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Redesigning Public Spaces around Transport Hubs:

A Framework for Sustainable, Inclusive, and Accessible Public Spaces

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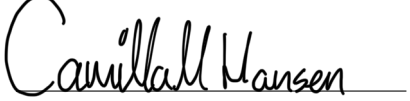

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ABSTRACT

This project investigates how public areas around transport hubs can be redesigned to promote environmental sustainability, social inclusion, and accessibility. The main outcome is a Framework developed to support municipal urban planners before and throughout the design process. Lyngby Transport Hub in Denmark serves as a case study, where qualitative data collected through mixed used methodologies has formed the empirical foundation. A mid-phase collaboration with the Dutch municipality of Roermond provided external feedback to refine the Framework's applicability.

The Framework is grounded in several theoretical perspectives. Multi-Level Perspective is used to understand urban transitions, with the current planning context as the regime, climate challenges and mobility needs as landscape pressures, and the Framework itself as a niche innovation. While Nudge Theory guides decision-making towards maintaining a design without limiting user freedom, Actor-Network Theory helps understand the relationship between the human and non-human participants in the construction of a public space.

The Framework outlines Five Concepts: Social Factors, Environmental Factors, Wayfinding & Navigation, Accessibility, and Active Mobility Infrastructure. It provides practical tools for municipalities to evaluate and improve spaces around Transport Hubs. While developed from a single case, the Framework is intended as a complementary planning tool, with the potential for broader application. The study concludes by reflecting on the Framework's strengths and limitations, its foundation in regenerative urban design and SDG principles, and the need for further research and testing across different contexts.

SUMMARY

The project focuses on public areas around transport hubs, and how can these be redesigned to become more sustainable, inclusive and accessible. The main outcome of the project is a Framework, which aims to help municipal urban planners both before and throughout the design process.

Lyngby Transport Hub was the case for developing the Framework, based on qualitative data collected on-site. Lyngby-Taarbæk Kommune was contacted to engage in a collaboration. Dutch municipality of Roermond was included as a test municipality in the mid-phase of the Framework development. The Framework is meant to complement existing municipal plans and strategies as a tool.

Several theoretical lenses are implemented in the project. Multi-Level Perspective serves as an underlying, supporting theory used to understand the connections, relationships and influences between different levels in urban transitions. The Framework itself is considered the niche innovation.

Actor-Network Theory helps understand the project in a creative way by acknowledging that the environment is made and influenced by both human and non-human entities. ANT's concepts of Spaces of prescription (prescribed) and Spaces of negotiation (flexible) are used and combined with Nudges.

Nudge Theory helps with developing the design architecture without restricting people's freedom of choice. The SDGs, regeneration and accessibility are topics researched for the urban development of the Framework.

Methodology employed a mixed-method approach. A small workshop was conducted with students from Technical University of Denmark, to gain an overview of the issues and shortcoming Lyngby Transport Hub is facing. Several qualitative data collection methods were used: behavioural mapping, non-participant observation, survey and semi-structured interviews.

Analysis I aimed to answer Sub-Question 1: "How can user experiences reveal the

strengths and shortcomings of the Lyngby transport hub?". Site Analysis and Qualitative Data Analysis were made for identifying the key shortcomings. Through user experiences include crowds, chaos, lack of navigation signs, bad aesthetics, and mess were identified. Perceived safety was linked to lack of natural surveillance, lighting, and active facades. Strengths mentioned included train punctuality, access to stores, and convenient location.

Analysis II presents the developed Framework, which is the outcome of the project and answers Sub-Question 2: "What steps should municipalities take to redesign public spaces around transport hubs into environmentally sustainable, socially inclusive and accessible?" The Framework consists of Five Concepts as its main pillars: Social Factors, Environmental Factors, Wayfinding & Navigation, Accessibility, and Active Mobility Infrastructure. The Framework includes checklists for municipalities to use before and after the design process to characterise and evaluate public spaces.

Chapter 9 answers the Main Research Question: "How can the design of transit-oriented public spaces, understood through Actor-Network Theory and Nudge Theory, promote environmental sustainability, social inclusion and accessibility?" ANT is used to acknowledge the influence of both human and non-human entities, applying the principles of prescription and negotiation spaces to improve social sustainability. Recognising the role of non-human objects is seen as essential for environmental sustainability. ANT helped analyse the interaction between users, technology, and physical objects to create integrated, inclusive solutions. Nudge Theory serves as a guiding principle to subtly influence user behaviour towards more sustainable choices through thoughtful design elements like paving, planting, lighting, art, facades, and signage. The importance of citizen involvement is also highlighted, linked to the initial phases of the Regenerative Framework.

The discussion critically reflects on the validity and applicability of the Framework, considering its foundation in a single case study. Further, it discusses the role of Multi-Level Perspective, the implications and limitations of the project. Recommendations for further research are presented as well.

LIST OF FIGURES

LIST OF ABBREVIATIONS

LTK – Lyngby-Tarbæk Kommune

SDG – Sustainable Development Goal

MLP – Multi-Level Perspective

ANT – Actor-Network Theory

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CHAPTER 1

INTRODUCTION

Extreme weather conditions from climate challenges in the form of cloudbursts, flooding and overheating have become a regular part of both the political agenda and our everyday lives (European Environment Agency, 2025). Sustainability has become a key concept in planning and design contexts, and there are now demands to think green in terms of mobility and urban development while staying user-friendly, accessible and comfortable to navigate. However, as a result of this increased awareness, it can be experienced that from both local and political perspective it can be asked how to deal and find sustainable initiatives (Solá et al., 2017). Previous projects by the authors have focused on analysing urban spaces to promote inclusion and improve conditions for people with disabilities. This project focuses on how urban spaces can be rethought and redesigned in light of climate change and social needs. This focus was specified through contact with Lyngby-Taarbæk Kommune, which is currently in a process of redesigning of the area close to Lyngby Transport Hub – in connection with the establishment of the upcoming light railway (Lyngby-Taarbæk Kommune, 2025). This area is a central hub where mobility, accessibility and sustainability must be balanced.

