AALBORG UNIVERSITET

STUDENTERRAPPORT

From wheels to rails

A Spatial Approach to Bicycle Parking at the Copenhagen S-train network

AALBORG UNIVERSITET
STUDENTERRAPPORT

Aalborg University Copenhagen
Department of Sustainability and Planning
A. C. Meyers Vænge 15
2450 København SV
https://www.aau.dk

Project title:

From wheels to rails: *A Spatial Approach to Bicycle Parking at the Copenhagen S-train network*

Program name:

Msc Sustainable Cities

Semester:

4th semester - Master thesis

Project period:

February 2025 – June 2025

Author:

Jasper Dallinga

Supervisor:

Irma Kveladze

Words: 10.185
Appendixes: 34
Hand-in: 28th May 2025

Signature

____

Jasper Dallinga

Preface

This master thesis is part of of the master program Sustainable Cities at Aalborg University Copenhagen. It is written in the period February until May 2025. Special thanks to Irma Kveladze for the supervision and cooperation during the project. Your expertise and support has been very valuable and helpful.

Summary

Cities around the world are aiming to promote sustainable urban mobility. Naturally, the integration of bicycles and public transport emerges as a critical strategy. This report investigates the spatial and functional integration of bicycle parking at S-train stations in Copenhagen, focusing on how these facilities influence bike-to-train transfers. Using a combination of Geographic Information Systems (GIS), Multi-Criteria Decision Analysis (MCDA), and on-site field observations, the study evaluates all 87 S-train stations based on three key parameters: parking capacity relative to population and passengers, the proximity of parking to platforms, and the availability of covered or locked facilities.

The analysis reveals significant spatial differences in parking facilities among stations. Some stations offer well-located and covered parking, while others lack facilities at part of the station or are underutilized due to poor design. Fieldwork at a selection of high- and low-performing stations confirms these findings and highlights user preferences and behavior, such as the importance of location. The results demonstrate that GIS-based spatial analysis is a powerful tool to identify conflicts with parking areas, such as low capacities.

The thesis concludes with practical recommendations for planners, emphasizing the need for strategic placement of facilities, better visibility, and creating a better balance between capacity and demand. These insights are particularly relevant for the planning of new transport nodes, such as the upcoming light rail in Greater Copenhagen, and can also be applied more broadly to support sustainable transport systems in different urban regions.

keywords

Bike-to-train integration, Bicycle Parking, Chain mobility, Geographical Information Systems (GIS), S-train, Sustainable urban mobility, Transit-Oriented Development (TOD), Urban Planning.

Contents

Chapter 1

Introduction

The integration of sustainable transport modes has become an important objective in urban mobility planning. As cities seek to reduce car dependency, combining the strengths of cycling and public transportation can be a compelling strategy. In particular, the combination of bicycles and trains allow for efficient long-distance travel supported by flexible first- and last-mile connections. However, successful integration is highly dependent on adequate infrastructure, especially in terms of bicycle parking at train stations.

Copenhagen is considered one of the world's leading cycling cities. Yet, there are still challenges when looking at the connection between cycling and train travel. Surveys indicate that satisfaction with bicycle parking at train stations are lagging behind the goals set by the municipality. Issues such as insufficient capacity, inconvenient locations, and unorganized use of facilities persist. These shortcomings can discourage new users from combining cycling with train travel. This ultimately limits the potential for multimodal transport.

The report aims to address these challenges by investigating the spatial and functional characteristics of bicycle parking facilities at S-train stations in Copenhagen. By doing a combination of a multi-criteria decision analysis, a GIS analysis, and field observations, this research aims to identify where and how improvements can be made to better support bike-to-train transfers. The S-train network is a particularly relevant case study due to its foundational role in Copenhagen's transit-oriented urban development.

Through this research, the thesis aims to give a better understanding of the relationship between infrastructure quality and traveler behavior. It offers practical recommendations for planners and policy-makers aiming to improve sustainable urban mobility.

Chapter 2

Problem Analysis and Theoretical Framework

2.1 Bike to public transport integration

Copenhagen's transport system is the responsibility of multiple different organizations (Cannon et al. 2024). Bicycle planning is primarily the responsibility of the municipalities. Copenhagen is by far the largest municipality in the network, and it's policies are leading for surrounding municipalities. The city of Copenhagen has published the "Copenhagen bicycle strategy 2011-2025" (City of Copenhagen, 2011), and the "Bicycle parking priority plan 2018-2025" (City of Copenhagen, 2018). The city of Copenhagen (2011) considers making it easier to combine cycling and public transport an explicit part of its 'recipe for success'. This includes the provision of better parking facilities.

However, in the most recent update (City of Copenhagen, 2023), only 55% of cyclists are satisfied with the possibility to combine cycling with public transport. When asked about bicycle parking options at stations, only 47% of cyclists are satisfied, much lower than the goal of 70% in 2025, that the municipality set in 2011 (City of Copenhagen, 2023).

Copenhagen is not the only city in Europe that deals with this problem. The city of Munich has in recent years developed a program called "bike-and-ride offensive" (Landeshauptstadt München, 2019). Part of this program are more than 100.000 new parking places built between 2019 and 2022. However, only 45% of user says to be satisfied with the availibility and quality of parking spaces (SINUS-Institut, 2023). This satisfaction is slightly higher in Vienna, where 60% of cyclists is satisfied with the bike-to-rail integration, stating security and weather protection as the biggest concern (Stadt Wien, 2021). During the latest survey in Paris, only 35% of respondents were happy with bike parking availability at stations (Île-de-France Mobilités, 2022). This has lead to the plan to construct 40.000 new parking spaces between 2022 and 2023.

On the other hand, cities in the Netherlands are setting the example for good bike to public transport integration. In Utrecht, a similar study showed that 82% of users are satisfied with the bicycle parking at the station (Gemeente Utrecht, 2023). This is after the opening of the world's largest bike parking in the world, with a total of 12.500 places bicycles (Centrum Ondergronds Bouwen (COB), 2023).

In the past years, various researchers have done extensive investigations into the use of bicycle parking. Such as Krizek and Stonebraker (2011) who have done a deep review of the existing literature. They describe that *"successful coordination of public transport and bicycle parking can enlarge the public transport catchment area, reduce the need of operating feeder (bus) services, and increase demand for bicycling and public transport."* Typically, bicycle parking is addressed as an element of bicycle to public transport integration. Existing literature addresses mostly issues of proximity, quality and price of the parking, and its effects on preferences and travel behaviour (Heinen and Buehler, 2019).

The combination of bicycles and trains offers the best of both worlds (Jonkeren and Kager, 2021). Trains are fast and well suited for long distance travel. Trains can become accessible to more people when integrated with bikes, because the catchment area is much larger compared to walking (Jonkeren and Kager, 2021).

Because bicycles are not bound to timetables, as opposed to busses and metros, Jonkeren and Kager (2021) argue that providing high quality and sufficient bike parking minimizes the "transfer effort" for those connecting from bicycle to train. This means that good bike parking makes the bicycle-train combination more attractive.

There are different types of bike parking available at public transport stops, ranging from simple bike racks without weather protection to full-service bicycle parking garages with video surveillance, repair services and bicycle rentals (Heinen and Buehler, 2019).

Research shows that cyclists prefer to park as close to public transport as possible. However, cyclists are willing to walk further to access higher quality parking (Arbis et al., 2016). Martens (2007) also reported that the inconvenient location of bicycle parking at some locations results in bicycles being parked closer to the transit stations, but not in designated bicycle-parking facilities.

2.2 Use of GIS in Bicycle Parking and multimodal Integration Research

Geographic Information Systems (GIS) are often used to analyze and improve bike parking and its integration with public transport. GIS can be used for the spatial analysis of parking accessibility, catchment areas, and infrastructure gaps (Heinen and Buehler, 2019; Jonkeren and Kager, 2021).

Multiple studies, such as (Santos et al., 2023) in Lisbon, have used GIS to model combined bicycle and train use, showing how bike-to-train integration expands accessibility and improves travel options. Similarly, research in Chinese cities such as Zhang et al. (2024) applies GIS to visualize cycling patterns and analyze integration with metro systems, to address the last-mile connectivity and parking challenges in Shenzhen and Shanghai. GIS also helps to identify mismatches in parking location relative to transit entrances, which can lead to informal, unorganized or insecure parking (Martens, 2007).

This shows that GIS is a valuable tool to understand spatial data that is relevant to research into the bike-to-train connectivity.

2.3 Node-Place theory in transit oriented development

This report use the theory of the "node-place model", first introduced by Bertolini (1999). It is a conceptual framework that is used in the analysis and planning of Transit-Oriented-Development (TOD). TOD is an urban planning and design strategy that focuses on creating compact, walkable, mixed-use communities centered around high-quality public transportation systems, such as metro or train stations (Curtis et al., 2009). Its main goal is to encourage the use of public transport by making it more convenient and attractive and thereby reducing the reliance on cars, lowering traffic congestion, and encourage sustainable growth.

The node-place theory makes the distinction between the "node" function and the "place" function of a location. A node refers to a location's role as a transport interchange, while a place has good urban qualities, such as the right density, land use mix, and pedestrian friendliness (Bertolini, 1999). Effective TOD require the balancing of the two. A location must provide both efficient transport connectivity (node) and an attractive urban environment (place) to attract users.

Recent studies such as Su et al. (2020), have applied this theory to the investigation of transit stations. The study on five Chinese cities showed that there can be a big difference in whether station areas have more of a node- or a place theory (Su et al., 2020).

When applying this theory to the case in Copenhagen it becomes apparent that stations need to be good places in order to stimulate people to use them for bike to rail connections. Promoting these connection is very important to promote transit-oriented development.

2.4 Case study: S-train network in Copenhagen

Copenhagen has an extensive public transport network consisting of regional and intercity trains, the metro, busses, water busses and the S-train. The S-train connects Copenhagen with the suburbs in the greater metropolitan area. In total there are 87 stations along 7 lines, as can be seen in figure 2.1(DSB, 2025b)

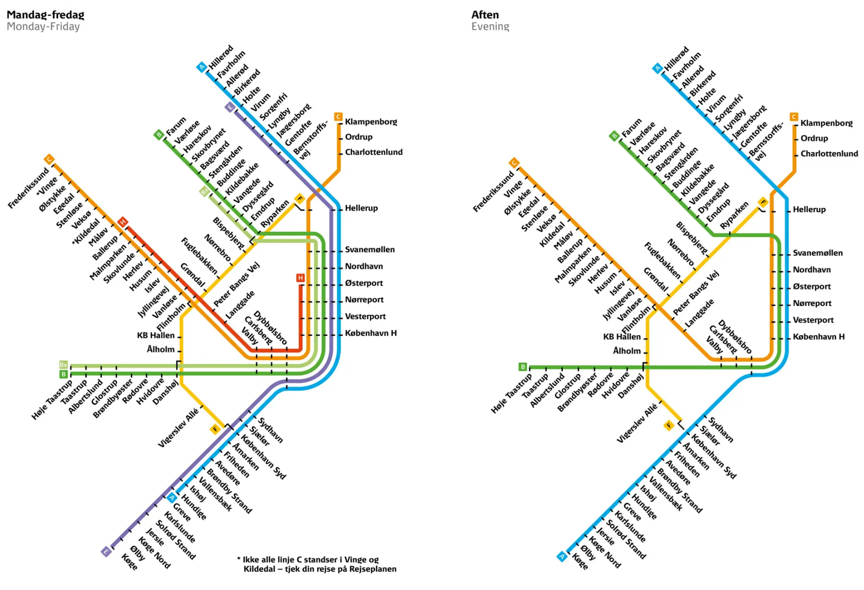

Figure 2.1. Map of the lines in the S-train network (DSB, 2025b)

The S-train network forms an important part of Copenhagen's five finger plan. The five finger plan is a foundational part of Copenhagen's urban strategy, first introduced in 1947 (Knowles, 2012). It promoted the expansion of the city along five corridors. Together these corridors would form the shape of a hand with five fingers, as can be seen in figure 2.2. The five finger plan is an early example of Transport-Oriented development (Knowles, 2012). This makes the S-train network an interesting case study for this research.

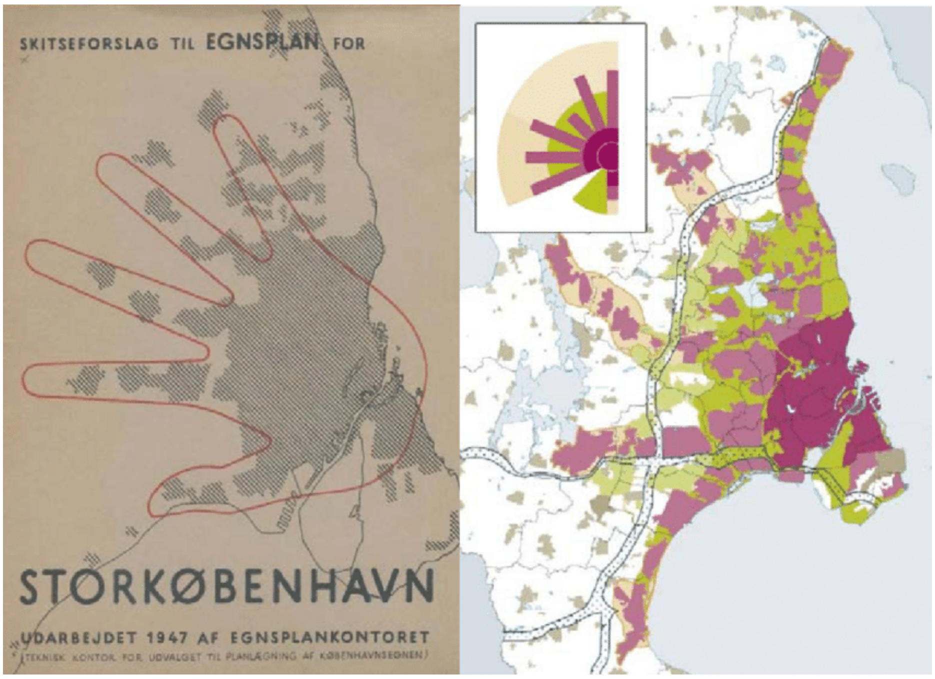

Figure 2.2. Map of the original finger plan from 1947 and the 2007 revision (Li, 2016)

A major issue of the five finger plan is the interconnectivity between the "fingers". Even though all the suburbs are well connected with the center of Copenhagen, getting from one suburb to the other by public transport can sometimes be tricky (Knowles, 2012). A transit-oriented development to solve this issue is the opening of a new light rail line between Ishøj and Lyngby (Hovedstadens Letbane, 2025). This light rail will have 29 stops, 6 of which are connecting to the S-train network. The first part of the line (between Ishøj and Rødovre) will open in fall 2025 (Hovedstadens Letbane, 2025). This case study of the S-train network can offer valuable insight for the planning of these new stations.

