Chair of Urban Structure and Transport Planning
TUM School of Engineering and Design
Technical University of Munich

Mobility Hubs in Urban Regions: Analysing Expected and Existing Impacts Using a Mixed-Methods Approach

Bachelor's Thesis
at the TUM School of Engineering and Design
at the Technical University of Munich

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Study program: Environmental Engineering (B.Sc.)

19 March 2024

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APPROVAL OF BACHELOR'S THESIS

Study Program Environmental Engineering

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03718883

Start and End Date: 18.09.2023 – 17.02.2024

Topic: A Systematic Literature Review on the expected and existing impacts of Mobility Hubs

Background and objectives:

Urban regions make up a relatively small area compared to the total land space on earth but comprise more than 50 % of the world population today (Ritchie & Roser, 2018). Therefore, a significant amount of planning and management is involved in developing cities into sustainable, efficient, and livable spaces. Mobility and transportation play a relevant role in ensuring a healthy environment for its inhabitants but, when defective, damage social and ecologic conditions in urban areas. As challenges such as battling congestion, air pollution and creating equal accessibility are gaining prominence due to the rapid growth of cities, mobility hubs become increasingly relevant for supporting sustainable transport (Arnold et al., 2023). Mobility hubs act as nodal points where a variety of modes offer the opportunity to travel seamless and efficient in between a transport network. Modes provided by hubs generally range from public transport, shared and on-demand mobility to active modes such as private bicycle parking or the linkage to pedestrian and bike paths (UITP, 2023).

Having a comprehensive insight of the interconnection between mobility hubs, modal shift, and climate resilience is crucial for several reasons. By understanding if mobility hubs can facilitate a modal shift towards sustainable transportation modes, cities can effectively manage congestion and reduce carbon emissions, contributing to improved air quality and public health. Additionally, this knowledge helps cities prepare for climate challenges, enhancing their adaptability and resilience. This understanding guides policymakers in devising holistic urban development strategies that align environmental, social, and economic goals, fostering a more sustainable and adaptable future.

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The first objective of this bachelor's thesis is to conduct a comprehensive review of the interrelation of mobility hubs, modal shift, and their environmental impact on contemporary cities. This involves examining certain typologies of mobility hubs and critically evaluating their impacts after projecting them on a realistic scale.

Following research questions will be examined:

- What are the expected and existing impacts of mobility hubs?
- How do these impacts relate to the different typologies and elements of mobility hubs?

Methods:

A systematic literature review will result in identifying the expected and existing impacts of mobility hubs. Examining typologies and concepts of these nodal points will lead to connecting them to the mobility behavior of users and the resulting influences on for example emissions, pollution and socioeconomic conditions in urban regions. Further, studies of existing mobility hubs will be analyzed regarding their elements and to what extend they specifically influence modal shift behaviors and ecological conditions. In case of lacking literature, interviews will be conducted for gaining additional insights.

Supervision:

The candidate will present to his supervisors Yihan Xu and Dr.-Ing. David Telmo Duran Rodas a draft of the structure for his bachelor's thesis and a work plan two weeks after this approval. Other supervision meetings will be planned with the candidate when necessary. The Chair of Urban Structure and Transport Planning supports the candidate with the contact to relevant actors and or experts if needed. After two weeks of the submission of his thesis, the candidate must defend it by means of a presentation (20 minutes) and the following discussion. The results are responsibility of the author. The Chair does not take responsibility for those results. The Chair of Urban Structure and Transport Planning and the thesis supervisor are allowed to use, reproduce, distribute, and display the bachelor's thesis and any generated data, for academic research and education purposes, provided that coordination with the student occurs. The thesis proposed has been suggested and will be overseen by the supervisor and the Chair of Urban Structure and Transport Planning, who maintain ownership of the research topic idea and may use data generated in this study for future academic purposes.

Yihan Xu

Dr.-Ing. David Telmo Duran Rodas

Abstract

Transport makes a decisive contribution to human-made climate change, which must be curbed. In addition, increasing global urbanisation presents cities with challenging tasks. These include finding ways to achieve a sustainable transport transition so that urban regions remain liveable and environmentally friendly. Innovative concepts such as mobility hubs, which have gained increasing attention in recent years, are tools that can significantly impact the transition to sustainable and user-friendly mobility. These nodes offer a wide choice of transportation modes and thus provide residents with access to multimodal travel. However, the question arises as to what potential lies behind the hubs. Using a mixed-method approach, this research examines relevant literature as well as the perspectives of experts regarding the impacts of mobility hubs. A clear presentation and categorisation of their expected and existing impacts on urban areas should provide policymakers and transport planners with a deeper understanding of the benefits of this concept and motivate them to implement it. Furthermore, comparing the impacts should clarify their relevance in the literature and among experts, as well as contrast the expectations with the actual effects. The results of this study indicate that mobility hubs are a viable solution with a significant impact, particularly on environmental and social conditions. The reduction of car traffic in cities and associated emissions, as well as the promotion of active transportation, social inclusion, and improved health, among others, contribute to the overall effectiveness and success of mobility hubs. The comparative analysis also shows that effects such as the reduction of emissions, accessibility or increased social interaction require complex observation and measurement or calculation and are still challenging to determine. This is underpinned by the data available in the relevant literature and the comments of the experts. Despite the limitations, this research emphasises the ability of urban mobility hubs to create sustainable and socially inclusive spaces.

Kurzfassung

Der Verkehr leistet einen entscheidenden Beitrag zum menschengemachten Klimawandel, den es gilt einzudämmen. Darüber hinaus, stellt eine zunehmende weltweite Urbanisierung Städte vor herausfordernde Aufgaben. Zu diesen zählen vor allem Wege zu einer nachhaltigen Verkehrswende zu finden, damit urbane Regionen lebenswert und umweltfreundlich bleiben. Innovative Konzepte, wie Mobilitätsstationen, die in den letzten Jahren immer mehr Aufmerksamkeit erlangten, sind Instrumente, die bei der Umstellung auf eine nachhaltige und nutzerfreundliche Mobilität bedeutende Auswirkungen haben können. Diese Knotenpunkte bieten eine breite Auswahl an Verkehrsmitteln und ermöglichen Einwohnern somit den Zugang zu multimodalem Reisen. Jedoch stellt sich die Frage, welches Potential hinter den Knotenpunkten steckt. Durch einen Mixed-Method Ansatz werden in dieser Forschung relevante Literatur sowie die Meinungen von Experten hinsichtlich der Auswirkungen von Mobilitätsstationen untersucht. Eine klare Darstellung und Kategorisierung ihrer erwarteten und bestehenden Auswirkungen auf städtische Gebiete sollte politischen Entscheidungsträgern und Verkehrsplanern ein tieferes Verständnis für die Vorteile dieser Konzepte vermitteln und sie zu ihrer Umsetzung motivieren. Außerdem sollte eine Gegenüberstellung der Auswirkungen, zum einen deren Relevanz in der Literatur sowie unter Experten verdeutlichen, sowie die Erwartungen in Kontrast zu den tatsächlichen Effekten stellen. Die Ergebnisse dieser Studie deuten darauf hin, dass Mobilitätsstationen eine praktikable Lösung mit erheblichen Auswirkungen sind, insbesondere auf ökologische und soziale Bedingungen. Die Verringerung des Pkw-Verkehrs in den Städten und der damit verbundenen Emissionen sowie die Förderung aktiver Verkehrsmittel, die soziale Eingliederung und eine Verbesserung der Gesundheit tragen u.a. zur Gesamtwirksamkeit und zum Erfolg von Mobilitätsstationen bei. Die vergleichende Analyse zeigt jedoch auch, dass Auswirkungen wie die Verringerung von Emissionen, Zugänglichkeit oder verstärkte soziale Interaktion einer aufwändigen Beobachtung und Messung bzw. Berechnung bedarf und weiterhin nur schwierig ermittelt werden können. Dies wird durch die Datenlage in der relevanten Literatur und die Äußerungen der Experten untermalt. Trotz der Einschränkungen betont diese Forschung die Fähigkeit von urbanen Mobilitätsstationen, nachhaltige und sozial integrative Räume zu schaffen.

Acknowledgement

Firstly, I would like to express my gratitude to my supervisors, Yihan Xu and Dr. David Duran Rodas, who guided me through this research and enriched me with their ideas. I would also like to thank my family, friends and girlfriend who have supported me throughout this work. A special thank you also to the experts I was given the opportunity to interview as part of this study, whose exciting perspectives significantly contributed to this research.

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Abbreviations

hvv	Hamburger Verkehrsbund
BRT	Bus Rapid Transit
MDS	Mobility Data Specification

1 Introduction

Urban regions cover a relatively small area compared to the total land space on Earth but comprise more than 50 % of the world's population today (Ritchie & Roser, 2018). Therefore, significant planning and management are involved in developing cities into sustainable, efficient, and liveable spaces. Mobility and transportation play a relevant role in ensuring a healthy environment for its inhabitants. However, when defective, they damage social and ecological conditions in urban areas (UN-Habitat, n.d.).

Due to the rapid growth of cities, challenges such as battling congestion and air pollution, as well as creating equal accessibility, are gaining prominence. Therefore, the concept of mobility hubs becomes increasingly relevant for meeting these challenges and progressing towards more sustainable mobility (Arnold, Frost, et al., 2023).

As mobility hubs are still a novel concept, little is known about their actual impact. However, a deeper understanding of the impacts is crucial for policymakers and transportation planners to implement an effective system for sustainable city transportation (Aono, 2019). This raises the question of what impact expectations are behind the establishment of mobility hubs and what actual impacts can be identified. In addition, the question of relevance in the literature and among experts plays another important role when considering the impacts of mobility hubs. Knowing whether the expectations match the outcomes is also essential for the development process.

This chapter introduces the significance of this research by highlighting the importance of an impact analysis of mobility hubs. In this regard, the research goals and questions are formulated in Chapter 1.2. Finally, the structure of this thesis is explained.

1.1 Significance of the study

The transport sector poses a wide range of challenges, including harmful effects on the environment, climate, and public health (European Environment Agency, 2024; UBA, n.d.). Notably, road traffic causes about 20 % of the total CO_2 emissions in the European Union, with passenger cars alone representing around 60 % of this share (Europäisches Parlament, 2019). This is mainly due to the fact that motorised private transport is still one of the most common modes of transport in cities today (Heineke et al., 2023; Münsch, 2024). As urbanisation continues, pressure remains high to find solutions to increasing environmental pollution and the negative impacts of traffic on residents (Ritchie & Roser, 2018). To address these challenges, multi- and intermodal mobility along with effective transportation networks are essential strategies for achieving sustainable and eco-friendly cities (Moulin, 2023; UBA,

n.d.). In addition, a necessary prerequisite for the promotion of sustainable mobility is an inclusive policy that removes unnecessary obstacles (Holota et al., 2022).

The concept of mobility hubs is an innovative tool that should be used to implement these strategies and has become increasingly prominent in recent years (Arnold, Frost, et al., 2023). However, a research gap was identified regarding a holistic view of the impacts and the relationship between the expectations and the results of this concept. This leads to the significance of this research, as it aims to provide valuable insights into the impacts of mobility hubs, especially for policymakers and transportation planners. This thesis highlights the need for a deeper understanding of impacts and establishes a connection between anticipated and actual impacts, thus addressing the research gap.

1.2 Research goals and questions

The primary goal of this thesis is to provide a deeper understanding of the impacts of mobility hubs in urban regions. It aims at a holistic view, by applying a mixed-method approach. Therefore, both findings from relevant literature and conducted interviews with experts are included in this research. The interviews have a complementary function, as they provide a practical perspective and compensate for limitations in the literature.

This thesis has two main objectives. First, the identification of expected and existing impacts of mobility hubs in urban regions. Second, the structuring of the results based on the findings from the literature review and the conducted interviews. This categorisation then allows for a comparison of impacts. The objectives above lead to the following research questions:

RQ1: What are the expected and existing impacts of mobility hubs?

RQ2: How can these impacts be categorised and compared?

The literature lacks a clear categorisation for expected and existing impacts, making it difficult to compare and assess expectations and outcomes. Therefore, having a distinct definition for expected and existing impacts is crucial. In the literature, intended and actual effects are typically categorised under environmental or socio-economic aspects (Arnold, Frost, et al., 2023; Meuleman & Signor, 2023). In some cases, the categorisation includes further detailed aspects such as health and safety and accessibility (Hached & L'Hostis, 2022; SEStran, 2020). Based on this information, the aim is to organise the impacts and define a fitting categorisation approach.

Another limitation in the literature is the absence of a comparative analysis of expectations and outcomes. However, this comparison is essential for a deeper understanding. Furthermore, such an analysis can help motivate stakeholders and activate inclusive policies

to facilitate the mobility turnaround. In this context, mobility hubs are a key concept whose potential must be increasingly prevalent.

Ultimately, this thesis intends to identify certain areas that future research must focus on. In this regard, it addresses both research and practical perspectives, such as those of policymakers, transportation planners, and researchers.

1.3 Structure

This thesis is structured as follows: In the second chapter, the literature review is carried out. The literature review aims to define the concept of mobility hubs and its features in more detail. The second part of the literature review forms the basis for answering the research questions by breaking them down and defining their different parts. This chapter concludes by summarising the findings from the literature review as well as revisiting the research question and objectives of this thesis. Chapter 3 justifies the use of a mixed-methods approach and describes the research design. Subsequently, the data collection and analysis of information from the literature and the conducted interviews are explained. The research questions are answered in Chapter 4 by presenting the findings from the literature and the interviews. The results section is structured to first present the expected and existing impacts according to the categorisation elaborated in Chapter 3.4.1. Moreover, the expectations are then compared to the outcomes. This process is carried out for the information found in the literature as well as in the interviews. In Chapter 5, the results from the literature and the interviews are juxtaposed to identify similarities and discrepancies to discover potential for improvement in both areas. Furthermore, the categorisation approach and the relevance of impact data are discussed. Chapter 5 concludes by addressing the methodological limitations of the research process. Lastly, Chapter 6 concludes by capturing the answers to the research questions, suggesting recommendations for mobility planners, policymakers, and researchers, and pointing out areas for future research.

2 Literature review

This chapter aims to provide a basic understanding of mobility hubs and their impacts, as discussed in the literature. It is divided into three parts. The first part presents the research strategy for the literature review. The second part defines the theoretical framework of mobility hubs, while Chapter 2.3 clarifies the definition of impacts and categorisation approaches used to describe mobility hubs. This chapter concludes by summarising the theoretical foundations found in the literature, providing a framework for the subsequent analysis of impacts.

2.1 Research strategy

This literature review aims to provide a theoretical background of mobility hubs by elaborating on their definition, different types, and physical characteristics. Furthermore, the research questions are examined, and their components are explained in order to answer them. Relevant literature had to be selected to provide a well-founded theoretical framework as well as a clear description of the research question components. Databases such as “Scopus”, “ResearchGate”, or “Google Scholar” were used to identify relevant literature for this literature review. The search was limited to the literature on mobility hubs and related descriptions for this concept, such as “mobility stations”, “mobility points”, and “transportation hubs”. These key terms were connected with the topics examined in the literature review, such as “definition*”, “typology”, “element*” or “component*”. Additionally, regarding examining the research questions, search terms were, among other things, words like “impact*” or “category”. The Boolean operators “AND” and “OR” were used to narrow the search to focus on relevant literature (Chan, n.d.). This included journals, scientific papers, articles, (case-)studies, dissertations, standards, reports, and websites from reputable sources. The terms were combined with the asterisk operator (*) to allow word alternatives and keep the search less restricted (onlyfy, 2023).

The literature was only considered if the abstract was screened first and similarities with the topic of this literature review were identified. If the title, the abstract or, at the latest, the full text did not match the aspects covered in this review, it was excluded. Once the required inclusion criteria were found, the full text was examined in detail and included in this review if applicable.

2.2 Understanding mobility hubs

The following chapter breaks down fundamental information about mobility hubs. First, a definition will be developed to create a clear starting point for the research. The last two subchapters will examine various typologies and physical characteristics for a thorough understanding.

2.2.1 Definition

Various interpretations of the term “mobility hub” have emerged in the last two decades. The abundance of explanations complicates the attempt to find a clear definition (Hached et al., 2023). By intersecting, a foundation for the basic principle of these hubs can be created, thus approaching an expressive description.

The commonalities lie in defining mobility hubs as places designated to change transportation modes. The initial idea of this relatively new concept goes back to seaports, which can be seen as the first form of a mobility hub. People and supplies switched modes from sea to land transport in this case. The development of large populations around these early nodes emphasises their significance and simultaneously shows the dependence on their existence, enabling mobility for both people and goods (Clemens, 2020).

Expanding on the foundation of the basic concept presented in the previous paragraph leads to a more detailed definition that contemporary mobility hubs act as nodal points where various modes offer the opportunity to travel seamlessly and efficiently between a transport network (Meuleman & Signor, 2023). Based on European best practices, it is essential to add that information features and digital services are an integral part of urban mobility hubs nowadays (Roberts, 2019). Also referred to as Mobility-as-a-Service (MaaS), these digital instruments extend on the physical hubs and offer synergies that increase attractiveness and efficiency for users (Lorena Axinte et al., 2022; Roberts, 2019). While this thesis focuses predominantly on mobility hubs as physical instruments of sustainable mobility, it should be stressed that their coexistence with digital services is indispensable regarding maximum effectiveness and ideal functionality (Esther Perrin, 2023). The analysis and review of mobility hubs and their impacts are based on the definition developed in this subchapter.

2.2.2 Typologies

There is a large number of categorisation approaches for mobility hubs. In this chapter, we mainly focus on the work of Wuestenenk and Mingardo (2023), in which six typologies are presented. Based on Dutch engineering experiences, the paper expands on understanding mobility hubs and creates a framework for typologies. It further describes mobility hub types using the findings from earlier works of Bell (2019), Anderson et al. (2017), Tran and Draeger

(2021) and Rongen et al. (2022). By implementing these typologies, it benefits policymakers who can reflect on the necessity and benefits of a well-thought-out concept (Peek, 2006; Weustenenk & Mingardo, 2023).

The main empirical characterisation features applied to group mobility hubs into types are the primary transportation mode, location, size, services, and amenities (Weustenenk & Mingardo, 2023). The following section elaborates on these features.

The primary transportation mode provides information about all other features as a key indicator. A bike-sharing hub is a practical example, with a smaller operating area and fewer services and amenities than a hub with interregional train linkage. The transportation mode types also indicate the location of a mobility hub within a transportation network – e.g., a tramline network (Weustenenk & Mingardo, 2023).

Experts frequently highlight services and amenities as the second feature for grouping. Mobility hub types may differ in terms of the amount and complexity of services and amenities offered. The addressed feature varies depending on the scale and location of the hub. There is a larger supply in more vibrant areas such as city centres. As mentioned, the primary mode of transportation sets the scale and can, therefore, indicate the offer of services and amenities (Weustenenk & Mingardo, 2023).

The geographical position and position in the transportation network can determine a mobility hub's location, introducing the third quality for grouping mobility hubs. Features such as scale, services and amenities are predominantly assigned to the geographical location of mobility hubs. In contrast, the mode of transport is assigned to the location in the transport network (Weustenenk & Mingardo, 2023).

The area occupied determines the scale of a mobility hub, which concludes the grouping features (Weustenenk & Mingardo, 2023). This feature is generally correlated with the surface area but also in other typologies defined by the service area (Onstein et al., 2021; von Ferber et al., 2008; Weustenenk & Mingardo, 2023). In either case, it is an essential indicator for grouping, as there are crucial differences between the sizes of hubs. The scale additionally decides to what spatial extent the hub is accessible (Peek, 2006; Weustenenk & Mingardo, 2023). Moreover, the features of location and scale are consistently related (Peek, 2006). Hubs are located in more central areas and, therefore, offer a wider range of functions if they have a stronger connection to other hubs (von Ferber et al., 2008).

Wuestenenk and Mingardo (2023) derive a set of typologies based on the features, as well as their relation and influence on each other. This set is just an example of a categorisation approach and, alongside other typologies, provides a comprehensive classification of Mobility Hubs. The clear organisation by scale makes this categorisation particularly easy for

policymakers or planners to understand and utilise. Listed below are the typologies of mobility hubs derived by Wuestenenk and Mingardo (2023), arranged by increasing scale:

- Community hub
- Neighbourhood hub
- Suburban hub
- City edge hub
- City district hub
- City centre hub.

In the following visualisation, the typologies are depicted according to the amount and complexity of services, amenities and offered modes of transportation (Weustenenk & Mingardo, 2023).

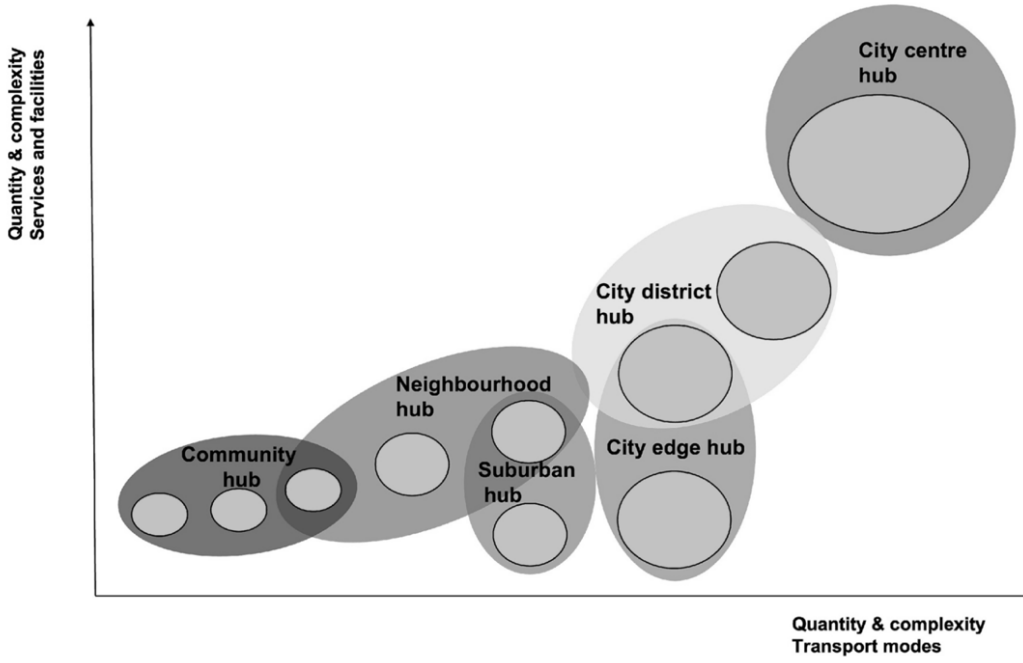

Figure 2-1: Graphic visualisation of typology classification. Source: Wuestenenk and Mingardo (2023)

Community hub

Typically situated in privately owned areas like garages or parking spaces, community hubs are limited to a specific set of users. The community, primarily employees, share transport modes such as (electric)-bicycles, -mopeds or -automobiles. Community hubs differ from other hubs, as they commonly lack the linkage to public transport and a broad scope of amenities and services. This is mainly due to the restriction to private areas. (Weustenenk & Mingardo, 2023)

Neighbourhood hub

Neighbourhood hubs have a wider range in scale than community hubs but still count as small-scale hubs. Besides the modes that can be found at a community hub, the neighbourhood hubs' modes can be extended by a linkage to low-frequency public transport such as buses or tramlines. This extension is optional and should not alter the typology when it is non-existent (van Rooiij, 2020). As the modes of transportation do not always determine the typology, in this case, the geographical location categorises this hub. The strategic placement of a mobility hub near facilities such as grocery stores or post offices could offer users additional benefits (Weustenenk & Mingardo, 2023).

Suburban hub

While these residential areas are mostly car-centred, access to parking spaces is a key feature which enables car owners to reach and use the hub in suburban districts (Weustenenk & Mingardo, 2023). The availability of high-frequent public transport in suburbs is rather low, which makes hubs located at the site sharing oriented. Services may offer the option of using (electric)-bicycles, -mopeds or -automobiles, as well as public transportation such as local, city or regional trains and buses (Choe et al., 2021). Based on empirical evidence, hubs in suburbs do not have an extensive number of services or amenities, as can be seen in Figure 3-1. The quantity and complexity of this feature may vary within a certain margin. It can be customised according to the population density in the region (Weustenenk & Mingardo, 2023).