This situation created the opportunity for a collaboration with the municipality, where the project aims to develop a strategic framework that can complement the municipality's existing strategies and local plans. The framework will serve as a planning tool that clarifies key considerations in the redesign process of areas close to transport hubs – including green mobility, social needs and climate conditions. From the authors' perspective, there is also a special focus on promoting conditions that can make it more attractive for citizens to choose sustainable modes of transport such as public transport, cycling and walking, which help support a long-term transformation of the city's infrastructure and mobility culture.

Organisation

The project is divided into 11 chapters. Chapter 2 – Problem Orientation, will present state of the art in Lyngby-Taarbæk Kommune and in Gemeente Roermond. Chapter 3 – Literature review introduces topics that were important to research before delving into the analyses. Research questions and assumptions are presented in Chapter 4, followed by theories in Chapter 5. Chapter 6 focuses on methodology, including research design and conceptual model of the project. Chapter 7 aims to answer the Sub-Question 1 through the first analysis, while Chapter 8 answers Sub-Question 2 through the second analysis. Analyses are followed by Chapter 9, which answers the Main Research Question. Finally, Chapter 10 is focused on discussion and Chapter 11 wraps up the project in a conclusion.

CHAPTER 2

PROBLEM ORIENTATION

The problem orientation in this project stems from a recognised issue in urban and transport planning: To what extent do the physical and experiential qualities around stations influence people's choice of public transport over more climate-impacting modes of transport? Based on their own professional and practical experience, both authors have observed that areas near stations often constitute overlooked and underutilised urban spaces, despite being key spaces for mobility infrastructure. In Lyngby, where one of the authors was previously employed by the municipality, it has been learned that even a busy and central station like Lyngby Transport Hub poses significant challenges related to quality of life, safety and accessibility. As the station is facing a comprehensive redesign process in connection with the establishment of the upcoming light railway (Lyngby-Taarbæk Kommune, 2025), Lyngby-Taarbæk Kommune (LTK) was contacted to enter into an informal collaboration – which will be elaborated further below.

The other author has also worked with public spaces in previous projects and has a particular interest in how open urban spaces can be developed to meet the needs of different user groups. With experience from the Dutch municipality of Roermond, a desire arose to include this area as a comparative study. However, due to financial and practical considerations, it was decided that Roermond would act as a test municipality in the final phase, rather than as a full-fledged case. Across the two research standpoints, the ambition has been to contribute to a new understanding of public spaces around transport hubs as strategic nodes in the green transition and thus develop a useful tool that can support municipalities in promoting attractive, accessible and sustainable urban spaces around mobility nodes.

In this chapter, the case area for the project in Lyngby and the test municipality Roermond are presented. This is followed by a review of the positive and negative aspects of the public urban spaces around the transport hubs in the two cities, which

were identified through workshops and interviews.

2.1 Lyngby

Lyngby Station serves as a major transportation hub in Kongens Lyngby, located north of Copenhagen. The station has undergone multiple transformations since its initial function as the terminus of the Nordbanen railway in 1863. Over time, its role evolved from a small terminus to a central node in the northern railway network of Sjælland (Danske Jernbaner, 2020). Figure 2.1 visualizes the case area of Lyngby Transport Hub. In 1936, Lyngby Station became a part of the S-train network, significantly improving

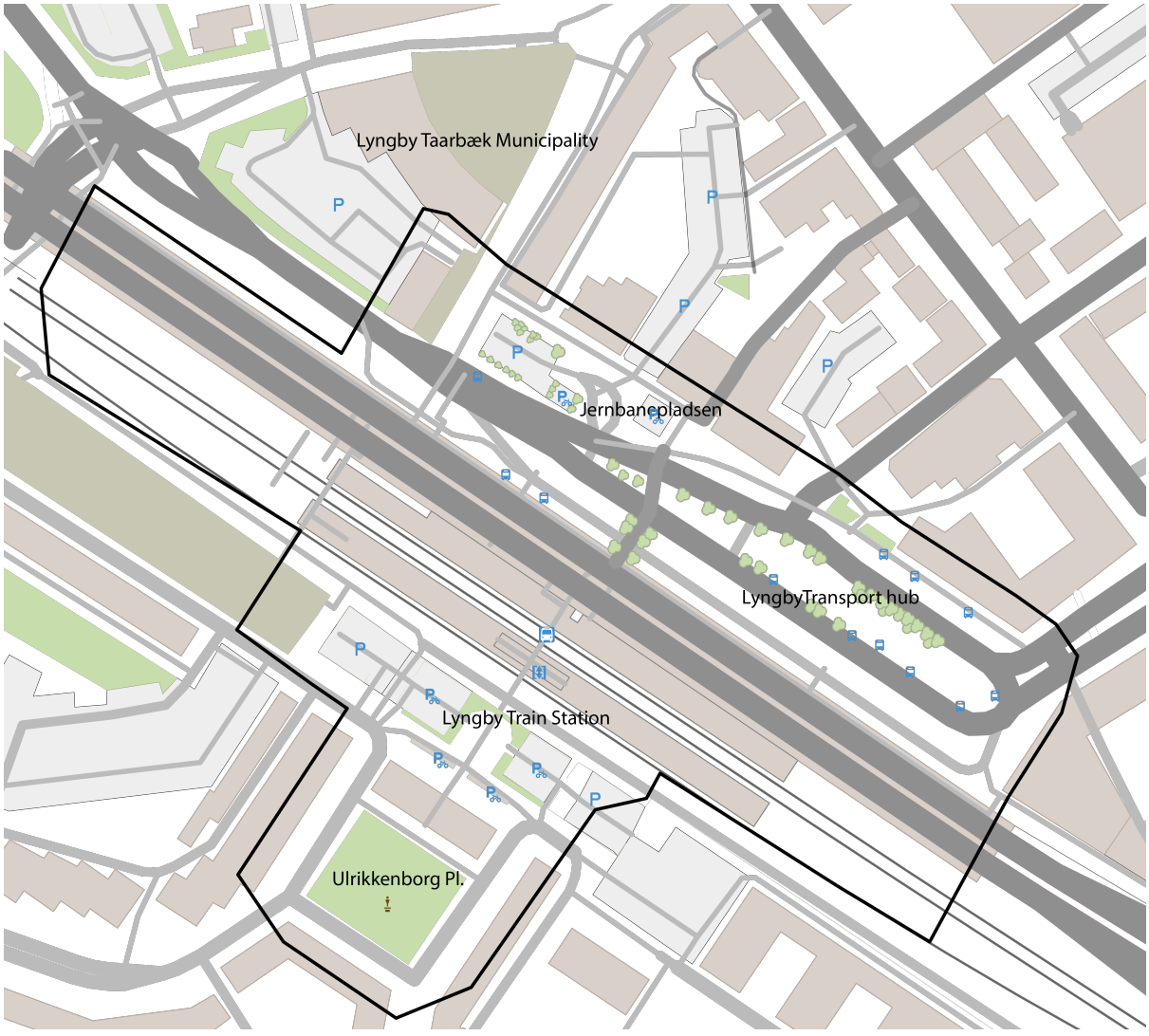


Figure 2.1: Lyngby Transport Hub – the black line borders the focus area, apprx. 60 000 m^2; created by the authors