2.5 Research question

Based on the problem analysis, the following research question will be investigated in this report:

"How do spatial and temporal variations in the usage patterns of bicycle parking facilities at train stations across greater Copenhagen impact the efficiency and attractiveness of bike-to-train transfer journeys, and in what ways can GIS-based spatial analysis methods be applied to effectively identify, evaluate, and optimise the planning strategies, placement decisions, and configuration designs of these bicycle parking facilities, thereby stimulating higher usage?"

Chapter 3

Methodology

.

The analysis of this report exists of two parts. Analysis 1 is a multi-criteria decision analysis (MCDA). This is a quantitative analysis, using GIS and available datasets on the theme. The MCDA is used to decide which S-train stations are further analyzed in analysis 2. Analysis 2 is a more qualitative approach to get more in-depth inside of bike parking at these stations. Section 3.1 explains how the MCDA is applied in this report. Section 3.2 gives a step-by-step explanation of how the data was processed using GIS. 3.3 explains how the fieldwork for analysis 2 was conducted.

3.1 Multi Criteria Decision Analysis (MCDA)

The multi criteria decision analysis, or MCDA, is a methodology that is used to evaluate options when multiple criteria are involved. The core idea of MCDA is to combine multiple criteria, which can be qualitative or quantitative, into a structured analysis. Each criterion is investigated and possibly weighted (Belton and Stewart, 2002). Mangold et al. (2022) applied a GIS-based MCDA framework to support geo-fence planning for dockless bike-sharing systems. This study demonstrates how the combination of GIS and MCDA can be used to balance multiple urban planning criteria, such as accessibility, demand, and land use compatibility. This forms the basis for the methodology in this thesis.

There are many researches done describing the different types of MCDA and their usecases. DCLG, 2009 has summarized this into a few key steps:

Define the problem and decision goal
We want to decide which stations are analyzed further in analysis 2.

Identify the alternatives
All 87 S-train station in the Copenhagen metro area.

Select evaluation criteria
As discussed in chapter 2, there are four important indicators when it comes to bicycle parking near train stations, namely

- Capacity - Is there always enough space
- Distance to the platform - How far do you need to walk from bike to train
- Coverage - Is the parking protected from the weather

- Security - Is it safe to leave your valuable bike there for multiple hours

Because the lack of data for security at each station, this parameter will not be considered in analysis 1.

Normalize or rank the criteria
We will use a simple-rank system. All three remaining indicators will be taken into account in the analysis.

The rank is based on four different parameters:

- $r(cap/pop)_i$: The ranking of the ratio capacity/population for station i
- $r(cap/pas)_i$: The ranking of the ratio capacity/passengers(2024) for station i
- $r(d(p\text{-}p))_i$: The ranking of the distance between parking and platform for station i
- $r(cov/cap)_i$: The ranking of the ratio covered+locked parking/total parking for station i

In section 3.2 is explained how each factor is calculated.

Weight the criteria
All three indicators will have equal weight. This means that r(cap/pop) and r(cap/pas) have a weight of 0,5. The total for the indicator "capacity" is 1. The other two parameters will have a weight of 1.

Aggregate the results
An overall ranking score is created based on the weighted average rank of four parameters. The average rank is calculated according to the following formula:

$$average\ rank_i = \frac{0.5 * r(cap/pop)_i + 0.5 * r(cap/pas)_i + r(d(p-p))_i + r(cov/cap)_i}{3}$$

Interpret and compare te results
This will result in an index score, which is the average rank. These scores are ranked and used to decide what stations are further investigated, as described in section 3.3.

3.2 GIS and Data Analysis

A GIS analysis of the S-train network is done in order to analyze the data and calculate the values that are used in the ranking.

3.2.1 S-train stations

Step one is to identify the locations of all the S-train stations. This done using Openstreetmap data (Geofabrik GmbH, 2025). In the layer *"gis_osm_transport_free_1"*, all features are selected where *"fclass=railway_station OR fclass=railway_halt"*. Than all stations with S-train services were manually selected and a new layer *"S-tog_stations"* was created.

3.2.2 Bike parking

Step two is to combine the locations of the S-train stations with the available data on the amount and types of bicycle parking available at the station. In the Cykelregnskab (Vejdiktoratet, 2024) the amount of bike parking is published for each station, divided into five categories. The features of all stations are exported to Excel, and the data from Vejdiktoratet (2024) are manually added. The amount of parking places in each category is then added up to calculate the total amount of parking for each station. The fraction of covered and locked, that is used in the ranking, is then calculated using the following fomula:

$$fraction\ covered\&locked_i = \frac{covered_i + locked_i}{total\ parking_i}$$

3.2.3 Passenger numbers

Step three is to combine the parking data with the data for the number of passengers. Data for the number of passengers who get on the S-train is published in the passagertal (Trafikstyrelsen, 2025). All the data for 2024 is added up and then divided by 366 to get the average daily amount of passengers per day. This is then combined with the data for the total amount of bike parking to get the ratio for parking/passengers that is used in the ranking:

$$ratio\ parking/passengers = \frac{total\ parking_i}{daily\ passengers(2024)_i}$$

3.2.4 Isochrones

Step four is to analyze the areas that can be reached in a certain time from each station, as well as which station is closest to each point in the city. This is necessary to establish the catchment area of each station. The isochrones are calculated using the *"Valhalla"* plugin. The tool *"Isochrones bicycle"* is run with the following inputs:

- Input point layer: s-tog_stations
- Time intervals [minutes]: 1, 2, 3, . . . , 15

The reason for choosing time intervals rather than distance intervals is that studies, such as Pan and Isham (2024), have highlighted that travel time is a more important factor in decision making than distance. The maximum interval of 15 minutes is used in multiple studies on bicycle-train connectivity, such as Santos et al. (2023) in Lisbon and de Kruijf (2021) in the Netherlands. After the isochrones are generated, the features are put in 15 different layers, based on the contour. These layers are then processed using the *"difference"* tool:

- Input layer: isochrones_bicycle_15
- Overlay layer: isochrones_bicycle_14

- Input layer: isochrones_bicycle_14
- Overlay layer: isochrones_bicycle_13

- (. . .)

- Input layer: isochrones_bicycle_2
- Overlay layer: isochrones_bicycle_1

This is done to remove parts of the isochrones that are closer to a different point (station) than its corresponding point. This will also remove the parts that are closer to the point than the number of minutes in the contour. These layers are then merged, resulting in a layer with polygons that contain data on its closest station, as well as the amount of minutes it takes to get there by bicycle.

In areas where there are two or more stations exactly the same distance away, the polygons overlap. This is taken into account when the population in the catchment area is calculated.

3.2.5 Catchment area

Step five is to establish the catchment area for each station. A layer is created using the *"dissolve"* tool:

- Input layer: merged_isochrones
- Dissolve fields: name (*of station*)

This will result in a polygon layer with the catchment area for each station. Areas that are the same distance from two or more stations still overlap.

3.2.6 population

Step six is to estimate the population that lives in the catchment area of each station. The smallest sub-regions for which population data is free and publicly available are postcode areas (Danmarks Statistik, 2025). This database is joined with the polygon data of the postcode areas (Dataforsyningen, 2025b) using the *"join attributes by field value"* tool:

- Input layer: postnummers
- Table field: postnummer
- Input layer: postnummers_population.xlsx
- Table field2: postnummer

The size of the postcode areas varies, between a small surface area, containing sometimes only one building, in the center of Copenhagen, to a larger area containing multiple towns in more rural places. The population is not evenly distributed throughout the postcode areas. Unfortunately, more precise data is not openly available, but the distribution of population can be made more precise by combining this data with the raster data of the built-up area (Copernicus Land Monitoring Service, 2020). This data contains a value between 0 and 100, which represents how much of the rasterpoint is built up. We will assume that the population is evenly distributed among the built-up area.

In order to do the geoprocessing, the raster is converted into a vector using the *"raster pixel to points"* tool. The total sum of the values of the built up area within the postcode area is calculated using the *"join attributes by location (summary)"* tool:

- Join to features in: postnummer
- Where the features: contain
- By comparing to: Built_up_points
- Fields to summarize: VALUE
- Summaries to calculate: sum

This number represents the total number of value points within the postcode area. A field is created in the postnummer layer to get the population per value point:

- output field name: value_2025
- expression: population_2025 / VALUE_sum

This data is then joined with the *built_up_points* layer, using the *"join attributes by location"* tool:

- Join to features in: built_up_points
- Features they: contain
- By comparing to: postnummers_joined

Before calculating the population per point it is important to take into account the areas in overlapping catchment areas. If a point is in two or more catchment areas (this means that there are multiple stations at the same distance away), we will count a fraction of 1 over the amount of overlapping areas of the population. For example, if a point is exactly 5 minutes away from two different stations, half of the population is counted towards station A, while the other half is counted towards station B. This is calculated using the *"join attributes by location (summary)"* tool:

- Join to features in: built_up_points_joined
- Where the features: contain
- By comparing to: Catchment area
- Fields to summarize: name
- Summaries to calculate: count

After this a new field containing the population for each point is calculated using the field calculator:

- output field name: pop_2025
- expression: VALUE * (1/name_count) * value_2025

After this, we only need to sum up the population of all the points that are within the catchment area. This is done using the *"join attributes by location"* tool:

- Join to features in: Catchment area
- Where the features: contain
- By comparing to: built_up_points_joined_joined
- Fields to summarize: pop_2025
- Summaries to calculate: sum

These steps will result in the estimated population in the catchment area of each station. This is used to calculate the ratio parking/population, used for the ranking. The ratio is calculated using the following formula:

$$ratio\ parking/population_i = \frac{total\ parking_i}{population(2025)_i}$$

3.2.7 Distance between parking and platform

Step seven is to calculate the distance between the parking places and the platform. To determine the locations of the parking areas, the dataset from Data-Science.dk (2025) is used. This is the most complete data set on bicycle parking that is free and publicly available.

The parking areas are separated into two layers: point data and polygon data. The tools *"centroids"* and *"merge vectors"* are used to create one layer containing the point data and the centroids of the polygon data.

The location of the platforms is determined using OpenStreetMap data (Geofabrik GmbH, 2025). A quick query is run using the plugin *"QuickOSM"*:

- Key: railway
- Value: platform
- In: Denmark

A buffer of 200 meters was created around the layer *"s-tog_stations"*. This layer was then *"clipped"*:

- Input layer: S-tog_stations_buffer
- Overlay layer: platforms_denmark

This resulted in a layer with only the platforms at S-train stations. For stations that also have platforms for regional, intercity, and/or metro trains, platforms that do not service the S-train are manually removed.

The tool *"centroids"* is used to determine the centroid of the platform. The distance to the nearest bicycle is then calculated using the *"distance to nearest hub (points)"* tool:

- Source point layer: platforms_clipped
- Destination hubs layer: cykelparkering_merged
- Measurement unit: Meters

This creates a layer containing all the platforms and the distance to the nearest bicycle parking. This is the distance in a straight line, so it does not take into account walking paths or stairs. However, it is still a good indication of how long it takes to get from the parking to the platform. For stations with more than one platform, the mean distance from all platforms is used. This is done using the tool *"join attributes by location (summary)"*:

- Join to features in: S-tog_stations_buffer
- Where the features: intersect
- By comparing to: Hub distance
- Fields to summarize: HubDist
- Summaries to calculate: mean

Using the *"join attributes by field value"* tool, this data is joined to the layer *"S-tog_stations"*. This number for distance is then used in the ranking.

3.3 Fieldwork/Observations

The second part of the analysis is to perform fieldwork at 10 different S-train stations. The stations are selected based on the overall ranking, created in chapter 4. The top 3 and bottom 3 are selected, as well as 2 other high and low-scoring stations. The fieldwork has been conducted at the following stations:

- Allerød
- Carlsberg
- Dybbølsbro
- Husum
- Peter Bangs Vej
- Stenløse
- Sydhavn
- Vallensbæk
- Veksø
- Ølstykke

The stations are visited on Tuesday, Wednesday, or Thursday between 10:00 and 15:00. At this time most commuters and people away for the day will have their bikes parked at the station. Studies such as van der Spek and Scheltema (2015) have also shown that occupancy at train stations is highest during these hours.

At the stations, observations are made and documented regarding the situation and usage of bike parking. Attention is paid to the following:

- Location of bike parking
- Design of parking
- Which bike racks are used
- Amount and location of bikes parked outside of racks
- Types of bikes parked

These observations are analyzed to determine how the bike parking is used at these stations. This can tell us about good design in bike parking, and what aspects can be improved.

Chapter 4

Analysis 1

In this chapter, all parameters in the MCDA are analyzed. After this, a ranking is created based on these parameters, as is discussed in chapter 3. Based on each parameter a ranking will be made. In section 4.5 an overall ranking will be created based on the average ranking. This ranking is used to decide which 10 stations are further investigated in chapter 5.

4.1 Parking places

The parking data (Vejdiktoratet, 2024) is divided into five categories: covered bike-racks, noncovered bike-racks, locked, without bike-racks and unknown.

There is only one station with data in the category 'unknown', namely 110 parking places in Birkerød. When analyzing the aerial photos for this station (Dataforsyningen, 2025a), a mix of covered and non-covered parking is visible, in line with the data. However, on Google street view, it is visible that there are many bicycles parked close to the platform, outside the area with racks. This appears to be unofficial parking, that is widely used as such, see also figure 4.1. It is possible that this area is designated as unknown in the data.

Figure 4.1. Bicycles parked at Birkerød station (Google, 2024)

Covered biking means that the parking places are covered by a roof, as opposed to non-covered bike racks. Locked bike parking are bike racks that are behind a digit lock or a card reader. In order to get access to these places you need to register through DSB plus (DSB, 2025a). Examples of these categories can be seen in figure 4.2.

Figure 4.2. Covered (left), Non-covered (middle) and Locked (right) parking areas at Albertslund station (own photos, 2025)

Figure 4.3 shows the total amount of parking at each S-train station. Figure 4.4 shows the type of parking available at each station. Full-sized versions of all the maps, as well as the data, can be found in the appendix.