City edge hub

With a higher complexity and quantity of services, amenities, and transportation modes than a suburban hub, the city edge hub can be referred to as the connector between cities and their surrounding areas. The name is derived from its location in the outer region of a city. The complexity of services and amenities is generally less distinct, but city edge hubs feature essential elements such as parking facilities, which enable a seamless transition to sharing services or public transportation. Moreover, fewer modes are available at this type of hub than at more central hubs, such as the city district and centre hubs (Weustenenk & Mingardo, 2023).

City district hub

City district hubs offer a variety of different transportation modes and are generally located in areas with stricter parking provisions, maintaining reachability for both residents and visitors. The main objective of city district hubs is to enhance urban development and attract potential residents into these districts (Bijma, 2021). These hubs are effective tools to promote economic growth in areas of cities where there might be a need for it. Additionally, these

hubs have significant effects on social conditions and can improve the liveability in certain districts (Weustenenk & Mingardo, 2023; Witte et al., 2021). The hubs primarily offer public transportation but also provide shared mobility options and taxis. Facilities and amenities in district hubs are more extensive and usually reach a regional scale compared to the smaller hubs previously presented (Weustenenk & Mingardo, 2023).

City centre hub

According to Wuestenenk and Mingardo's characterisation approach, the city centre hub is the largest and most complex hub in terms of size, transport modes, facilities, and amenities. There are various types of public transportation modes available. In addition, you can find regional and intercity trains, shared mobility as well as active modes. A city centre hub can usually be found in the form of a main train station in a city (Weustenenk & Mingardo, 2023). Additionally, it's the only hub that enables users to travel nationally. Businesses and residents are often drawn to areas where these hubs are located, which can enhance spatial development but may also lead to higher rents (Bekhuis et al., 2021; Weustenenk & Mingardo, 2023).

2.2.3 Physical characteristics and components

Certain physical characteristics and components can vary due to the uniqueness of each hub, its network and its specific typology, as shown in Chapter 2.2.2. Thus, a city district hub offers different transportation modes than a neighbourhood hub (SEStran, 2020). Types of physical characteristics and components can be found in the literature. Arnold, Frost, et al. (2023) organise the physical characteristics into two categories. The first category comprises the format, which includes the transportation modes and the hub design. The second category covers the location regarding the positioning of hubs.

By subdividing the first category, he shows that three primary parts of the format can be identified. With the first one being the transportation mode, car-sharing is mentioned as a key component despite the lack of availability (Arnold, Frost, et al., 2023; Münzel et al., 2020). Yet, car-sharing can be registered in most typologies as well as other free-floating modes such as taxis or demand-responsive transport (SEStran, 2020). Micro-mobility is another mode that is getting increasingly integrated into mobility hubs and has shown positive effects on environmental conditions in cities. This includes facilities for electric and standard types of bicycles and scooters (Arnold, Frost, et al., 2023; PBOT, 2019). Pedestrian access is a notable component, as it shows environmental benefits as well as enhanced health (Arnold, Frost, et al., 2023). As a crucial feature, the SUMC describes public transport as *"the core on which a diverse array of options depends"* (SUMC, 2019, Strategies section, pt. 1). By locating mobility hubs in a position accessible to public transport, they can contribute to solving the first and last-mile issues (Arnold, Frost, et al., 2023; Avedisian et al., 2020; City of

Rochester, 2018; Humm, 2020; PBOT, 2019). Determined by the local situation, a combination of rail, bus, and tram can be offered (Arnold, Dale, et al., 2023). The development of hubs is not always well received, especially when it comes to residents in proximity to these locations. Therefore, it is essential to ensure that the design of hubs, as Arnold, Frost, et al. (2023) define the second subcategory, does not interfere with the cultural or historical environment in certain areas (Arnold, Frost, et al., 2023; Haselmayer, 2019). Additionally, a well-thought-out design of hubs can facilitate efficient operation by integrating elements such as *"floor communications, colour coding on the pavement and attractive surroundings"* (Arnold, Frost, et al., 2023; van Gent et al., 2020, p. 12). The third subcategory of amenities includes mobility-related elements such as *"bike lockers, EV charging infrastructure, cycle maintenance facilities and digital display features providing real time transport info"* (Arnold, Dale, et al., 2023, p. 2). These amenities complement a mobility hub's infrastructure (Arnold, Dale, et al., 2023). Benches and shelters are important features of mobility hubs that contribute to user comfort (Aono, 2019). Another common component in connection to mobility hubs is the linkage to leisure activities with health or educational purposes (Meuleman & Signor, 2023). These physical components support the objective of mobility hubs by enhancing the socio-spatial component, helping to develop a safe and efficient way of transportation, and making sustainable mobility more attractive (Arnold, Frost, et al., 2023).

The selection of a suitable location for a mobility hub is essential to ensure ideal functionality and integration into a transportation network. When considering the optimal strategic positioning of mobility hubs, there are some key factors to keep in mind. One important consideration is the size of the hub, which must be carefully chosen to fit the available space in the area. To achieve the right scale and size for the spatial condition, it may be necessary to select from a range of different hub typologies (Arnold, Frost, et al., 2023; Nottingham City Council, 2020). In addition to size, it is also important to ensure that the hub is co-located with both public transport and shared mobility options (Arnold, Frost, et al., 2023; Roberts, 2019). This linkage is crucial for achieving an efficient mobility hub that can help solve the first and last-mile problems. As a best practice, hubs should be positioned in areas that already have good transport linkages (Arnold, Frost, et al., 2023; Gray, 2017). Taken together, these factors demonstrate the significant influence that public transport locations can have on the positioning of mobility hubs (Arnold, Frost, et al., 2023). On a larger scale, physical characteristics can also mean the need for either a single hub or a network of mobility hubs. Generally, networks tend to be more common than single hubs (Arnold, Frost, et al., 2023). Several mobility hub network projects, such as the one in Bremen with 48 hubs or the one in Bergen with 13, have demonstrated great success (Karbaumer & Weltring, n.d.; Kvalbein & Ljosheim, 2020). As a result, the city of Bremen is adding 8 to 10 new hubs to

their network each year (Arnold, Frost, et al., 2023; Roberts, 2019). However, determining a suitable number of hubs can be a complex decision. CoMoUK recommends having one hub per 2000 inhabitants in urban areas, but this guideline cannot be applied to every city due to varying densities and conditions (Arnold, Frost, et al., 2023; Roberts, 2019). Topology is another factor to consider, as people are less likely to travel further or choose active modes in areas with many inclines or hilly terrain. In such cases, a more concentrated network of hubs should be considered (Arnold, Frost, et al., 2023; Liao & Correia, n.d.). The selection of hub size and type is an additional indicator of the number of mobility hubs needed in a network. For instance, Bremen's two-tier system has resulted in a network with increased user options and efficient use of space, thanks to mobility hubs of two different types and sizes (Karbaumer & Weltring, n.d.). However, these indicators cannot be generalised since each city has distinct needs and circumstances. In rare cases, even a single hub can have a significant impact (Arnold, Frost, et al., 2023).

2.3 Defining the impacts of mobility hubs

After introducing mobility hubs and describing their concept and features in the first chapter of the literature review, the following section focuses on providing the necessary background to answer the research questions. It mainly refers to the aspects mentioned in the research questions and, therefore, leads to defining the impacts of mobility hubs. The first subchapter specifies how expected and existing impacts are presented in the literature. Subsequently, typical categorisations and parent categories of impacts are identified and explained.

A thorough analysis and definition of the contents of the research questions is an essential part of this thesis, as these findings act as the theoretical framework for the results presented in Chapter 5. It is important to note that this section merely defines expected and existing impacts and categorises them.

2.3.1 Presentation of expected and existing impacts in the literature

Expected and existing impacts must be defined to build a basis for a comparison. The literature on mobility hubs is examined using these definitions to identify the aspects from which impacts can be derived. This method is applied to both expected and existing impacts.

Expected impacts

According to the Cambridge Dictionary, an *expectation* is *“what you believe or hope will happen in the future”* (Cambridge Dictionary, n.d., business english). In connection with the term *impact,* it describes *“effects, expected to be positive, [that] … can be technological, social, environmental, and economic.”* (ID Consortium, 2021, para. 8). These definitions are

now applied to the literature on mobility hubs. A set of terms aligned with the definition are categorised under the classification of *expected impacts*.

The term *objectives* is frequently used in literature on mobility hubs and typically refers to goals that aim to be achieved and contribute to solving a problem (Cambridge Dictionary, n.d.-b; Hached & L'Hostis, 2022). This term is somewhat associated with action (Coleman, 2023). However, it is still interpreted by the researcher, subordinate to the classification of the *expected impact,* as it describes the aim of a favourable condition or an effect in the future (Cambridge Dictionary, n.d.-b). An interesting perspective comes from Arnold, Frost et al. (2023), as they expand on the objectives by mentioning the purpose behind developing mobility hubs, highlighting the need for environmental and socioeconomic improvement. In this case, the purpose can be seen as a first step in building objectives. In conclusion, setting clear objectives essentially outlines the expected results or impacts to be achieved through the implementation of certain measures or strategies. Mobility hubs are practical tools for realising such an achievement (Hached & L'Hostis, 2022).

A hypothesis drawn up by the Rocky Mountain Institute (RMI) formulated certain outcomes to be achieved from pre-established goals. The results in the hypothesis do not measure existing outcomes but the expected effects of specific previously set goals (Holland et al., 2018). Therefore, by the researcher's interpretation, outcomes, in this context, meet the above definition of *expected impacts.* As in the previous section, a similar pattern can be observed, as goals are the first step in formulating outcomes.

Existing impacts

In order to clarify the term *existing impacts*, it is necessary to take a closer look at the word *existing*. The adjective describes something that is *"found or used now"* (Oxford Learners Dictionaries, n.d., def. 1). Therefore, the classification of existing impacts includes effects that were already detected, perceived, and documented in any way.

An efficient way to detect relevant data on the effects of mobility hubs is through surveys (Cornell, 2023). Using this method, Czarnetzki and Siek (2023) showed how the frequent use of mobility hubs affects the interest in car ownership. These findings outline the effectiveness of conducting surveys (Aschenbrenner, 2023). The results not only provide insights into the public's perceptions of mobility hubs but also offer valuable data that can be used to derive their impacts (Czarnetzki & Siek, 2023). A similar survey-based approach was implemented to investigate how Munich's multimodal mobility services impact mobility behaviour (Miramontes et al., 2017).

In their dossier, CoMoUK delivers evidence of mobility hubs in five cities across Europe and America. By the researcher's interpretation, the evidence is clearly to be categorised under

the term of *existing impacts* and, in this dossier, refers to a broad spectrum ranging from environmental to socioeconomic aspects (CoMoUK, 2022). The British NGO also refers to their own source in which they conducted a case study in Bremen (CoMoUK, 2022; Share North, n.d.). CoMoUK titles the results from this study based on Bremen's mobility hubs as *impacts* (CoMoUK, 2021). The literature rarely uses the term *impact* regarding mobility hubs. A further study on the Bremen mobility hubs outlines the effectiveness of the mobility concept (CoMoUK, 2022; Schreier et al., 2020).

Pfertner (2017) conducted a relevant analysis on the reduced CO_2 emissions resulting from mobility hubs and especially changes in mobility behaviour in Würzburg city. However, the author points out that the approach used to calculate CO_2 emission reductions was rather simplistic, as it did not consider data from private vehicle usage. Despite this limitation, the analysis provides a trend pointing out mobility hubs' impacts. Furthermore, he conducted a survey revealing the influence of mobility hubs on travel behaviour and privately owned cars. Both these findings provide valuable information about the existing impacts.

2.3.2 Categorisations

Organising and categorising impacts allows for easy comparison and contextualisation and therefore serves as a foundation for the analysis of impacts. Impacts are often intertwined and categorising them may not be straightforward. Nonetheless, literature suggest approaches that this subchapter will cover.

A clear categorisation is provided by Hached and L'Hostis (2022). They have divided the set of objectives into four classes based on SEStran (2020): *Economy*, *Accessibility*, *Environment*, and *Safety and Health*. The first class mainly covers economic aspects in direct connection to the efficiency of mobility hubs and their networks. Equal access is the primary aspect of the second class, which highlights the social impacts mobility hubs should have, especially for financially or physically impaired people (SEStran, 2020). The third class centres around the environmental aspects, which are the driving forces behind the concept of mobility hubs (Hached & L'Hostis, 2022; Meuleman & Signor, 2023; SEStran, 2020). SEStran (2020) emphasises the switch to sustainable transportation modes by implementing mobility hubs. Lastly, the *Safety and Health* class highlights the importance of the safety and security of users and these physical locations as tools for community strengthening (SEStran, 2020).

Meuleman and Signor (2023) break down impacts into three classes. Like the categorisation of SEStran (2020), they keep the environmental and accessibility aspect but combine social and economic aspects to *socio-economic benefits*. A similar approach is made by Arnold et al. (2023), who present only two classes in which he subordinates impacts – first, the class of environmental aspects as well as socioeconomic aspects.

2.4 Summary of literature review

This literature review is divided into two main sections. The first section elaborated on the theoretical background of mobility hubs and provided a detailed definition of their concept and features. The second part of this literature review focused on examining the content of the research questions. It aimed to establish a definition for expected and existing impacts and their categorisation in literature to lay the groundwork for the analysis. A research gap was found concerning identifying expected and existing impacts in the literature. Furthermore, there is no evidence in the literature that comparable approaches exist. The following research questions were formulated on this basis:

RQ1: What are the expected and existing impacts of mobility hubs?

RQ2: How can these impacts be categorised and compared?

Answering these research questions aims to contribute to a richer research pool by providing a deeper understanding of the mobility hubs impacts and a juxtaposition of their expectation and outcomes. Thus, this thesis should offer a detailed overview of impacts as well as valuable insights into realistic outcomes of mobility hubs.

3 Methodology

The method for answering the research questions is carried out as part of a mixed-methods approach. This research concentrates on the existing and expected impacts of mobility stations in urban regions and how these impacts can be categorised and compared. Therefore, the following research questions are defined:

RQ1: What are the expected and existing impacts of mobility hubs?

RQ2: How can these impacts be categorised and compared?

The research questions are intended to be answered by applying a mixed-methods approach, which is justified in the first chapter of this section. The data found in the literature is supplemented by interviews with three experts on mobility hubs to obtain additional perspectives and enable a holistic approach, filling the research gap. Firstly, the mixed-method approach is described and justified. Chapter 3.2 addresses the research design used in this thesis by presenting the literature search process in the first section of this chapter. Subsequently, the eligibility criteria are defined, and the selection of the literature is illustrated and explained. The following two chapters, 3.2.4 and 3.2.5, deal with the interview participant selection and its structure. Lastly, the data collection and analysis are presented for both literature and interviews.

3.1 Justification and application of the mixed-method approach

This approach aims to first present findings from the literature in the form of quantitative data. However, it is worth noting, that the availability of quantitative data on the effects of mobility hubs in literature is limited. Subsequently, the findings of the conducted interviews will complement the quantitative data by including qualitative information. Eventually, quantitative and qualitative data are juxtaposed, and similarities and discrepancies are identified, mainly due to validation reasons (Harvard Catalyst, n.d.).

As data from the literature is insufficient to lead to a deeper understanding due to the research gap found in the literature, the mixed-method approach is appropriate for this study (Clark & Ivankova, 2016). This approach allows for a deeper understanding and provides multiple perspectives on the impacts of mobility hubs (Harvard Catalyst, n.d.). Moreover, having a comprehensive research strategy, including a literature review and interviews, is crucial. This combined approach intends to create a holistic view of expected and existing impacts. Furthermore, the mixed-method approach is complementary, as the interview questions are designed to address the limitations identified in the literature (Alele & Malau-Aduli, 2023).

When applying a mixed-method approach, there are various designs that can be distinguished. Based on the limitations of quantitative data, as mentioned in the previous paragraph, the qualitative data aims to follow up on the findings from the literature (Subedi, 2016). This approach is also referred to as the explanatory sequential design and is illustrated in Figure 3-1 below (Creswell & Plano Clark, 2017).

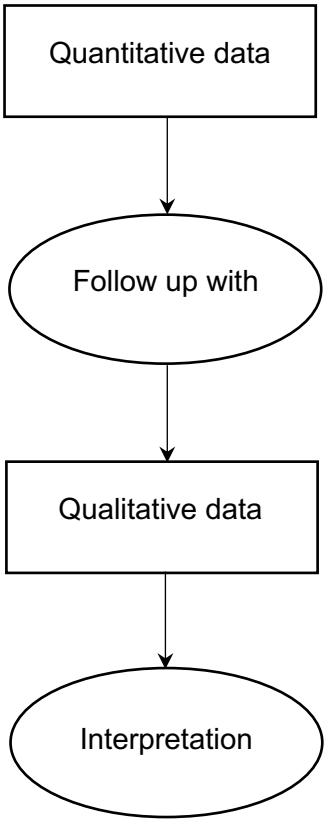

Figure 3-1: Explanatory sequential design after Creswell and Plano Clark (2017). Source: Own depiction.

3.2 Research design

This chapter focuses on the strategy used for searching and selecting relevant literature as well as choosing suitable participants for the interviews conducted as part of the mixed-method approach. In detail, the search process and eligibility criteria for the literature are discussed in subchapters one and two. A graphic visualisation of the selection strategy in Chapter 3.2.3 illustrates the top-down process of diluting the set of sources by further excluding irrelevant literature. The process of selecting participants for interviews is explained in Chapter 3.2.4. Subsequently, the structure of the interviews is clarified, which can be found in Appendix 3. Lastly, the conduction of interviews is explained in Chapter 3.2.6.

3.2.1 Literature search process

In the search process, scientific databases such as “Scopus”, “ResearchGate” or “Google Scholar” were used to identify relevant literature regarding the expected and existing impacts of mobility hubs. Search terms including “mobility hub*”, “transport* hub*”, “mobility station*” and “mobility point*” were connected with keywords such as “impact*”, “effect*”, “environment*”, “economic”, “social”. The asterisk operator (*) was used to widen the search by allowing certain terms to have variants (onlyfy, 2023). The Boolean operators “AND” and “OR” helped narrow down the search and assist in specifying the focus on the expected search results. Thus, the input for searches was a combination of the abovementioned terms and operators, for example, “mobility AND hub* AND impact*”.

3.2.2 Eligibility criteria for literature

Establishing eligibility criteria before searching is crucial for selecting high-quality literature that lays the foundation for an extensive and precise systematic literature review (McCrae et al., 2015). The fundamental inclusion criteria target publications with the term 'mobility hubs' or the related terms mentioned in Chapter 3.2.1 in their title. Journals, scientific papers, articles, (case-)studies, dissertations, standards, reports and websites from reputable sources were consulted for the systematic literature research. Literature used in the analysis of impacts was published within the last seven years. As mobility hubs are a novel concept in the realm of sustainable mobility, there are no obsolete materials on the subject. German and English publications were included to reach a broader research scope.

Literature found irrelevant was excluded after seeing the title, or at the latest, the abstract not directly related to the topic. Due to restricted access, a certain amount of literature had to be excluded. By focusing on urban regions in the context of this thesis, literature that deals with mobility hubs in rural areas was ruled out. An additional exclusion criterion was established for non-German and non-English publications due to language barriers. The review strategy with a quantified indication of the included and excluded literature is presented in the following chapter (see Figure 3-2).

3.2.3 Systematic literature review strategy

The following flowchart illustrates the selection of literature and should simplify the decision-making process by including relevant sources. After each step, the number of sources is narrowed down and presented in parentheses by the parameter ‘n’. They divide the process depicted in the flowchart into four steps, resulting in the initial search phase, where literature and additional sources are searched for through different databases. In the second step, the found sources are screened by abstract and excluded if they are irrelevant. The third step involves a review of the full text, which leads to the exclusion of literature that can only be ruled out after a more thorough screening. This concludes the final step in which the number of sources used for the systematic review is specified (Borrego et al., 2014).

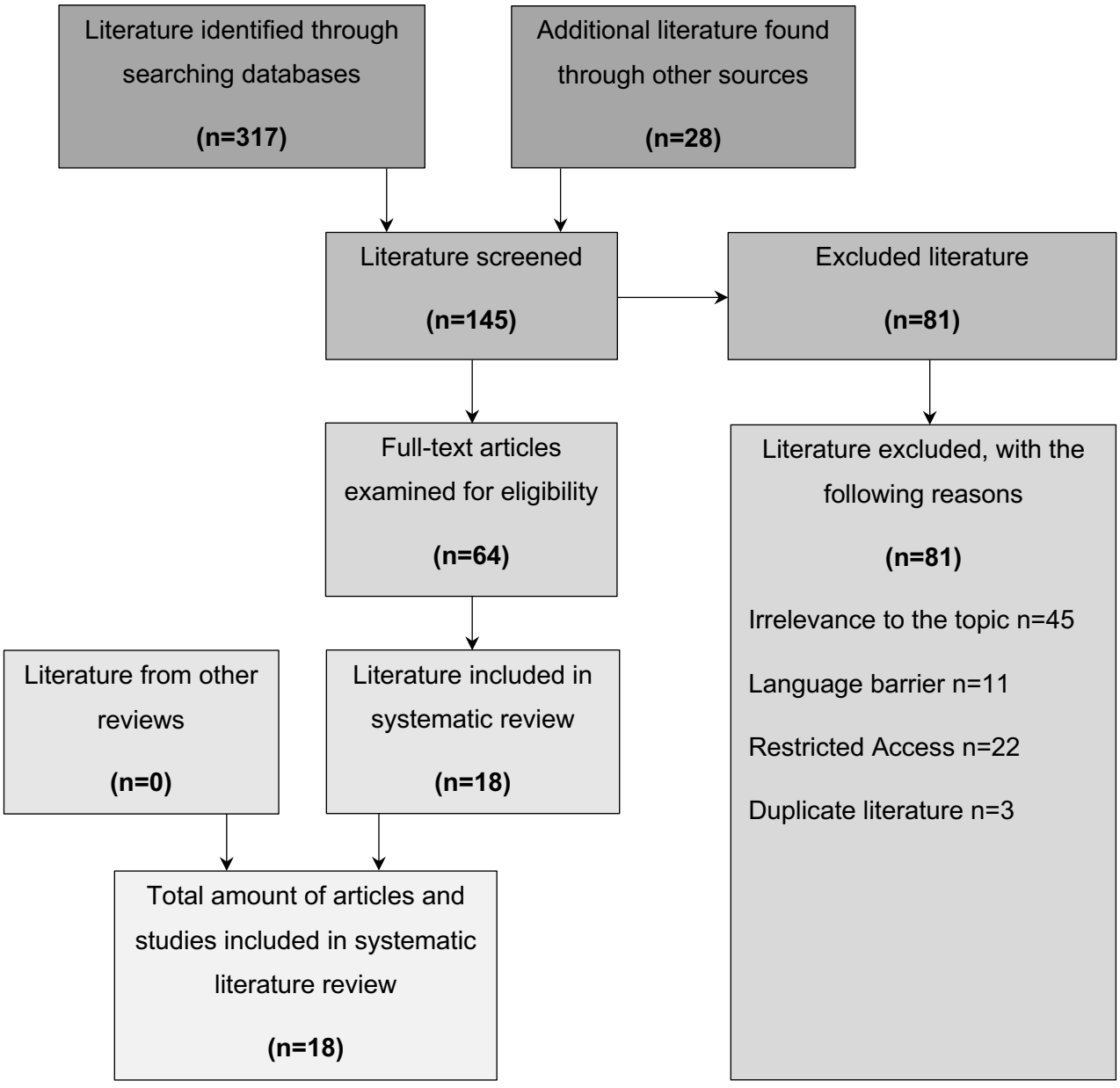

Figure 3-2: Flowchart of the selection strategy of sources based on Borrego et al. (2014). Source: Own depiction.

3.2.4 Interview participant selection

The first and third participant were identified through own research and contacted by e-mail. The second interview participants were recommended by members of the chair of urban structure and transport planning of the Technical University Munich and contacted through the social network “LinkedIn”.