transportation options. Further modernisation efforts and the construction of major

road infrastructure in the 1950s led to additional changes. The station building, which is the focal point of this case study, was established in 1957 (Danske Jernbaner, 2020). With increasing traffic, double-track railway lines were introduced between Hellerup and Holte stations, the two neighbouring urban centres connected via Lyngby. This transformation aimed to accommodate growing commuter demand and align with contemporary urban planning, integrating road infrastructure and bus connections (Danske Jernbaner, 2024).

Despite modernization efforts, the platforms of Lyngby Station have been preserved from earlier station layouts, making it one of Denmark's older railway stations. Its central location near a major bus terminal further establishes it as a critical transportation hub in Copenhagen's northern suburbs (Danske Jernbaner, 2020). Due to its accessibility, the station is closely connected to the city's daily life and serves thousands of commuters, including local residents, students, and office workers.

In 2024, Lyngby Station recorded 3,725,853 boardings on the Hillerød railway line, ranking it among Denmark's ten busiest stations (Passagertal.dk, 2025). Furthermore, projections suggest that its usage will increase in the coming years, particularly with the development of a new light rail transfer station connecting the upcoming light rail line from Ishøj to Lundtofte (Licitationen, 2015).

The new light rail is expected to be operational by the summer of 2026, significantly enhancing regional transportation. This light rail system will connect key destinations in Lyngby along Ring 3, including business districts, educational institutions, and shopping centers. The initiative aims to improve urban mobility by facilitating commuter access while enhancing the connectivity for the users (Danske Jernbaner, 2024). Lyngby-Taarbæk Municipality's traffic department has emphasized that the light rail will contribute to the municipality's climate strategy by promoting sustainable urban development and strengthening local infrastructure (Lyngby-Taarbæk Kommune, 2023). Currently, Lyngby Station features two tracks surrounding an island platform with a partially covered waiting area. Passengers can access the station either from Jernbanepladsen, where the bus terminal is located, or from Ulrikkenborg Plads on the opposite side of the railway tracks. Track 1 serves trains bound for Hillerød and Holte, while Tracks 2 and 3, serving trains to Copenhagen, are accessible via the underpass beneath the station (Danske Jernbaner, 2024).

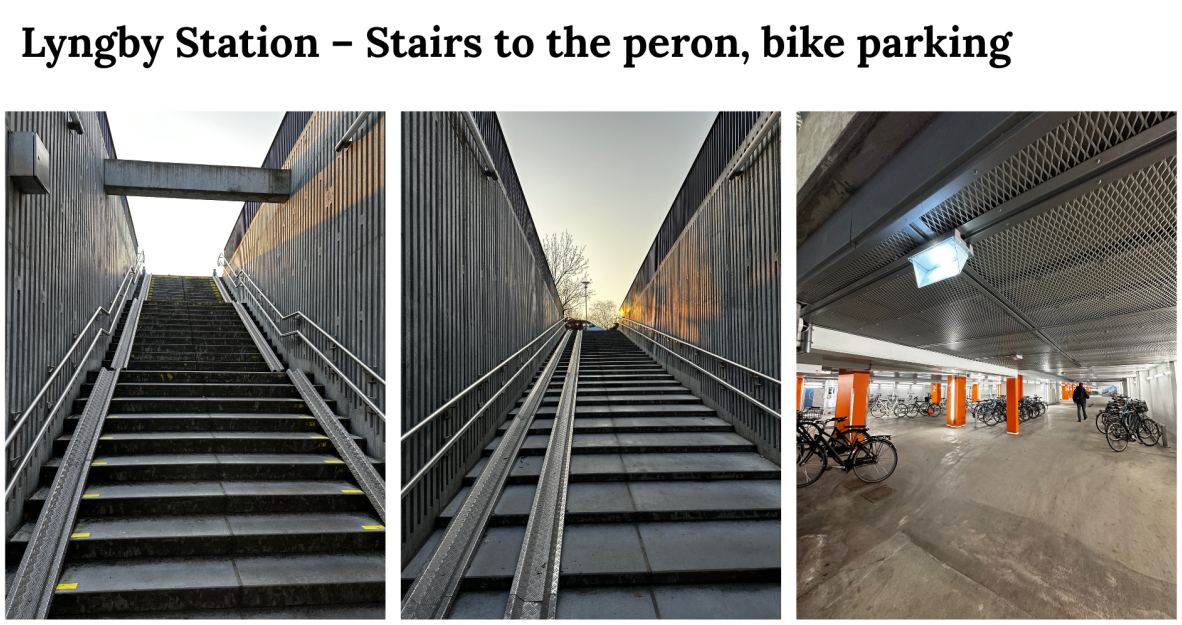


Figure 2.2: Access to the perons and bike parking at Lyngby Train Station

In 2012, DSB Properties acquired Lyngby Station and its adjacent 200-meter arcade from the LTK. Following the acquisition, DSB initiated extensive renovation and redevelopment plans, appointing Gottlieb Paludan Architects as the lead consultant (Gottlieb Paludan Architects, 2016). The renovation project was divided into multiple phases, including the refurbishment of the station's central area, primary access points, the arcade along Jernbanepladsen, retail spaces in the 200-meter extension, and an underground bicycle parking facility (Gottlieb Paludan Architects, 2016).

2.2 Roermond

Roermond is situated at the confluence of the rivers Maas and Roer, a location that historically granted the city a strategic advantage as a market hub and trading center. It was granted city rights in the 13th century and later became a Diocese in the 16th century. During the Second World War, Roermond was occupied by Nazi Germany, but it sustained relatively limited damage during its liberation in 1944 (We Are Roermond, 2025).