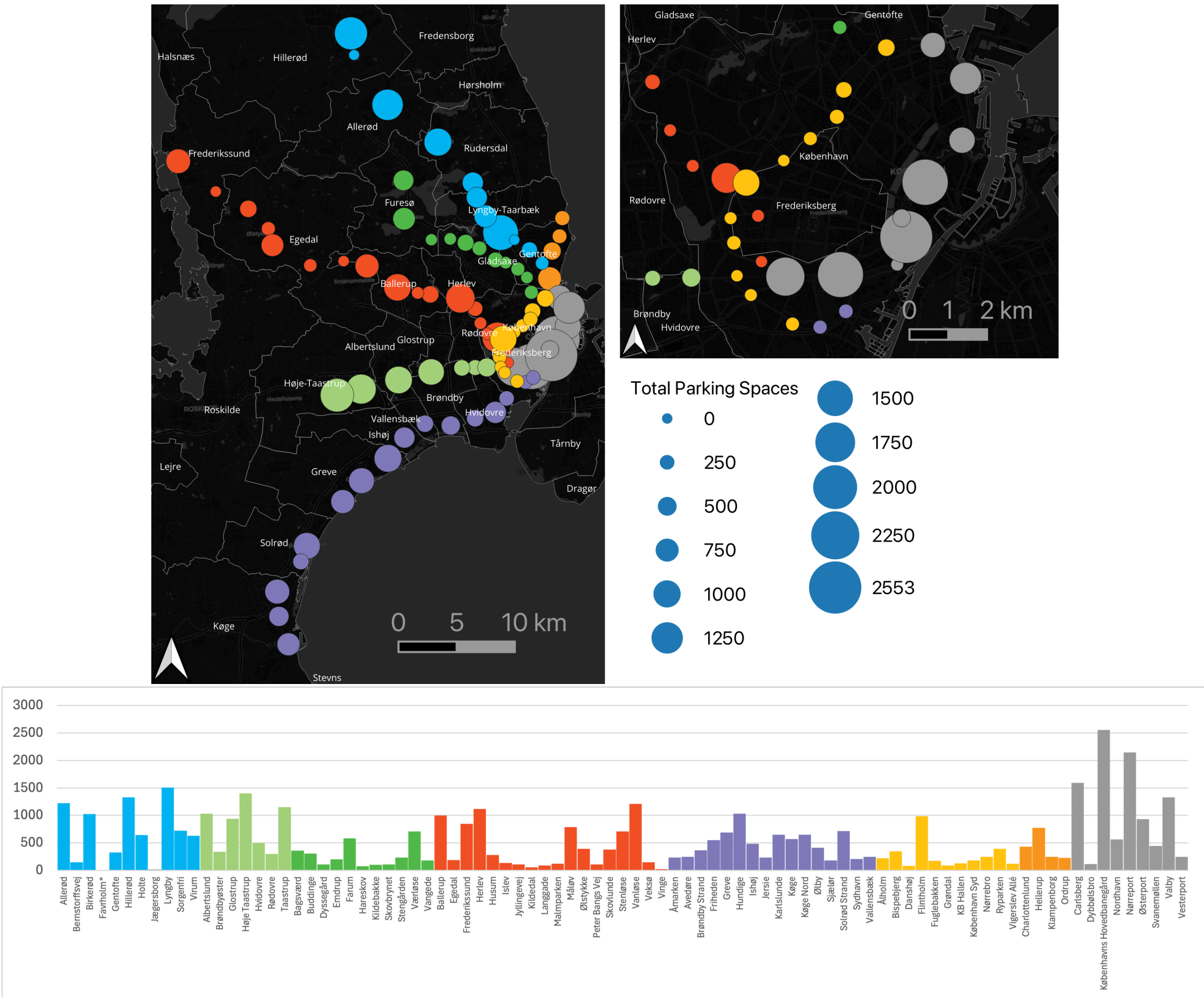

Figure 4.3. Map and bar chart of the total amount of parking places per station. Full-size figure: appendix B.1 and B.2, data: appendix A.3 and D.1

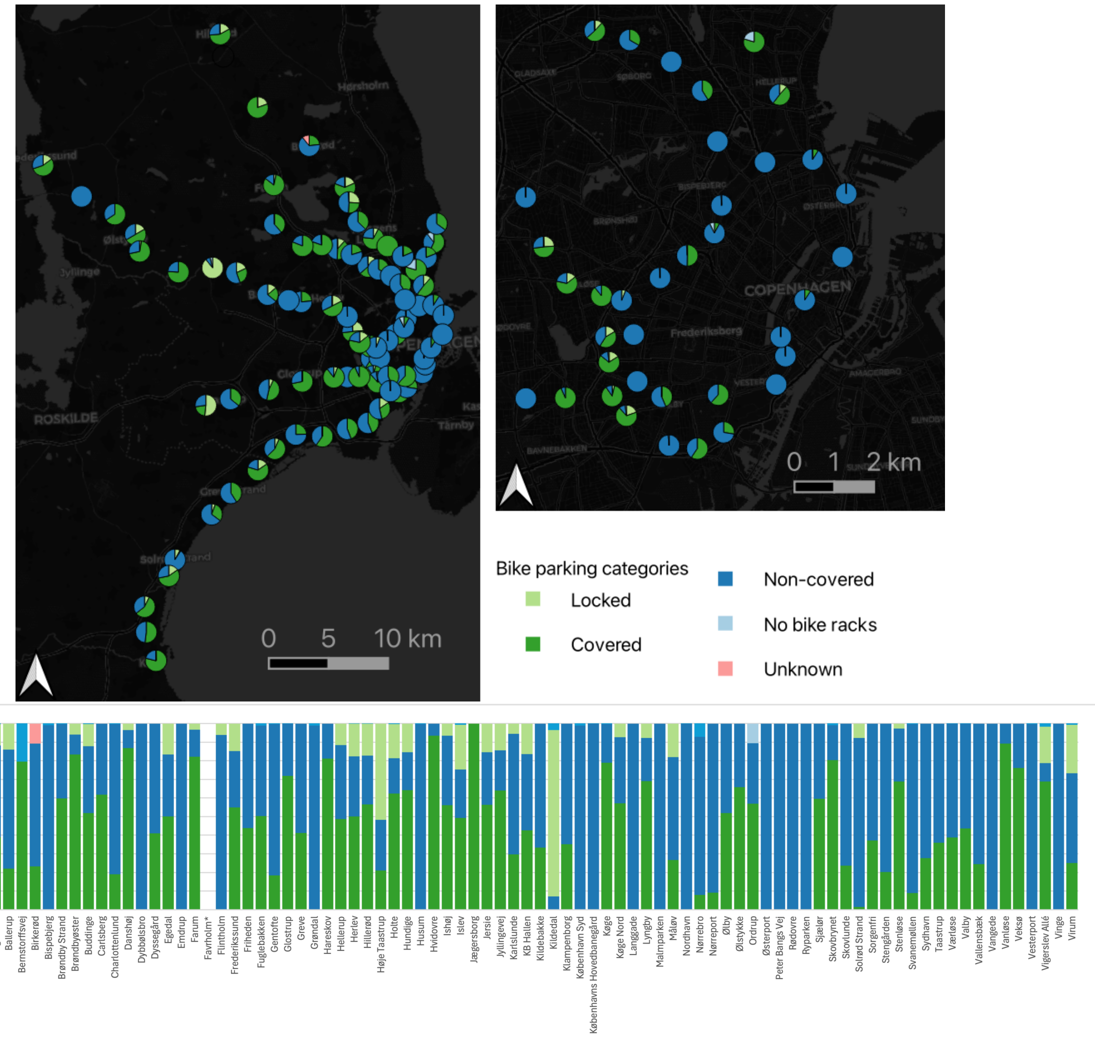

Figure 4.4. Map of parking place per station categorized in pie charts and bar graph. Full-size figure: appendix B.3 and B.4, data: appendix A.3 and D.1

The largest amount of parking can be found at the Copenhagen central station, with a total of 2553 parking places. This is not surprising considering the fact that this is the largest and busiest station in the city. The total amount of parking is analyzed further in combination the the passenger and population count in sections 4.2 and 4.3.

When looking at these categories, it becomes clear that at most stations the majority of parking is either covered or non-covered. Locked parking is only found at a few stations, and is almost always a minority. The exception is station Kildedal. According to the data, 50 of the in total 56 parking places at this station are locked parking. When checking the station on Google street view (figure 4.5) you can see that the parking is fenced off, but it appears to be accessible to everyone. When looking at the map, it becomes apparent that most stations in the city of Copenhagen almost exclusively have non-covered parking. The covered parking is more commonly found at stations in the suburbs.

Figure 4.5. Parking at station Kildedal (Google, 2021)

This data is used to create a ranking based on the fraction of locked and covered parking. The top 5 can be found in table 4.1. Jægersborg is the only station with 100% covered parking. There are also 17 stations without any locked or covered parking. These are the following:

- Bispebjerg
- Dybbølsbro
- Emdrup
- Grøndal
- Husum
- København Syd
- Københavns Hovedbanegård
- Langgade
- Malmparken
- Nordhavn
- Østerport
- Peter Bangs Vej
- Rødovre
- Ryparken
- Vangede
- Vesterport
- Vinge

Rank	Station	Percentage locked/covered
1	Jægersborg	100%
2	Allerød	99,92%
3	Hvidovre	93,36%
4	Danshøj	90,36%
5	Brøndbyøster	89,35%

Table 4.1. Top 5 stations by percentage ranked/covered. Data: appendix A.3

4.2 Passengers

In this section, we are determining the ratio parking/passengers for each station. The data on the average daily amount of passengers are calculated based on data from Trafikstyrelsen (2025), and represented in figure 4.6. The most amount passengers are getting on the train at station Nørreport (33.377 passengers per day) followed by Copenhagen Central station (24.237 passengers per day). These two stations see by far the most passengers, as third place Lyngby only has an average of 10.180 passengers getting on the S-train per day.

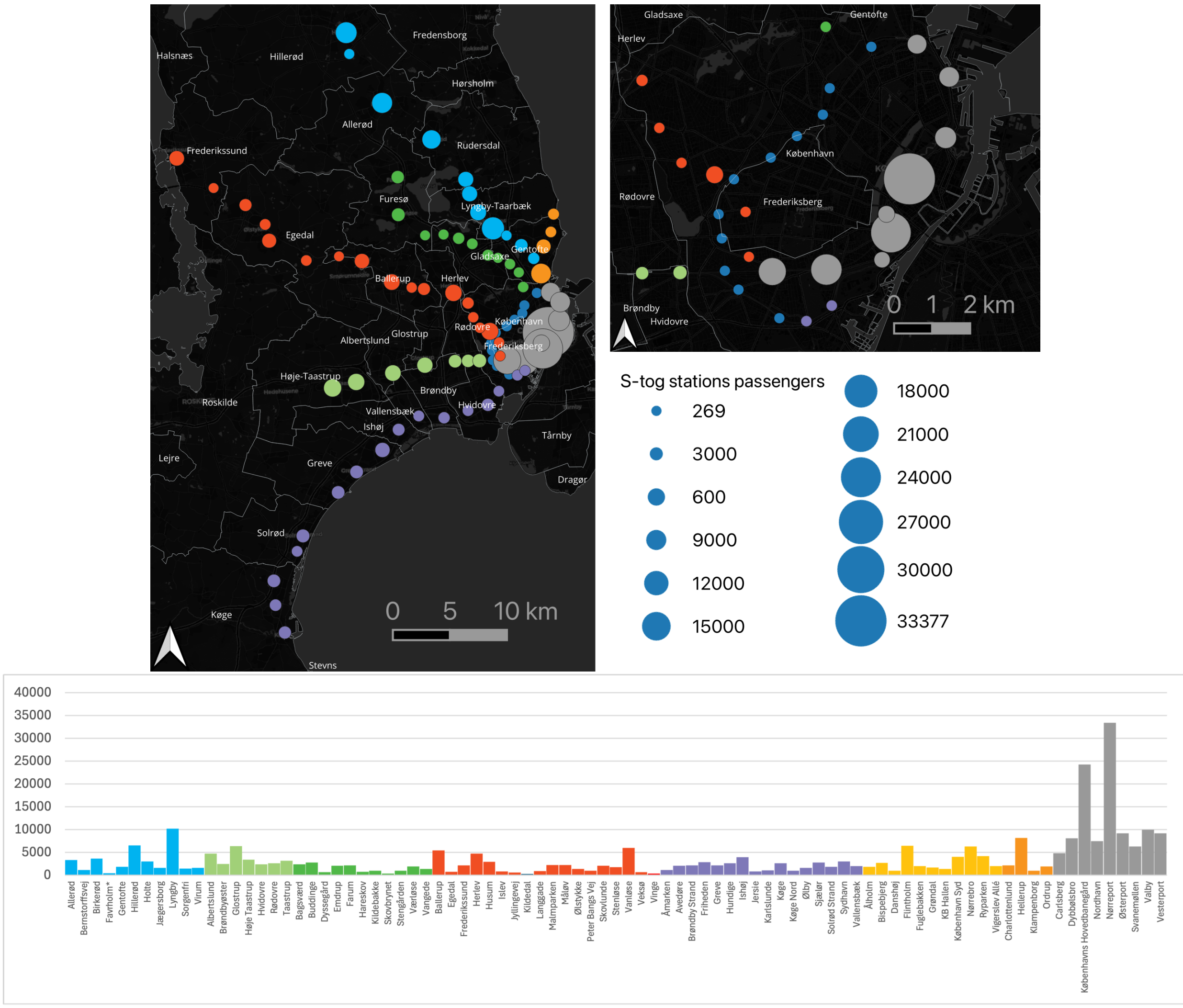

Figure 4.6. Map and bar chart of the average daily amount of passengers per station. Full-size figure: appendix B.5 and B.6, data: appendix A.4 and D.1

The passenger data, combined with the data for the total parking spaces is visualized in a scatterplot in figure 4.7. In this plot, we can see a clear positive trend. This means that generally, if a station has more passengers, it also has more parking places. The stations that are to the top left of the plot have the highest ratio of parking places vs passengers, while station to the bottom right have a lower ratio. This can also be seen in the ranking, as is seen in table 4.2

Figure 4.7. Scatterplot of daily passengers and total parking spaces. Full size figure: appendix B.7 and B.8, data in appendix A.4

As can be seen in table 4.2, station Køge Nord has the highest number of parking places for its passenger count. However, this station also has regional and intercity train services. This means that the parking spaces are also used by passengers of these trains. Second ranked station Karlslunde only has S-train service. At this station more than half of the passengers who get on the train can park their bike at the station. The lowest ranking station is Jægersborg, followed by Dybbølsbro. Here only about 1 in 100 passengers are able to park their bike.