3.2.5 Interview structure

The interviews are designed using a semi-structured approach. This approach was chosen as it offers various benefits in the context of this research. First, the open-ended questions allow the answers of the participants to have a broader focus. As there is room for interpretation, the interviewees must not follow a strict response pattern, which in turn allows them to answer more freely (Adams, 2015). Secondly, due to the flexible structure, the interviewer can ask follow-up questions if responses from the interviewees explore a new topic that might be significant to the research (Kallio et al., 2016). Additionally, when interviewing different experts, it is essential to receive independent perspectives. This is particularly important with regard to the present study, as it also focuses on results through comparative approaches in order to gain valuable insights. Moreover, resulting from the identified research gap, the open-ended interview questions were formulated to provide a wide scope with the ulterior motive of letting the interviewees find and pursue crucial information (Adams, 2015).

A set of two interview guides in both English and German were established (see Appendix 3). This way, a language barrier was avoided in the case of the German-speaking respondents. Therefore, the information could be distributed more clearly and in a more comprehensible way. The guide is organised into three main question blocks:

1. *Introductory questions*
2. *Key questions*
3. *Concluding questions*

Clearly, the focus lies on the second block which comprises of nine questions concerning the motivation, expectations and observed effects of mobility hubs in urban regions (see Appendix 3). The introductory questions are meant to obtain personal information about the interviewees and their connection and experience in the field of urban mobility and the concept of mobility hubs. The concluding questions allow respondents to add unaddressed aspects.

3.2.6 Conduction of interviews

In order to minimise the organisational effort, the first and second interviews were conducted via online conference. The “Webex” and “Microsoft Teams” applications were used for this

purpose. The questions were sent to the respondents beforehand via e-mail so the interviewees could prepare thoughts in advance, enabling them to provide more detailed information. The third interview was conducted in written form. The questions were sent and answered via e-mail.

For the verbal interviews, the interviewer opened with an introductory statement by presenting the topic and its research goal, as well as assuring confidentiality and data protection. Subsequently, the participants were asked the same three main blocks of questions (see Appendix 3). According to the semi-structured interview method, the key questions were open-ended, and follow-up questions were asked when necessary (Adams, 2015). The interview concluded with expressing gratitude towards the participants and a brief explanation of how the results will be used. The possibility of contact for further information was agreed upon. For the written interview, the assurance of confidentiality and anonymity was written out.

3.3 Data collection

This chapter presents the data collection processes for the systematic literature review and the interviews. It starts by explaining the literature data collection process and then moves on to the interview data collection process.

3.3.1 Literature data collection

The relevant literature was collected and stored in the management software “Zotero”. The creation of folders helped in organising the literature according to specific topics. Furthermore, the software “Excel” was used to thematically organise the literature and identify key aspects. The selection process, as well as the inclusion and exclusion criteria, was derived in the previous chapter (see Chapters 3.2.1, 3.2.2, 3.2.3).

3.3.2 Interview data collection

In order to retain the information that was shared by the participants and prepare the data for analysis, steps had to be taken to achieve an organised data collection. As interviews can be documented in several ways, in this case, audio recording was chosen to report and analyse data accurately. The participants gave their consent beforehand. The audio recording was made with the application “QuickTime Player” and was backed up by starting a second recording on a mobile phone. Additionally, the interviewer took notes to document important thoughts and capture key points (Halcomb & Davidson, 2006). Afterwards, the audio recording was transcribed using the dictating function of “Microsoft Word” using the online version through the “Microsoft Edge” browser. The verbal data was transcribed non-verbatim, as repetitions, filling words and phrases were removed to create a more reader-friendly text

(Kumar, 2019). However, apart from the edits explained above, the recordings have not been summarised or shortened in any way. Since conducting a thematic analysis of the qualitative data, a verbatim transcription is not necessary, according to Halcomb and Davidson (2006).

3.4 Data analysis

In this chapter, the process of data analysis of the systematic literature review and the interviews is outlined.

3.4.1 Literature data analysis

The relevant literature was organised according to the differentiated examination of impacts. This way, the expected and the existing impacts were initially analysed separately. The selected literature, determined in the research design (see chapters 3.2.1, 3.2.2 and 3.2.3), was extracted from the management software “Zotero” and inserted in the analysis software “MAXQDA”.

Initially, the data from the literature was to be analysed and assigned according to environmental, social, and economic categories. These categories were also explored as part of the literature review (see Chapter 2.3.2). However, due to a refinement in the categorisation approach in the course of the study, the generic terms, as presented in the result section (see Chapter 4), were established as the final categories. These categories are based on more specific and differentiated terms, reflecting an accurate and descriptive representation of the data. The decision was made to maintain the integrity of the analysis and leave certain impacts uncategorised due to their unique characteristics or individual occurrences. Examples of this include *resilience*, *social interactivity*, *development costs* and *acceptance*. It is important to note that some impacts differ in their specificity, as some are more abstract, e.g. *resilience*. However, this lack of specificity is cancelled out by the closer examination in the results section. The occurrence of various impacts related to a generic term, on the other hand, required the formation of certain groups in order to enable a bundled examination. This process also describes the refinement of the categorisation approach. In total, seven impact groups were established. The table below represents the impact groups alongside their general descriptions related to the impacts that are subordinated to that group.

Furthermore, the impacts that were found in the literature were counted according to their frequency within each source (see Table 4-3). Subsequently, these counted impacts were assigned to an inductively determined impact group if applicable. It is worth noting that there is a subjective element in counting key terms, and therefore, it impacts the literature. However, this approach merely serves to illustrate the emphasis that authors in the literature

place on certain impacts and should not make a definitive statement that only these impacts exist to the extent counted in this research.

Impact Group	Description
Sustainable mobility behaviour	Impact group relating to the change of individuals' mobility behaviour towards more sustainable modes; reduction of use or renouncement of current "non-sustainable" modes
Emissions	Impact group relating to traffic related emissions
Safety	Impact group relating to traffic safety or security of individuals and their personal items
Urban space	Impact group relating to the transformation of urban space and visible or perceptible changes to urban space
Cooperation	Impact group relating to emerging partnerships; possibility of co-operations
Equity and Accessibility	Impact group relating to equal access in financial, social, or physical terms
Health	Impact group relating to health conditions; related to mental but also physical health

Table 3-1: Established groups for impacts and their descriptions. Source: Own depiction.

3.4.2 Interview data analysis

The data collected from the interviews is analysed through a thematic analysis. According to Maguire and Delahunt (2017), *"thematic analysis is the process of identifying patterns or themes within qualitative data."* (Maguire & Delahunt, 2017). This analysis aims to use the identified themes to answer the research questions. Establishing themes by examining responses is part of the analysis and a crucial step in interpreting data rather than just summarising it (Maguire & Delahunt, 2017). Since the findings of this research focus on interpreting the qualitative data and gaining further insight by contextualising and comparing information, the themes are located on a latent level, as stated by Braun and Clarke (2006). The thematic analysis in this thesis distinguished between four main themes. As an example, the themes of Interview 1 are illustrated in Figure 3-3 below. This thematic approach was applied to all three interviews.

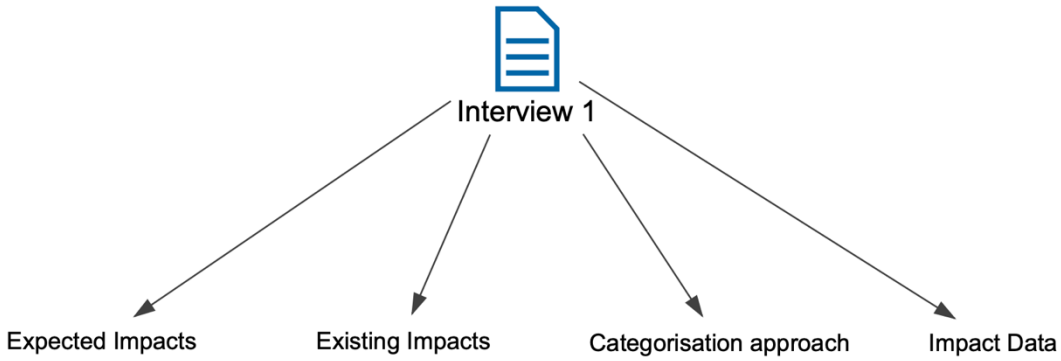

Figure 3-3: Main themes for thematic analysis in qualitative data. Source: Own depiction.

For the themes “Expected Impacts“ and “Existing Impacts”, codes were established acting as generic terms based on the impact groups of the systematic literature review, to which key information mentioned in the interviews was assigned. This process was carried out similarly to the systematic literature review, as the generic terms act as categories to which the impacts mentioned were counted based on frequency. The codes, resulting in the impact groups, are illustrated in connection to their themes in Figures 3-4 and 3-5 below.

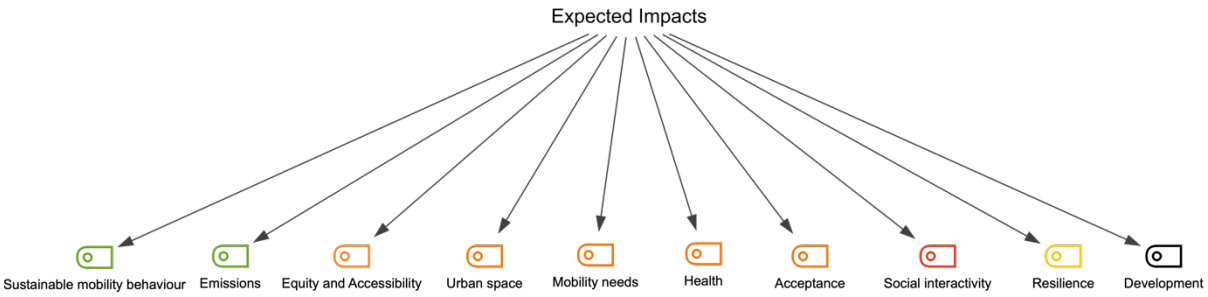

Figure 3-4: Codes in relation to the theme “Expected Impacts”. Source: Own depiction.

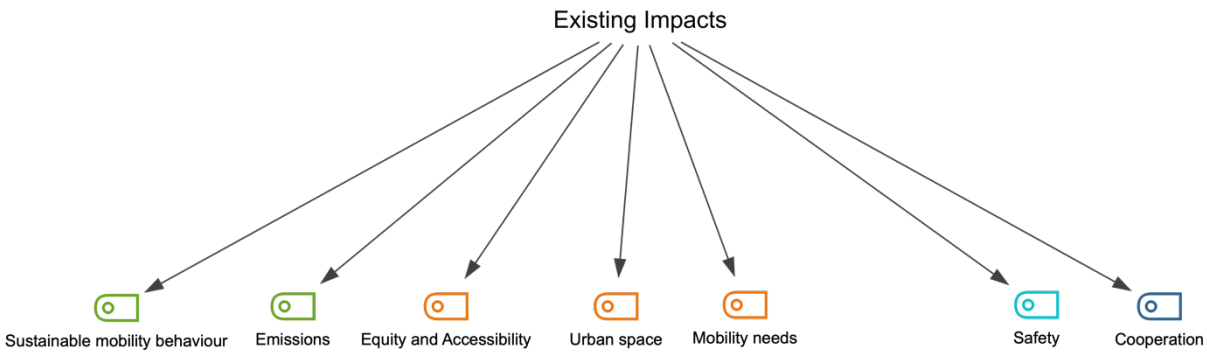

Figure 3-5: Codes in relation to the theme “Existing Impacts”. Source: Own depiction.

The themes shown in Figure 3-3 correspond, among other things, to the chapters in the result (see Chapter 4.2) and discussion section (see Chapter 5.1) of this thesis. The themes applied to the interview were formed using a deductive approach. Further themes and the coding strategy were established using the hybrid approach by defining them inductively. Therefore, the predetermination of themes and their inductive expansion through additional themes and codes realise targeted research results and extend the findings through valuable insights (Proudfoot, 2023). A qualitative representation was created in the form of a word cloud, in which the relevance of the generic terms, that is, impact groups, is compared (see Figures 4-3 and 4-4).

The software “MAXQDA” was used to analyse the qualitative data. The transcripts of the interviews (see Appendix 4) were imported into the software and screened and analysed in detail. Themes and codes were established, as shown in Figures 3-3, 3-4 and 3-5.

4 Results

In this chapter, the following research questions are answered based on the findings from the literature as well as the interviews:

RQ1: What are the expected and existing impacts of mobility hubs?

RQ2: How can these impacts be categorised and compared?

This chapter is structured into two main subchapters. Firstly, the findings from the literature are presented in Chapter 4.1. It starts by exploring the expected impacts by applying the elaborated categorisation approach. Subsequently, in Chapter 4.1.2, the existing impacts are worked out by applying the same categorisation approach as in the previous subchapter. The impacts found in Chapters 4.1.1 and 4.1.2 are compared in Chapter 4.1.3. Chapter 4.1 concludes with a summary of the findings of the literature. The structure of Chapter 4.2 follows the same concept as that of Chapter 4.1. Additionally, it contains background information about the interviewees in Chapter 4.2.1.

4.1 Literature review

This chapter presents the results from reviewing the literature regarding mobility hubs and their impacts. Chapters 4.1.1 and 4.1.2 present the expected and existing impacts. In the respective chapter, impacts are categorised according to the impact groups established in Chapter 3.4.1 (see Table 3-1). The categorisation is applied throughout the results section for both literature and interview findings. This provides a clear and organised overview of the impacts and facilitates comparability. In Chapter 4.1.3, expectations and outcomes are compared. Finally, the results presented are summarised in Chapter 4.1.4.

4.1.1 Expected impacts

This chapter presents the expected impacts of mobility hubs. In the following section, these impacts are presented narratively according to Table 4-1, which provides a more detailed overview of the expected impacts and categorises them according to the established impact groups (see Table 3-1). This chapter concludes with a graphical representation of the groups and individual impacts as part of a stacked bar chart, which underlines the frequency of the expected impacts within the relevant sources in a comparative way.

Expected Impacts	
Sustainable mobility behaviour	Modal shift
	Reduction in car mileage
	Reduction in car use
	Reduction in car ownership
Emissions	Reduction of CO_2
	Reduction of NO_x
	Reduction of Noise
	Reduction of PM
Resilience	
Social interactivity	
Safety	Traffic safety
	Security
Urban space	Sustainable urban development
	Community spaces
Cooperation	PPP (Public Private Partnerships)
	Improvement of local economy
Equity and Accessibility	Physical accessibility
	Social accessibility
	Financial accesibility
Health	Improvement of physical health
	Improvement of mental health

Table 4-1: Overview table of expected impacts and their respective category. Source: Own depiction.

The following sections present the findings of expectations towards impacts resulting from the implementation of mobility hubs in urban regions. The derivation of the impact groups and their description can be found in Chapter 3.4.1. The structure of the following sections is based on the previously identified impact groups (see Table 3-1). The detected individual impacts include resilience and social interactivity.

Sustainable mobility behaviour

A modal shift is frequently anticipated in relation to the impacts of mobility hubs. This aspect is subordinate to sustainable mobility behaviour, as it describes a shift from private car use to more sustainable modes of transport offered at mobility hubs, such as active transportation, including shared bikes, scooters, or even walking (Meuleman & Signor, 2023). However, a foundation for achieving a modal shift must be present. Arnold, Frost et al. (2023) state that "*providing seamless connectivity and improving user experience"* is necessary to facilitate a switch to more sustainable modes of transport (Arnold, Frost, et al., 2023, p.3).

As part of the “Mobi-Mix project”, expected impacts in Norfolk caused by mobility hubs are estimated to avoid around 81.400 driven kilometres in the short run and are scaled up to 359.500 kilometres in a longer-term view. In the city of Valenciennes, a reduction of up to 215.900 kilometres is expected (Babio, 2023; Hached et al., 2023). This impact is a key point, as it is mainly responsible for a decrease in carbon emissions (Aono, 2019; Arnold, Frost, et al., 2023). The reduction in private car use has further significant effects on the ecological condition of cities, as it contributes to a cleaner environment by reducing air and noise pollution as well as utilising freed up public space (Meuleman & Signor, 2023). It is also stated in the study of Arnold, Dale et al. (2023) that the main aim is to reduce the use of private cars due to their great potential to reduce carbon emissions.

Mobility hubs are not only expected to reduce the use of private cars but also to encourage people to forgo car ownership. One of Graz's main objectives is to create mobility hubs that make it easier for people to forgo their own car (Weiland, n.d.). In Amsterdam, 200 people are to be motivated to give up their own cars by setting up mobility hubs (Arnold, Frost, et al., 2023). Meuleman and Signor (2023) address an interesting positive side effect as a smaller number of cars contributes to *“a reduction in resource use for production, [and] maintenance“* (Meuleman & Signor, 2023). An additional expected impact worth noting in connection with the reduction in vehicle volume in cities is a decline in congestion. The establishment of mobility hubs is financially supported in the UK due to the realisation that traffic jams considerably impact productivity and, therefore, the economy (Arnold, Frost, et al., 2023; Metropolitan Council, 2020). Added to this is the high environmental impact caused by increased fuel consumption during congestion (Supa Quick, 2022).

Emissions

The short-term numbers calculated as part of a “Mobi-Mix project” estimated about 23 tonnes of CO_2 of emission savings per year for Norfolk’s mobility hub. The long-term impact will amount to around 57 tonnes per year. In the case of the city of Valenciennes, the mobility hub is estimated to save 67 tonnes of CO_2 per year (Babio, 2023; Hached et al., 2023). Interviews conducted by Arnold, Dale et al. (2023) showed that certain stakeholders have specific goals and expectations towards the performance of mobility hubs as they aim to reduce carbon emissions by 19% (Arnold, Dale, et al., 2023). Holland et al. (2018) have also come to this conclusion when defining the expected outcomes of implementing mobility hubs. According to the anticipated impacts of Austin’s case study, replacing car trips with active modes reduces emissions from mobility. The case study also suggests that “*carbon emissions [are reduced] by more than 95% when taking a scooter or bicycle ride instead of taking a gasoline-vehicle trip”* (Holland et al., 2018, p. 33). This result is derived by comparing energy consumption and weight of cars and active modes such as scooters and

bikes. However, logistical and charging aspects are not included in this assumption. Nevertheless, this leads to the conclusion that a reduction in carbon emissions through establishing mobility hubs and the associated change in mobility behaviour is realistic.

At 37 %, traffic is a significant contributor to air pollution in Germany, with motorised traffic being the leading cause. Nitrogen oxides and particulate matter are particularly relevant here (Umweltbundesamt, 2023). Mainly caused by the reduction in private car use, mobility hubs are expected to substantially enhance air quality in cities (Arnold, Dale, et al., 2023; Meuleman & Signor, 2023). In the city of Graz, solving the problem of particulate matter is seen as one of the main objectives of setting up mobility hubs (Weiland, n.d.). Additionally, noise emissions caused by traffic can lead to considerable damage to health (Umweltbundesamt, 2012). As mobility hubs reduce car use, they are expected to reduce noise emissions due to lower traffic volumes (Arnold, Dale, et al., 2023; Meuleman & Signor, 2023).

Resilience

When planning and realising a mobility hub, the main goal is to create a long-term solution leading to new, sustainable mobility. According to Aono (2019), this concept will show resilience by adapting to innovative developments in the digital and physical world of mobility. This flexibility makes it easy to implement new transportation technologies (Aono, 2019).

Social interactivity

Aono (2019) emphasises the importance of community spaces in mobility hubs to promote social interactivity. This goes beyond mobility-related features, as Aono (2019) considers including activities and creating an interactive environment. Nilforoshan et al. (2023), while not directly addressing expectations of the impact of mobility hubs, examined human mobility networks and warned of potential segregation if not carefully planned. Their study revealed that implementing hubs in areas with similar demographics can negatively impact diversity and social interaction. To ensure positive interactivity among various demographic groups, careful planning and selecting hub locations that connect residents from different socio-economic backgrounds become crucial (Nilforoshan et al., 2023).

Safety

Given that mobility hubs are characterised by high pedestrian activity, the infrastructure and design must prioritise both comfort and efficiency for users staying or transiting within these spaces. A fundamental requirement is to establish safeguards protecting passengers from surrounding traffic, thereby reducing the risk of casualties. Safety measures should extend to facilities that enable passengers to securely lock personal items, including bikes, scooters,

and luggage, enhancing overall security and peace of mind (Aono, 2019). Furthermore, Research by Arnold, Dale et al. (2023) found that stakeholders are firmly committed to a *"zero policy of trying to reduce traffic fatalities"* (Arnold, Dale, et al., 2023, p. 4).

Urban space

With an expected reduction in car use and ownership, the freed-up space that would have been needed to provide parking provision can be utilised to build *“green areas or shared transport spaces”* (Arnold, Frost, et al., 2023, p. 3). This impact plays a vital role in sustainable urban development and in creating community spaces to increase social interactivity (Arnold, Dale, et al., 2023; Arnold, Frost, et al., 2023; Meuleman & Signor, 2023).

Cooperation

Firstly, mobility hubs require a physical location to offer their services. Additionally, included transportation modes at a hub can vary from privately or publicly owned services. Moreover, an extension through digital services must be provided to guarantee functionality and efficiency (Aono, 2019). The collaboration will further increase the value of the land, and business opportunities and partnerships will boost sustainable economic development (Aono, 2019; Arnold, Frost, et al., 2023). Beyond the scope of the mobility-related elements at the hubs, the partnerships are also likely to benefit local businesses, as the hubs are lively places where there is an opportunity to set up cafés or local shops, for example (Arnold, Frost, et al., 2023).

Equity and Accessibility

It is crucial to ensure the accessibility of mobility services across all demographic groups, including all ages and abilities (Aono, 2019). Achieving equal access requires the implementation of appropriate measures. This also addresses the needs of individuals who face challenges in operating digital systems (Meuleman & Signor, 2023). To realise expected impacts, particularly more sustainable mobility behaviour and thus a reduction in greenhouse gas emissions, it is essential to establish mobility hubs accessible to residents across all areas of an urban region (Aono, 2019). Beyond physical accessibility, financial considerations play a significant role. Initiatives must be implemented to ensure that all mobility services at hubs are affordable (Aono, 2019). These requirements are expected to transform mobility hubs into spaces that offer equal opportunities for mobility, ultimately contributing to a better economic situation for groups facing financial obstacles (Arnold, Frost, et al., 2023). The objective is to make mobility hubs inclusive spaces where everyone can access and benefit from the services provided regardless of their economic status or physical capabilities (Arnold, Frost, et al., 2023). Expectations are particularly centred on addressing the critical mobility needs of individuals requiring access to essential locations

such as schools, grocery stores, workplaces, and health institutions, who may not have the possibility to reach certain facilities without publicly available mobility services (Holland et al., 2018).

Health

Combined with the reduction of traffic volumes and congestion in urban areas and the associated improvement in air quality, these effects are expected to contribute to solving health problems caused by traffic-related impacts (Arnold, Frost, et al., 2023). According to Holland et al. (2018), the impacts of mobility hubs will enhance both physical and mental health. Research indicates that individuals using public transport tend to walk more than those who drive individual cars, thereby meeting minimum requirements for physical health through their commute. Expanding public transport modes to include active modes as part of mobility hub implementation has the potential to increase physical activity further, contributing to enhanced health (Holland et al., 2018; NIH News in Health, 2017). Place-making efforts also play a crucial role in improving the availability and quality of public spaces, encouraging community engagement and well-being. The development of a sustainable infrastructure, such as bike or pedestrian paths, motivates individuals to adopt active modes of transportation (Holland et al., 2018). Studies conducted by the University of Hawaii have shown the potential negative impacts of driving on mental health, leading to a surge of negative emotions. Moreover, this research by psychology professor Leon James and his team has revealed that commuting and congestion can result in increased "*blood pressure and irritability"* (Holland et al., 2018, p. 8). Direct contact with the environment and community can help prevent these adverse conditions. Additionally, the "Center for Urban Design and Mental Health" showed in their research that *"a strong correlation between better urban design […] and reductions in anxiety, ADHD, and dementia"* exists (Holland et al., 2018, p. 9). For example, these conditions can be improved by implementing greener and community-friendly infrastructure as part of the development of mobility hubs (Holland et al., 2018). In conclusion, mobility hubs promote sustainable mobility and can significantly contribute to enhancing physical and mental health conditions by encouraging active modes of transport and supporting greener and socially interactive spaces.

Comparison of expected impacts

Figure 4-1 compares the previously described impacts. The generic terms are located on the y-axis. The expected impacts are shown in the stacked bars beside their affiliated group. The frequency of the expected impacts was determined by analysing the literature. They were captured according to the occurrence of key terms associated with a specific impact.