Today, Roermond remains a significant destination, particularly known for shopping tourism. The McArthurGlen Designer Outlet is a primary attraction for visitors. In response, the city aims to draw more tourists into the historic city center, which offers a

variety of cultural and commercial experiences.

Roermond's train station is served by trains heading in the direction of Maastricht, Nijmegen and Amsterdam.

2.3 State of the Art in Lyngby and Roermond

Figure 2.3 shows the positive and negative aspects of transport hubs in both Lyngby and Roermond. The aspects were identified during a workshop, interviews, a survey, and prior personal experience. The bubbles on the middle line show which aspects are shared by both spaces.

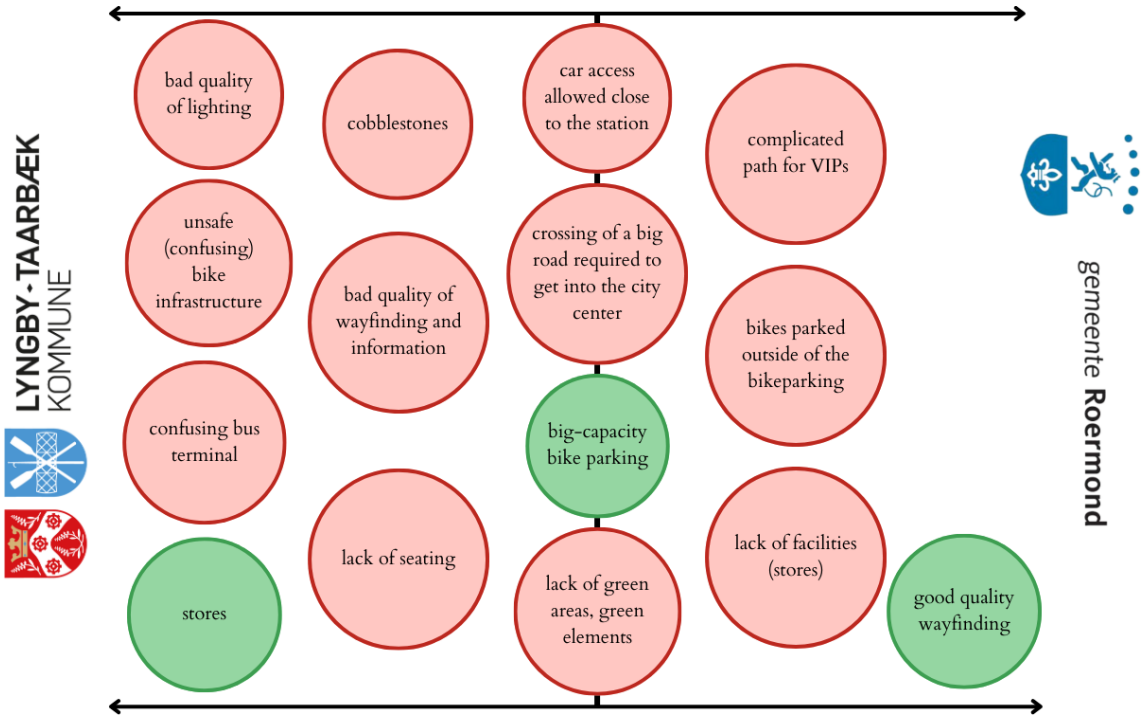


Figure 2.3: The positive and negative aspects of public spaces around transport hubs in Lyngby and Roermond, identified during a workshop and interviews

CHAPTER 3

LITERATURE REVIEW

The literature review will present the approach of the sources used, followed by the selected Sustainable Development Goals (SDGs), interpretations of green urban spaces, and regenerative approaches to design, development and sustainability. In addition, it will highlight how transport hubs are treated based on the existing literature. The review forms the project's knowledge base. Finally, the project's overall research questions and associated sub-questions are presented.

3.1 Sustainable Development Goals

The United Nations introduced the Sustainable Development Goals (SDGs) in 2015 as part of Agenda 2030, a global commitment to enhancing sustainability by 2030 (Fleming et al., 2017). Comprising 17 goals, this framework addresses multiple dimensions of sustainability and represents a significant effort toward a more sustainable future (Pradhan et al., 2017; Fleming et al., 2017).

The SDGs are designed to reshape the world by simultaneously promoting human well-being, economic growth, and environmental preservation. With a total of 17 goals and 169 specific targets, they seek to tackle complex societal challenges (Pradhan et al., 2017). The framework is structured around five core principles – Prosperity, People, Planet, Peace, and Partnership (Sachs et al., 2019).

Given their interconnected and interdependent nature, some SDG targets may at times be in conflict with one another (Nilsson et al., 2016). To maximize their effectiveness, it is essential to coordinate global, national, and local strategies in a way that integrates human, technological, and natural systems (Sachs et al., 2019).

Figure 3.1: Sustainable Development Goals and targets used in this project; Appendix 1A

3.1.1 Relevant SDGs addressed in this project

This project has created a Framework that is supposed to help municipalities in the process of developing public spaces around smaller transport hubs into more sustainable, equal, accessible and regenerative spaces, and by doing so it fulfills several SDG targets (cf. Figure 3.1). Mostly, the targets relate to the SDG 11 – Sustainable Cities and Communities, but other SDGs are also represented (SDG 9 – Industry, Innovation and Infrastructure, SDG 12 – Responsible Consumption and Production, SDG 13 – Climate Action).

3.2 Green spaces in urban areas

Urbanization is happening faster around the world, and by 2050, 70 % of the world population would live in cities (UN-Habitat, 2022). Urban environments and land use negatively impact ecological processes, leading to increased carbon and nitrogen emissions, the emergence of the urban heat island effect due to dense building structures, greater vulnerability to flooding, and higher temperatures that contribute to the formation of toxic tropospheric ozone (Semeraro et al., 2021).

Green spaces in urban areas offer numerous benefits, including improvements to physical, psychological, and mental well-being (Jabbar et al., 2022), achieved through mechanisms such as mitigation of air and noise pollution. They also help mitigate urban heat island effects, reduce air and water pollution, and lower energy consumption

(Semeraro et al., 2021). Green spaces support social interactions between citizens and enhance physical activity (Bauwelinck et al., 2021; Black et al., 2024). Urban planners and public health policy makers should prioritize integrating green spaces into urban areas, as they offer significant benefits for both people and the environment (Bauwelinck et al., 2021; Black et al., 2024).