Rank	Station	Parking places per 100 passengers
1	Køge Nord	65,50
2	Karlslunde	58,73
3	Sorgenfri	48,42
4	Høje Taastrup	40,68
5	Stenløse	40,68
⋮	⋮	⋮
82	København Syd	4,48
83	Nørrebro	3,98
84	Vesterport	2,71
85	Dybbølsbro	1,43
86	Jægersborg	1,03

Table 4.2. Top and bottom ranked stations by ratio parking/passengers. Data: appendix A.4

4.3 Catchment area

In this section, the ratio between the population of the catchment area and the number of parking places at each station are calculated. The catchment area for a station contains all the points for which this station is the closest station based on travel time by bicycle, with a maximum of 15 minutes. This means that people who live within the catchment area of a certain station will generally prefer to travel this station to park their bike and take the S-train.

The catchment areas are generated based on the isochrones that can be seen in figure 4.8. It is remarkable that the contours of the 5 finger plan are clearly visible when looking at this map. Because the density of stations is much higher in the city center of Copenhagen than in the suburbs, we can see that the maximum travel time here is usually not more than 6 minutes, shorter than the travel time in the suburbs.

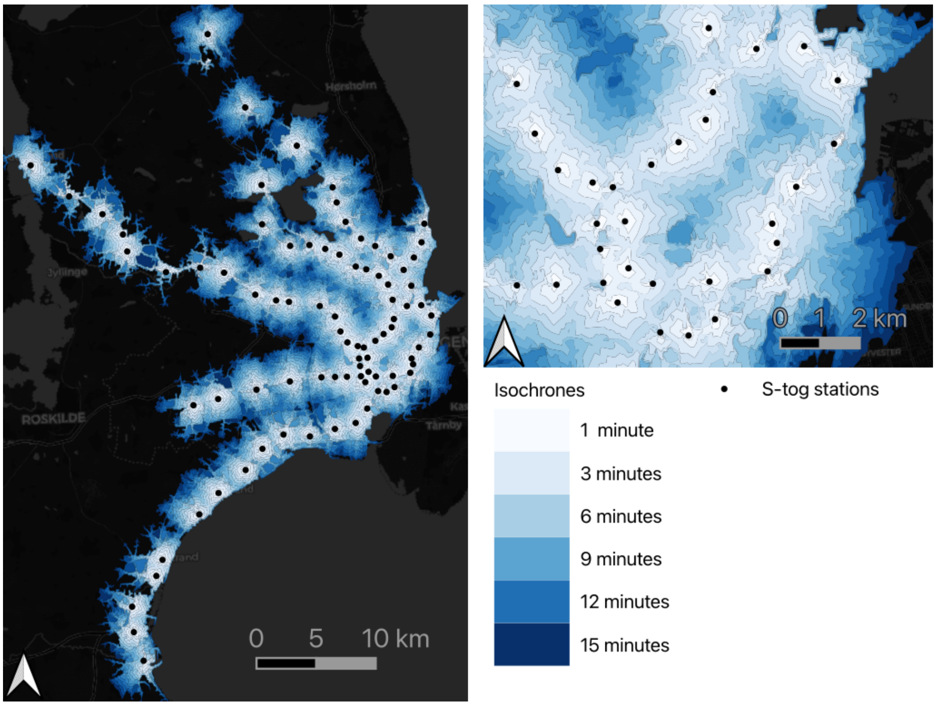

Figure 4.8. Map of isochrones for cycling from the S-train stations. Full-size figure: appendix B.9, data: appendix D.2

Figure 4.9 shows catchment areas for each station, including the population living in these areas. The station with the largest catchment area is station Østerport (64.317 people) followed by Dybbølsbro (56.463 people) and Nørrebro (55.583 people). These stations all serve a large portion of the city center, the densest part of the network. Favrholm has the smallest catchment area, only 646 people live here. This station is primarily used to transfer to or from the local railways in Northern Zealand and as a park and ride next to highway 6. The station is not near any urban area, and according to the data there is no bike parking. The next smallest catchment areas are Veksø and Vinge, with only 2.078 and 2.777 residents respectively. These are two of the smaller suburbs in the network. Although there is a lot of new housing under construction near station Vinge, so the population is likely to grow in the future. It is important to note that the population data are estimates. Details on how this data was calculated can be found in section 3.2.6.

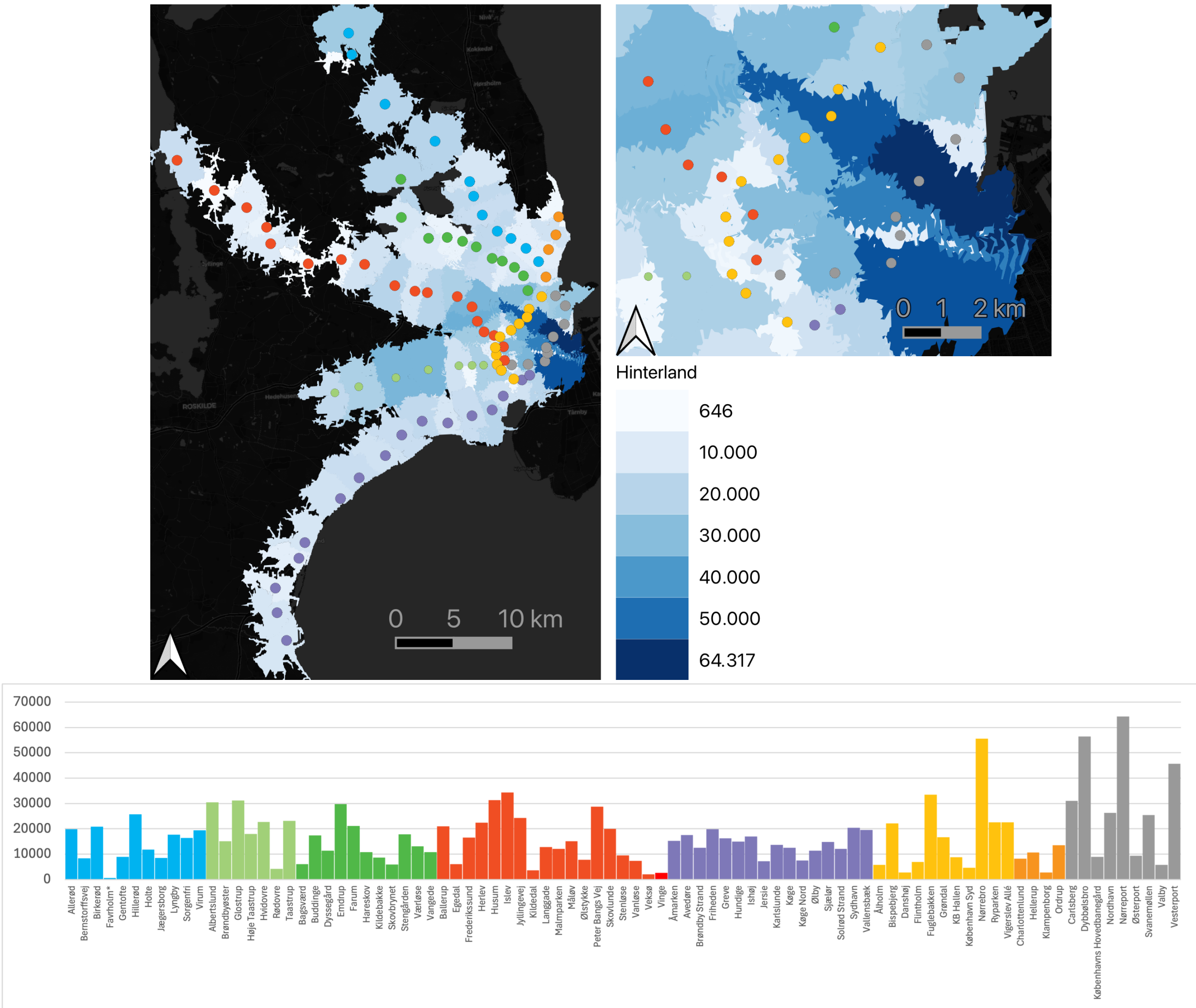

Figure 4.9. Map of catchment areas including population and bar chart. Full-size figure: appendix B.10 and B.11, data: appendix A.5 and D.3

This data is combined with the data of the total parking spaces, as can be seen in figure 4.10. There is a clear positive trend visible. This means that stations with a larger catchment area generally have more parking spaces. This data is used to calculate the ratio between parking places and population. Stations to the top-left of the plot have the best ratio, while stations on the bottom right have the worst ratio.

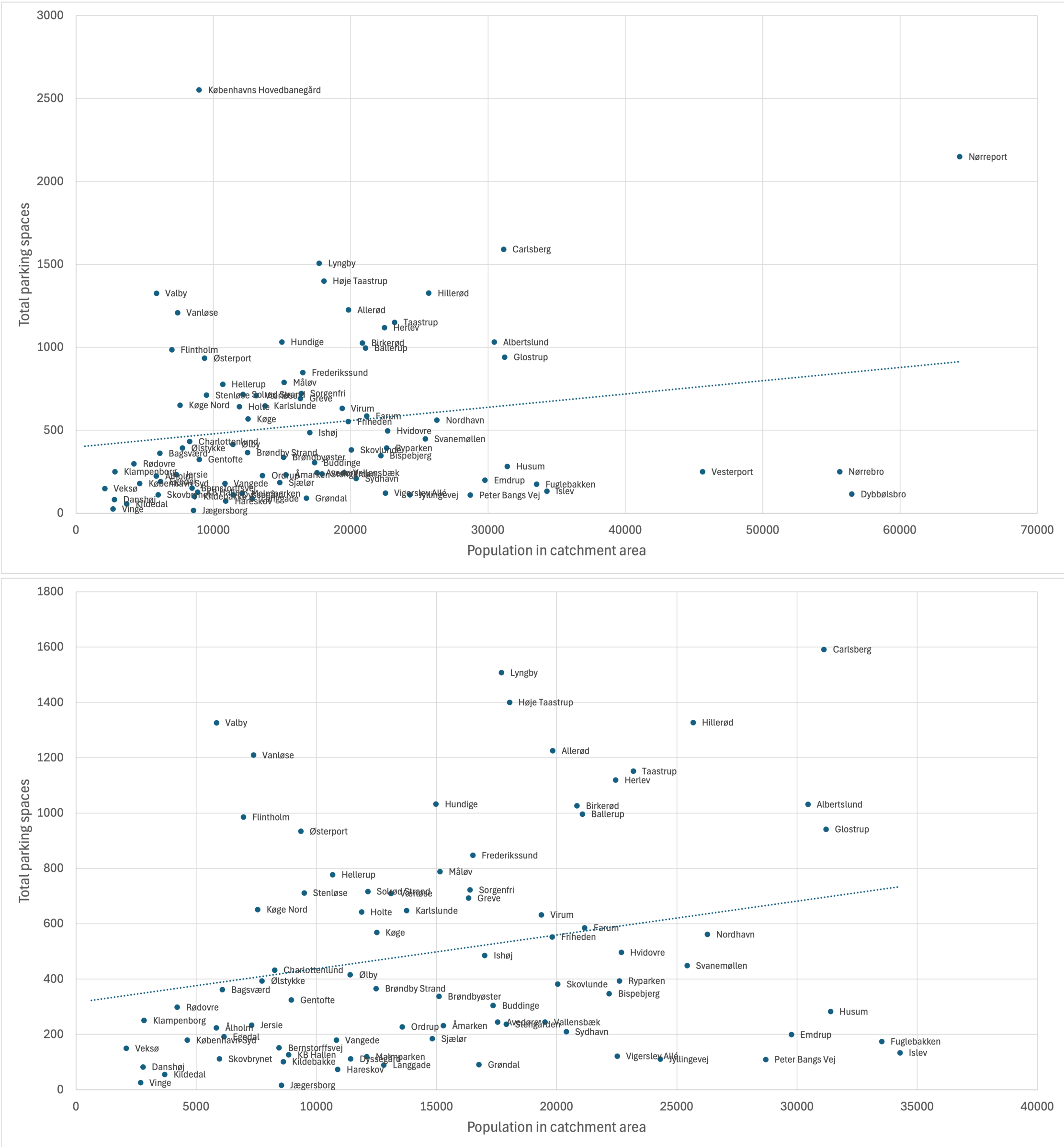

Figure 4.10. Scatterplot of the population in the catchment area and total parking spaces. Full size figure: appendix B.12 and B.13, data: appendix A.5

The top and bottom rank stations can be found in table 4.3. Copenhagen Central station has the most parking places compared to the population. This is the station with connections to the most destinations, within Denmark and abroad. Residents of other catchment areas are likely to travel further to park at the central station. This is in line with van Mil et al. (2020) who found that cyclists are prepared to cycle longer distances to stations that offer direct train services, thus avoiding transfers. This can also be seen from the fact that the highest ranked stations in this list do not only serve the S-train, but are also connected by intercity, regional, and/or metro services. The highest ranked station that exclusively serves S-trains is Stenløse on rank 10. This can also explain some of the lower ranking stations. Dybbøslbro is very close to the central station, while Peter Bangs vej is right in the middle of Valby, Vanløse and Flintholm. It is possible that cyclists prefer to go to these stations due to their better connectivity. The lowest ranked stations are Jægersborg and Dybbølsbro, which have only about 2 parking places for every 1.000 residents.

Rank	Station	Parking places per 1.000 residents
1	Københavns Hovedbanegård	285,51
2	Valby	227,46
3	Vanløse	164,11
4	Flintholm	141,79
5	Østerport	100,10
⋮	⋮	⋮
82	Nørrebro	4,52
83	Islev	3,91
84	Peter Bangs Vej	3,84
85	Dybbølsbro	2,05
86	Jægersborg	1,99

Table 4.3. Top and bottom ranked stations by parking places per 1,000 residents

4.4 Distance between platform and parking

The last parameter that is calculated to be used in the ranking is the distance between the platform and the nearest bicycle parking. The results for each station are mapped in figure 4.11. The highest and lowest ranked stations are shown table 4.4. The shortest distance between the platform and the parking can be found at stations Carlsberg (6,2 m) and Ålholm (8,5 m). Both stations are located in a deepening, with the parking area right above the platform. The lowest ranked stations are Klampenborg, Vallensbæk and Ordrup. The data shows that for all these stations, the closest parking area is over a kilometer away. Unfortunately, this likely means that the used data is incomplete and that the parking areas at this station are not included. More complete data is unfortunately not publicly available. Because the simple-rank methods ensure that extreme outliers do not have a large effect on the results, we will continue to use this data for the ranking.