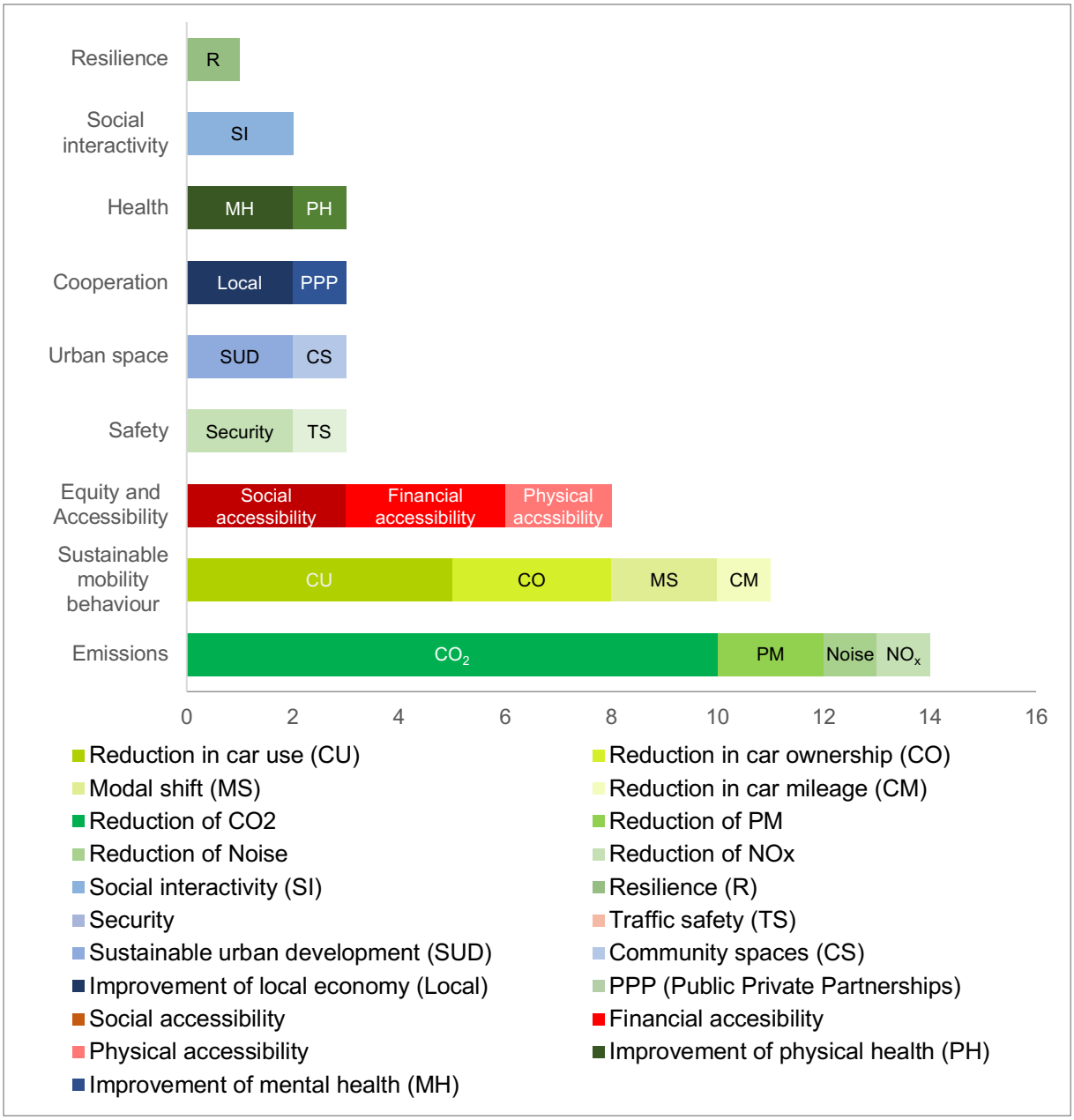

Figure 4-1: Comparison of expected impacts depending on their frequency in the literature. Source: Own depiction.

It can be observed that impacts related to emissions, predominantly the reductions in carbon emissions, are frequently mentioned in the respective literature set. Specifically, the reduction of carbon emissions is mentioned about ten times, while impacts related to particulate matter are mentioned twice. Impacts such as a reduction in noise and nitrogen oxides are mentioned once. Subsequently, sustainable mobility behaviour is frequently discussed, particularly the reduction in car use and ownership, followed by aspects of modal shift and the reduction in car mileage. Related impacts on equity and accessibility, such as social, financial, and physical accessibility, are commonly found in the literature. The impacts of mobility hubs on health, cooperation, urban space, and safety are consistently addressed, with each aspect receiving comparable attention. Lastly, impacts associated with resilience

appear to be mentioned less frequently, with only one occurrence in the respective literature set.

4.1.2 Existing Impacts

This chapter presents the existing impacts of mobility hubs. The data presented in the following chapters are mainly derived from research and case studies by CoMoUK, Miramontes et al. (2017), Pfertner (2017) and Czarnetzki and Siek (2022), who substantially contributed to collecting, measuring, and observing the impacts of mobility hubs. Table 4-2 below provides a detailed overview of the existing impact groups and individual impacts, analogous to Chapter 4.1.1.

Existing Impacts	
Sustainable mobility behaviour	Modal shift
	Reduction in car use
	Reduction in car mileage
	Reduction in car ownership
Emissions	Reduction of CO_2
Social interactivity	
Equity and Accessibility	Physical accessibility
Health	Improvement of physical health
Acceptance	
Development costs	

Table 4-2: Overview table of existing impacts and their respective category. Source: Own depiction.

The following section presents the measured and observed impacts of mobility hubs detected within the relevant sources. The included impacts are represented in the overview table (see Table 4-2), which is based on the elaboration and description of impact groups as presented in the methodology section of this thesis (see Table 3-1). The detected individual impacts include social interactivity, acceptance, and development costs.

Sustainable mobility behaviour

New developments in Bremen, in proximity to mobility hubs, showed a change in mobility behaviour, according to the study by CoMoUK. It was found that households in these developments *"are much more likely to use a public transport season ticket (56%) than the control group (46%)"* (CoMoUK, 2022, p. 1). Introducing a community mobility hub in Austin, where private vehicles were predominantly used to address the last mile, resulted in observable impacts. In connection with place-making efforts, people made less use of cars and chose more active forms of travel, such as walking, which increased by 25%. According to statements from car users, the mode share of private vehicles decreased by 39% in

Austin. Moreover, as the data shows, it was mainly bicycles and e-scooters that replaced car journeys (CoMoUK, 2022). Miramontes et al. (2017) contribute further essential information with their study on mobility stations in Munich. The findings reveal that using mobility hubs significantly affects the respondent's mobility behaviour to more multimodal travel. The following section addresses the responses of users of free-floating car-sharing and stationary bike-sharing services. Thus, around 20% of car-sharing users and 26% of bike-sharing users indicated a more frequent use of public transport. Users of car-sharing services also stated that they use bike-sharing services more frequently and vice versa. Furthermore, the implementation of the mobility station had a considerable impact on awareness and patronage. The study documented that 18% of car-sharing users and approximately 31% of bike-sharing users joined the locally offered mobility services as a direct result of the mobility hub. In addition, the study highlighted cross-service membership trends, as 9% of car-sharing users joined the bike-sharing service. Also, 36% of car-sharing users and 21% of bike-sharing users considered joining another car-sharing service (Miramontes et al., 2017). In a similar evaluation of mobility stations in the city of Würzburg, Pfertner (2017) elaborated valuable findings on the change in mobility behaviour by introducing mobility hubs. Firstly, 75% of car-sharing users reported an increased frequency of service utilisation due to the presence of mobility hubs. In addition, the use of public transport by users of mobility stations increased by 23%, indicating their positive impact on the overall attractiveness of the transport network. Although some respondents expressed scepticism about the impact of mobility hubs on public transport usage, the study's observations revealed a tangible rise in public transport utilisation and a shift towards more sustainable mobility behaviour. A significant aspect of sustainable mobility behaviour, as identified by Pfertner (2017), involves reducing private car use. Pfertner's research in Würzburg found that introducing car and bike-sharing services led to decreased car usage. Specifically, 40% of bike-sharing users and 60% of car-sharing users acknowledged reducing their car use, with some expressing a strong reduction. Furthermore, 80% of respondents agreed that mobility hubs decrease the necessity for private car use. These findings collectively emphasise the positive influence of mobility hubs on encouraging sustainable mobility behaviour and reducing reliance on private vehicles. Following the introduction of mobility hubs in 2019, the use of car-sharing in Bergen experienced a significant increase of around 70 % (CoMoUK, 2022). The Bremen case study by CoMoUK (2021) identified and analysed households that use car-sharing. As part of this analysis, they found that the total number of kilometres travelled by car is only half that of an average household. In general, a lower traffic volume was observed in Bremen compared to other German cities, which can be attributed to the provision of mobility hubs (CoMoUK, 2021).

The following section focuses on reducing car ownership in connection to sustainable mobility behaviour. Firstly, 16 cars were replaced as part of the Bremen car club's introduction. The owners of seven of these cars gave up owning a car, and nine were not purchased at all. Overall, mobility hubs in Bremen, which offer car clubs, contributed to 2,700 cars not being bought and a further 2,300 vehicles being reduced (CoMoUK, 2021). Initially, the introduction of 43 mobility hubs in Bremen, which started in 2003, has substantially reduced approximately 6000 cars, demonstrating the positive influence these hubs have by decreasing private car ownership and promoting sustainable transportation alternatives. Additionally, a correlation emerges in areas with mobility hubs, as shown by the fact that 18% of households in developments featuring a mobility hub reported not owning a privately owned car (CoMoUK, 2021, 2022). This was also recognised in a survey conducted by Miramontes et al. (2017), where 80% of respondents thought that the modes offered at mobility hubs corresponded to their needs. The majority of these respondents also concluded that owning a car is no longer necessary. As part of evaluating the impacts of mobility stations in Würzburg, Pfertner (2017) compared the behaviour of users and non-users regarding car ownership. Pfertner (2017) observed that new purchases of cars prevail over the renouncement of a private car among non-users of the mobility station. However, regarding users of shared mobility services offered at these hubs, a trend towards forgoing car ownership could be identified, as 15% and 21% of car-sharing and bike-sharing users indicated a smaller number of privately owned cars. Czarnetzki and Siek (2023) conducted another representative study focusing on the relationship between the utilisation of mobility hubs and the decision to forgo car ownership. Their analysis revealed a correlation between the frequency of use of mobility hubs and the willingness to do without a private car. In particular, it was found that people who use mobility hubs more frequently are more willing to forgo car ownership. Moreover, a social experiment in Amsterdam highlights the broader impact of multimodal travel options, the principle foundational to mobility hubs. The experiment revealed that when participants were provided travel credits for using various modes such as public transport, bike-sharing, car-sharing, and taxis, 30% ultimately chose to forgo car ownership (CoMoUK, 2022). Overall, these observations emphasise the impact of multimodal travel and, thus, the rationale behind mobility hubs.

Emissions

By implementing mobility hubs in Bergen, 31 shared electric vehicles were introduced simultaneously, contributing to a reduction in carbon emissions of 464 tonnes per year (CoMoUK, 2022). As Pfertner (2017) evaluated the impacts of mobility hubs in the city of Würzburg, he found that the reduction of emissions is primarily caused by less car mileage due to other more sustainable alternatives to the private vehicle. Additionally, carbon emissions decreased per travelled kilometre due to more efficient vehicles included in the car

fleet, compared to privately owned cars (Pfertner, 2017). Based on these findings, Pfertner (2017) calculated a saving of around 650 tonnes of carbon emissions in one year.

However, it must be added that Pfertner (2017) used a rather simplistic approach to calculate the carbon emissions in the case of Würzburg's mobility stations, and the results should be regarded as approximate values. This limitation highlights the general difficulty and complexity of accounting for an exact number of carbon emission savings. Moreover, the reduction in emissions is not only due to the use of car-sharing but also to the use of other means of transport offered at the hubs, the effects of which are difficult to determine in exact figures (Pfertner, 2017).

Social interactivity

Observing the impact in Bergen has shown that the concept of "shared spaces" associated with mobility hubs brings tangible results. These spaces have improved social interactivity by including features such as green spaces and communal areas while ensuring accessibility for people with special needs. However, it is essential to recognise that the effectiveness of these "shared spaces" depends on their connection to mobility hubs and the associated infrastructure that ensures accessibility (CoMoUK, 2022).

Equity and Accessibility

An evaluation conducted by the "Technical University of Hamburg" on Hamburg's mobility hubs provides insights into their impact and user dynamics. The findings reveal that the effects of the "hvv switch stations" primarily affect residents within a 200-meter radius. Accessibility is a crucial factor, emphasising frequent use by women and families, as reserved parking spaces eliminate the effort to find a free space (Meuleman & Signor, 2023). Insights from CoMoUK (2021) further highlight the transformation of spaces initially allocated for parking provisions. These areas are now repurposed to enhance accessibility, particularly for individuals with disabilities. Space that is not utilised is reserved for a potential expansion of the hub (CoMoUK, 2021). Finally, it must be noted that equity and accessibility are challenging aspects to observe and indicate. Taking sufficient measures to ensure access to mobility hubs for all demographic groups is crucial. This should guarantee an equal right to mobility and expand the user groups of mobility hubs, thus maximising their use to steer urban transport further in a sustainable direction (CoMoUK, 2022).

Health

Due to the findings presented in the previous chapter on the existing environmental impacts of mobility hubs on emission reduction, the study of Austin's mobility hubs validates the hypothesis that a lower burden of emission enhances physical health (Holland et al., 2018). In particular, this contributes *"to reduced obesity, improved respiratory health, and healthy*

birth weight" (Holland et al., 2018, p. 34). Furthermore, CoMoUK (2022) reports about a 25% increase in walk trips in the case of Austin's placemaking efforts and the introduction of shared mobility at the mobility hub. This finding suggests an additional positive impact on health due to an increased amount of physical activity (NIH News in Health, 2017).

Acceptance

The placement of mobility hubs in or near residential areas raises the question of community acceptance and approval. A survey conducted in Bremen sheds light on public sentiments, revealing that approximately 55% of respondents express a positive view of having mobility hubs near their homes, preferring this idea over cars and parking spaces (CoMoUK, 2022). Another survey by Miramontes et al. (2019) reveals that a substantial percentage of respondents are open to the concept of mobility hubs and would even prefer to increase mobility hub development in their area. Specifically, 68%, 59%, and 73% of people in Munich, Offenburg, and Würzburg, respectively, hold this opinion (Miramontes et al., 2019). This indicates that people are increasingly tending to view mobility hubs as a practical and attractive alternative to private motorised transport.

Development costs

In the planning of new housing developments, the provision of parking spaces is a crucial aspect that creates additional costs. However, integrating mobility hubs into these developments presents an opportunity for a mutually beneficial outcome for both housing and sustainable development stakeholders. As presented in the previous chapter regarding the reduction in car ownership and usage, the inclusion of mobility hubs eliminates the need for extensive parking provision, thereby creating an opportunity for cost savings for developers (CoMoUK, 2022). This freed-up space, no longer designated for parking, can be repurposed for other sustainable urban development initiatives. Evidence from Vienna highlights the financial advantage of this approach, demonstrating that developers save up to 8.5% of their costs for a 70-square-meter apartment (CoMoUK, 2022). This way, developers can not only reduce expenses but also contribute to sustainable urban planning practices.

Comparison of existing impacts

Figure 4-2 represents the previously described impacts in a comparative way. This graphical visualisation follows the same principle as the bar chart presented at the end of Chapter 4.1.1.

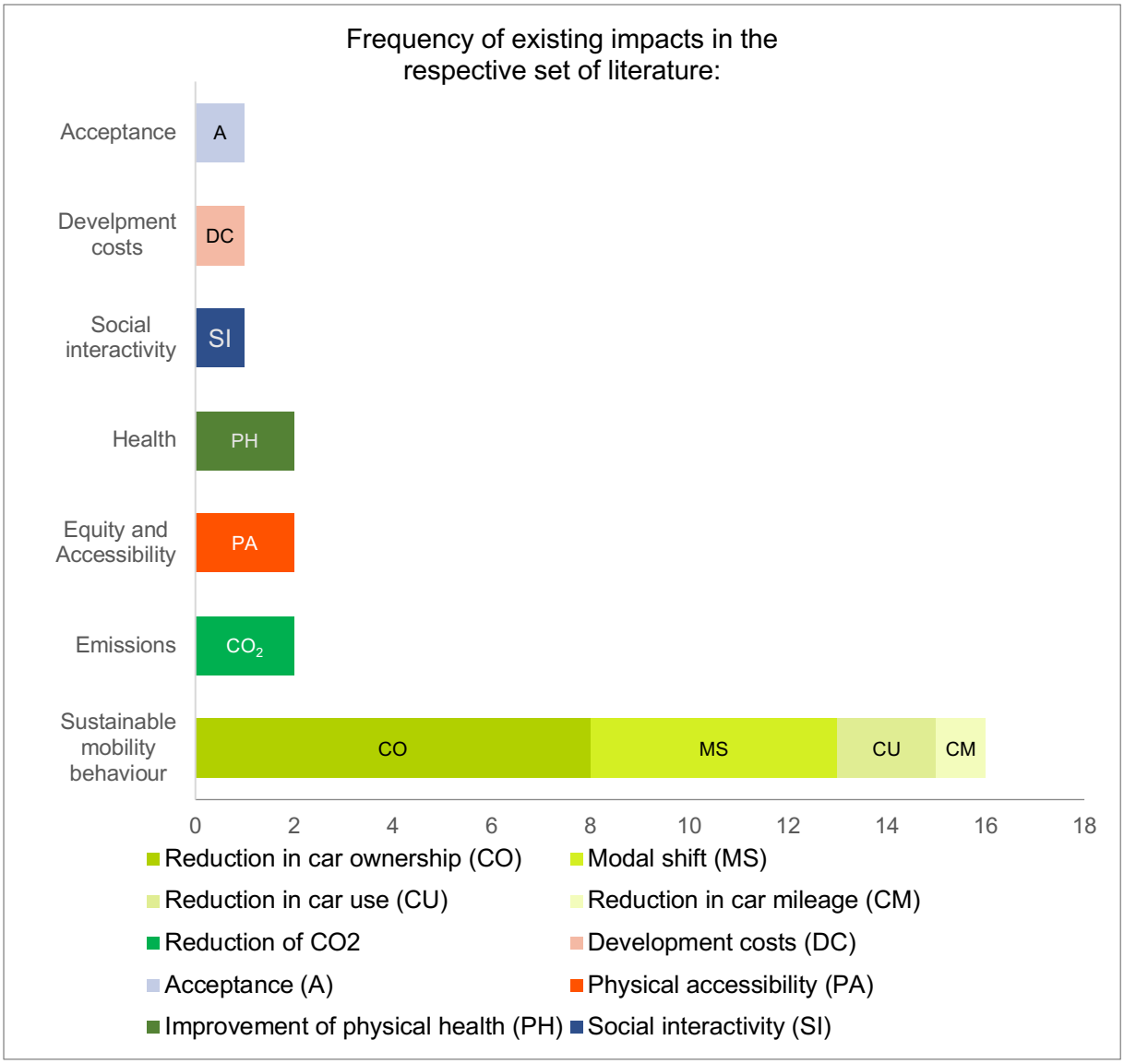

Figure 4-2: Comparison of existing impacts depending on their frequency in the literature. Source: Own depiction.

The diagram indicates that the existing impacts in the relevant literature focus predominantly on sustainable mobility behaviour. This is shown by the fact that the majority of observed outcomes mentioned in the literature involve reduced car ownership and a shift towards more sustainable transportation options. Additionally, impacts related to a reduction in carbon emissions, improvements in physical accessibility, and enhancements in physical health are commonly discussed, with each impact occurring two times in the respective set of literature. Impacts such as enhancing social interactivity, a reduction in development costs, and effects on the acceptance of residents are also mentioned in the literature but to a lesser extent than the impacts above.

4.1.3 Comparison of expectations and outcomes

Firstly, comparing the data found in the literature shows that emission-related impacts are becoming increasingly rare in the literature on existing impacts. Furthermore, the number of

references referring to the impact group of sustainable mobility behaviour slightly increased. Expectations towards an impact on equity and accessibility were frequently mentioned. However, in the respective literature on existing impacts, only two mentions of physical accessibility could be found. The impact group “Health” was present in both sets of literature, with a slight decrease in the literature on existing impacts. The same also applies to the impacts on social interactivity. Impact categories not detected in the literature on existing impacts were urban space, safety, cooperation, and resilience. Yet, there were impacts only detected in the literature on existing impacts such as development costs and acceptance. It is important to note that this comparison is based on the impact occurrences in the selected literature. If expectations were not detected in the selected literature, this does not mean they are non-existent.

Due to the large number of different impact data, it is difficult to draw conclusions from a comparative graphical presentation. In most cases, the expected and existing cannot be directly compared because of their different metrics. However, a complete overview of expectations and outcomes towards the impacts of mobility hubs is provided in the appendix (see Appendix 1).

4.1.4 Summary of literature results

The data from the literature enabled an extensive examination of the expected and existing impacts of mobility hubs in urban regions. In summary, the expectations towards the impacts of mobility hubs provided a multifaceted view of the potential of mobility hubs. Figures on existing impacts even showed tangible numbers regarding the impact groups of sustainable mobility behaviour and emissions. However, the latter is predominately characterised by approximation. Importantly, surveys conducted as part of the studies selected for this research proved the positive impacts that mobility hubs have, especially on the reduction in car use, ownership and modal shift. Moreover, the existing impacts showed that this concept achieved further benefits such as enhanced health and physical access, social interactivity, and reduced development costs. A direct comparison of expected and existing impacts was complicated and challenging to draw conclusions from, mainly due to the often uncoherent metrics used to indicate the impacts. The impact groups are represented below (see Table 4-3) with an indication of their occurrence in the respective literature set. Additionally, the corresponding literature is listed for the respective impact groups.

Literature on expected impacts		
Sustainable mobility behaviour	11	Meuleman & Signor (2023); Arnold, Frost, et al. (2023); Babio (2023); Hached, et al. (2023); Aono (2019); Arnold, Dale et al. (2023); Metropolitain Council (2020); Weiland (n.d.)
Emissions	14	Hached, et al. (2023); Babio (2023); Holland, et al. (2018); Weiland (n.d.); Arnold, Dale et al. (2023); Meuleman & Signor (2023);
Resilience	1	Aono (2019)
Social interactivity	2	Nilforoshan, et al. (2023); Aono (2019)
Safety	3	Aono (2019); Arnold, Dale et al. (2023)
Urban space	3	Arnold, Frost, et al. (2023); Arnold, Dale et al. (2023); Meuleman & Signor (2023)
Cooperation	3	Aono (2019); Arnold, Dale et al. (2023), Arnold, Frost, et al. (2023)
Equity and Accessibility	8	Aono (2019); Holland, et al. (2018); Arnold, Frost, et al. (2023); Meuleman & Signor (2023)
Health	3	Arnold, Frost, et al. (2023); Holland, et al. (2018)
Literature on existing impacts		
Sustainable mobility behaviour	16	CoMoUK (2022); Miramontes et al. (2017); Pfertner (2017); CoMoUK (2021); Czarnetzki & Siek (2023)
Emissions	2	CoMoUK (2022); Pfertner (2017)
Social interactivity	1	CoMoUK (2022)
Equity and Accessibility	2	CoMoUK (2021); Meuleman & Signor (2023)
Health	2	CoMoUK (2022); Holland et al. (2018)
Acceptance	2	CoMoUK (2022); Miramontes et al. (2019)
Development costs	1	CoMoUK (2022)

Table 4-3: Data bar representation of impact groups with corresponding literature. Source: Own depiction.

4.2 Interviews

This chapter presents the results of the interviews conducted. They aim to complement the findings of the literature and expand the information with practical insights from stakeholders. In Chapter 4.2.1, background information on the interview participants is presented. Subsequently, the findings on expected and existing impacts are presented in Chapters 4.2.2 and 4.2.3. The interviewees' responses on the categorisation approach and the impact data are analysed in the following chapters. Chapter 4.2.6 compares expectations and outcomes as discussed in the interviews. Lastly, the results of the interviews are summarised.