Green spaces are a fundamental feature for a sustainable city and are referenced in SDG targets 11.6 and 11.7, which are selected as relevant for this project.

3.3 Regenerative approach to design, development and sustainability

The widely recognized definition of sustainability, brought to life by Brundtland (1987) states that:

> *Humanity has the ability to make development sustainable to ensure that it meets the needs of the present [generation] without compromising the ability of future generations to meet their own needs.* — Brundtland (1987, p.15)

This definition is anthropocentric, putting humans above all else, fulfilling the definition of anthropocentrism as introduced in Benne and Mang (2015):

> "[Anthropocentrism] *describes the belief that the purpose of science and the knowledge gained from its pursuit is "to create useful things for the improvement of the human condition and its estate," and that nature is to be controlled and managed toward that end (Hes and Du Plessis, 2014, p. 24).*"
> – Benne and Mang (2015, p.43)

In anthropocentrism, nature is considered to serve human needs and consumption (Gibbons, 2020).

Benne and Mang (2015) and Mang and Reed (2012) introduce two worldviews – mechanistic and ecological. Worldviews are coherent systems of beliefs shaping how individuals interpret and interact with the world (Mang and Reed, 2012), intertwined,

Mechanistic worldview		Ecological worldview	
beliefs	**description**	**transitions from beliefs**	**description**
Reductionism	any complex phenomenon can be understood by taking it apart and reducing it to its individual components	from Reductionism to Integration, Relationship and Interdependence	Understanding relationships within the complex networks as a whole
Determinism	predictable universal laws determine how the component parts of system will behave and thus enable predictions concerning the behavior of the whole	from Determinism to Unpredictability, Emergence and Evolution	*"All living systems are capable of regulating themselves, learning from their mistakes, and reorganizing themselves, expressing themselves through the process of self-organizing or autopoiesis."* – Benne and Mang, 2015, p. 44 Living systems are open to interact with their environments Dynamics within living systems are nonlinear, multiple relationships between multiple actors
Dualism	*"beliefs that mind and matter, the subjective and the objective, are wholly separate and independent phenomena. The universe consists entirely of matter and of the dynamics or forces affecting it. Humans, for whom mind (thinking) is the distinguishing feature (Descartes's "I think therefore I am."), thus stand apart from nature (Harman and Sahtouris, 1998). Separating mind from matter and the subjective from the objective dictates that the only true knowledge is whatever can be objectively observed and measured (Hes and Du Plessis, 2014)."* – Benne and Mang, 2015, p. 43	from Dualism to Wholeness, Co-Creation and Co-Evolution	Humans are integral to nature, one among many players in co-creation and co-evolution that shape the world Coupled objective and subjective (inner experience as important as outer existence)
Anthropocentrism	*"describes the belief that the purpose of science (indeed, of all activities) and the knowledge gained from its pursuit is "to create useful things for the improvement of the human condition and its estate," and that nature is to be controlled and managed toward that end (Hes and Du Plessis, 2014, p. 24)."* – Benne and Mang, 2015, p. 43	from Anthropocentrism to Biocentrism	*"maintaining the health and viability of the whole and the ability of all players to live out their roles in contributing toward that"*– Benne and Mang, 2015, p. 44

Figure 3.2: Mechanistic vs. Ecological Worldview, adapted from Benne and Mang (2015); Appendix 1B

interrelated, interconnected systems of beliefs, a filter through which a phenomena are perceived and comprehended (Benne and Mang, 2015). Mechanistic worldview perceives universe as a whole, while all of its material components, living organisms included, function like mechanical systems, and can be governed by universal laws. Anthropocentrism, together with reductionism, determinism and dualism, are the core beliefs that shape the mechanistic worldview. Reductionism understand complex phenomena by reducing them to their individual components; determinism believes that universal laws will determine how components of a system behave; dualism says that the subjective and objective (mind and matter) are completely separate – human's mind keeps humans separated from nature (matter) (Benne and Mang, 2015). Mechanistic worldview is built on discrete building blocks, and its strategies are linear and not useful to explain the complex issues of living systems.

Ecological worldview, on the other hand, replaces the building blocks with interdependent, interconnected network of complex living systems. Instead of focusing on individual components, it focuses on the multiple relationships between multiple

actors. Ecological worldview understands humans as part of nature, part of the co-creation and co-evolution; it couples the subjective and objective and believes that all players can contribute toward maintaining the health and viability of the whole (Benne and Mang, 2015).

Sustainable development defined by Brundtland (1987) is not good enough for the complex living systems to survive and flourish[1] (Gibbons, 2020). Seeing the world through ecological worldview offers the best principles for regenerative design that are based on natural laws, which "have supported the evolution of nature for millennia" – (Benne and Mang, 2015, p.45). Regenerative development stands on the pillars of sustainable development, yet it is different in terms of spatial and temporal scope (Dietz, 2019). Regenerative development is oriented towards local processes that can help achieve larger goals. However, regenerative development systems must be designed with certain goals, and both systems and goals must take into account the uncertain future (Dietz, 2019). Regenerative design principles must be nature-led, systemic and equitable (Arup, 2024).

3.3.1 Regenerative Sustainability Paradigm

Regenerative sustainability sees the world holistically, bringing a fresh lens for developers (Gibbons, 2020). Ehrenfeld defines the regenerative sustainability paradigm as "the possibility that human and other life will flourish on the planet forever" (Ehrenfeld, 2008, p.6). According to Mang and Reed (2013), the goal of regenerative sustainability is to "reverse the degeneration of the earth's natural systems, but also to design human systems that can coevolve with natural systems" (Mang and Reed, 2013, p.116).

