://ikdpforusdotcom.files.wordpress.com/2019/06/planbeskrivelse-revidert-08.05.2019-1.pdf

Rogaland Fylkeskommune. (2019). *Regionalplan for Jæren 2050*. https://www.rogfk.no/_f/i82081179-7a60-4bd0-9702-a4ed2f70d380/rgeionalplan-jaren-2050-vedtatt-12062019.pdf

Rogaland Fylkeskommune. (2022a). *Kart med status delstrekninger*. https://www.rogfk.no/vare-tjenester/vei-og-kollektivtransport/bussveien/kart-med-status-delstrekninger/

Rogaland Fylkeskommune. (2022b). *Konseptet Bussveien*. https://www.rogfk.no/vare-tjenester/vei-og-kollektivtransport/bussveien/hva-er-bussveien/konseptet-bussveien/

Røyneberg, I. (2020). *Uttappingen av Stokkavatnet (Forus). Sola Historielag*. https://www.solahistorielag.no/uttappingen-av-stokkavatnet-forus/

Saeidizand, P., Fransen, K., & Boussauw, K. (2022). Revisiting car dependency: A worldwide analysis of car travel in global metropolitan areas. *Cities*, *120*, 103467. https://doi.org/10.1016/j.cities.2021.103467

Śleszyński, P., Olszewski, P., Dybicz, T., Goch, K., & Niedzielski, M. A. (2022). The ideal isochrone: Assessing the efficiency of transport systems. *Research in Transportation Business & Management*, 100779. https://doi.org/10.1016/j.rtbm.2021.100779

slocat. (2020). *Global Transport and Climate Change—SLOCAT Transport and Climate Change Global Status Report*. https://tcc-gsr.com/global-overview/global-transport-and-climate-change/

SSB. (2022). *Virksomheter*. https://www.ssb.no/virksomheter-foretak-og-regnskap/virksomheter-og-foretak/statistikk/virksomheter

Statens vegvesen. (2019). *Den nasjonale reisevaneundersøkelsen 2018/2019*. https://www.vegvesen.no/fag/fokusomrader/nasjonal-transportplan/den-nasjonale-reisevaneundersokelsen/reisevaner-2019/

Statens vegvesen. (2020). *Sykkelstamveg Nord-Jæren*. https://www.vegvesen.no/vegprosjekter/prosjekt/sykkelstamvegnordjaren/

Statens vegvesen. (2022). *Søk etter parkeringsområder*. https://www.vegvesen.no/trafikkinformasjon/reiseinformasjon/parkeringsregisteret/#/kart/58.897909,5.699836,12?_k=bxnn00

Statens vegvesen, & RVU gruppa. (2020). *Nasjonal reisevaneundersøkelse (RVU). Nøkkeltallsrapport 2020*. https://www.vegvesen.no/globalassets/fag/fokusomrader/nasjonal-transportplan-ntp/reisevaner/2020/nokkeltallsrapport-2020-versjon-per-23.12.21.pdf

Stavanger Kommune. (2021). *Den store sykkelundersøkelsen*. https://www.stavanger.kommune.no/vei-og-trafikk/stavanger-pa-sykkel/sykkelstatistikk/

Stavanger Municipality. (2018). *Climate and Environmental Plan 2018-2030: Action Plan 2018-2022*. Stavanger kommune. https://www.stavanger.kommune.no/siteassets/renovasjon-klima-og-miljo/miljo-og-klima/climate-and-environmental-action-plan--stavanger-2018-2022---final-version.pdf

Stavanger Statistiken. (2021). *Detaljhandel—Rogaland | Tableau Public*. https://public.tableau.com/app/profile/stavanger.statistikken/viz/Detaljhandel1_havr-Rogaland/Terminvisendringfraforriger

Stavanger Statistiken. (2022). *Befolkning | Tableau Public*. https://public.tableau.com/app/profile/stavanger.statistikken/viz/Befolkning_0/Folkemengdeogrligeendringer

TomTom. (2022). *Stavanger traffic report | TomTom Traffic Index*. https://www.tomtom.com/en_gb/traffic-index/stavanger-traffic/

Tvedtsenteret. (n.d.). *Butikker, Tvedtsenteret*. Retrieved May 3, 2022, from https://tvedtsenteret.no/butikker/

van Rees, E. (2020). *How to Create Public Transport Isochrones in ArcGIS Pro—GIS Lounge*. https://www.gislounge.com/how-to-create-public-transport-isochrones-in-arcgis-pro/

Venter, C. (2016). *Developing a Common Narrative on Urban Accessibility. A Transportation Perspective*. https://www.brookings.edu/wp-content/uploads/2017/01/transportation-digital.pdf

Vervik Salte, I. (2021). *Equinor har 6000 ansatte på Forus som alle skal bidra til transformasjonen*. https://www.forus.no/nyheter/equinor-har-6000-ansatte-p%C3%A5-forus-som-alle-skal-bidra-til-transformasjonen-

Wigan Council. (2015). *Connecting People to Places: The importance of Transport for the Borough*. https://www.wigan.gov.uk/Docs/PDF/Council/Strategies-Plans-and-Policies/Transport-Strategy/05-Chapter6.pdf