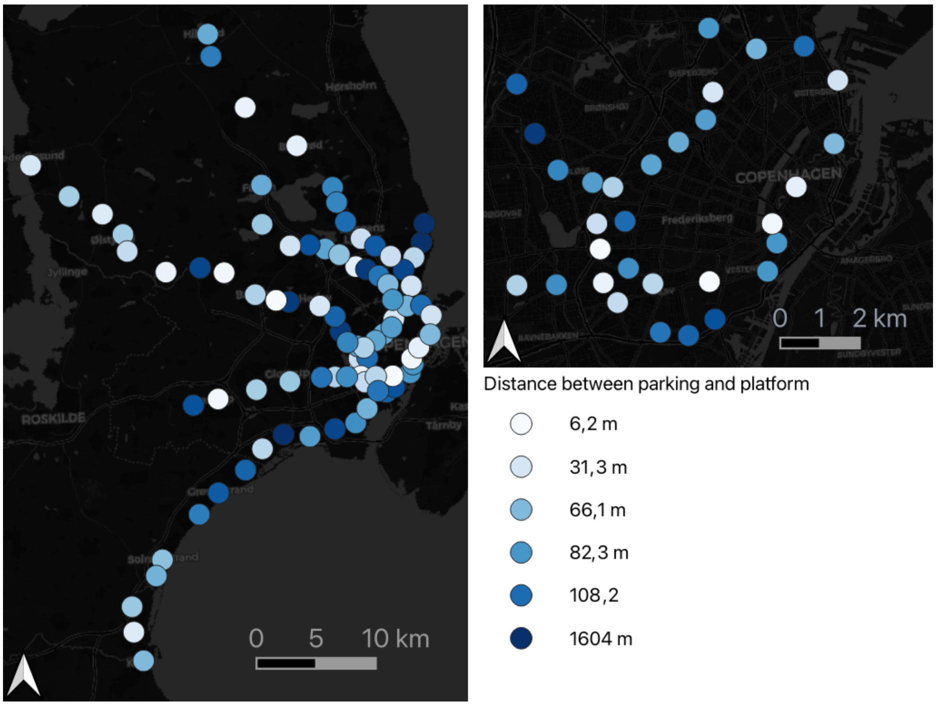

Figure 4.11. Map showing the distance between the platform and the nearest bike parking for each station. Full-size figure: appendix B.14, data: appendix A.6 and D.1

Rank	Station	Distance platform to parking (m)
1	Carlsberg	6.17
2	Ålholm	8.45
3	Malmparken	15.79
4	Taastrup	15.99
5	Måløv	16.81
⋮	⋮	⋮
82	Kildebakke	724.12
83	Islev	886.34
84	Ordrup	1041.37
85	Vallensbæk	1376.18
86	Klampenborg	1604.07

Table 4.4. Distance from platform to parking at stations

4.5 Ranking

After creating a ranking for each of the parameters we can calculate the average rank of every station. This average rank is used to create the overall ranking. A description of how this ranking is calculated can be found in section 3.1. This ranking is used to make a decision on what stations should further be investigated in chapter 5.

The full ranking can be found in figures 4.12 and 4.13. A more detailed ranking is found in appendix A.2. The highest ranking station is Allerød. Husum is the lowest scoring station.

Based on this ranking, the top 3 and bottom 3 stations, as well as 2 extra high ranking, and 2 extra low ranking stations are further investigated in chapter 5. These stations are:

- Allerød
- Veksø
- Carlsberg
- Stenløse
- Ølstykke
- Vallensbæk
- Sydhavn
- Dybbølsbro
- Peter Bangs Vej
- Husum

Station	Rank	Passenger ratio	Population ratio	Covered/locked	Distance
Allerød	1	11	15	2	7
Veksø	2	25	12	19	8
Carlsberg	3	14	24	33	1
Ålholm	4	54	35	9	2
Frederikssund	5	8	23	26	15
Stenløse	6	5	10	25	25
Ølstykke	7	19	25	29	14
Lyngby	8	47	8	18	21
Måløv	9	13	21	45	5
Herlev	10	24	26	27	16
Køge Nord	11	1	7	30	36
Danshøj	12	72	44	4	9
Taastrup	13	12	27	53	4
Vanløse	14	34	3	7	53
Ølby	15	23	36	40	13
Køge	16	28	31	16	41
Farum	17	20	48	10	47
Egedal	18	21	42	28	32
Hellerup	18	68	11	34	18
Hillerød	20	33	22	20	46
Birkerød	21	18	28	61	10
Hundige	21	6	14	14	70
Holte	23	29	19	12	60
Jersie	23	17	41	23	44
Buddinge	25	59	56	31	11
Hareskov	25	62	75	11	20
Værløse	27	10	18	51	35
Valby	28	51	2	48	27
Hvidovre	29	31	50	3	59
Albertslund	30	27	38	39	34
Glostrup	30	46	43	24	37
Høje Taastrup	30	4	9	22	77
Ishøj	33	55	46	32	28
Vigerslev Allé	34	79	79	8	24
Solrød Strand	35	9	17	65	38
Charlottenlund	36	35	20	63	26
Ballerup	37	39	29	54	30
Brøndbyøster	37	49	49	5	64
Bagsværd	39	45	16	42	49
Flintholm	40	44	4	69	29
Skovbrynet	41	16	53	13	75
Gentofte	42	40	37	64	23
KB Hallen	42	70	63	37	22
Virum	44	7	40	41	62
Brøndby Strand	45	41	45	35	52
Kildedal	46	30	61	6	80
Åmarken	47	32	62	44	43

Figure 4.12. Complete ranking 1/2. Detailed ranking in appendix A.2

Station	Rank	Passenger ratio	Population ratio	Covered/locked	Distance
Karlslunde	47	2	30	55	63
Nørreport	49	78	39	66	12
Rødovre	49	58	13	70	31
Jyllingevej	51	37	81	17	61
Sorgenfri	52	3	32	52	69
Bispebjerg	53	52	60	70	17
Østerport	54	63	5	70	40
Bernstorffsvej	55	48	54	15	79
Friheden	56	36	47	47	58
Stengården	56	26	65	62	39
Greve	58	15	33	49	74
Malmparken	59	80	70	70	3
Dyssegård	60	42	71	50	42
Nordhavn	61	73	51	70	19
Klampenborg	62	22	6	56	86
Vesterport	63	84	77	70	6
Københavns Hovedbanegård	64	61	1	70	56
Jægersborg	65	86	86	1	73
Fuglebakken	66	71	80	43	48
Islev	67	43	83	21	83
Vinge	68	77	72	70	33
Ryparken	69	69	57	70	45
Ordrup	70	57	58	38	84
Sjælør	70	76	67	36	72
Avedøre	72	56	64	46	78
Skovlunde	73	38	52	60	81
Vangede	74	50	59	70	65
København Syd	75	82	34	70	66
Emdrup	76	67	76	70	54
Langgade	77	65	74	70	57
Svanemøllen	78	74	55	67	67
Grøndal	79	81	78	70	50
Nørrebro	80	83	82	68	51
Vallensbæk	81	53	66	59	85
Kildebakke	82	64	68	57	82
Sydhavn	83	75	69	58	76
Dybbølsbro	84	85	85	70	55
Peter Bangs Vej	84	60	84	70	68
Husum	86	66	73	70	71
Favrholm*					

Figure 4.13. Complete ranking 2/2. Detailed ranking in appendix A.2

Chapter 5

Analysis 2

5.1 Allerød

Based on the MCDA, Allerød scores overall the highest out of all the s-train stations, with a top-15 rank in all four categories. There are four different bike parking areas around the station, marked on the map in figure 5.1. At the time of the fieldwork there were no trains running through this station due to long-term maintenance work on the line between Virum and Hillerød. Passengers from the station are still served by a replacement bus.

Figure 5.1. Aerial photos (Dataforsyningen, 2025) and pictures of Station Allerød including locations and directions of the platforms. Full resolution in appendix C.1

In line with the data, there is a large amount of covered bike parking at the station. There are 4 parking areas. The area in pictures D,E and F is the largest, offering covered bike parking directly adjacent to the platform. In addition to normal bike parking, this area also offered a special area for cargo bikes (figure 5.1, D). There are also covered and uncovered parking areas on the opposite side of the railway (figure 5.1, A & B). All the covered parking offered a mechanism to hang the bikes on the ceiling (figure 5.1, C), basically doubling the capacity compared to when only the racks on the ground are being used.

At the time of the observations, only one bike was hanging off the ceiling, with most of the bikes parked in the designated bike racks. The parking in areas A and B was practically full. Because the replacement bus is leaving from this side of the railway. The parking area on the opposite side of the railway was practically full in area F, and empty in area D. This indicates that most bikes are parked from where the walk to the replacement bus is the shortest. It is likely that the bikes will start to spread out again once the train is running from the platforms again.

5.2 Veksø

Station Veksø ranks high in all four categories. The station has a large amount of parking and much of it is covered, as can be seen in figure 5.2. The largest amount of parking can be found in area A. However, as can be seen in the picture (figure 5.2, A), at the time of observation there were only three bikes parked in this area. The reason that the parking here is not used as much is likely its location. From this area it is still a long walk to the platform. Because this parking area is located next to the old station building, it is likely that it was closer to the platform when it was constructed, but the platform has since been moved.

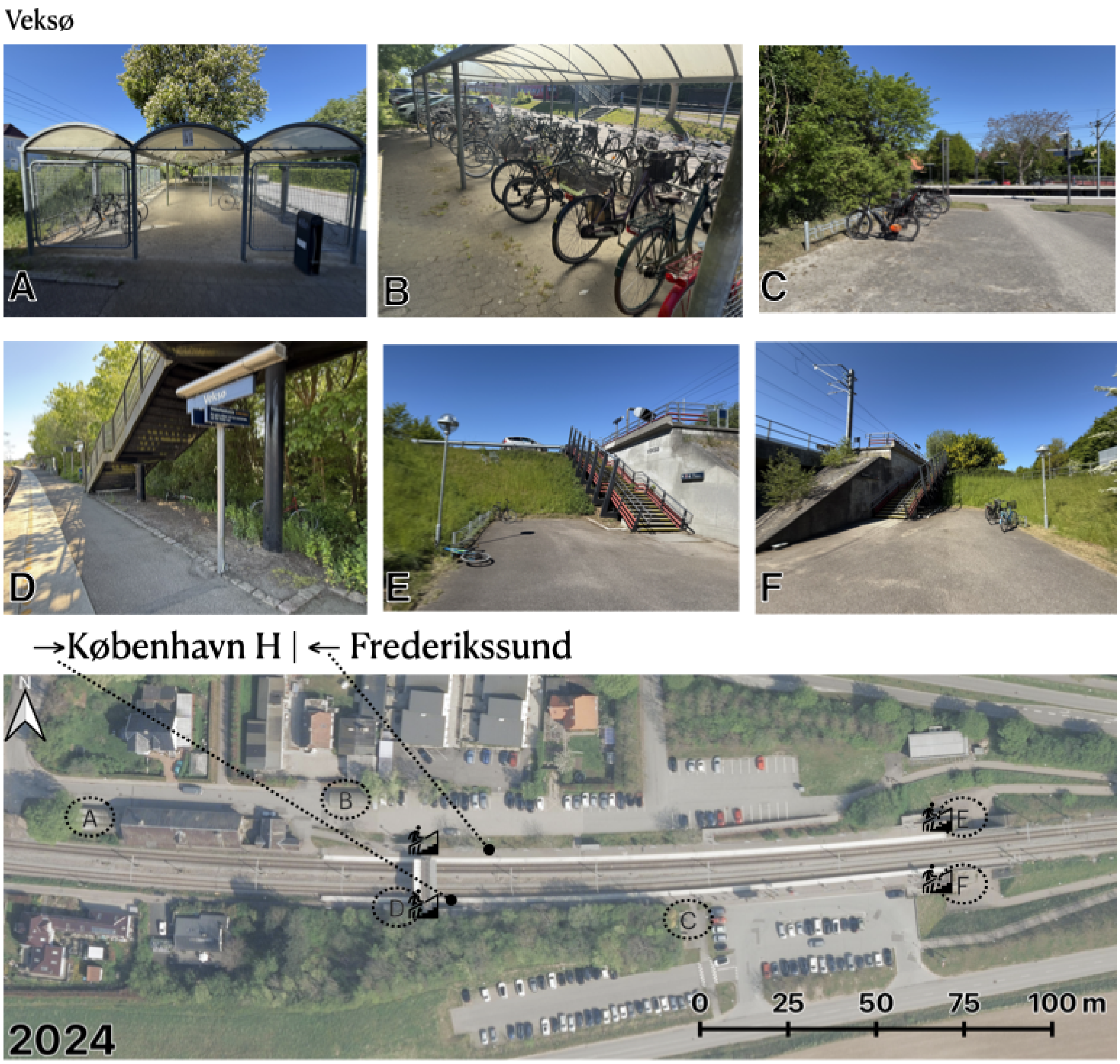

Figure 5.2. Aerial photos (Dataforsyningen, 2025) and pictures of Station Veksø including locations and directions of the platforms. Full resolution in appendix C.10

Most bikes are parked in area B. During the observations, basically all the bike racks in this covered parking were occupied. This is the most attractive parking area because it is closest to the build-up area, is covered, and close to the platform and the stairs. There are three more parking areas, close to the three other entrances to the platform as can be seen in pictures C, E and F. There were a few bikes parked at these areas, but there were also still many empty racks. However, there were still people who wanted to park their bike even closer to the platform. There were two bikes parked under the bridge, right next to the platform as can be seen in picture D.

5.3 Carlsberg

The analysis shows that the distance between the parking and the platform is the shortest at Carlsberg station. Also in terms of capacity and the amount of covered parking, the station scores in the top 1/3rd of all stations.

Carlsberg scored especially well on the distance between the parking and the platform, ranking 1st. This is because the parking at this station is right above the platform and requires only taking the stairs down, as can be seen in figure 5.3. There are two different types of parking at this station: covered parking in the garage and uncovered outdoor parking.