Mang and Reed (2012) introduce six concepts that shape the regenerative sustainability paradigm. **Regeneration** is understood as a hierarchy of four levels of work. Charles Krone (in Mang and Reed (2013)) created a framework which works on both existence (operate, maintain) and potential (improve, regenerate). Work on the the lower, existence level, is increasing efficiency and performance of a living system, while work on the upper, potential levels, introduces potential for a new life and advancement (Mang and Reed, 2013, 2012). All levels must be skillfully managed to achieve a thriving living

[1] live within healthy and resilient ecosystems (Ehrenfeld, 2008)

system. **Regenerative design** is a "vehicle to reverse damage caused by source-to-sink one-way flows, and creating self-renewing resource systems" (Mang and Reed, 2012, p.28). **Place** is considered a complex and dynamic socio-ecological whole – a project should acknowledge the socio-ecological context a place is embedded in (Mang and Reed, 2012). Regenerative development returns place to its core position within human life, supporting the co-creative relationship between humans and the place they inhabit. (Benne and Mang, 2015). Human memory is story based, not data based, and stories are fundamental to how people learn and organize what they know (Mang and Reed, 2012). A story is a coherent organization of information, relationships, connections between discreet pieces of information and different types of information (Mang and Reed, 2012). The **story of place** give humans a context about a certain place.

> "*First, history has shown that a society will not sustain the will needed to make and maintain the needed changes, day after day, without evoking the spirit of caring that comes from a deep connection to place. Second, discovering the story of a place enables one to understand how living systems work in that place, and provides greater intelligence about how humans can then align themselves with that way of working to the benefit of all. Finally, the Story of Place provides a framework for an ongoing learning process that enables humans to co-evolve with their environment.*" – Mang and Reed (2012, p.30)

Pattern literacy is the ability to read, understand and generate the relationship patterns in a space (Mang and Reed, 2013).

> "*[...]reading or understanding patterns reveals the underlying energy flows, both actual and potential, shaping a system. A pattern can reveal the directionality and strength of flows (wind, water, foot traffic, etc.), [...] Using pattern literacy to 'read' the landscape thus provides the relational understanding required to design a built environment that harmonizes with and contributes to these flows.*" Mang and Reed (2012, p.29)

It is important for urban designers and developers to adapt complex systemic thinking,

to get beyond designing "just" the physical infrastructure. Complex systemic thinking emphasizes:

- "On-going learning",
- Plurality and diversity,
- A constant dialogue between project and environment,
- An acceptance of ambiguity,
- An understanding of paradoxes as sources of creativity among other things" – Benne and Mang (2015, p.51)

3.3.2 Regenerative Framework

Mang and Reed developed a three-phase framework for regenerative projects. The framework is shaped as a spiral that grows capacity as it actualizes the project.

First phase – **Understanding and conceptualizing the right relationship to place** – starts with understanding a place as a dynamic holon[2] influenced by the holarchy[3] its embedded in. Each place has its own history and future – the first thing to do is to determine the place's reach, its core patterns, its story, understand the patterns and undergo stakeholder dialogue.

Phase 2 – **Designing for harmony with place** – requires the "attention to a place as a living system in order to build a place, not formula" (Mang and Reed, 2012, p.34).

Phase 3 – **Co-evolution** – suggests that the project must have an ongoing capacity to regenerate, as regeneration is not an event, but process. Regenerative projects mutually evolve – humans and natural systems support each other.

3.3.3 Regenerative Urban Design

As mentioned previously, by 2050, 70% of a whole population will live in cities, which will create new challenges and opportunities for urban planners (United Nations et al., 2018; UN-Habitat, 2022). Cities have characteristics that allow them to act as efficient platforms for promoting regenerative development:

1. Cities concentrate and can accelerate economic activity.

[2]constituent system within the whole (Benne and Mang, 2015)
[3]structure of nestedness (Benne and Mang, 2015)

2. Urban infrastructure investment can enable growth, employment, and poverty reduction.
3. Urban areas are sites for social transformation.
4. Local governments are nimble.
5. Cities are sites of innovation.
6. Cities are interconnected with rural areas.
7. Cities are interconnected with the natural environment.
8. Cities have the potential to minimize environmental footprint.
9. Cities are suited for systems-based approaches. – (de Baro, 2022, p.3)

As mentioned earlier, sustainability is not enough anymore, and cities, as well as the rest of the world, must become regenerative. That means not only emit less carbon and consume less finite resources, but also contribute to the regeneration of the underlying support systems (Girardet, 2017). Implementing strategies to achieve a regenerative city is a long-term process, and it is necessary to implement them globally, to create prevention rather then treatment (Gabel, 2015). Cities must minimise the dependence on finite resources like fossil fuels and the unsustainable use of other natural resources (Girardet, 2017). The surrounding areas' capacity to absorb carbon emissions must be increased. Carbon emissions are not only concerning in regards to human health, but also to planetary health (Girardet, 2017).

3.4 Accessibility

Accessibility is a broad and complex concept that can be defined and operationalised in multiple ways, often depending on policy, urban planning, and transport research. In mobility studies, accessibility plays a crucial role in shaping transport policies, but it remains challenging to define inclusively. This is partly because political agendas tend to frame accessibility based on the 'average' user, focusing on mainstream mobility needs while often overlooking diverse user groups (Guzman et al., 2023). As a result, accessibility measures may lack consensus and inclusion, raising concerns about their effectiveness in ensuring equitable mobility for all (Guzman et al., 2023).

For public spaces near transport hubs, accessibility extends beyond the physical infrastructure – it also encompasses safety, inclusion and social interaction. Sustainable

accessibility therefore requires a holistic approach, considering how urban spaces function, how they are integrated into transport networks and how they accommodate different users. The success of accessible public spaces depends not only on the presence of transport options, but also on the quality of the surrounding environment and whether it encourages people to use these spaces efficiently (Solá et al., 2017). It is especially relevant when designing barrier-free environments that support different user needs, including commuters, the elderly, and the disabled.

However, accessibility is not just about infrastructure and mobility – it also involves perceptions of safety and social cohesion. Jane Jacobs' concept of 'eyes on the street' is a fundamental principle, which argues that natural surveillance – where public spaces are passively monitored by people engaging in daily activities – enhances safety and fosters a sense of community (Jacobs, 1961). In the case of public spaces near transport hubs, this means that pedestrian areas, waiting zones, and pathways should be well-lit, visible, and actively used to improve both perceived and actual safety.

A well-designed, open, and transparent space, seamlessly integrated into its urban surroundings, can help deter crime and anti-social behaviour, making it more inviting and comfortable for vulnerable users, such as women, elderly, and people with disabilities (Solá et al., 2017). This principle reinforces the idea that accessibility is not only a technical issue but also a social one. The way public spaces near transport hubs are structured and maintained directly impacts whether people choose these spaces over alternative routes and how they experience their journey in terms of safety and comfort (Guzman et al., 2023).