4.2.1 Background information on the participants

In total, three participants were selected for the interviews. Table 4-4 presents the interviews and the institution with which the interviewee is associated. The first participant has been working as an advisor for sustainable mobility at the "Agency for the Urban Environment" in Bergen, Norway, for ten years. In the second interview, two persons from the mobility department of Munich participated, working in shared networked transport systems. The third interview was conducted with a programme manager for mobility hubs in the province of Drenthe in the Netherlands, who has 20 years of experience in the field of multimodal mobility. An overview of the interviews and the participants' institutions are provided in the following table:

Number of Inteview	Intitution
Interview 1	Agency for Urban Environment, City of Bergen
Interview 2	Mobility department, City of Munich
Interview 3	Province Drenthe

Table 4-4: Number of interviews and associated institution of the participants. Source: Own depiction.

4.2.2 Expected impacts

This chapter presents the expected impacts of mobility hubs discussed in the interviews. The word cloud in Figure 4-3 shows the thematic fields of commonly mentioned terms related to the expectation towards mobility hubs in urban regions. The size of the words represents their frequency, thus indicating the relevance of certain expectations from the stakeholder's perspective. The words shown in Figure 4-3 were defined by applying a coding system as part of a hybrid thematic analysis approach, as described and illustrated in Chapter 3.4.2 of the methodology section. This approach combines a deductive and inductive determination of codes (Proudfoot, 2023).

Figure 4-3: Word cloud of expected impacts discussed in the interviews. Source: Own depiction.

As shown in Figure 4-3, expectations in relation to sustainable mobility behaviour were most frequently mentioned in the interview. Furthermore, the interviewees emphasised the importance of aspects such as equity and accessibility, urban space, and mobility needs. Moreover, factors such as development, acceptance, health, emissions, and social interactivity were also addressed. The following section examines the perspective of stakeholders and their expectations regarding the impact of mobility hubs in urban regions. It is worth noting that the participants were not specifically asked about the established topics (see Figures 3-4 and 3-5), according to which the following sections are structured. The responses from the interviewees were analysed and assigned to the impact groups that emerged inductively from the interviews or as part of the systematic literature review.

Sustainable mobility behaviour

As part of the interviews, the participants were not explicitly asked about their expectations of sustainable mobility behaviour in the context of implementing mobility hubs. The term was defined based on the results of the literature and thus serves as a categorisation that allows for a bundled presentation of the qualitative findings. When asked about the motivation and expectations for the planning and implementation of mobility hubs, participant 2 mentioned a fundamental aspect:

> And the overall aim of the whole thing is actually to influence the modal shift, so to speak, away from private motorised transport towards more space-efficient mobility options. (28-30).

Participant 1 recognises this aspect as well and stresses that changing “transport habits into sustainable modes” is crucial (24-25). Moreover, participant 1 highlights the potential that mobility hubs can have. They expect them to have significant impacts on urban mobility,

such as solving the first and last mile problem while enhancing public transport systems at the same time (128-137).

The impact of a reduction in car use and ownership is another aspect that was discussed in the interviews. Participant 2 expresses, among various factors, the focus on “reducing the need for a private car” (36-37) through the implementation of mobility hubs. They expect that this will affect flexibility of residents in a positive way, which expands mobility opportunities while not being dependent on the own car (42-43). Additionally, participant 1 mentions that mobility hubs will make “alternatives to the private car more competitive” (33), thus indicating an expected reduction in car use and ownership. Car-sharing plays an essential role in the shift toward more sustainable mobility behaviour, as participant 1 states:

> To use car-sharing has so many indirect impacts on mobility behaviour I think, so that's the really sort of trigger point, if you get a new relation to the car, not having to own it, not having to have it near outside your door and then lots of things can happen. (208-211).

By providing car-sharing services as part of mobility hubs a trend could be observed from individual personal reports in Munich, that an efficient car-sharing offer supports the decision to forgo car ownership (Participant 2: 107-113). Especially participant 1 frequently mentions car-sharing as key feature of mobility hubs to achieve sustainable mobility behaviour among residents. In contrast to the expectations addressed in the first two interviews, participant 4 focused more on social aspects, thus not engaging in environmental aspects in the responses.

Emissions

In the interviews, the focus on emissions was limited, with only one explicit mention related to the expected impact of mobility hubs. Participant 1 stated that:

> So the motivations and expectation, this goes all into our strategies and plans on how to cut direct emissions. (22-24).

However, this shows that the primary goal, is to implement a strategy to reduce emissions according to participant 1. It highlights the importance of the impacts leading up to achieve emission cuts.

Resilience

Only little insight was gained into the aspects of resilience, and the term "resilience" was not explicitly mentioned by the participants. While participant 1 believes that “mobility hubs are also really important in preparing people for the future” (197-198), detailed insights specifically on resilience were limited.

Social interactivity

Participant 4 emphasised the importance of “bundling facilities” (24) to ensure social interactions within the spatial environment (24-25). When participant 1 was asked about the social impact, he expressed the difficulty of directly observing any significant impact in this area (77). However, he expects that community spaces as part of mobility hubs could have an effect:

> So, it's a place where people meet a lot, or have a chance to meet, and those kind of features like benches and barbecue spots and things like that, we assume they will have some social impact and they're placed in neighbourhoods where people usually appreciate these kinds of things. (82-85).

Additionally, participant 1 mentioned that they included “green street spaces” (86) and “areas for play” (87) which can further positively affect social interactivity (85-88).

In summary, Participant 4 thinks that bundling facilities will encourage social interactions, while Participant 1 anticipates positive social impacts through community spaces within mobility hubs. Features like benches, barbecue spots, green spaces, and areas for play are expected to enhance social interactivity. This emphasises the importance of a well-thought-out design of mobility hubs, especially for facilities and community spaces, so that people can interact with each other effortlessly.

Urban space

Apart from the literary findings that the implementation of mobility hubs aims to free up space, participant 2 further highlights the goal to organise “public street space” through the concept of mobility hubs (25-26; 154-156). Additionally, participant 2 mentions an efficient and fair distribution of space due to a modal shift that reduces the space required by cars (32-34). This opinion is also shared by participant 1, who stated:

> And you know free up street space for means than just parking cars that sit there and are unused 98% of the time over into more car-sharing and those kinds of things. (27-28).

Participant 1 further stresses the importance of implementing car-sharing as part of mobility hubs, which can significantly create enough space for everybody, even for residents who keep their private cars (126-128). Especially targeting areas where space is limited due to high parking pressure can positively impact the availability of space and its utilisation (Participant 1: 123-127; Participant 2: 32-34). In conclusion, the participants' expectations relate primarily to organising and freeing up space through a modal shift and the efficient and targeted use of car-sharing services within the framework of mobility hubs.

Equity and Accessibility

The expectations of Participant 4 towards mobility hubs relate primarily to social aspects and, among other things, accessibility. Participant 4 thinks that:

> We are in a transition, where mobility is not central, but the accessibility of facilities. We want to ensure that everyone can participate independently in society. (8-9).

Through this critical statement, the participant underscores their expectations by placing accessibility as a key impact in achieving social equality among various demographic groups. In addition, participant 2 is of the opinion that mobility hubs should also offer "a good mix of services for a broad section of the population" (116-117) in order to ensure equal access. Moreover, by strategically planning and placing mobility hubs, participant 4 has the expectation that the use of the hubs should be effortless. (23). According to participant 2, mobility hubs will enhance equality:

> That it also plays into equality in any case, so that women, who often don't get a car because the husband is usually away, would have the option of having a car-sharing vehicle or a cargo bike or something similar available to them if they need to take the child away or have another need of some kind. (119-124).

With this statement, participant 2 illustrates that equality as an effect of mobility hubs can have a much more specific impact area and can already be felt even within small households. The participant further mentioned the cost of using the services guarantees for various demographic groups to have access, either “for special needs or daily use” (127-128), (124-128). Furthermore, participant 1 mentioned that users can significantly save costs:

> Because people potentially can cut their car expenses in half, roughly, you know, by using car-sharing. (92-93).

On the one hand, this refers to the acquisition costs, and on the other hand to the maintenance costs, which can be decisive for car ownership, as participant 2 also emphasised (125-128).

Health

While participants were not directly questioned about health impacts, expectations can be derived from their responses. The participants mention promoting active transport as part of the implementation strategy (Participant 1: 23-25), as it may potentially impact an individual’s physical health. Similarly, the statement on the design of mobility hubs to ensure “many (informal) encounters between people" (Participant 4: 24-25) suggests a focus on social interactivity to improve "quality of life" (Participant 4: 25). From this emphasis on improved quality of life, possible positive effects on mental well-being can be drawn. It is important to note that the participants did not directly address health impacts, and these deductions are based on broader interpretations of their responses.

Acceptance

The aspect of acceptance regarding the implementation of new mobility systems, such as mobility hubs in connection with car-sharing, was mentioned only by participant 1. This observation suggests that the initial acceptance of these innovations may be weak, as the direct effects of such implementations may not be immediately showing (125-127). Residents need to adjust to a step-by-step impact and understand that it will take time for the full effects to be realised (125-127). Participant 1 also brings attention to the perspective of companies and developers, who may face challenges dealing with stricter parking regulations around their properties:

> It's a really hot potato, when you try to impose very strict and low parking regulations in urban transformational areas where everything's going to be built up new, where you have businesses and offices and housing and many property developers, they are on board on the idea of having a low parking norm for housing (…). (109-112).

Development

The participants from the first two interviews highlighted expected impacts related to the development of the sustainable transformation of the urban environment. Specifically, participant 1 emphasised:

> (…) And also to solve mobility needs in the densification project where you build along like a light rail line and transform the urban environment. (25-27).

Similarly, Participant 2 expressed a goal of achieving "sustainable urban and mobility development", (35). The emphasis was placed on the potential impact of reducing occupied space by private vehicles and a more effective and more equitable utilisation of this space. (32-35).

Mobility needs

Moreover, expectations towards solving mobility needs were a commonly discussed topic. As already mentioned, participant 1 mentioned that the expectations are aimed at solving mobility needs and that urban development is oriented accordingly (25-27). In addition, mobility hubs are expected to fulfil the mobility needs of companies and their employees by enabling seamless commuting and saving additional costs at the same time. (Participant 1: 102-106). Participant 2 stresses that:

> That there are simply so many offers available that you can find a suitable offer for every usage requirement without having to own it. (37-39).

Based on the participants guiding principles, expectations focus on the efficient provision of transport through mobility hubs by emphasising the reliability of the services offered at these hubs regarding the users' transport needs (Participant 2: 36-43). Participant 2 thinks that

mobility hubs fulfil the different needs of users by “offering flexibility and expanding mobility options” (42-43), (39-43). This view highlights the importance of mobility hubs in providing a comprehensive and reliable transport system that meets the varying needs of users.

4.2.3 Existing impacts

This chapter presents the existing impacts of mobility hubs discussed in the interviews. The word cloud in Figure 4-4 shows the thematic fields of the frequently mentioned terms in connection with the observed effects of mobility hubs in urban regions. The size of the words represents their frequency, thus indicating the relevance of outcomes from the stakeholder’s perspective.

Figure 4-4: Word cloud of existing impacts discussed in the interviews. Source: Own depiction.

Figure 4-4 highlights that sustainable urban mobility is an aspect mentioned rather frequently, similar to the expectations of the interviewees presented in the previous section. Moreover, effects related to urban space and equity and accessibility are still commonly named. Additionally, outcomes regarding cooperation, safety, mobility needs, and emissions are referred to occasionally. The following section explores the stakeholder's perspectives on the existing impacts of mobility hubs.

Sustainable mobility behaviour

When asked about observed environmental impacts in the respective urban region, the participants mentioned various aspects that are subordinate to sustainable mobility behaviour. Participant 1 addressed the emission-free share of the car fleet in proximity to an operating mobility hub. They stated that:

> From data for the quite local areas around the mobility hubs (…) we can see a rise in (…) the zero-emission share of the car fleet in that area. (39-41).

For participant 1, this effect reflects the local success of the mobility hubs implementation and shows that “it's working” (42-44). Moreover, shared cars can even have a more significant impact than switching to a private electric vehicle, by replacing several cars which are mostly fossil fuel powered (Participant 1: 66-69). It is worth noting that participant 1 mentioned the limitation in concisely determining the impacts. However, there are reports on user data that validate the actual impact of sharing services as part of mobility hubs (68-74).

Achieving a modal shift through the implementation of mobility hubs is crucial to steer towards more sustainable mobility behaviour and, therefore, reaching certain environmental goals and conditions. A substantial observation was made by Participant 1:

> Because what we see from our service is that people that use car-sharing, they also walk, cycle and take public transport much more than others. (204-205).

From this, it can be deduced that mobility hubs play a critical role in affecting the users’ mobility behaviour by making inter-modality seamless and effortless. In contrast to the findings and observations of participant 1, responses from interviews 2 and 3 towards environmental impacts, specifically the aspect of sustainable mobility behaviour were limited. Participant 4 stated that:

> The impact is far too small for that. In Groningen we do have a good BRT system, which ensures that the city is easily accessible, despite the restrictions on car traffic. This does have a major impact on the environment. (12-14).

The response of participant 2 to the questions, if any environmental impacts have been observed, was as follows:

> Yes, that's a difficult question, because so far we haven't really observed or recorded much in the way of figures. (55-56).

Being in the implementation phase, participants from the second interview focus on achieving their goal of building 200 mobility hubs until 2026, of which 46 are already in operation (86). However, the observation and measuring of impacts is restricted for now, mainly because:

> That's probably also why there is still this big gap in research, is that mobility behaviour doesn't change so quickly. And just because car-sharing has been on my doorstep for two weeks now doesn't mean I'll immediately get rid of my private car or change my behaviour. (57-60).

In summary, Participant 1 highlighted positive trends and observed impacts in sustainable mobility behaviour. Participants 2 and 4 faced challenges measuring and recording environmental impacts, emphasising the gradual nature of behaviour change during the early stages of mobility hub implementation.

Emissions

Little insight was gained into the thematic field of emissions. However, participant 1 mentioned, that “tangible number” (74) in regard to emission cuts exist (73-74). Estimates on carbon emission cuts primarily result from the evaluation of user data, participant 1 says (70-74). Participant 2 emphasised the complexity of the calculation of emission savings through mobility hubs and that the publication of such figures must, therefore, be handled with care (79-83).

Safety

Closely related to the aspect of transforming urban space as an organisational tool for urban areas, as participant 2 pointed out, it also has a positive impact on safety conditions on traffic routes. By instrumentalising mobility hubs for the organisation of public space and the creation of a geofencing network, participant 2 observed that:

> And that's exactly where it fulfilled its objectives. (...) it also plays into road safety, that you don't stumble across vehicles that are somehow parked all over the place. (156-158).

Before measures were taken, participant 2 had to deal with “many complaints” (148) especially in connection to micro-mobility (148-150). After the introduction of geofencing measures and no-parking zones, participant 2 is “very satisfied” (153) with the results. (148-159).

Urban space

As the transformation of urban space is an important aspect regarding the implementation of mobility hubs, the participants observed impacts resulting from the development of mobility hubs. Participant 1 stated that:

> Some of our mobility hubs have (…) features like (…) benches and trees and green space, places to meet, one of the latest one have even have a barbecue spot and you know, pieces of cycling infrastructure, bike parking and those kind of things. (77-80).

In this case, the urban space as part of the mobility hubs facilities and services was transformed to include features, that enhance both social and environmental condition in that area. (Participant 1: 77-91). While participant 1 focused more on the social aspects of transforming urban space, participant 2 mentioned the importance of utilising the space provided at mobility hubs to improve the organisation of public space:

> Mobility hubs are there to create this organising effect, to provide infrastructure and parking spaces so that these vehicles have a place to park, and we are definitely very satisfied with this; it works very well thanks to geofences, i.e. no-parking zones around parking areas. (150-154).

In summary, mobility hubs contribute to the transformation of urban space by improving the social environment and organisation of public space. The participants' observations highlighted the addition of features such as benches and green spaces for social enhancement, as well as an organisational impact through the provision of infrastructure and parking spaces.

Cooperation

Another impact relates to creating opportunities for cooperation. A mobility hub must offer means of transport and services, which often requires a partnership with private providers. Additionally, participant 1 underlines the strategic importance of working with a car-sharing provider, offering their service at the mobility hubs on site, to meet the mobility needs of the municipal organisation with around 22,000 employees in Bergen (97-100). The cooperation is not limited to direct mobility-related services but also includes cooperation in data exchange, as participant 1 stated:

> We're working with the car-sharing operators now in its research and development project where we are coming with some regulations that require them to share data on their vehicles, with us, not personal, but only vehicle data through MDS standard. (167-170).

To both regulate mobility services and learn more about user behaviour to gain deeper insights into how mobility hubs impact urban mobility, it is crucial to build partnerships to enable seamless and collaborative data sharing. (Participant 1: 167-176). The cooperation between the city’s mobility department and car-sharing providers in Munich offers the opportunity to implement mobility hubs in more outer-lying urban areas successfully. By combining car-sharing and micro-mobility into the mobility hubs in the outskirts, this partnership offers a wide range of services for residents in less central locations. (Participant 2: 159-166).

In summary, mobility hubs require collaborations with private providers, such as car-sharing and micro-mobility services. Participant 1 stressed the strategic partnership with a car-sharing provider to meet the mobility needs of the municipal organisation in Bergen. This collaboration extends to data exchange for regulating services and gaining insights about user behaviour. In Munich, the cooperation between the city's mobility department and car-sharing providers also enables successful mobility hub implementation in outlying urban areas.

Equity and Accessibility

The participants broadly shared the same opinion that the provision of mobility hubs must take equality and accessibility into account. This means that making the services accessible

for residents in urban areas also needs to focus on potential users who do not live near the city centre or high-density urban areas. Participant 2 has noticed this:

> And we now also have the opportunity to bring shared mobility services to the outskirts of the city. The goal has already been achieved for the mobility points that have now been set up. (159-161)

In this way, residents of outlying neighbourhoods can use the service in the same way as residents in a more central location. Participant 4 followed up on the opinions and feedback of mobility hub users and found that:

> By offering facilities closer to people, people have to travel less often and far. This is experienced as very positive, especially by people who are less mobile. (16-17).

In summary, participants emphasised the importance of equality and accessibility when setting up mobility hubs. Successful initiatives, such as the extension of mobility services to the urban edge, are an example of efforts to ensure greater accessibility. Additionally, the positive feedback from users, which was taken up by participant 4, emphasises the importance of short distances, especially for people with limited mobility.

Mobility needs

The participants were not specifically questioned about the aspect of mobility needs, but participant 1 addressed that the “needs of daytime business” (100) are met as large mobility hubs are “accessible for businesses or municipal users” (102-103). Participant 1 observed this impact when examining the user behaviour:

> That sort of serves the needs of daytime business (…), it's a fantastic match with the use of citizens at evenings, afternoons (…) and weekends. (100-102).

Participant 1 further expresses their confidence in the potential of mobility hubs and believes that when businesses discover the benefits of this concept, mobility needs are met, and a significant amount of costs can be saved at the same time. (103-107). Furthermore, participant 1 observed that car-sharing providers are “targeting business users” (108) and increasingly adjusting “their services to fit their needs” (108-109).

4.2.4 Comparison of expectations and outcomes

Firstly, participant 1 mentioned that no specific expectations were determined due to the novelty of the concept (147-148). In general, expectations were met and even exceeded expected impacts especially in terms of popularity, leading to “political backings” (153) an increased development of mobility hubs (Participant 1: 149-152). Participant 2 expressed satisfaction that measures such as geofences and no-parking zones ensure order in public spaces, especially in view of the numerous complaints voiced in the past about the disorder caused primarily by micro-mobility (148-154). In the context of taking measures in connection

to mobility hubs by organising public space, participant 2 stated that safety conditions were enhanced, which is another key goal that was realised (154-159). Additionally, a successful expansion of shared mobility to suburban areas was achieved (Participant 2: 160-164). Participant 4 shared a further interesting perspective: He believes that “a development is never finished” (29), so measuring the outcomes and juxtaposing them with the expectations is unnecessary. By highlighting the dynamic nature of users and their environment, participant 4 stresses that “interchange will have to continue to adapt to this” (30). A general satisfaction of users with the current development was still observed (Participant 4: 30-31).

4.2.5 Summary of interview results

To summarise, the participants contributed a wide range of perspectives that comprehensively supported and enriched the research and served as complementary data to the previously discussed literature data. In general, the participants had clear expectations regarding the impacts of mobility hubs. Observations provided evidence of the existing impacts, validating the potential of mobility hubs. Limitations and obstacles in the measurement and observation of existing impacts were also presented, which justify the limited data situation. Both expected and observed changes were mentioned regarding sustainable mobility behaviour, emission reduction, equity and accessibility, mobility needs as well as urban space. Perspectives on expected impacts were shared in connection to social interactivity, resilience, health, acceptance, and development. Furthermore, the participants observed effects regarding categories such as cooperation and safety. The experts were generally satisfied with the outcomes, some of which even exceeded expectations. At the same time, however, it was said that the comparison was difficult due to highly dynamic characteristics of user behaviour and their environment, thus complicating a comparable observation. A summarised presentation of the key statements sorted by impact groups and thematic fields can be found in the appendix (see Appendix 2).

5 Discussion

In this chapter, the results and limitations of this research are discussed. In the first chapter, the literary findings are followed up with the results from the interview, thus comparing and interpreting the various impacts and identifying trends, similarities, and discrepancies. Subsequently, the categorisation approach and the role of impact data are discussed based on the interview findings. In the second chapter of the discussion, the limitations resulting from this study are presented.

5.1 Comparison and interpretation of findings

The explanatory sequential design after Creswell and Plano Clark (2017), applied as part of the mixed-methods approach, enabled the literary findings to be complemented with expert perspectives to expand the scope of information and create a holistic view of the topic (Alele & Malau-Aduli, 2023). In this chapter, the expectations and outcomes concerning the impacts of mobility hubs from both the literary and the interviewee perspectives are interpreted and juxtaposed to identify similarities and discrepancies. Additionally, the categorisation approach and the relevance of impact data are critically examined. This discussion aims to contrast findings from the scientific and practical side, thus discovering potential research areas and recommendations for stakeholders of mobility hubs.

5.1.1 Expected impacts

Firstly, sustainable mobility behaviour as an expected impact of mobility hubs was a commonly mentioned topic in literature and interviews. The information found in the literature provided precise estimates regarding a reduction in car mileage. The expectations towards a modal shift, forgoing car ownership and reduced car use as part of the implementation of mobility hubs were also present. Similarly, the participants mentioned aspects of sustainable mobility behaviour in the interviews. Participants 1 and 2 regarded the modal shift as a crucial impact of mobility hubs (Participant 1: 24-25, Participant 2: 28-30). Interestingly, participant 1 primarily focused on the expectations towards the impacts of car-sharing as part of mobility hubs, thus highlighting the component and stressing its importance in increasing sustainable mobility behaviour among residents (Participant 1: 208-211). This opinion was shared by participant 2, who believes car-sharing is a critical feature that motivates people to do without a private vehicle (Participant 2: 107-113). Similar to the findings from the interviews (Participant 1: 208-211), the data from the literature showed that the impacts are interconnected, as a reference was often made to further effects. In particular, the reduction in car use is closely related to a decrease in carbon emissions and air and noise pollution, as well as freeing up space (Aono, 2019; Arnold, Dale, et al., 2023; Arnold, Frost, et al., 2023; Meuleman & Signor, 2023).

Secondly, the expectations towards emissions were treated differently in the literature and interviews. The quantitative data featured carbon reduction estimates and clear expectations towards reducing air and noise pollution (Arnold, Dale, et al., 2023; Hached et al., 2023; Holland et al., 2018; Meuleman & Signor, 2023; Weiland, n.d.). In contrast to the quantitative data, interview findings showed that the factor of emissions was a somewhat irrelevant topic in responses from the experts. It is worth noting that the emissions aspect was not directly formulated into a question. However, participant 1 mentioned that the main goal is to implement strategies to reduce emissions (22-24).

Thirdly, the aspect of resilience was found infrequently in both quantitative and qualitative data. Aono (2019) related that hubs are more resilient to new technologies. Participant 1, on the other hand, believes that “mobility hubs are (…) important in preparing people for the future” (197-198). This comparison suggests an interesting contrast. The literature presents the concept of mobility hubs as resilient, while the interview results suggest that this concept is intended to prepare people to be resilient.