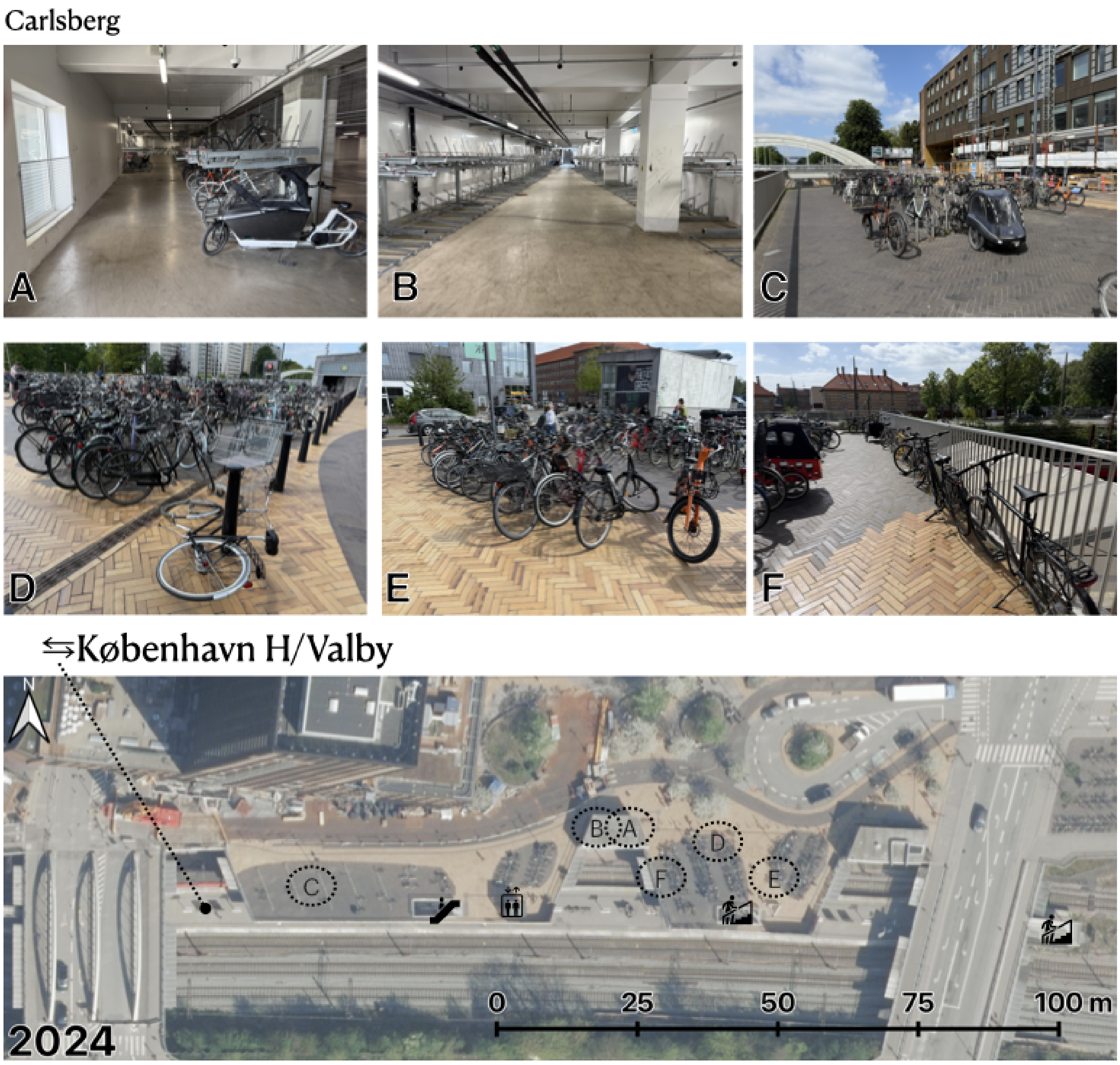

Figure 5.3. Aerial photos (Dataforsyningen, 2025) and pictures of Station Carlsburg including locations and directions of the platforms. Full resolution in appendix C.2

The outdoor parking is well used. During the observation, the parking in area D was practically full with many bikes parked outside the stands and next to the fences. This is not the case for all areas. In area C, there are plenty of available stands. The indoor parking, as seen on pictures A and B, only a fraction of the available bike racks are in use.

To reach this area, you need to carry your bikes down the stairs or use the elevator. There is no bike ramp present. It is possible that people do not want to make this effort and prefer to park their bike outside where they can simply cycle in and out. It is also possible that users are not aware that the indoor parking exists. The entrance is marked with a small sign that says "cykel P", but it is easy to miss when you're in a hurry. When you approach the station from the Vesterfælledvej, you might only see the bike parked in areas D and E, and assume that's the only parking available. This can also explain why uncovered parking area C is less used. Most traffic approaches from the east and are required to cycle past the first areas to reach the station. Even though both areas have a similar distance to the nearest staircase to the platform, the areas closest to the road from where cyclists approach see the highest usage.

5.4 Stenløse

As seen in chapter 4, Stenløse scores well on the capacity to passengers/population ratio, as well as on the amount of covered bike parking. The observations show that there are indeed multiple areas of covered bike parking around the station, as can be seen in figure 5.4 on pictures A, B, D, E and F.

Figure 5.4. Aerial photos (Dataforsyningen, 2025) and pictures of Station Stenløse including locations and directions of the platforms. Full resolution in appendix C.7

Most of these covered parking areas are well-used, but also have enough space available for more bicycles. The only exception is the area in picture F. As can be seen in the picture, this covered parking is completely full and there are even bikes parked outside the racks. It is possible that cyclists approaching from this direction are not aware that there is more parking available or prefer to park here as opposed to further away.

This phenomena can also be seen in picture C. Here it shows that there are bikes parked under the staircase, likely in order to park closer to the platform than the designated bike racks. It is also worth noting that areas D and F offer both covered and non-covered bike racks. In both cases almost all bikes are parked in the covered part of this area. This shows that, in this case, when both are in the same location, cyclists tend to use the covered parking.

5.5 Ølstykke

Ølstykke ranks in the top 25 for every metric in chapter 4. There are various parking facilities around the station, as can be seen in figure 5.5. The majority is covered, but there are also some uncovered bike racks, right next to the platform, as can be seen on picture B.

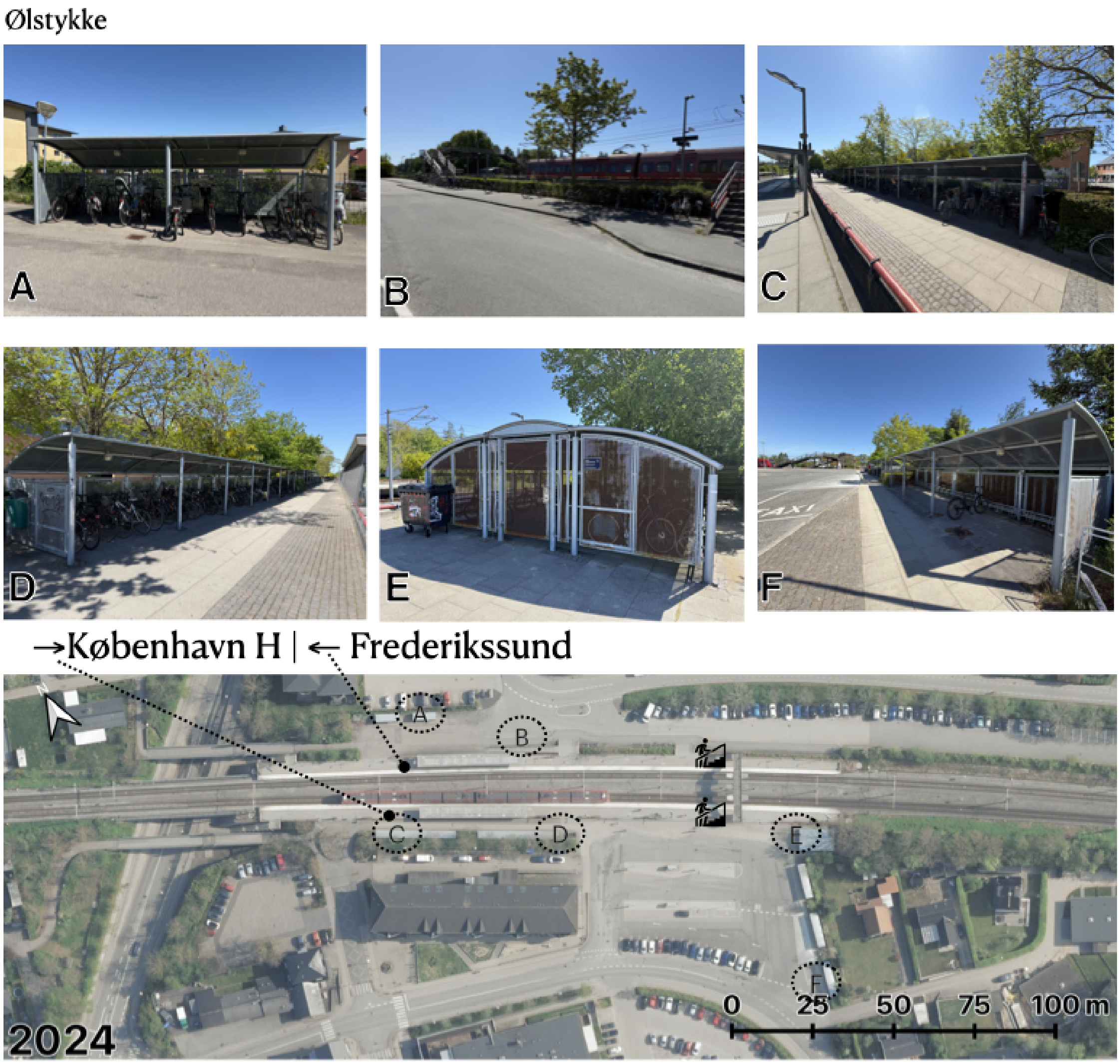

Figure 5.5. Aerial photos (Dataforsyningen, 2025) and pictures of Station Ølstykke including locations and directions of the platforms. Full resolution in appendix C.5

During the observations it became apparent that there is sufficient capacity at the station: there were plenty of available racks, and almost no bikes parked outside of the racks. The highest occupancy was at areas C and D. These are the covered racks right next to the platform in the direction of Copenhagen. There is also a locked parking (figure 5.5, E), that was about half-full, and extra bike parking at area F, although there were not as many bikes parked here as at the other areas. There were also bikes parked on the opposite side of the railway, although not as many, probably because most construction is on the southern side of the station. There was a small covered parking (figure 5.5, A), which was almost full. There are also uncovered racks closer to the platform (figure 5.5, B). The racks closest to the staircases appear to be used the most.

5.6 Vallensbæk

Vallensbæk station ranksthe lowest in terms of distance from the parking to the platform. It also ranked in the bottom 1/3rd for it's capacity and lack of covered parking. There are two uncovered parking areas, as can be seen in figure 5.6, pictures A and B, as well as a locked parking area (figure 5.6, C). Area A was practically full, but was not yet overflowing with bikes parked outside the racks. Area B and the locked areas still had plenty of bike racks available. The observation also confirmed that the parking at this station is relatively far away from the stairs connecting the platforms.

Figure 5.6. Aerial photos (Dataforsyningen, 2025) and pictures of Station Vallensbæk including locations and directions of the platforms. Full resolution in appendix C.9

There is a secondary entrance to the platform along the Søndre Ringvej. There are no bike racks at this entrance, but, as can be seen in figure 5.6, pictures D and E, there are still many bikes parked here, on the sidewalk and on the grass. People likely park here because it's closer to the road, closer to the stairs to the platform and is covered by the railway bridge.

As can be seen in figure 5.6, picture F, these bikes are also parked close to the new light rail station. Although the light rail is scheduled to begin operating within just a few months of the time of writing, there does not seem to be any new bike parking under construction around the stop. This can have negative consequences, because when the light rail operates, it is likely that even more people will want to park their bikes in this area.

5.7 Sydhavn

Station Sydhavn also scores low on the ranking. Most of the parking at the station is marked in the data as uncovered. However, the observations show that most of the parking is covered by the railway bridge going over the station, meaning that the parking is still protected from the rain. Because most parking is under the bridge it's not possible to see it from the aerial photos in figure 5.7.

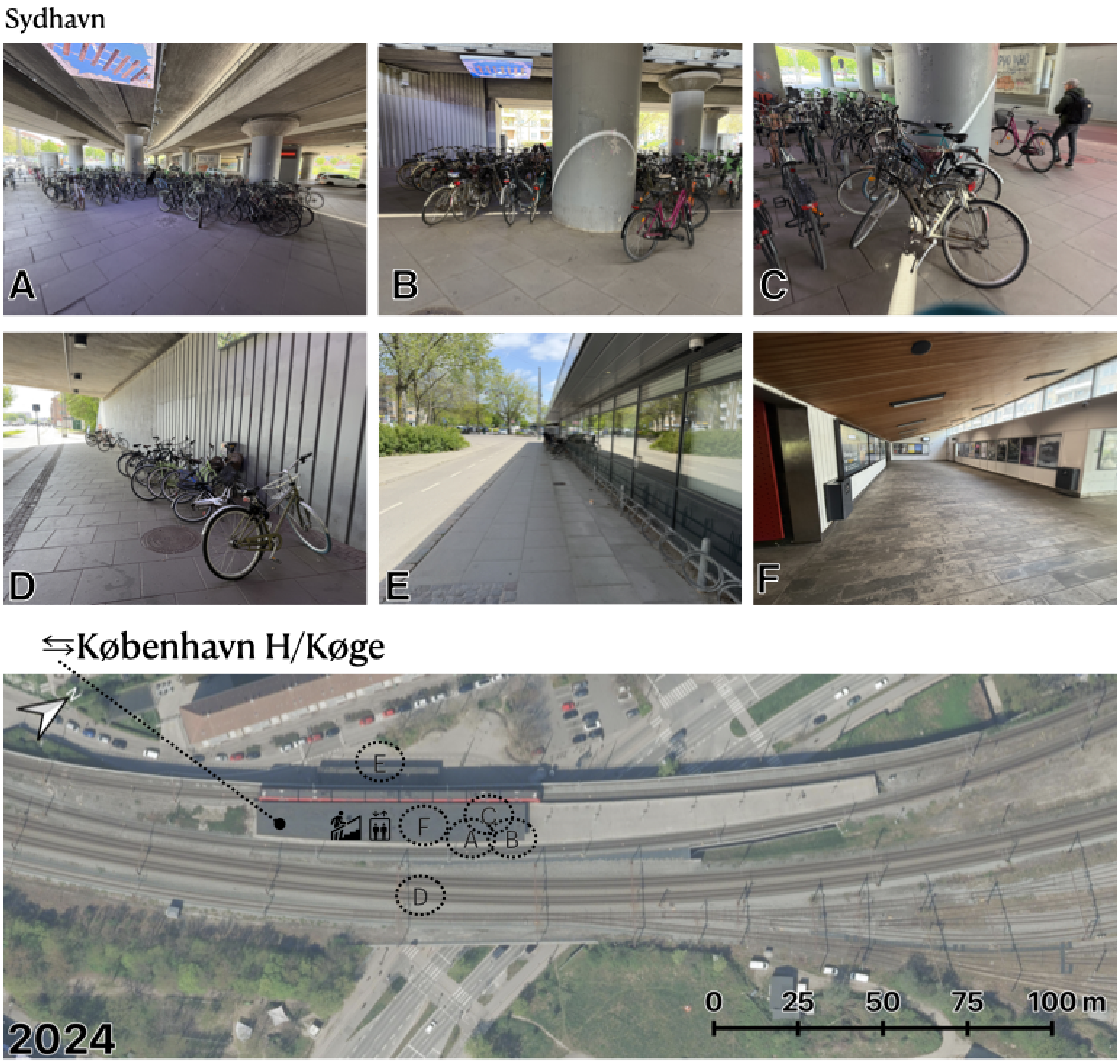

Figure 5.7. Aerial photos (Dataforsyningen, 2025) and pictures of Station Sydhavn including locations and directions of the platforms. Full resolution in appendix C.8

The largest parking area (Figure 5.7, pictures A, B and C) was very full during the observations. Almost all the bike racks are taken, and many bikes are parked outside the bike racks, as can be seen on the pictures. There are also many bikes parked outside of bike racks, along the wall, as is shown in figure 5.7, picture D. This indicates that there is simply not enough capacity at this station for the amount of people who want to park their bike here.