Enhanced accessibility in urban planning plays a crucial role in creating safe, inviting, and efficient public spaces that encourage people to use them.

3.5 Transport Challenges

Traffic in Denmark – and globally – continues to increase, placing significant pressure on both public and private transport infrastructure. More people commute longer distances, and mobility needs are changing in response to urbanisation, technological development and population growth (Brand et al., 2021). This development does not only increase congestion, but also intensifies climate challenges, as the transport sector

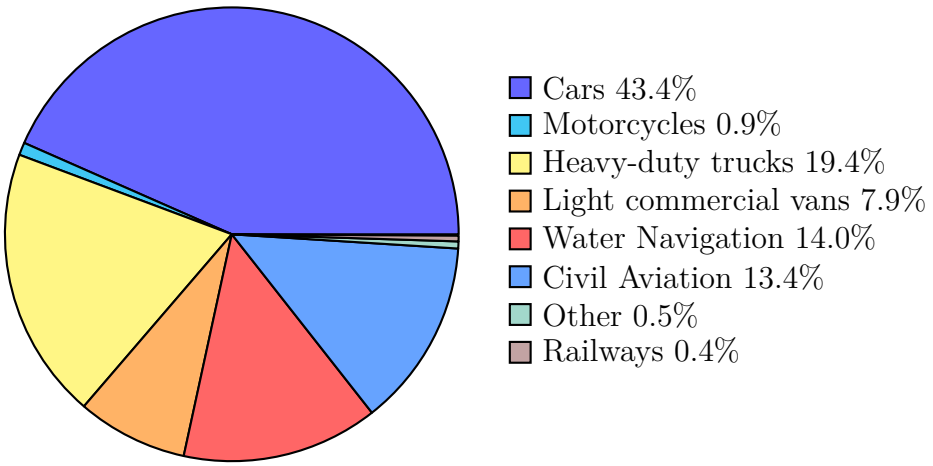


Figure 3.3: Greenhouse Gas Emissions by Transport Mode, (European Parliament, 2019)

remains one of the largest sources of carbon emissions (European Environment Agency, 2022).

To address these challenges, it is essential to integrate transport planning and urban development together. According to a report by the Danish Society for Engineers, there is a growing need for more integrated planning and a holistic approach to infrastructure and transport hubs, where a sustainable urban structure can play a crucial role in reducing congestion and minimizing environmental impact and improving human experiences (Byplanlaboratoriet, 2021).

In 2019, transport accounted for almost a quarter of the total CO_2 emissions in the EU, of which 71.7% came from road transport according to the European Environment Agency (European Parliament, 2019). Figure 3.3 highlights that CO_2 emissions from passenger transport vary significantly depending on the mode of transport. It is clear that passenger cars are the biggest polluters, accounting for 60.6% of the total CO_2 emissions from road transport in Europe. Improving opportunities for passengers to use other modes of transport, such as public transport, cycling or walking, will help reduce emissions and improve the chances of reaching the EU's 2050 climate neutrality target as part of the Green Deal (European Parliament, 2019). Denmark, like other EU countries, is committed to the adopted climate goals. Despite the country's many positive initiatives and ambitious climate targets set in the Climate Act, which aims to reduce greenhouse gas emissions by 70% from 1990 levels by 2030, it is clear that in 2022, the transport sector emitted 13 million tonnes of CO_2, accounting for about 30% of Denmark's total emissions (Klimatræ, 2025). In addition, studies have shown that if

no action or changes are taken, this figure will rise to 35% by 2035, which could challenge Denmark's climate goals (Klimatræ, 2025).

In Denmark, road transport is also a significant source of CO_2 emissions, with passenger cars alone being one of the biggest culprits. Achieving national, EU, and UN global targets will require a mix of technological innovations, policy changes, and shifts in consumer behaviour. At the regime level, this means improving public transport, developing more efficient logistics solutions, and making it easier for people to choose more sustainable transport options (Klimatræ, 2025).

Acting on the problems described above allows for more effective solutions. A report published by Roskilde University, *7 Green Planning Principles in Climastrategic City Management* (Grindsted et al., 2024), highlights that "a shift from car to walking and cycling will reduce CO_2 emissions by 84% on average" (Grindsted et al., 2024, p.18).

A critical question could then be asked: Why people then prefer cars over more sustainable transport options? Grindsted et al. (2024); Brand et al. (2021) used methodological approaches to explore the reasons behind this choice and potential solutions. Several studies suggest that the issue largely stems from strategic planning, where urban design and physical infrastructure directly influence social behaviour. Based on these findings, the focus of this project has been placed on public spaces near transport hubs, as these areas are key to people's daily mobility.

3.6 Transport Hubs

A transport hub is a central gathering place where different modes of mobility meet and integrate to enable a seamless journey. These hubs can be stations, terminals, bus stops and carpooling points, connecting public and individual transport (Syddanmark, 2025). Depending on the location, transport hubs can include public transport such as buses, trains, light rail, while private mobility solutions such as carpooling, taxis, bike sharing, and electric scooters can complement existing options.

Transport hubs are also dependent on the surrounding areas that can have potential to promote sustainable and soft modes of transport. However, this is only possible if the area is attractive and easily accessible to people.

Based on Brand et al. (2021) and Grindsted et al. (2024), these urban spaces are often

characterised by social and environmental challenges, which raised questions about whether people want to spend time there and thus use public transport. Planning transport hubs can not only help optimise travel times and reduce carbon footprints, but also support more flexible and inclusive mobility.

At the same time, it is important to recognise that transport choices are not just about efficiency – all human beings have different mobility patterns, needs and preferences. This means that people use different modes of transport at varying times, depending on factors such as work and leisure activities, family circumstances and individual habits (Schwanen et al., 2008). A well-functioning transport infrastructure, with transport hubs as its foundation, must therefore take this diversity into account and ensure that mobility systems can adapt to the varying needs of citizens.

In light of this, transport hubs become crucial for creating a more cohesive and sustainable mobility network. By connecting different modes of transport efficiently, hubs can reduce waiting times, improve the user experience and support the shift towards more sustainable transport choices (Tran and Hyeong, 2023). This leads to the question of how municipalities should redesign public spaces around transport hubs to help improve the overall travel experience and promote the use of public transport and active mobility.