Fourthly, the expected impacts of mobility hubs on social interactivity were present in literature and interviews. Findings from both the literature and the interviews revealed that social interactivity is dependent on the spatial design of the mobility hub. While Aono (2019) expects that including activities and public spaces will enhance social interactivity, participant 1 believes that integrating spaces where people “have a chance to meet” (82-83) will have “some social impact” (84). Participant 1 even mentions a barbecue spot as part of the mobility hubs in Bergen, which is similar to Aono's idea of integrating activities into the layout of hubs. It is important to note that planning the location and network design of mobility hubs can strongly influence diversity and social interactivity in cities and can lead to segregation if poorly planned (Nilforoshan et al., 2023).

Findings from literature data showed that measures can be taken to enhance safety standards at mobility hubs. Aono (2019) assumes that the risk of accidents can be reduced by taking proper measures, while Arnold, Dale et al. (2023) found in their study that the number of traffic-related accidents will also decrease if the traffic volume is expected to fall. In contrast to the findings from the literature, the interviewees did not mention the aspect of safety in connection to expected impacts. In conclusion, mobility hubs can have a decisive influence on road safety, as human lives are often at stake.

Literature findings reveal that the transformation of urban space is a further positive side effect that can be achieved through the implementation of mobility hubs and, therefore, a reduction in occupied space by vehicles, either by a decrease in car use or ownership (Arnold, Frost, et al., 2023). The transformation of urban space plays a crucial role in providing areas to enhance social interactivity (Arnold, Dale, et al., 2023; Arnold, Frost, et al.,

2023; Meuleman & Signor, 2023). In contrast to transforming urban space as presented in the literature, interview findings show that organising urban space is viewed as another important aspect, as micro-mobility can contribute to creating disorder and chaos due to poor parking restrictions (Participant 2: 25-26; 154-156). Participant 1 stresses the ineffective use of space as private cars are not in use most of the time. This space could be used to implement services such as car-sharing as part of mobility hubs, which are expected to free up even more space (126-128). In conclusion, a discrepancy between the literature and interview findings can be observed, as the literature focuses more on the transformation of urban space to enhance social interactivity. The interview findings suggest that urban space is expected to be organised and freed-up in the course of mobility hub implementation.

Mobility hubs are expected to develop partnerships between the private and public sectors and boost the local economy by providing opportunities for small businesses (Aono, 2019; Arnold, Frost, et al., 2023). The participants did not mention expectations towards cooperation. However, the responses from participants 1 and 2 indicate that public-private-partnerships exist (Participant 1: 167-170; Participant 2: 159-166).

The aspect of equity and accessibility in literature could be dissected into social, financial, and physical accessibility. Expectations focussed primarily on effects such as improving social and physical access to mobility and reducing the financial burden of mobility services on residents (Aono, 2019; Arnold, Frost, et al., 2023; Holland et al., 2018; Meuleman & Signor, 2023). Interestingly, the expectations of participants towards the impacts of mobility hubs regarding equity and accessibility were similar to the literature findings. Participants 2 and 4 stressed social accessibility as a main expectation, while participant 1 predicted a significant potential of saving transportation expenditures by using mobility hub services (Participant 1: 92-93; Participant 2: 119-124; Participant 4: 8-9).

Expectations towards health impacts through the provision of mobility hubs were presented in the literature as well as the interviews. Findings from the literature mainly referred to enhancing physical health issues by achieving a modal shift, thus increasingly making people use active modes (Arnold, Frost, et al., 2023; Holland et al., 2018). Similarly, the use of active modes was mentioned in the interviews as well (Participant 1: 23-25), from which it can be derived to enhance physical health. Holland et al. (2018) showed in their study that reducing the amount of time spent in a car in traffic can positively affect mental health. The design of mobility hubs also plays a key role in improving mental health (Holland et al., 2018). Although participants were not specifically asked about the expected impact on health, participant 4 mentioned that improving social interactivity as part of mobility hubs can improve “quality of life” (25), which can also have an impact on mental health.

The expected effects on acceptance, development and mobility needs were only discussed in the interviews, and no specific references could be found in the respective set of literature. Interview findings on the aspect of acceptance suggest that residents need to adjust to a step-by-step impact and understand that it will take time for the full effects to be realised (Participant 1: 109-112). The acceptance of companies and property stakeholders is a critical aspect in facilitating the development of sustainable mobility solutions such as mobility hubs, but at the same time, it points to the complexity of implementing concepts, as various affected parties need to be involved. In connection to expected impacts on development, Participant 1 stressed the importance of steering urban development in a people-centred direction by meeting the demand for mobility needs (25-27). This shows that development is often dependent on people's mobility needs. Additionally, the aspect of transforming urban areas to more effective and equitable use of space through development supports that statement (Participant 2: 32-35). The opinion on mobility needs and how these can be influenced showed that the participants generally favour fulfilling these needs (Participant 2: 37-39). However, the goal of covering all mobility needs can only be achieved if hubs are planned efficiently so that a wide range of available options can be used without restrictions.

5.1.2 Existing impacts

Findings from the literature show the positive impact of mobility hubs on urban mobility. Results reveal an increase in the use of public transport, a greater use of sustainable transport modes, and a significant decrease in car ownership. Specifically, cities such as Bremen, Munich and Würzburg experienced a modal shift towards shared mobility (CoMoUK, 2021, 2022; Czarnetzki & Siek, 2023; Miramontes et al., 2017; Pfertner, 2017). The results show the success of mobility hubs in enhancing multimodal transport and moving residents away from private car use and ownership. The interview findings are more ambivalent, as participants faced challenges in observing and measuring impacts, mainly due to a slow change of mobility behaviour (Participant 2: 55-60). However, participant 1 highlighted positive trends towards sustainable mobility behaviour (39-41). In conclusion, the quantitative data shows that impacts regarding sustainable mobility behaviour can be observed and measured or at least estimated. Still, the practical perspective highlights the gradual change in mobility behaviour after implementing mobility hubs, thus making it challenging to provide short-term figures on impacts.

The literature provides data on the impacts of emissions as well; however, this data is limited, as the calculations of Pfertner (2017) show results that are approximated values. This highlights the complexity and difficulty of calculating exact numbers, as mobility hubs are highly dynamic systems with various features and components to consider. The findings from the interviews align with the previous realisation, as participant 2 also emphasised the

complexity of an emission calculation (79-83). However, participant 1 mentioned that numbers on emission cuts exist, resulting from user data (73-74).

The mobility hubs' impact on development costs was mentioned in the literature, which presented tangible numbers regarding cost savings for developers (CoMoUK, 2022). This suggests that developers do not have the need to provide parking spaces when building in proximity to a mobility hub. Developers can not only reduce expenses but also contribute to sustainable urban planning practices, by supporting the concept of mobility hubs. In contrast, the interviews did not reveal any findings regarding a reduction in development costs.

Surveys have shown that people increasingly view mobility hubs as a practical and attractive alternative to private motorised transport (CoMoUK, 2022; Miramontes et al., 2019). In addition, a survey was conducted without comparing the preference for mobility hubs and motorised private transport, which showed that people are generally open to the concept and even prefer increasing the development of hubs (Miramontes et al., 2019). This is a crucial aspect, as public acceptance is a decisive factor in implementing mobility hubs. Observations from participant 2 revealed that it is essential for mobility hubs to have measures in place, for example, geo-fences, to avoid clutter in the public space, thus preventing complaints and, therefore, a deterioration of the reputation of mobility hubs (150-154).

Insights from the literature show that impacts on equity and accessibility are difficult to observe and measure. Important to note is that mobility hubs are primarily accessible to users in a 200-meter radius (Meuleman & Signor, 2023). This indicates that mobility hub networks should be efficiently planned by providing hubs according to resident density and topographical conditions in the area, which was already addressed when presenting the physical characteristics of hubs (see Chapter 2.2.3). This way, optimal physical accessibility is guaranteed. Beyond that, insights from the literature on existing impacts on equity and accessibility were limited. Findings from the interviews showed that successful initiatives, such as the extension of mobility services to the urban edge, are examples of efforts to ensure greater accessibility (Participant 2: 159-161). Additionally, the positive feedback from users, which was taken up by participant 4, emphasises the importance of short distances, especially for people with limited mobility (16-17).

CoMoUK (2022) refers to a 25% increase in walk trips due to mobility hubs, which indicates a rise in the physical activity of users. Similarly, interview data showed that the use of mobility hub services promotes multimodal transport, which includes active modes such as walking and biking, thus encouraging physical activity (Participant 1: 204-205). This impact depends on the proximity of the hub to the respective user group, as the motivation to overcome distance to a hub is limited. It is, therefore, essential to plan a mobility hub network that enables users to cover distances using active modes to continue to motivate active travel.

Community spaces in connection to mobility hubs have proven to have positive impacts on social interactivity (CoMoUK, 2022). Participant 1 mentioned examples of these community spaces, such as barbecue spots, green spaces, and benches (Participant 1: 82-86). Even if these elements are not directly related to mobility, they can contribute significantly to social interaction and positive user experience.

The interview findings show that mobility hubs can fulfil mobility needs, as participant 1 mentioned (100-102). The initial results regarding the existing impacts of the literature findings did not include the aspect of mobility needs. The course of the discussion revealed further valuable insight from Miramontes et al. (2017), who found, through a survey, that mobility hubs mostly provide elements that meet the needs of users. Therefore, attention must be paid to offering a wide range of transport options at hubs to reach a large target group.

The implementation of mobility hubs has positive impacts on the transformation and organisation of urban space, as the findings from the interview suggest. In the course of the implementation, urban space was used to build community spaces such as barbecue spots and green spaces, as previously mentioned (Participant 1: 77-80). Additionally, mobility hubs have an organising effect on urban space, as they create parking zones, especially for micro-mobility, which prevents clutter in public spaces (Participant 2: 150-154). The course of the discussion also revealed further insights from the literature, as the reduction in car use and ownership frees up a significant amount of space (CoMoUK, 2021). The freed-up space can then be used for sustainable development. In conclusion, urban space is a valuable and limited resource that mobility hubs can protect and transform to ensure efficient and sustainable use.

The results on the impact of mobility hubs on safety show that the organisational effect already mentioned also plays an important role in safety. Geo-fences introduced at mobility hubs, as observed by participant 2, prevent the risk of accidents involving incorrectly parked vehicles (156-158). Existing impacts on safety could not be found in the respective set of literature. However, expectations towards mobility hubs address safety concerns (Arnold, Dale, et al., 2023). These highlight the mobility hubs' potential to avoid the risk of traffic-related casualties by reducing the traffic volume.

Interesting aspects of the existing impacts on cooperation were addressed during the interviews. Participant 1 mentioned the benefits of a public-private partnership with car-sharing providers that now fulfils the needs of city employees by offering mobility services (97-100). Additionally, data is required for regulations and observing and measuring mobility behaviour. Cooperation in Bergen leads to data exchange between mobility providers and the city (Participant 1: 167-170). In Munich, it leads to an expansion of the mobility hub

network to outlying urban regions (Participant 2: 159-166). This demonstrates that partnerships go beyond mobility services and that data exchange is crucial for operating mobility hubs.

5.1.3 Categorisation approach

Initially, the categorisation approach allocated the impacts to environmental, social, and economic aspects. While these categories became relatively insignificant for the impact analysis in the course of this study, they were refined and kept more detailed. The approach that resulted from the research specialised in allocating impacts to a more descriptive category, as seen in Tables 4-1 and 4-2. Thus, specific impacts were grouped and assigned to a generic term. For example, modal shift, reduction in car use, mileage and ownership were assigned to the group of sustainable mobility behaviour. This approach facilitated a bundled presentation and exploration of impacts while keeping the categories descriptive and detailed.

However, the interview findings suggest additional categorisation approaches that could be utilised as an alternative. Firstly, participant 1 stated that:

> I'm just thinking maybe some of the impacts you wouldn't really instantly know which category they belong to, like the freeing up space impact (…) it could be mostly (…) environmental, but it's also social and economic in some ways right. (180-182)

Participant 1 indicates that some impacts are not assignable to a specific category, thus highlighting another difficulty of the initial categorisation approach. Participant 1 further mentions subcategories of environmental aspects (184-186), hence suggesting a more descriptive approach. Participants 2 and 3 believe that a breakdown of user and provider perspectives could be helpful as a categorisation approach (183-199). A breakdown of this kind would help with a more differentiated analysis of impacts. Interestingly, participant 4 moved away from the thematic allocation of impacts and suggested a location-based approach by distinguishing between “neighbourhood, village or district” (37-39).

In conclusion, various ideas exist on how to categorise impacts. Ultimately, it depends on how the effects are to be presented and which conclusions are to be drawn. Due to the large number of impacts, the chosen approach distinguishes between different impacts but presents them in descriptive groups, making it easier to compare relevance and identify trends.

5.1.4 Impact data

This chapter discusses the role and assessment of impact data. Participant 1 rated the emissions reduction data as "tangible numbers" (74), indicating the credibility of the data available to him (68-74). Furthermore, participant 1 stresses the importance of data sharing

and mentions the partnership with one of the car-sharing operators. Partnerships of this kind could benefit stakeholders, as the data is useful for gaining more insight into mobility behaviour and, therefore, the impacts of mobility hubs. Participant 2 stresses that the gradual change in mobility behaviour makes it difficult to gain or use expressive data for publishing figures (55-71). In addition, participant 2 addresses the difficulty of tracing back impacts to mobility hubs, especially emission reductions (73-77), as Pfertner (2017) also acknowledges after his calculation. Moreover, participant 4 explicitly stated that they have no data or models of resulting impacts (33).

In conclusion, opinions on impact data and measurement differ. While the potential of impact data is clear, obtaining it is often the obstacle. Moreover, data collection efforts are essential to clearly communicating the impacts of mobility hubs and further promoting the concept. Regarding the impact data in the literature, a mixture of indications and metrics was found, which complicated a clear comparative representation of impacts.

5.2 Limitations

This chapter presents general limitations, reflects on the methodology used for this study and discusses the existing and emerging limitations of the research.

Firstly, as mobility hubs are still a novel concept, impact measurements and observations are limited. This trend emerged from this study, especially when dealing with impacts such as reduction in emissions. Additionally, the focus of this research lies primarily in exploring the positive impacts of mobility hubs. This is mainly due to the innovative nature of this concept as a viable and sustainable mobility solution but also to the fact that the literature on the negative effects of mobility hubs is limited, and no specific sources can be found. There are, however, critical aspects, such as the risk of increased segregation due to poor planning, which were also presented as part of the findings of this study (Nilforoshan et al., 2023). Moreover, the covered impacts are interlinked and often mutually dependent, such as the reduction in emissions due to a decrease in car ownership or mileage, which was disregarded in the case of this study. The results merely represent the occurrence of impacts (see Chapter 4) and their respective frequencies (see Figures 4-1 and 4-2) regardless of their similarity or interconnectedness. Another significant aspect that could not be extensively addressed due to the limitation of resources and the scope of this study is a direct comparison between the expected impacts of mobility hubs and the actual effects. A detailed investigation of this question would require more comprehensive data collection and analysis to draw precise conclusions about the extent to which the expected effects are achieved.

Secondly, the methodological limitations of the systematic literature review are discussed. The systematic literature review was part of a mixed-method approach according to the

explanatory sequential design after Creswell and Plano Clark (2017). As previously discussed, limitations in the literature exist, especially regarding measurements and observations. While the qualitative data still serves as a supplement and provides a more holistic view of the impact of mobility hubs, additional methodological approaches could have been used to support the limited quantitative data. One approach that was also frequently found in the literature is to conduct surveys. As questions could have been tailored precisely to the topic relevant to this study, the results could have provided tangible data to supplement this research. Additionally, the presentation of the results (see Chapter 4.1) is based on a subjective approach to identifying generic terms and allocating impacts. This categorisation depends on the perspective of the researcher and could, therefore, differ from other studies on this topic. The frequency count of the effects (see Figures 4-1 and 4-2) was carried out on the basis of what the researcher considered to be the relevant parts of the text in the respective set of literature. Identified impacts and their graphical representations in similar research can, therefore, differ. However, this study does not aim to provide an exact generalised indication of impacts but to identify patterns and trends emerging from the literature.

Lastly, the limitations arising from the interviews are discussed. The format of a semi-structured interview was chosen for this research, which was analysed by applying a thematic analysis by identifying themes and codes to answer the research questions (Maguire & Delahunt, 2017). The participants are all stakeholders of mobility hubs working in the public sectors and are responsible for their cities or regions. This represents a limitation, as the choice of a participant from the private sector would have contributed to a more diverse perspective on the impacts of mobility hubs. In addition, the possibility of bias is high, as public stakeholders were generally convinced of the implementation of mobility hubs and could, therefore, have ignored critical thoughts. Moreover, the third interview was conducted in written form and is consequently less extensive. Due to the refinement of the categorisation approach during this research, the questions were formulated based on the initial categories. A more precise formulation of the questions according to the descriptive categories established later could have contributed to a narrower range of answers with a more precise focus on specific impacts.

6 Conclusion

The conclusion of this thesis will revisit the research questions and explain how they were answered. Furthermore, it will provide recommendations as well as areas of future research.

6.1 Answering the research question

The research questions are revisited as part of this concluding chapter. The following research questions were formulated:

RQ1: What are the expected and existing impacts of mobility hubs?

RQ2: How can these impacts be categorised and compared?

To answer the research question, a theoretical framework had to be established first to provide a basis. This included defining the concept of mobility hubs and their physical characteristics. In addition, analysing the components of the research questions was essential for answering them.

A mixed-method approach was chosen to conduct this research. First, relevant literature was identified and analysed as part of a systematic literature review. Interviews were then conducted, for which experts were selected and questioned. Subsequently, the interviews were analysed by applying a thematic analysis. The qualitative data from the interviews followed up the quantitative data from the literature according to the explanatory sequential design after Creswell and Plano Clark (2017).

The initial categorisation approach was refined as more descriptive categories were established in the form of impact groups. This adjustment resulted from the systematic literature review and the thematic analysis of the interview data. The mixed-method approach further explored expected impacts, including sustainable mobility behaviour, which primarily relates to a reduction in car use, ownership, and mileage, as well as a modal shift towards more sustainable transportation. Additionally, impacts on emissions, such as a reduction in carbon, nitrogen oxide, noise, and particulate matter, were identified. Other expected impacts of mobility hubs that were detected refer to resilience, social interactivity, safety, urban space, cooperation, equity and accessibility and health. In addition to those already mentioned, the interviews examined further expected effects regarding acceptance, development, and mobility needs. Existing impacts identified include aspects such as sustainable mobility behaviour, emissions, social interactivity, equity and accessibility, health, acceptance, and development costs. The interview expanded on these aspects by dealing with impacts regarding safety, urban space, cooperation, and mobility needs.

The categorisation approach enabled a differentiated observation of impacts, thus building the basis for a comparative analysis. First and foremost, this refers to the comparison of the various impact groups to demonstrate the relevance within the respective expected and existing impacts. Thus, it could be recognised that the expectations towards a change in mobility behaviour, a reduction in emissions, and the improvement of equity and accessibility are of great relevance in the selected literature. The comparison of the existing impacts showed that, most relevantly in the literature, a change in mobility behaviour towards more sustainable habits was achieved. In addition, the expected and existing impacts were compared. The difficulty of drawing conclusions from this direct comparison was recognised, as various metrics and measures are often used when specifying the impacts. However, an overview of the expected and existing impacts was presented to gain deeper insights into the occurrence of impacts and the complexity of a comparative approach between expectations and outcomes (see Appendix 1). The interviews enrich the research landscape by providing an additional comparison between expectations and outcomes. The findings reveal that the experts are generally satisfied with the outcomes of their expectations. However, there is still room for improvement. As emphasised by the participants, it should be noted that a direct comparison in the future will be difficult due to a constant change in mobility behaviour and the environment.

6.2 Recommendations

This chapter presents recommendations for stakeholders of mobility hubs. These recommendations are based on the results of this study and are aimed at political decision-makers, mobility planners and developers, and research-related stakeholders of mobility hubs.

Firstly, findings from the interviews suggest a positive attitude from policymakers toward the planning and operation of mobility hubs. However, policymakers need to navigate the challenges posed by existing policies, which often complicate the implementation of new technologies and concepts. Therefore, they need to recognise the potential of mobility hubs at an early stage and establish inclusive policies for mobility concepts that facilitate the shift towards sustainable mobility in cities. In addition, politicians can contribute to making mobility hubs affordable and thus further motivate their use.

Mobility planners play an essential role in the mobility hub development process. It is, therefore, crucial for them to have a holistic and transparent view of the implementation process. Recommendations towards mobility planners and developers focus on a realistic outcome prediction. Thus, goals should be defined based on something other than needs and desires but based on achievable impacts. A well-thought-out concept is a prerequisite for

achieving impact, which includes a planning approach tailored to the city's environmental, physical, and demographic conditions. Other mobility hub projects should also be used as a guide, and their achieved impacts should be taken into account to be able to assess them correctly in advance. For a functioning, widely used mobility hub to achieve positive results, residents must be motivated to use the service. Therefore, a great deal of emphasis must first be placed on publicising the concept and making it attractive.

Recommendations for research-related stakeholders can be concluded from this study as well. This generally includes an increased focus on analysing impacts, especially observing and measuring the existing impacts. Promoting mobility hubs by providing tangible figures and observations effectively draws attention to this promising concept. Of course, this requires solid data, which must also be supplied by the providers and operators of mobility services. Nevertheless, frequent impact monitoring is essential for research purposes, further demonstrating the potential of mobility hubs in all dimensions.

This leads to the need to spread the concept of mobility hubs further and consider setting up networks that connect cities, regions, and even countries, thus making motorised private transport obsolete.

6.3 Future research

As parts of the recommendations already show, future research should focus on a better data situation on impacts, especially existing impacts of mobility hubs. As there are tangible numbers, especially on sustainable mobility behaviour, areas such as the reduction of emissions must be researched more intensively. This includes developing standardised methods for calculating and presenting emission reductions regarding mobility hub systems. In addition, as noted in the interviews, research into long-term studies is an essential topic that would contribute to a deeper understanding of mobility hubs.

This research referred to a general descriptive categorisation approach, which aimed to provide a holistic overview of the impacts of mobility hubs in urban regions from different perspectives. However, other categorisation approaches would benefit a specific target group, such as an impact analysis differentiated by user and provider perspective. Further categorisation approaches could also include location-based, component-based or target-group-based methods.

As the results of this study show, most of the effects are also strongly interlinked. This means that impacts can act as causes and effects of other impacts. The relation of impacts is a further topic that would enrich the research landscape on mobility hubs by gaining insights into how impacts influence each other.