However, there are a few extra bike racks just around the corner, as can be seen on figure 5.7, picture E. Most of these racks remain empty, even though there are many bikes parked outside the racks. People are likely not aware of this parking area or they prefer to park closer to the entrance of the station, even when there are no racks available.

5.8 Dybbølsbro

Dybbølsbro ranks among the bottom 3 out of all the S-train stations. None of the parking is covered, and the capacity is very low for the amount of passengers and people living in the catchment area. This also became apparent during the observations. All the bike racks at the station are used during the day and many bikes are parked outside the racks due to a lack of capacity, as can be seen in figure 5.8. There are bike racks practically along the entire length of the bridge. The areas without racks were still filled with bikes that parked outside the racks due to the limited capacity.

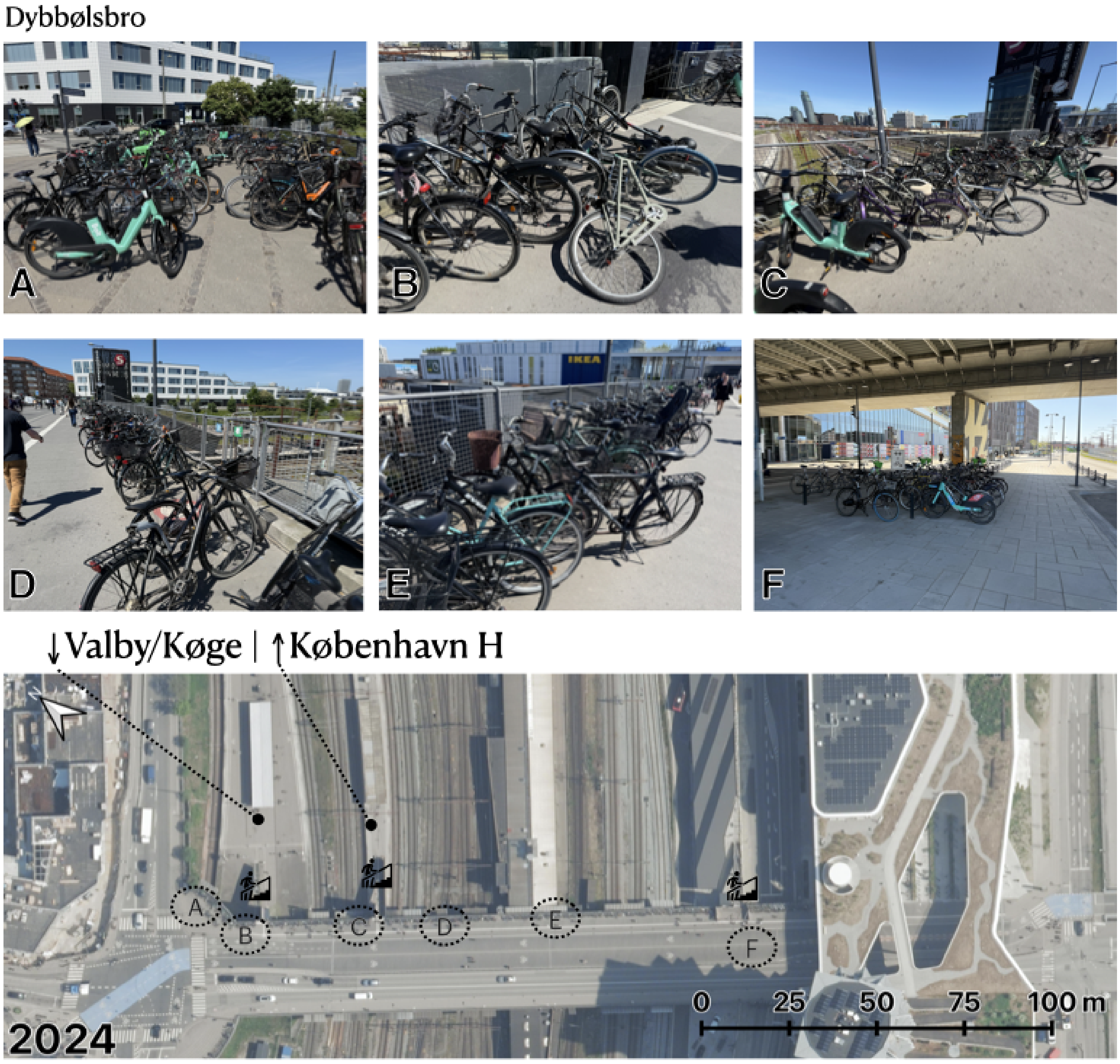

Figure 5.8. Aerial photos (Dataforsyningen, 2025) and pictures of Station Dybbølsbro including locations and directions of the platforms. Full resolution in appendix C.3

Dybbølsbro station is named after the adjacent bridge. The bridge has been redesigned in recent years, to give more space to cyclists. Although the bicycle path is very comfortable, parking your bike on the bridge often leads to inconveniences. The bike racks are on the side walk, which sees heavy foot traffic. This makes it nearly impossible to get from the bike lane to the parking without forcing at least one pedestrian to stop and wait for you. Similar problems arise when getting onto your bike from the parking to the bike path.

There are also many bike-share bikes, such as those from Bolt and Lime parked at the station. These are above-average parked outside the racks and sometimes even blocking other parked bikes. Because these bikes can be left anywhere in the city and the last user doesn't own the bike or has to use it again, there is less incentive to leave them properly inside the bike racks.

During rush hours the sidewalk also easily get congested by people exiting and entering the station. This is because each platform is only connected through one narrow staircase and an elevator. During busy moments this staircase is too narrow to handle all the passengers causing them to wait on the sidewalk, resulting in congestion for foot passengers and making the bike racks even harder to reach.

5.9 Peter Bangs Vej

Station Peter Bangs Vej scored low on all parameters. The parking is more than 100 meters from the platform, uncovered and the capacity is low for the population and amount of travelers. The observations confirmed this data. As can be seen in figure 5.9, pictures A and B, there are two parking areas at this station. Both parking areas are filled close to capacity, with just a few empty spots available in the racks furthest away from the platform. In area A there are a few bikes parked outside the racks, closer to the platform.

Figure 5.9. Aerial photos (Dataforsyningen, 2025) and pictures of Station Peter Bangs Vej including locations and directions of the platforms. Full resolution in appendix C.6

Peter Bangs Vej is one of only four stations where the S-train stops only once every 20 minutes on weekdays. It is possible that cyclists living in the hinterland prefer to park their bikes at stations KB Hallen or Flintholm. These stations are respectively 600 and 900 meters away, and have service every 5 minutes, and in the case of Flintholm also connection to the Metro, making them more attractive for cyclists.

5.10 Husum

Husum ranks in the bottom 20 for all parameters, and lowest in the overall ranking. The observations confirmed that there are no covered or locked bike racks, that the racks are relatively far from the platforms and that there is insufficient capacity at the station, as can be seen in figure 5.10. There are bike racks located in areas A and B. During the observations practically all the bike racks were occupied and there were bikes parked outside the racks. There were also bikes parked in area C, right next to the staircases, indicating that the users couldn't find a parking spot in the racks, or that they preferred to park closer to the staircases.

Figure 5.10. Aerial photos (Dataforsyningen, 2025) and pictures of Station Husum including locations and directions of the platforms. Full resolution in appendix C.4

Although the bike racks are located closest to the main entrance on the Islevhusvej, there is also an entrance on the opposite side of the platform that is connected to a bike path. For many cyclists going to the station, this is the easiest entrance to reach. However, there are no designated bike racks in this area. Because people still want to park their bike when approaching the station at this entrance, they end up parking their bikes on the bridge, close to the staircase. As can be seen in figure 5.10, pictures D and E, this bridge is filled with parked bikes. This is the result of the fact that there is not enough designated bike parking, and that there is no parking near the entrance close to the bike path.

Chapter 6

Discussion

6.1 Good and Bad parking

The analysis shows that there is a great variety in bicycle parking between stations. There are many different factors that people consider when deciding their mode choice for the trip. Having good parking facilities is essential, if the city of Copenhagen wants to promote the use bicycles and public transport.

However, not at every station the bike parking is of the desired quality. The issues of the state of the bike parking at stations can be summarized in two categories: whether there is enough capacity, and whether a design issue leads to the parking area not being used as intended. This leads to four categories, as can be seen in figure 6.1.

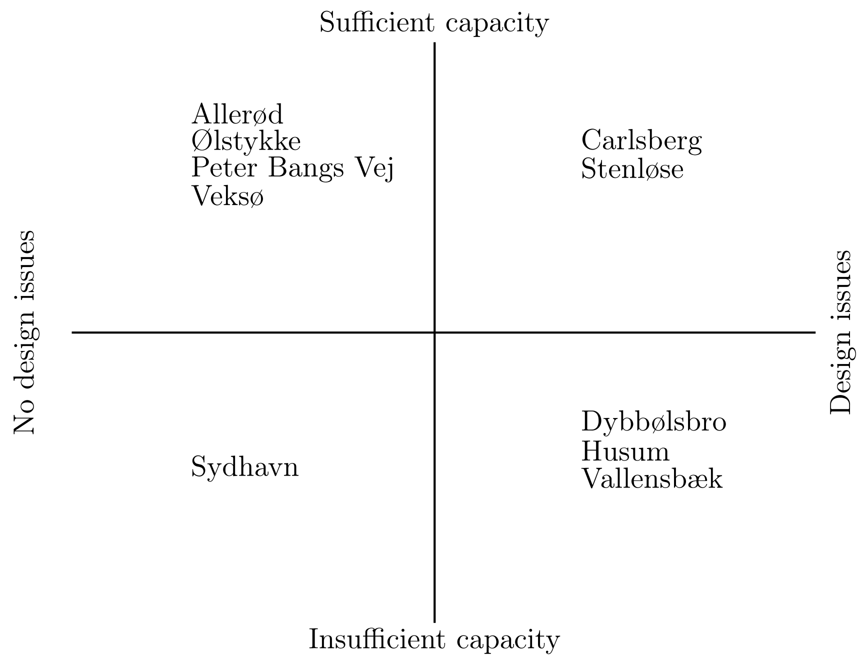

Figure 6.1. Bike parking performance of selected stations classified by capacity and design quality

The stations in the top left of the quadrant chart have sufficient capacity, and there are no clear design issues. This means that there is enough space for everyone to park their bike, and that people are parking their bikes in the designated areas.

Stations in the bottom left do not have a direct design issue, but they do not have enough parking spaces for all cyclists to leave their bikes. For example at station Sydhavn there were many bikes parked just outside the bike racks, simply because there are no available spaces. If there is not enough capacity, it is possible that people decide to use different modes of transport because they cannot find space to park their bikes.

Stations in the top right of the graph have sufficient parking areas, but bad design choices have lead to it not being used as intended. For example, at station Carlsberg, the indoor parking area is not being used, while the outdoor area is overflowing. The area is not well marked, only a small sign stating "cykel-p" indicates that it is there. Entering the area requires going down a staircase without bike trench or waiting for the elevator. This can be time consuming for the users, who prefer to park their bikes elsewhere. At Stenløse the parking was planned in the wrong location. here the parking area closest to the road was overflowing, even though there was plenty of capacity available, even at parking areas next to the platform.

The most attention is required for stations that fall into the bottom-right category. Here, there is not enough capacity, and there are clear design issues with the available parking areas. At stations Husum and Vallensbæk the design lacks parking areas near the busiest bike paths resulting in people leaving their bikes here, as opposed to the designated parking areas. In Dybbølsbro, cyclists have to cross the sidewalk to reach the bike parking, resulting in conflicts.

6.2 Recommendations for planners

Based on this research, there are a couple recommendations that can be made for planners who need to design bike parking at public transport stations. This is useful in the context of improving existing stations, as well as for newly-planned stations, such as the 29 stops on the soon-to-be-opened light-rail line between Ishøj and Lyngby. It can be applied in Copenhagen, as well as the rest of Denmark and abroad.

Plan at the right location.
Most people park their bikes the closest to the road where they approached from or closest to the platform. It is important that there is enough capacity at these locations. If a station has more than one entrance, there should be enough parking at every entrance.

Show where people can find more parking.
Not everyone is aware that there is more, or better, parking available. It can help to put up signs to make people aware where they can find available parking, such as in figure 6.2. This will prevent people from parking outside the racks because they think none are available.

Figure 6.2. Sign at Hilversum station (the Netherlands) saying "there are more parking places around the corner" (Google, 2022)

Make parking as easy as possible.
It is not pleasant to have to carry your bicycle up and down stairs or in an elevator. For underground bike parking it could be better to build a ramp, so people can simply cycle, or walk their bike, in- and out of the parking.