Appendix

Appendix 1: Additional literature results

Impact		Expectations	$Metric_{EXP}$	Outcomes	$Metric_{OUT}$
Sustainable mobility behaviour	Modal shift	Shift from private car use to more sustainable modes	Qualitative	**Bremen:** - Households more likely to use public transport season ticket (56% vs. 46% control group) **Austin:** - Increased walking by 25%, 39% reduction in private vehicle mode share **Munich:** -Around 20% car-sharing users and 26% bike-sharing users indicated more frequent use of public transport **Würzburg:** -75% increase in car-sharing service utilization, 23% increase in public transport use by mobility station users	Percentage
	Reduction in car mileage	**Norfolk:** - 81.400 km short-run; 359.500 km long-run **Valencinennes:** - 215.900 km long-run	km	**Bremen:** - Total traveled kilometers by car in car-sharing households is only half that of an average household	Percentage
	Reduction in car use	Expected reduction	Qualitative	**Würzburg:** - Reduction in private car use reported by 40% of bike-sharing users and 60% of car-sharing users - 80% agreement that mobility hubs contribute to decreasing the necessity for private car use **Bremen:** - Lower volume of car traffic compared to other German cities	Percentage; Qualitative
	Reduction in car ownership	Expected reduction	Qualitative	**Bremen**: - Lower volume of car traffic in Bremen compared to other German cities	Qualitative
Emissions	Reduction of CO_2	**Norfolk:** - 23 tonnes CO2 per year short-run; 57 tonnes CO2 per year long-run **Valencinennes:** - 67 tonnes CO2 per year long-run	Tonnes CO_2 / year; Percentage	**Bergen:** - 31 shared electric vehicles contributed to a reduction in carbon emissions of 464 tonnes per year **Würzburg**: - Calculation of a saving of around 650 tonnes of carbon emissions in one year	Tonnes CO_2 / year
	Reduction of NO_x	Expected reduction due to less car use	Qualitative	-	-
	Reduction of Noise	Expected reduction due to less car use	Qualitative	-	-
	Reduction of PM	Expected reduction	Qualitative	-	-
Resilience		Flexibility towards new technologies	Qualitative	-	-

Social interactivity		-Enhancing social interactivity -Avoiding segregation if network is well-planned	Qualitative	**Bergen:** - Improved social interactivity through green spaces and communal areas in mobility hub-associated shared spaces	Qualitative
Safety	Traffic safety	Less traffic-related casualties	Qualitative	-	-
	Security	Protection of personal objects	Qualitative	-	-
Urban space	Sustainable urban development	Development of green areas and shared transport spaces	Qualitative	-	-
	Community spaces	Development of community spaces	Qualitative	-	-
Cooperation	PPP (Public Private Partnerships)	Establishing partnership between publlic and private sector	Qualitative	-	-
	Improvement of local economy	Opportunities for local buisnesses	Qualitative	-	-
Equity and Accessibility	Physical accessibility	Enhance physical accessibility to mobility services for diverse demographic groups	Qualitative	**Hamburg:** - Primary impact within a 200-meter radius - Reserved parking spaces to eliminate the effort of finding a free space, particularly benefiting women and families	Qualitative
	Social accessibility	Enhance social accessibility to mobility services for diverse demographic groups	Qualitative	-	-
	Financial accesibility	Enhance financial accessibility to mobility services for diverse demographic groups	Qualitative	-	-
Health	Improvement of physical health	Promotion of active transport improves physical activity	Qualitative	**Austin:** - Lower burden of emissions enhances physical health - Contribution to reduced obesity, improved respiratory health, and healthy birth weight - Additional positive impact on health through increased physical activity (25% increase in walk trips)	Qualitative; Percentage
	Improvement of mental health	Direct contact with environment and community improves mental health	Qualitative	-	-
Acceptance		-	-	**Bremen:** - Approximately 55% of respondents express a positive view of having mobility hubs near their homes - Preference for mobility hubs over cars and parking spaces **Munich, Offenburg and Würzburg:** - 68%, 59%, and 73% of people in these areas, respectively, express openness to the concept	Percentage; Qualitative
Reduction of development costs		-	-	**Vienna:** - Developers can save up to 8.5% of their costs for a 70-square-meter apartment	Percentage

Overview of the comparison of expected and existing outcomes. Source: Own depiction.

Appendix 2: Additional interview results

Expected Impact	Quotes
Sustainable mobility behaviour	"And the overall aim of the whole thing is actually to influence the modal shift, so to speak, away from private motorised transport towards more space-efficient mobility options." (Participant 2: 28-30) "To use car sharing has so many indirect impacts on mobility behaviour I think, so that's the really sort of trigger point, if you get a new relation to the car, not having to own it, not having to have it near outside your door and then lots of things can happen." (Participant 1: 208-211).
Emissions	"So the motivations and expectation, this goes all into our strategies and plans on how to cut direct emissions." (Participant 1: 22-24).
Resilience	"Mobility hubs are also really important in preparing people for the future." (Participant: 197-198)
Social interactivity	"So, it's a place where people meet a lot, or have a chance to meet, and those kind of features like benches and barbecue spots and things like that, we assume they will have some social impact and they're placed in neighborhoods where people usually appreciate these kinds of things." (Participant 1: 82-85) "Spatial quality is therefore very important and bundling facilities ensures many (informal) encounters between people." (Participant 4: 24-25)
Urban space	"And you know free up street space for means than just parking cars that sit there and are unused 98% of the time over into more car sharing and those kinds of things." (Participant 1: 27-28).
Equity and Accessibility	"We are in a transition, where mobility is not central, but the accessibility of facilities. We want to ensure that everyone can participate independently in society." (Participant 4: 8-9) "That it also plays into equality in any case, so that women, who often don't get a car because the husband is usually away, would have the option of having a car-sharing vehicle or a cargo bike or something similar available to them if they need to take the child away or have another need of some kind." (Participant 2: 119-124). "Because people potentially can cut their car expenses in half, roughly, you know, by using car sharing." (Participant 1: 92-93).
Health	"Promote active transport." (Participant 1: 23-25) "Spatial quality is therefore very important and bundling facilities ensures many (informal) encounters between people. This ensures a higher appreciation of the quality of life." (Participant 4: 24-25)
Acceptance	"It's a really hot potato, when you try to impose very strict and low parking regulations in urban transformational areas where everything's going to be built up new, where you have businesses and offices and housing and many property developers, they are on board on the idea of having a low parking norm for housing (...)." (Participant 1: 109-112).
Development	"(...) And also to solve mobility needs in the densification project where you build along like a light rail line and transform the urban environment." (Participant 1: 25-27).
Mobility needs	"That there are simply so many offers available that you can find a suitable offer for every usage requirement without having to own it." (Participant 1: 37-39).

Overview of quotes from the interviews on the expected impacts. Source: Own depiction.

Existing Impact	Quotes
Sustainable mobility behaviour	"From data for the quite local areas around the mobility hubs (...) we can see a rise in (...) the zero emission share of the car fleet in that area." (Participant 1: 39-41) "Because what we see from our service is that people that use car sharing, they also walk, cycle and take public transport much more than others." (Participant 1: 204-205) "Yes, that's a difficult question, because so far we haven't really observed or recorded much in the way of figures." (Participant 2: 55-56) "That's probably also why there is still this big gap in research, is that mobility behaviour doesn't change so quickly. And just because car sharing has been on my doorstep for two weeks now doesn't mean I'll immediately get rid of my private car or change my behaviour." (Participant 2: 57-60)
Emissions	"(...) We can sort of make some estimates on CO2 emission cuts and so on. So, that's quite tangible numbers." (Participant 1: 74-75) "(...) We have not measured any." (Participant 2: 72)
Safety	"And that's exactly where it fulfilled its objectives. (...) it also plays into road safety, that you don't stumble across vehicles that are somehow parked all over the place." (Participant 2: 156-158)
Urban space	"Some of our mobility hubs have (...) features like (...) benches and trees and green space, places to meet, one of the latest one have even have a BBQ spot and you know, pieces of cycling infrastructure, bike parking and those kind of things." (Participant 1: 77-80) "Mobility hubs are there to create this organising effect, to provide infrastructure and parking spaces so that these vehicles have a place to park and we are definitely very satisfied with this, it works very well thanks to geofences, i.e. no-parking zones around parking areas." (Participant 2: 150-154)
Cooperation	"We're working with the car sharing operators now in its research and development project where we are coming with some regulations that require them to share data on their vehicles, with us, not personal, but only vehicle data through MDS standard." (Participant 1: 167-170)
Equity and Accessibility	"And we now also have the opportunity to bring shared mobility services to the outskirts of the city. The goal has already been achieved for the mobility points that have now been set up." (Participant 2: 159-161) "By offering facilities closer to people, people have to travel less often and far. This is experienced as very positive, especially by people who are less mobile." (Participant 4: 16-17)
Mobility needs	"'That sort of serves the needs of daytime business (...), it's a fantastic match with the use of citizens at evenings, afternoons (...) and weekends." (Participant 1: 100-102)

Overview of quotes from the interviews on the existing impacts. Source: Own depiction.

Appendix 3: Interview guides

1. **Einleitende Fragen**
   1.1. Können Sie bitte kurz Ihre Rolle und Erfahrung im Bereich der urbanen Mobilität, besonders von Mobility Hubs beschreiben?
2. **Schlüsselfragen**
   2.1. Was sind Ihre Beweggründe und Erwartungen bei der Planung und Umsetzung von Mobility Hubs? Was sollten sie erreichen?
   2.2. Welche Umweltauswirkungen von Mobility Hubs (in ihrer urbanen Region) haben Sie beobachtet?
   2.3. Welche sozialen Auswirkungen von Mobility Hubs (in ihrer urbanen Region) haben Sie beobachtet?
   2.4. Können Sie ökonomische Auswirkungen für Anwohner oder Geschäftsleute durch die Präsenz von Mobilitätshubs beschreiben?
   2.5. Fallen ihnen noch weitere Auswirkungen von Mobility Hubs (in ihrer urbanen Region) ein?
   2.6. Könnten Sie bitte Ihre Meinung dazu äußern, ob die von den Mobility Hubs erzielten Ergebnisse die Erwartungen erfüllt haben, und wenn ja, welche?
   2.7. Haben Sie bereits Daten oder Modelle von resultierenden Auswirkungen?
   2.8. Würden Sie diese Auswirkungen von Mobility Hubs aus Ihrer Sicht genauso (Umwelt, Sozial, Ökonomisch) kategorisieren? Gibt es bestimmte Kriterien oder Maßstäbe, die Sie bei der Kategorisierung der Auswirkungen für besonders relevant halten?
   2.9. Welche Auswirkungen von Mobility Hubs halten Sie für besonders bedeutsam und wichtig?
3. **Abschließende Fragen**
   3.1. Gibt es weitere Aspekte der Auswirkungen von Mobility Hubs, die wir noch nicht angesprochen haben?

Interview guide in German language. Source: Own depiction.

1. **Introductory questions**
   1.1. Please briefly describe your role and experience in the field of urban mobility and especially mobility hubs.
2. **Key Questions**
   2.1. What are your motivations and expectations for the planning and implementation of Mobility Hubs? What should they achieve?
   2.2. What environmental impacts have you observed from Mobility Hubs in [your urban region]?
   2.3. What social impacts of Mobility Hubs (in your urban region) have you observed?
   2.4. Can you describe the economic impact of the presence of mobility hubs on residents or businesspeople?
   2.5. Can you think of any other impacts of mobility hubs that you have observed (in your urban region)?
   2.6. Could you please give your opinion on whether the results achieved by the Mobility Hubs have met expectations, and if so, which ones?
   2.7. Do you already have data or modelling of resulting impacts?
   2.8. From your perspective, would you categorise these impacts of mobility hubs in the same way (environmental, social, economic)? Are there specific criteria or benchmarks that you consider particularly relevant when categorising the impacts?
   2.9. Which impacts of mobility hubs do you consider to be particularly significant and important?
3. **Concluding Questions**
   3.1. Are there other aspects of the impact of mobility hubs that we have not yet addressed?

Interview guide in English language. Source: Own depiction.

Appendix 4: Interview transcripts

Interview Nr.: Interview 1

Date: 19.01.2024

Transcriber: Jakob Bitterwolf

Interviewee: Participant 1

Interviewer: Jakob Bitterwolf (TUM)

Interview length: 00:29:44

Language: English

Jakob Bitterwolf: Could you please briefly describe your role and experience in the field of urban mobility and especially mobility hubs?

Participant 1: Yes, I'm what you call an advisor for sustainable mobility in the city of Bergen, so I've been doing this for almost 10 years now, since 2014 and I have been developing a lot of the measures in the field of sustainable mobility on the basis of green statutory climate emission reductions and that kind of framework in our organisation. So, I'm now part of the Agency for Urban Environment in the city of Bergen.

Jakob Bitterwolf: OK, great and now I would jump, right to the key questions and the first one is, what your motivations and expectations are for the planning and implementation of mobility hubs? And what specific effects they should have in your opinion?

Participant 1: Yes, there was just a little bit of the sound that disappeared. But I think I got the question. My part of the organisation is on the planning side, the development side of it, but other parts of this organisation that I'm in the agency has to do more with the you know street department saying yes or no things and also the project leader that manages projects, when it gets built, you know, does the contracting with the entrepreneurs and those, that kind of things. So in the beginning I was a bit hands on on all of that, because it was very new and we got the inspiration from our, after the visit to Bremen in 2015, something like that. And there was already issues around access to charging, charging all the electric cars. We now have more than more than 40% electric cars of the total fleet. Private cars in Bergen, so there's been a tremendous development there and also quite good growth in, in car-sharing. We've been having some operators here that been here for a long time like the Co-based

operators, it's been here for 25 years and then some new players, more commercial ones, latest year. So the motivations and expectation this goes all into our strategies and plans on how to cut direct emissions with electrification and those kind of things, but also to change transport habits into sustainable modes and to promote active transport and to also to solve mobility needs in the densification project where you build along like a light rail line and transform the urban environment. And you know free up street space for means than just parking cars that sits there and are unused 98% of the time over into more car-sharing and those kind of things. So that's the motivation for the, to explore the idea of the mobility hubs to see if we can sort of, we can gather all these things and services make into one place, make it accessible visible to the public locally. We have not done that much of a communication effort, but you know, building these things and branding it and making it visible and attractive, we believe it's a good way of you know making the alternatives to the private car more competitive I would say, yeah.

Jakob Bitterwolf: Cool. OK, thank you. And now sort of more like a categorisation approach already from my side. What environmental impacts have you already observed from the mobility hubs in Bergen?

Participant 1: There are some that are really tangible and measurable that we can see and some are a bit, a little bit less tangible and we have to do surveys and things to find change, but we can from data for the quite local areas around the mobility hubs that has been established and has been there for some years we can see a rise in the electrification. I mean the zero emission share of the car fleet in that area. Yeah, but also a decline in the number of cars per household. And it's been the from the figures that we've done so far, you can see it quite significantly these cars change just after the mobility hubs has been introduced and put into, yeah, it's working so. But of course there are all the little bit different components in them depending on space and local needs and so on. So, but we can see like this kind of electricfication, cars per household are quite, quite tangible, measurable numbers. Yeah, so we're working on making that more systematic to measure this, this. But in addition to that, we have a report on car-sharing, if you know Bremen's reports, and it’s very similar to that. And I can send it to you if you'd like that’s made by TOI Region Transport Research Institute and yeah, it was finished in 22.

Jakob Bitterwolf: That would be perfect, yes.

Participant 1: You can quite easily compare numbers and figures with the result from Bremen, like the substitution rate and those kind of things. So that gives an overview or some of the more less measurable things that you know people how much they know about for instance car-sharing and if they're willing to try it or those kind of things, yeah.

Jakob Bitterwolf: OK perfect, so this is but more like a, do you have secondary data on these things because these are environmental impacts, but more, the environmental impacts can be usually only measured with secondary data. Do you have that as well or you do any, yeah, models for this environmental data or impacts or not.

Participant 1: We didn't do any modelling, but we also in addition to these kind of statistics that we look into, we also have very and the survey data that's what I would think with secondary data, but I'm not that familiar to those terms, but we also have very primary data as well. Because we are managing and controlling all our charging, chargers that are on the mobility hubs ourselves, so we can measure very accurately how many kilowatt hours has been charged by the different charging poles at these various places. And from that it's very easy to calculate zero emission cuts, both for private cars and for the shared cars. And for the shared cars there's also the impact of it replacing more fossil fuel cars than, you know, the private electric cars because they usually just replace one car, yeah. But the shared cars replace several cars and most of them are fossil fuel cars, so the impact is larger, but it's sort of, it could be more like a guessing or a modelling on how much that impact is, but we've done these kind of reports where we've looked at, OK, how much have been charged here, how many kilometres of driving does that compute to based on average consumptions, different car models and then we can sort of make some estimates on CO2 emission cuts and so on. So, that's quite tangible numbers.

Jakob Bitterwolf: OK, Yeah, got it. Got it. All right, so next the social impacts. What are what are the social impacts that you have observed, if any, in Bergen?

Participant 1: That's a bit more tricky one, that we have observed. Some of our mobility hubs have like features like, you know, benches and trees and green space, places to meet, one of the latest one have even have a barbecue spot and you know, pieces of cycling infrastructure, bike parking and those kind of things. And some of them are even connected to the underground garbage collection system that we have in in the central parts of Bergen, where you know, it's getting sucked in, large pipes on the ground. So, it's a place where people meet a lot, or have a chance to meet, and those kind of features like benches and barbecue spots and things like that, we assume they will have some social impact and they're placed in neighbourhoods where people usually appreciate these kinds of things. Yeah, one of the mobility hubs we even have a, you know, areas for play, for children, so connected to, sort of a green street space that we have there and some pieces of cycling infrastructure. So we believe that they have social impacts in that way, but also, yeah, maybe more in the next question about the economic impact is also we tried to target it now into areas that have, maybe have some social issues, low income areas so that they can sort of contribute to an upgrade of their environment there. And the access to the car-sharing when

people discover how cheap, much cheaper that is. That's also an economic and social impact, in that sense, right? Because people potentially can cut their car expenses in half, roughly, you know, by using car-sharing.

Jakob Bitterwolf: All right, so you already answered the next question, that's great. Have, you observed any impacts on businesspeople, or do you know anything about that, or not?

Participant 1: Yes, we do. We have focus on car-sharing in our own organisation as well. We have 22,000 employees, in the city of Bergen and all those units and departments. And the city has its own car fleet as well, so to have a agreement with one of the providers of car-sharing that sort of serves the needs of daytime business or business in this case, but service use it's a fantastic match with the use of citizens at evenings, afternoons and evenings and weekends. So that happens in some of the large mobility hubs that are accessible for businesses or municipal users and so we know that. And it's where businesses discover this opportunity and use it, they are really, they get really excited because, they can, they have good access to cars and could save a lot of money and some of their employees don't have to bring their own cars to work with the excuse that they might need it during business hours, right? So, but that's a huge potential there, I believe that we haven’t fully explored. And the car-sharing operators have been targeting business users more and more and also adjusting their service to fit their needs. So this is been a growth area the last years and has a lot more potential, I think. It's a really hot potato in the, when you try to impose very strict and low parking regulations in urban transformational areas where everything's going to be built up new, where you have businesses and offices and housing and many property developers, they are on board on the idea of having a low parking norm for housing because they see that car-sharing can work there. But for the business, they want to rent out to businesses, these buildings, and then they're really much more reluctant to go low on parking because they haven't really discovered yet, that the effects of the car-sharing can have on business use.

Jakob Bitterwolf: Yeah. And they and they probably have less costs because of less space needed for the development if the parking provisions or parking provision is less or not existent, maybe that's another motivation, yeah. But yeah, that's really interesting. All right. So that's on the economic impact and. Yeah, just another question, if you can think of any other impacts that kind of, fall out of this categorisation with environmental, social and economic impacts. Do you have any other impacts that you can think of that you haven't talked about yet?

Participant 1: Yeah. Did I mention the sort of, well, we can observe actually, when we have more car-sharing, in an area that we also have more space in the streets can be introduced into an area where it's actually quite crowded, quite hard to get a parking spot.

But when we get car-sharing, they're even that, you know, they might be some protest in the beginning because people are sort of losing their parking spaces to car-sharing and it ends up being more space for everybody, even those that still keep their private cars. So that's freeing up space for any everything else is really an important impact. And also then to try to connect them new modes, new modes of transport like Micro Mobility, to this, to the network of mobility hubs, I think it's a, it's a quite good thing, and things that could match quite well. And I believe that in the, well we have focused most on the neighbourhood hubs you know for the daily use, for mostly for car-sharing and those kind of things but when you, in much more in the future now tie it up to public transport and maybe put them out in the more peripheral areas, more suburbs of the city, it could have another impact as well, it could really make, strengthen the public transport offer and help solve some last, first mile issues as well, so that people can leave their cars at home and go to work by public transport and the combination of some last miles and first mile solution.

Jakob Bitterwolf: I saw that you also, that the suburban hubs in Bergen are already in in planning, right?

Participant 1: Yeah, well, we are discussing this with our PTA in the area so we're trying to bring them up to speed now on all our experiences on this more urban neighbourhood mobility hubs and try to develop this concept further for the outskirts with them. So that's an ongoing work, absolutely.

Jakob Bitterwolf: Yeah, OK, cool. The next question is if you can give your opinion on the results achieved by the mobility hubs have met the expectations and if so, which ones? And maybe to what extent?

Participant 1: Yes, I would, I didn't have that very specific expectations, so because it was so new in the beginning. But now, yes, I would say yes, in general it met my expectations, but it kind of changes. It's quite slow, and I think, well, in the beginning it was, it was over, it was exceeding our expectation actually, because they became so popular and so much used in the first areas, we had to build more than we thought in the beginning, more of them, and also now expand all, many of them with more spaces. So. I think they were actually in many ways exceeded my expectations and they and got some really good political backings caught them, and, but there are things that we, we haven't gotten as far as we would like to and some of it is this integration with public transport, both in place and digitally also communications, we haven't really done a bigger effect on that. So I think the potential is much bigger actually than we have taken up so far also, and bike solutions are also weak, we could do better on that when it comes to connecting it to the bike-sharing scheme that we have, connecting it to micro-mobility and provide the secure bike parking facilities for people

in the neighborhood, that more and more have electric bikes and cargo bikes and so on, expensive ones.

Jakob Bitterwolf: Interesting, alright.

Participant 1: We we've done something on that, but we'd like to, you know, do it better and more systematic.

Jakob Bitterwolf: OK, so I would jump over the next question you already answered that for the data and modeling of resulting impacts and go to the next question.

Participant 1: If I can mention one thing on that, one more, that we're working with the car-sharing operators now in its research and development project where we are coming with some regulations that require them to share data on their vehicles, with us, not personal, but only vehicle data through MDS standard, if you know that. It's the way that we've been used, we regulate micro-mobility because they send us data all the time and we use that for, both for control and also for regulating this digitally. And there's a potential both to have more accurate data of usage, but also and understand car-sharing more, but also in the future to use it to, you know, regulate this in a way that we could provide subsidies for setting out, putting out cars in the suburbs, and then, or make it more expensive in urban areas and things like that. So that's something we explore to get better data to the MDS standard.

Jakob Bitterwolf: OK, great, thank you. And yeah, you saw that I did like kind of a categorisation with the impacts, I did the environmental, social and economic impact. Can you think of any other way to categorize these impacts or are there specific criteria or benchmarks, that you consider relevant when categorizing impact.

Participant 1: Yeah I'm just thinking maybe some of the impacts you wouldn't really instantly know which category they belong to, like the freeing up space impact. Is that, it could be mostly an environmental, but it's also social and economic in some ways right. So yeah, that was just a thought. Maybe there are other ways to categorize it, but these are those natural maybe categories that you would think of, yeah. And there are under categories, you know in environmental you could put in you know stormwater management or you know climate adaption into that climate emissions, pollutions that are reduced and all that sort of stuff as well. Because we're trying, when you put in green space we're also managing you know, [inaudible].

Jakob Bitterwolf: So everything is kind of related and not every impact can be categorized into one category. And maybe it has other further impacts, environmental impacts, maybe that are direct and then you have some indirect impact that can be categorized in other ways.

Participant 1: Exactly, exactly. And one thing that's important for us is that we sort of see, we're very concerned about the future autonomous cars that we are getting that right. And one way of getting that right is that we know that if you're just making all the private cars now autonomous, the city will, you know, grind to a halt so that will work so we need we that's a very good argument for that we need to practice sharing both, sharing the vehicles, but also sharing the seats in the vehicles with, you know, with carpooling. That's another aspect of that and, so in that sense, the mobility hubs are also really important in preparing people for the future.

Jakob Bitterwolf: OK, great. So now for the last question is just kind of uh, yeah, another opinion from you which category or which impact you would consider to be most significant or important, yeah?

Participant 1: Yeah, I yeah, I have one favorite for me, and that would be, you know, the most important would be to increase car-sharing as a as a way of, as an alternative to having your private car. Because what we see from our service is that people that use car-sharing, they also walk, cycle and take public transport much more than others. So if you learn, if you get into that mindset, and you see the cost of every trip, like when you have a private car, you don't see the cost of everything you just try to, you know, you don't want to see the cost, with the private car. So that car-sharing, getting people to explore, to find, to use car-sharing has so many indirect impacts on mobility behavior I think, so that's the really sort of trigger point, if you get a new relation to the car. Not having to own it, not having to have it near outside your door and then lots of things can happen.

Jakob Bitterwolf: Yeah. Yeah, right. Great. OK. Alright. That that's it for my questions. The the last question is if you have any other aspects of impacts of mobility hubs that we have not yet addressed or that you have not yet addressed, yeah?

Participant 1: Maybe you could mention one more thing that all these projects, well not all of them, but most of them will try to improve the situation at the place a little bit for pedestrians and cycling, cyclists, also in those projects, so that's also one impact. So in the first [inaudible] we built, we made some mistakes that we learnt from, you know, where to put the charges and things like that, to not decrease the width of the pavement, not to be in the way for pedestrians and so on. Yeah, so that's a little thing that could be mentioned.

Jakob Bitterwolf: OK, great. Yep. Alright, that's it. Thank you so much for all your information and the interesting perspective. This will help me a lot for my thesis.

Interview Nr.: Interview 2

Date: 29.01.2024

Transcriber: Jakob Bitterwolf

Interviewee: Participant 2, Participant 3

Interviewer: Jakob Bitterwolf (TUM)

Interview length: 00:22:10

Language: German

Jakob Bitterwolf: Ja, jetzt die erste Frage. Einfach mal kurz eure Rolle und Erfahrung im Bereich von Urban Mobility und vor allem Mobilitätshubs beschreiben.

Participant 2: Genau dann starte ich einfach mal also, wie gesagt, ich bin im Team geteilte vernetzte Mobilität im Mobilitätsreferat der Landeshauptstadt München und vielleicht fange ich davor an. Also ich habe an der Uni meine Masterarbeit auch zum Thema Mobilitätsstationen geschrieben und hab die bestehenden Modellprojekte aus Forschungsprojekten in München evaluiert und bin dann quasi zur Stadt München gekommen und konnte dann von Anfang an den Beschluss, oder die Teilstrategie Shared Mobility mitverfassen und die Strategie oder ein Konzept für die Umsetzung von Mobilitätspunkten, also so nennen wir es München, quasi mitschreiben beziehungsweise halt noch bisschen mit den Inhalt schärfen und das war, genau 2021. Und genau, seitdem haben wir den Stadtratsbeschluss und Auftrag, 200 Mobilitätspunkte bis 2026 umzusetzen und jetzt bin ich quasi mit im Team der Umsetzung beziehungsweise mach halt Qualitätsmanagement, Umsetzungsplanung, Product Management könnte man es auch nennen, genau der Umsetzung. Und jetzt steht halt noch bisschen mehr Qualitätsmanagement an. Ich habe jetzt einige neue Kolleginnen bekommen, unter anderem, Sprecherin 3, die eben da auch unterstützen und gemeinsam werden wir jetzt dann gucken, dass wir das, was wir geplant haben oder auch noch gerade planen, dass in die Umsetzung bringen und dann quasi begleiten mit Kommunikationsmaßnahmen mit, ja, einfach Qualitätsmanagementmaßnahmen, dass das Ganze auch läuft, funktioniert und ja.

Jakob Bitterwolf: Cool. Interessant. Okay dann würde ich gleich mal in die in die Hauptfragen reingehen. Und zwar, was sind denn deine, oder eure Beweggründe und Erwartungen bei der Planung und Umsetzung von Mobilität Hubs und was sollten Sie erreichen?

Participant 2: Mhm, also grundsätzlich wollen wir Shared Mobility stadtweit ausweiten beziehungsweise Angebote stadtweit auch ein bis in Stadtrandlagen bereitstellen und, genau

einerseits bereitstellen, andererseits auch ordnen. Also gerade diese Ordnung des öffentlichen Straßenraums ist da noch mal ein wichtiger Punkt. Genau und ansonsten halt Bereitstellung für einerseits Münchnerinnen, aber genauso für die ganzen Besuchenden, Touristen, Touristinnen. Und das Überziel des Ganzen, ist es eigentlich, quasi auf dem Modal-Shift einzuwirken, das mal weg vom MIV, also motorisierten Individualverkehr hinzu flächeneffizienteren Mobilitätsangeboten geht. Das bedeutet einerseits Unterstützung und Erweiterung von ÖPNV und aktiven Mobilitätsformen hinzu, ja, Shared Mobility beziehungsweise als ein Teil des Model Shifts oder der Nutzungsmöglichkeiten, und genau da drin steckt dann eben auch eine fairere oder bessere Verteilung vom öffentlichen Raum, dass es nicht nur als Parkraum für MIV genutzt wird oder als Verkehrsraum, hinzu, ja, einer nachhaltigen, nachhaltigeren Stadtentwicklung und Mobilitätsentwicklung. Genau, also was möchte man noch? Da stecken ja ganz viele kleine Punkte drin, natürlich auch den Bedarf am privaten PKW zu reduzieren, dass man einfach so viele Angebote also bereitgestellt hat, dass man quasi für jedes Nutzungsbedürfnis einfach auch ein passendes Angebot findet, ohne es halt dann besitzen zu müssen. Also das ist also eine unserer Leitsprüche, dass man quasi, sie es jetzt, Carsharing auszuleihen, dass es möglich ist, aber auch n Lastenrad oder auch wenn es Besuch da ist, dass man sagt, ja OK, dann leihen wir uns halt mal ein paar Räder und erkunden damit die Stadt und sind jetzt nicht auf eigene Fahrzeuge angewiesen also diese Flexibilität und Möglichkeitsausweitung.

Jakob Bitterwolf: Ja, super, danke. Genau also vielleicht da auch ähnlich die nächste Frage, nur jetzt schon mal so ein bisschen kategorisiert. Welche Umweltauswirkungen von Mobility Hubs in München hast du oder habt ihr beobachtet?

Participant 2: Ja, wir haben uns die Frage vorhin schon angeguckt und haben überlegt, was deine Definition von Umweltauswirkung ist. Also meinst du jetzt wirklich auch auf CO2-Reduzierung oder also quasi jetzt wirklich auf Hard Facts, Umweltspezifisch oder auch im Endeffekt so Umwelt miteinander Auswirkungen.

Jakob Bitterwolf: Das genau das kann indirekt sein, es kann sein, jetzt zum Beispiel durch den Modal Shift gibt es weniger Privatautos und dadurch senken sich die Co2-Emissionen. Sowas zum Beispiel. Also es muss jetzt nicht spezifisch nur auf Umweltauswirkungen bezogen sein, sondern es kann auch dieses indirekte Thema sein.

Participant 2: Ja, schwierige Frage, weil bisher haben wir noch wenig richtig beobachtet oder auch quasi mit Zahlen festgehalten. Wir evaluieren das Ganze natürlich auch. Das startet aber jetzt auch also das ist ein Riesenpunkt, das ist auch das warum es vermutlich auch diese große Forschungslücke noch gibt, ist, dass sich ein Mobilitätsverhalten nicht so schnell ändert. Und nur weil jetzt seit 2 Wochen Carsharing vor meiner Tür steht schaff ich ja nicht direkt sofort meinen privaten Pkw ab oder ändert es. Das ist jetzt auf jeden Fall n langer

Prozess. Und es ist super schwierig jetzt also zu dem Zeitpunkt schon der richtige Effekte zu messen. Wir hoffen ab Sommer gibt es das erste Ergebnisse, aber selbst da sind wir jetzt sicher, ob es jetzt wirklich ein messbaren Effekt geben wird, das ist jetzt eher so ein langfristiger Horizont, wo wir sagen, Na ja, in 5 Jahren hoffen wir dann schon, dass mehr zeitwägen abgeschafft werden und dass man da vielleicht was spürt. Und die Umsetzungen der Mobilitätspunkte in München hat ja auch erst im Sommer letzten Jahres oder so im Frühjahr Sommer gestartet also es ist auch noch natürlich nicht in Zahlen zu fassen, weil das sind dann ja so kleine Hubs und im Bezug auf München natürlich oder eben auch auf die Umgebung noch sehr unbekannt und klein und haben jetzt keinen Effekt, also wir haben keine gemessen. Genau, also sobald es Ergebnisse gibt. Werden wir die auch transparent als zur Verfügung stellen, aber es ist jetzt kein messbares Ergebnis da. Ja, genau.

Jakob Bitterwolf: OK.

Participant 2: Und ein Punkt, ist halt auch noch, dass es halt super schwierig ist, es dann auch mal auf Umweltauswirkungen zu quantifizieren oder des wirklichen Zahlen festzuhalten, weil es ist ja quasi ein, also eine Maßnahme von vielen, die auf Mobilitätsverhalten einwirken und das dann wirklich nur auf die Mobilitätsstationen zurückzuführen wird und auch glaube ich in Zukunft super schwierig sein also. Es hat vielleicht n Einfluss drauf aber genauso wichtig ist auch ein gut funktionierendes ÖPNV-Netz oder welche anderen Push-Pull Maßnahmen gibt es? Wie ist das Parkraumanagement? Ja, wie ist die Fahrradinfrastruktur? Genau und deswegen sind wir da auch so n bisschen, nicht bescheiden, aber wir sind auf jeden Fall vorsichtig das in Zahlen zu groß zu verpacken und sagen jetzt allein dieser Mobilitätspunkt hat so und so viel CO2-Emissionen eingespart, weil ich glaub das wird auch schwierig bleiben in Zukunft.

Jakob Bitterwolf: Ja, absolut. Aber also, es sind 60 Mobilitätsstationen geplant im Raum München oder?

Participant 2: 200 bis 2026 und grad haben wir 48 eingerichtet.

Jakob Bitterwolf: OK, ok.

Participant 2: Genau, aber es ist halt sehr vieles noch Ende letzten Jahres gekommen und genau jetzt gucken wir mal mit Öffentlichkeitsmaßnahmen, oder Kommunikationsmaßnahmen, dass man es erstmal bekannter macht. Und dann dauert es aber noch, bis man das wirklich auf die Nutzung zurückführen kann, welchen Einfluss das hat. Und das dann noch speziell auf die Mobilitätspunkte beziehen wird auch sehr schwierig.

Jakob Bitterwolf: Ja, absolut verständlich, ja.

Participant 3: Ich würd noch ergänzen, dass ja eben bis 2026, 200 gebaut werden und ich glaub, wenn man dann anfängt ab da dann auch den Effekt zu messen, dass es sinnvoller ist als jetzt mit 45. Also ist ja irgendwie klar, desto mehr Mobilitätspunkte es gibt, desto einfacher wird es vielleicht sein, da einen Effekt zu untersuchen und deswegen, wir fangen intern gerade an, eben zu überlegen, Was können wir Wie messen, aber das ist einfach ein super langfristiges Thema und super schwierig zu messen deswegen glaube ich hilft es auch, wenn dann einfach mehr Mobilitätsstationen existieren.

Jakob Bitterwolf: Mhm, ja. Okay, vielen Dank. Ja, jetzt zur nächsten Frage. Das ist jetzt noch mal auf die sozialen Auswirkungen bezogen, das sind jetzt eher so qualitative Auswirkungen, habt ihr da was beobachtet im Münchner Raum?

Participant 2: Also genau, wir haben keine direkten Beobachtungen, also keine gemessenen über Evaluationen, bisher. Ich glaub das wird dann noch mal einfacher, auch durch Haushaltsbefragungen. Welchen Effekt hat, auch so an Entscheidungen des Mobilitätsverhaltens? Ich glaube das geht dann noch einfacher, dass jemand sagt, naja, jetzt wo es dann doch so viel Carsharing gibt, wir wollten das Auto eh schon lange abschaffen, weil sonst sowas hört man tatsächlich oft, dass jetzt quasi das die Entscheidung gegen den privaten PKW dadurch beeinflusst wird oder quasi, dass es halt auch einfacher ist, den dann abzuschaffen, weil man weiß, na ja, in München, jetzt haben wir ja am Ende, es ist ja noch tausendsechshundert Carsharing Stellflächen geplant, also es gibt hier n Angebot und ich kann mich drauf verlassen, aber tatsächliche Evaluationsergebnisse haben wir auch hier nicht, das sind eher so Sachen, die man halt einfach mitkriegt, wo Leute was sagen, oder genau. Erwartungen haben wir natürlich auch hier. Und Ziele also sozial auf jeden Fall, einerseits, dass man für eine sehr breite Bevölkerungsschicht oder Bevölkerungsmasse einen guten Angebotsmix bereitstellt, der natürlich dann das Mobilitätsverhalten auch stark beeinflusst. Beziehungsweise auch die PKW-Besitzquote, also wie viele Leute brauchen denn 2 PKW oder schaffen sogar einen einzigen ab? Genau, und wir haben auch noch gesagt, dass es halt auch auf jeden Fall auf Equality einspielt, also dass quasi auch Frauen, die oft dann nicht den PKW kriegen, weil der Mann da meistens unterwegs ist, halt eher die Möglichkeit hätten, dass sie, wenn sie mal irgendwie das Kind wegbringen müssen oder irgendwie einen Bedarf haben ein Carsharing Fahrzeug oder ein Lastenrad oder ähnliches quasi zur Verfügung haben. Und es ist halt eben auch für viele egal, wieviel finanzielle Möglichkeiten sie haben, eine einen Zugang da, also man kann sich ein Fahrzeug ausleihen. Und es ist natürlich jetzt nicht gleich eine PKW-Anschaffung und Unterhaltungskosten mit einzurechnen, aber jeder hätte die Möglichkeit zu einem fairen Preis eben Angebote, sich mehr auszuleihen für besondere Bedürfnisse oder für den täglichen Bedarf auch genau.

Jakob Bitterwolf: OK. Da wurden aber noch keine Befragungen gemacht, sondern das ist bis jetzt noch geplant. Also diese Haushaltsbefragung und so weiter.

Participant 2: Genau ist noch geplant. Also es gibt alte Ergebnisse aus Forschungsprojekten, aber nicht der aktuellen Umsetzung.

Jakob Bitterwolf: Gut, dann kommen jetzt den ökonomischen Auswirkungen, für Anwohner oder Geschäftsleute von Mobilität Hubs. Hier auch wieder wahrscheinlich keine messbaren, sondern auch vielleicht eher wieder Erwartungen. Ist ja auch interessant.

Participant 2: Genau. Nur haben wir tatsächlich in Hinblick auf ökonomische Auswirkungen gerade auf Geschäftsleute sind wir uns gar nicht so sicher, wie sehr man das Messen oder wie stark wir das messen werden. Also wir haben ja auch eine Ausschreibung zur Evaluation, da war das jetzt gar nicht so unser Hauptpunkt, also natürlich die Nutzung der Angebote als, also als ökonomische Säule natürlich, aber nicht jetzt quasi auf die Auswirkungen auf Anwohner oder Geschäftsleute. Das betrachten wir bisher noch gar nicht, es kann schon sein, dass es dann im Laufe der Jahre noch dazu kommt, bisher ist es nicht einmal so angedacht, dass wir wissen auch gar nicht, wie das, oder wir spekulieren noch nicht so stark damit, dass das jetzt unser Fokusthema wird. Genau.

Jakob Bitterwolf: Alles klar. Die nächste Frage, genau ist dann, könnt ihr bitte eure Meinung dazu äußern, ob die von Mobilität Hubs erzielten Ergebnisse, die Erwartungen erfüllt haben. Wenn ja, welche?

Participant 2: Mhm, also ein Ziel, war eben auch, dass wir super viele Beschwerden hatten, gerade bezüglich Mikromobilität, E-Tretroller und Co., dass die irgendwas so kreuz und quer in der Gegend rumstehen und dafür ist, sind ja Mobilitätspunkte auch quasi da, um diesen ordnenden Effekt zu schaffen, um Infrastruktur und Stellflächen dafür bereitzustellen, damit diese Fahrzeuge auch einen Platz haben, auf den sie dann auch stehen sollen und damit sind wir auf jeden Fall sind wir super zufrieden, das funktioniert auf jeden Fall durch Geofences, also Abstellverbotszonen um Abstellflächen sehr gut. Also das ist ja auch einer unserer Hauptziele, dass man quasi den Stadtraum, also den öffentlichen Straßenraum auch ordnet. Und genau da hats die Ziele erfüllt. Das ist halt, klar jetzt meine Antwort auf die Beschwerden und aber gleichzeitig spielt sie auch auf die Verkehrssicherheit ein, dass man nicht über Fahrzeuge stolperte, die irgendwie kreuz und quer abgestellt werden, sondern, genau. Also das sind auf jeden Fall 2 Ziele, dieser ordnende Effekt und Verkehrssicherheit. Und wir haben jetzt halt auch dadurch die Möglichkeit, dass wir Shared Mobility Angebote in den Stadtrand bringen. Das Ziel hat es bisher auch schon erfüllt, für die Mobilitätspunkte, die jetzt eingerichtet wurden. Also Anbieter, operierende Anbieter in München, zum Beispiel jetzt bei Free-Floating Carsharing weiten dann eben auch ihr

Geschäftsgebiet, um die Mobilitätspunkte aus. Sprich, wir haben halt dadurch die Möglichkeit, dass wir eben auch in Stadtrandlagen den Bewohnern oder Bewohnenden Angebote zur Verfügung stellen. Und das ist einerseits für Carsharing, aber auch für Mikromobilität ein großes Thema.

Jakob Bitterwolf: OK, super danke.

Participant 2: Participant 3, fällt dir noch Was ein?

Participant 3: Ne also, das andere sind ja einfach alles, wie schon gesagt, Dinge, die wir eben leider noch nicht gemessen haben, deswegen ja.

Participant 2: Aber das kann man auf jeden Fall schon mal nennen, also das einen Effekt hat ja. Vor allem Geofences.

Jakob Bitterwolf: Genau die nächste Frage hat sich dann wahrscheinlich auch schon beantwortet, ob es schon gemessene oder ob es Daten gibt zu resultierenden Auswirkungen oder vielleicht Modelle.

Participant 2: Nee, noch nicht. Aber sobald wir die haben, werden wir die auch online transparent allen zur Verfügung stellen. Also da kann man dann auch damit arbeiten.

Jakob Bitterwolf: Alles klar. Genau jetzt die nächste Frage ist nochmal eine, ja, Sichtweise von euch, ob ihr das genauso kategorisieren würdet, nach eben Environmental Social und Economic impact. Oder ob ihr da andere eine andere Weise habt wie ihr das kategorisieren würdet, diese Auswirkungen oder ob ihr da bestimmte Kriterien oder Maßstäbe habt, die da besonders relevant wären für eine für eine andere Kategorisierung.

Participant 2: Also wir haben auch schon mal kurz drüber nachgedacht, also Environmental und Social auf jeden Fall und Economic eigentlich auch nur da glaube ich ist halt auch noch mal die Perspektive entscheidend ob es quasi aus unserer Sicht ist oder aus Anbietersicht. Genau von daher müsste man das wahrscheinlich nochmal ein bisschen auftrennen und wir würden jetzt quasi nicht aus Anbietersicht, natürlich ist es für uns auch wichtig, weil sobald es für den Anbieter völlig unwirtschaftlich ist, brauchen wir auch nicht damit zu rechnen, dass da Angebote stehen oder man muss dann halt eben andere Maßnahmen ergreifen. Genau, also grundsätzlich macht die Dreiteilung schon Sinn.

Participant 3: Ja, ich kann noch ergänzen bei ökonomisch genau das, wie es Participant 2 grad meinte. Ich glaube, dass hier interessant wäre, die Nutzersicht was für einen Einfluss die hat. Haben die Shared Mobility Maßnahmen, also die Mobilitätspunkte im Bezug auf, zum Beispiel die Ausgaben die eine Person hat für Mobilität, ob sich das zum Beispiel positiv darauf beeinflusst oder ob wirklich für so ein Durchschnittsnutzerverhalten, in Bezug auf Auto fahren, ob es da wirklich langfristig irgendwie schlauer wäre n Carsharing-Auto zu haben,

wenn man nicht so viel Auto fährt und so weiter. Also ich glaub die Nutzerperspektive die wär super spannend halt ja. Und die anderen beiden würde ich auch sagen genau, sind einfach an sich schon selbsterklärend und interessant, ja.

Jakob Bitterwolf: OK, super danke. Ja, fallen euch denn noch weitere Auswirkungen ein, die jetzt nicht vielleicht in dieses Kategorisationsschema passen, und über die ihr jetzt noch nicht geredet habt?

Participant 2: Nein, also im Endeffekt was halt wichtig ist, ist die Mobilitätsverhaltensveränderung, aber das sind ja auch soziale Umweltauswirkung natürlich. Vielleicht Verkehrssicherheit wird man dann auch bei sozial mit Eingliedern. Participant 3?

Participant 3: Nein, also ich glaub halt dieser Punkt, auch Teilhabe und Accessibility ist super wichtig. Es ist halt teilweise sehr schwierig eben alle Gruppen gleich einzubeziehen, aber ich glaube das ist etwas, ja, was halt auch super wichtig ist, dass halt alle Menschen Zugang haben, dass auch genug darüber geredet wird, also auch so, Kommunikation, Öffentlichkeitsarbeit, dass alle Leute die gleiche Chance haben davon zu hören und daran teilzunehmen, und das ist bestimmt auch noch mal ein Thema, was wir weiter angehen werden in der weiteren Ausbaustufe und im Qualitätsmanagement, dass man halt die Leute besser informiert darüber, dass sie es dann auch nutzen, ja.

Jakob Bitterwolf: Ok, super.

Participant 2: Und wenn du halt nach Maßstab fragst, dann auf jeden Fall, ist es halt kurzfristig, also was wir ja schon oft genug gesagt haben, jetzt, Maßstab ist super langfristig, dass man halt wirklich Auswirkungen hat, von daher.

Jakob Bitterwolf: Ok, gut, das war's von meiner Seite. Vielen Dank für die interessanten Antworten und das spannende Interview!

Interview Nr.: Interview 3

Date: 26.02.2024

Transcriber: Jakob Bitterwolf

Interviewee: Participant 4

Interviewer: Jakob Bitterwolf (TUM)

Interview length: -

Language: English

Jakob Bitterwolf: Briefly describe your role and experience in the field of urban mobility and mobility hubs in particular.

Participant 4: Since 2021, I have been working as a program manager for the Hub Groningen Drenthe program. I have been working for the province of Drenthe for almost 20 years and have been working on multimodal junctions all that time.

Jakob Bitterwolf: What are your motivations and expectations for the planning and implementation of Mobility Hubs? What do they need to achieve?

Participant 4: We are in a transition, where mobility is not central, but the accessibility of facilities. We want to ensure that everyone can participate independently in society.

Jakob Bitterwolf: What environmental impacts have you observed from Mobility Hubs in your urban region?

Participant 4: No. The impact is far too small for that. In Groningen we do have a good BRT system, which ensures that the city is easily accessible, despite the restrictions on car traffic. This does have a major impact on the environment.

Jakob Bitterwolf: What social impacts of mobility hubs in your urban region have you observed?

Participant 4: By offering facilities closer to people, people have to travel less often and far. This is experienced as very positive, especially by people who are less mobile.

Jakob Bitterwolf: Can you describe the economic impact of the presence of mobility nodes on residents or entrepreneurs?

Participant 4: This is very limited. Our goal is also not to have a major economic impact.

Jakob Bitterwolf: Can you think of any other impacts of mobility hubs that you have observed in your urban region?

Participant 4: We try to organize the nodes in such a way that everyone dares to use them. Spatial quality is therefore very important and bundling facilities ensures many (informal) encounters between people. This ensures a higher appreciation of the quality of life.

Jakob Bitterwolf: Can you give your opinion on whether the results of the Mobility Hubs have met expectations, and if so, which ones?

Participant 4: We do not measure the before and after situation, because it simply does not exist. A development is never finished. The users and environment continue to change and the interchange will have to continue to adapt to this. From conversations with users we can deduce that people are satisfied with the development so far.

Jakob Bitterwolf: Do you already have data or models of the resulting impact?

Participant 4: No.

Jakob Bitterwolf: From your perspective, would you categorize these impacts of mobility hubs in the same way (environmental, social, economic)? Are there specific criteria or benchmarks that you consider particularly relevant when categorizing impacts?

Participant 4: In general, it concerns the quality of life of a neighborhood, village or district. We want to view everything as broadly as possible and deliver customized solutions. Thinking in boxes is not appropriate.

Jakob Bitterwolf: What impacts of mobility hubs do you consider particularly significant and important?

Participant 4: Put people first. That's what it's about. The rest are all political and official activities that apparently are necessary, but this makes you forget the basics.

Jakob Bitterwolf: Are there any other aspects of the impact of mobility hubs that we have not yet discussed?

Participant 4: Think broadly. A mobility hub will never work, because it is based on mobility and not people. People don't want to walk around a parking lot alone at night, but that's how a mobility hub is often designed.

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I herewith formally declare that I have authored the submitted thesis independently. I did not use any outside support except for the declared literature and other sources mentioned in the paper.

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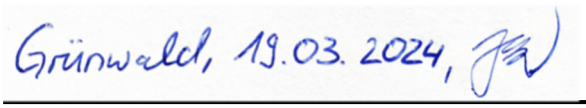

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