Covered parking is preferred, but not necessary.
The analysis showed that, when given the choice, more people park their bikes at the covered parking areas than at the non-covered areas. However, the location of the bike parking is the most important factor when deciding where to park your bike.

Match capacity with demand
The parking at some train stations is simply too full. It is important that the capacity is higher than the demand on the busiest moment of the day to ensure that there is always enough space for everyone who wants to park their bike.

Have enough space for cargo bikes.
Of the ten analyzed stations, only one has a dedicated area for cargo bikes. At the other stations, cargo bikes are parked in the normal bike racks. Cargo bikes take up at least three to four spaces. This takes up valuable capacity not available to other bikes.

Increase security for more expensive bikes.
During the fieldwork there were no newer electric bikes parked at any of the stations. It is possible that people do not think there are enough security measures at the stations to prevent bike theft. The available locked parking is still not guarded, and can be accessed by anyone. For larger stations it can be a solution to have manned security, or gates that prevent more than one person to go in, such as in figure 6.3.

Figure 6.3. Entrance to guarded bike parking in the Netherlands (Nederlandse Spoorwegen, 2025)

Have mechanisms for two-layered parking only when necessary

Some stations have mechanisms to park two bikes on top of each other. However, at none of the stations that featured these mechanisms were they being used. This means that people prefer to park their bike in the racks on the ground, even if it means parking at an inferior location. This two-layered parking can be great to increase capacity when limited space is available, but if there is space it can be better to build more bike racks on ground level.

Prevent parking outside racks

At many stations there are bikes parked outside the racks. These bikes can block walking paths, and can result in the station looking more cluttered, discouraging people from taking their bike to the station. The points mentioned above help reducing this issue, but if the problem persist, it can help to threaten to remove wrongly parked bikes. If a bike is parked outside the bike racks, it should be removed by the municipality, and given back to the owner for a fee. This will prevent people from parking their bikes in the wrong place. Of course, it is important that there is enough capacity for people to park their bike elsewhere. People should also be made aware that their bike can be removed through signs, such as in figure 6.4

Figure 6.4. Sign saying "bike wrong = bike gone" at station Deurne in the Netherlands (DMG Deurne, 2023)

6.3 Use of GIS

GIS proved to be a valuable tool in this research, by enabeling a comprehensive spatial analysis of the bike parking at Copenhagen's S-train stations. GIS allowed for the integration of multiple datasets, such as parking types, parking locations, passenger data and to calculate the population distribution. GIS made it possible to indicate possible bottlenecks, where the capacity is too low for the demand.

GIS also made it easy to calculate isochrones, which gave a realistic idea of travel times, as well as the catchment areas, giving insight into the number of people served by each station.

While GIS provided powerful insights, its effectiveness was partly limited by the availability and precision of public data. It would, for example, have been useful to have extra data on security or informal parking. Nonetheless, the ability to map, quantify, and compare spatial patterns across the entire network demonstrates how GIS can support planning decisions. The analysis can help planners in the future to identify priority locations for improvements.

6.4 Recommendations for further research

Even though this report aims to give a good overview of the state of bicycle parking at the S-train stations in Copenhagen, there are still gaps that can be explored in further research. It can be for example useful to include the user's perspective, for example by conducting interviews or surveys with the users. This could provide insights into behavioral patterns, preferences and barriers that are not visible through observations.

It can also be beneficial to investigate the entire transport network, not just the S-trains. The parking at some stations is also used by other users, while some of the people getting onto the train at these stations are also transferring from other modes of transport. It is also possible that people park their bikes at metro stations, or bus stops. Looking at the entire network can give a more complete overview of the situation.

Although this report looks at the situation as it is in 2025, it is also important to look into the future. What developments are planned/expected, and is the infrastructure prepared for that. This can be new developments or an increase in population, but also new lines, such as the light-rail, that is opening in fall 2025. A great example is station Vallensbæk, that is not yet prepared for the opening of the light-rail, because there are already not enough parking places near the platforms.

Chapter 7

Conclusion

This report aims to investigate how spatial and temporal patterns of bicycle parking at S-train stations in Copenhagen affect bike-to-train transfers, and how GIS-based analysis can be used to optimize the planning of these facilities. Through a combination of GIS analysis and field observations, this study investigates both quantitative and qualitative factors influencing bike-to-train integration. Quantitative factors, such as the capacity of bike parking relative to the number of passengers or the surrounding population, and qualitative aspects, such as location and visibility, play a crucial role in its success.

There is a significant difference in quality among stations in the network. Stations such as Allerød and Veksø show good practice, as there is sufficient parking that is being used as intended. On the other hand, stations such as Dybbølsbro and Husum suffer from both insufficient capacity and bad design. This has lead to chaotic and informal parking patterns, such as many bikes being parked outside of the designated areas.

The most important factor in how bike parking is used is the location. To improve bike-to-train integration, planners should focus on locating facilities at locations where cyclists actually approach the station. Furthermore, bicycle parking has to be well visible and easy to access and use. It is also important that there is sufficient capacity at the stations to meet peak demand.

The GIS based multi-criteria decision analysis helped to identify possible points of conflict in the network by identifying station that have too limited capacity, or are of too low quality. Furthermore, the combination with field observations provided valuable insights into actual user behavior and parking preferences, which are often not captured by spatial data alone.

Ultimately, this research demonstrates that GIS can be a powerful tool to improve multi-modal transport systems, especially when combined with field observations. A thoughtful and user-centered approach to bicycle parking has the potential to improve bike to train connection, reduce car dependency, and support the broader goals of sustainable urban mobility.

Bibliography

Arbis, A., T. H. Rashidi, V. Dixit, and U. Vandebona (2016). Evaluating the quality of bicycle parking facilities: An analysis of user preferences and walking distances. *Transportation Research Record: Journal of the Transportation Research Board 2587*, 51–59.

Belton, V. and T. J. Stewart (2002). Multiple criteria decision analysis: An integrated approach. *Journal of the Operational Research Society 53*(11), 1247–1248.

Bertolini, L. (1999). Spatial development patterns and public transport: the application of an analytical model in the netherlands. *Journal of Transport Geography 7*(2), 111–123.

Centrum Ondergronds Bouwen (COB) (2023). Fietsenstalling stationsplein utrecht. Online report. Accessed: 2025-05-27.

City of Copenhagen (2023). Mobilitetsredegørelse 2023. City of Copenhagen. Available at: https://kk.sites.itera.dk/apps/kk_pub2/pdf/2619_283116b64746.pdf.

Copernicus Land Monitoring Service (2020). Land Cover 2019 (Raster 100 m), Global, Yearly – Version 3 (Area: Denmark). https://land.copernicus.eu/en/map-viewer?dataset=a8d945f0edd143a0a5240c28bafa23da. Accessed: 2025-05-23.

Curtis, C., J. L. Renne, and L. Bertolini (2009). *Transit Oriented Development: Making It Happen*. Ashgate Publishing.

Danmarks Statistik (2025). Postnr1: Population 1. january by postal code, sex and age. Accessed: 2025-05-23.

Data-Science.dk (2025). Cykelparkering GIS Download. https://data-science.dk/datasat/gis/osm/land-og-by/infrastruktur/cykelparkering-gis-download/. Accessed: 2025-05-23.

Dataforsyningen (2025). Forårsbilleder ortofoto – geodanmark. https://dataforsyningen.dk/data/981. Accessed: 2025-05-27.

Dataforsyningen (2025a). Forårsbilleder Ortofoto - GeoDanmark. https://dataforsyningen.dk/data/981. Accessed: 2025-05-23.

Dataforsyningen (2025b). Postnummerinddeling. Accessed: 2025-05-23.

de Kruijf, J. (2021). Two-thirds of dutch people live within 15 minutes cycling of train station. Accessed: 2025-05-23.

Department for Communities and Local Government (2009, January). Multi-criteria analysis: A manual. Accessed: 2025-05-27.

DMG Deurne (2023). Borden in strijd tegen fietsenchaos op station. https://dmgdeurne.nl/borden-in-strijd-tegen-fietsenchaos-op-station/. Accessed: 2025-05-26.

DSB (2025a). Aflast cykelparkering med dsb+. Accessed: 2025-05-27.

DSB (2025b). S-tog | kom nemt rundt i hovedstaden. Accessed: 2025-05-27.

Gemeente Utrecht (2023). Inwonersenquête 2023 – verkeer en vervoer. Online dashboard. Available at: `https://utrecht.incijfers.nl/mosaic/inwonersenquete/verkeer-en-vervoer`.

Geofabrik GmbH (2025). Download Server for OpenStreetMap Data — Denmark. `https://download.geofabrik.de/europe/denmark.html`. Data © OpenStreetMap contributors, licensed under ODbL 1.0.

Google (2021). Google Street View Image of Kildedal, Denmark. `https://maps.app.goo.gl/XvdEokUqFeWXPcdU6`. Image captured in 2021. Accessed: 2025-05-23.

Google (2022). Google Street View Image of Hilversum Station, Stationsstraat 2, Netherlands. `https://maps.app.goo.gl/nrRh8A8vTbJa99pYA`. Image captured in 2022. Accessed: 2025-05-26.

Google (2024). Google Street View Image of Birkerød, Denmark. `https://maps.app.goo.gl/PebGX6t44ViM9NDv5`. Image captured May 2024. Accessed: 2025-05-23.

Heinen, E. and R. Buehler (2019). Integration of bicycle and public transport. *Transportation Research Part A: Policy and Practice 131*, 3–18. A comprehensive review of bicycle parking and public transport integration.

Hovedstadens Letbane (2025). Hovedstadens letbane. Accessed: 2025-05-27.

Jonkeren, O. and R. Kager (2021). Bicycle parking at train stations in the netherlands: Travellers' behaviour and policy options. *Research in Transportation Business Management 40*, 100581.

Knowles, R. D. (2012). Transit oriented development in copenhagen, denmark: from the finger plan to Ørestad. *Journal of Transport Geography 22*, 251–261.

Krizek, K. J. and E. W. Stonebraker (2011). Assessing options to enhance bicycle and transit integration. *Research in Transportation Business Management 1*, 3–12.

Landeshauptstadt München (2019). Bike and ride-offensive in münchen. City of Munich. Available at: `https://www.muenchen.de/rathaus/Stadtinfos/Verkehr/Bike-and-Ride.html`.

Li, H.-r. (2016, 12). Study on green transportation system of international metropolises. *Procedia Engineering 137*, 762–771.

Mangold, M., P. Zhao, H. He, and A. Mansourian (2022). Geo-fence planning for dockless bike-sharing systems: a gis-based multi-criteria decision analysis framework. *Urban Informatics 1*(17).

Martens, K. (2007). Promoting bike–transit integration: The role of bicycle parking. *Transportation Research Record: Journal of the Transportation Research Board 2030*, 79–87.

Nederlandse Spoorwegen (2025). Sneller stallen: sneller je fiets parkeren bij de NS. `https://www.ns.nl/fietsenstallingen/sneller-stallen.html`. Accessed: 2025-05-26.

Pan, M. M. and E. Isham (2024). Interplay of travel time, distance, and speed estimation in transportation mode choice decision-making. `https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4701223`. Accessed: 2025-05-22.

Santos, T., R. N. Mendes, and R. P. Julião (2023). The potential of integrated transport modes: modelling the combined use of bicycles and train in lisbon, portugal. *CIDADES, Comunidades e Territórios 47*, 193–210. Accessed: 2025-05-22.

SINUS-Institut (2023). Fahrrad-monitor 2023 – boost report münchen. Online report. Available at: https://muenchenunterwegs.de/content/2956/download/sinus-institut-fahrrad-monitor-2023-boost-report-munchen-11122023-1.pdf.

Stadt Wien (2021). Fahrrad und Öffis: Kombinierte mobilität in wien. City of Vienna. Available at: https://www.wien.gv.at/verkehr/radfahren/strategien/.

Su, F., J. Ren, Q. Chen, Y. Huang, and F. Zhang (2020). Transit-oriented development (tod) typologies around metro station areas in urban china: A comparative analysis of five typical megacities for planning implications. *Journal of Transport Geography 87*, 102939.

Trafikstyrelsen (2025). Passagertal.dk: Realtime and historical public transport passenger counts. https://passagertal.dk/Embed#vfs://global/passagertal.dk/Velkommen.xview. Accessed: 2025-05-22.

van der Spek, S. and N. Scheltema (2015). The importance of bicycle parking management. *Research in Transportation Business & Management 15*, 39–49.

van Mil, J. F., T. S. Leferink, J. A. Annema, and N. van Oort (2020). Insights into factors affecting the combined bicycle-transit mode. *Public Transport 13*(3), 649–673.

Vejdiktoratet (2024). Cykelregnskab 2024. https://stormgmtpbie.z6.web.core.windows.net/cykelregnskab.html. Accessed: 2025-05-22.

Zhang, X., L. Gu, and N. Zhao (2024). Navigating the congestion maze: Geospatial analysis and travel behavior insights for dockless bike-sharing systems in xiamen. *arXiv preprint arXiv:2401.03987*.

Île-de-France Mobilités (2022). Plan vélo: 40 000 places de stationnement vélo d'ici 2026. Île-de-France Mobilités. Available at: https://www.iledefrance-mobilites.fr/actualites/plan-velo-40000-places-2026.

List of Figures

Appendix A

Ranking and data

The .xlsx file is uploaded separately

A.1 Ranking

A.2 Detailed ranking

A.3 Parking data

A.4 Passenger data

A.5 Catchment area data

A.6 Parking-platform data

Appendix B

Full resolution maps and graphs

The .png files are uploaded separately

B.1 Map of total parking places

B.2 Graph of total parking places

B.3 Map of categorized parking places

B.4 Graph of categorized parking places

B.5 Map of daily passengers

B.6 Graph of daily passengers

B.7 Plot of daily passengers / total parking

B.8 Plot of daily passengers / total parking (zoomed in)

B.9 Map of isochrones

B.10 Map of catchment areas

B.11 Graph of catchment areas

B.12 Plot of population / total parking

B.13 Plot of daily population / total parking (zoomed in)

B.14 Map of the distance parking to platform

Appendix C

Full resolution station summaries

The .png files are uploaded separately

C.1 Allerød

C.2 Carlsberg

C.3 Dybbølsbro

C.4 Husum

C.5 Ølstykke

C.6 Peter Bangs Vej

C.7 Stenløse

C.8 Sydhavn

C.9 Vallensbæk

C.10 Veksø

Appendix D

GIS layers

The .gpkg files are uploaded separately

D.0 Information on GIS layers

D.1 S-tog_stations

D.2 Isochrones

D.3 Catchment areas