3.6.1 Safety

As mentioned above, transportation plays a crucial role in daily life and is a central factor in moving from point A to point B. However, the travel experience is not only about the trip itself: waiting times, transitions between modes of transport, and the physical environment in transport hubs significantly impact the overall experience of the trip. Waiting times can be short or long, but they can also *feel* short or long depending on the surroundings and the amenities available (Tran and Hyeong, 2023). In the report *Passagernes oplevelse af tryghed på togstationer* (Forbrugerrådet Tænk, 2019a), it is emphasised that the area including the station is an important part of the travel experience, where passengers or passers-by stay for shorter or longer periods of time. Therefore, these areas can also have a major impact on the satisfaction of the travel experience during delays (Forbrugerrådet Tænk, 2019a). A survey was conducted, and its results show that physical conditions are crucial for the experience of the space.

For instantce, 31% of respondents mentioned "poor lighting" and 25% mentioned "poor maintenance/cleaning" as a significant factor. "Lack of overview of the station" was mentioned by 11% of the respondents (Forbrugerrådet Tænk, 2019a). In addition to this, the results showed that the most unsafe places at S-train stations were considered to be platform tunnels, access routes to platforms and poorly lit places (Forbrugerrådet Tænk, 2019a). These factors also play a role in people's choice to use public transport.

An important aspect that reoccurs is the importance of active facades and social contact points close to the station (Forbrugerrådet Tænk, 2019a). Several respondents describe stores and kiosks as a kind of "safe space" where they can seek refuge if they feel unsafe (Forbrugerrådet Tænk, 2019b). This reflects the value of Jane Jacobs' 'eyes on the street' concept – the idea that activity and visible presence create social control mechanisms that support safety (Jacobs, 1961). At Lyngby Transport Hub, there are stores and kiosks close to the platforms, but they are not perceived as active or welcoming. Passengers are greeted by dark, closed arcades that many describe as uncomfortable and unsafe. A woman mention in the report, that she does not dare let her children travel alone to or from Lyngby Station because of the unsafe atmosphere (Forbrugerrådet Tænk, 2019b).

An example of a failed safety promotion effort can be seen in the recent installation of classical music in Lyngby Station's bicycle cellar. Instead of creating a sense of calm and security, the sound has in many cases caused discomfort – some respondents even describe it as feeling like being in a horror film (Forbrugerrådet Tænk, 2019b). This shows how important it is to base safety measures on user experiences and local context rather than generic solutions.

The report's data also shows that safety is about more than physical safety – it is also about atmosphere, maintenance and social coding of the place (Forbrugerrådet Tænk, 2019a). Many people mention that the station's lack of cleanliness negatively affects their experience. The absence of proper toilet facilities leads to inappropriate behaviour in the corners of the station area, further reinforcing the perception of disorder and insecurity. One male respondent notes that "dirt breeds dirt" – an observation that confirms the psychological effect of poor maintenance on citizens' behaviour and sense of safety (Forbrugerrådet Tænk, 2019b).

Overall, the analysis shows that safety at stations – and especially at Lyngby Transport

Hub – cannot be reduced to a question of physical safety alone. In contrast, safety arises from the interaction between aesthetics, function, visibility, and social life of the place. If the station is to become an attractive, well-functioning hub, it is necessary to prioritise lighting, cleanliness and active, open facades as key design parameters in future transformations.

Summary of the findings

SDGs included in this project are SDG 9, SDG 11, SDG 12, SDG 13.

Green spaces in urban areas offer plenty of benefits, e.g. mitigating UHI effects, lowering temperatures, improving health an enhancing physical activity.

The goal of **regeneration** is human and other life flourishing on the planet forever. To support regeneration, work must occur on four levels: operate, maintain, improve, regenerate.

Regenerative sustainability paradigm is shaped by six concepts: regeneration, regenerative design, place, story of place, pattern literacy, potential.

Regenerative framework introduces three phases of design: understanding and conceptualizing the right relationship to place, designing for harmony with place, co-evolution.

Regenerative design principles are nature-led, systemic and equitable.

The understanding of **accessibility** needs to shift. It currently focuses on the average user, making environments less inclusive. Accessibility in public spaces around transport hubs should prioritize safety, comfort, and social interaction.

Transport and climate are closely linked, as road traffic remains a major source of CO_2 emissions both in Denmark and across the EU. Integrated urban and transport planning is essential to reduce environmental impacts and improve mobility.

Transport hubs are central nodes where different modes of mobility connect to support seamless and sustainable travel. Their design influences travel efficiency, accessibility, and user experience.

CHAPTER 4

RESEARCH QUESTIONS

This chapter presents three research questions that explore how public spaces near transport hubs can be redesigned with an emphasis on environmental sustainability, social inclusion, and accessibility.

Main Research Question

How can the design of transit-oriented public spaces, understood through Actor-Network Theory and Nudge Theory, promote **environmental sustainability**, **social inclusion** and **accessibility**?

Sub-Question 1

How can user experiences reveal the strengths and shortcomings of the Lyngby transport hub?

Sub-Question 2

What steps should municipalities take to redesign public spaces around transport hubs into environmentally sustainable, socially inclusive and accessible?

The Sub-Questions are answered in Chapter 7 and Chapter 8.

CHAPTER 5

THEORY

This chapter introduces theories through which the project is viewed and constructed. Multi-level Perspective is an underlying, supporting theory, which helps to understand the connections, relationships and influences of the individual levels in this project. Actor-network theory and Nudge theory are theoretical approaches focused on humans and non-human actors. The goal is to create a a strong theoretical foundation by combining these theories.

5.1 Multi-level Perspective

Multi-level perspective (MLP) is a "middle-range framework" for analysing socio-technical transitions to sustainability (Geels, 2011, p.24). Often, transition studies are focused on illustration, exploration, learning and co-evolution rather than systematic research (Geels, 2011; Sovacool and Hess, 2017). The framework analyses issues on three levels: niches, regimes, and landscape. **Regimes** are the primary interests, as transitions occur as changes from one regime to another; **niches** are the spaces in regimes where users are willing to support innovations; **landscape** is the wider context that influences niches and regimes (Geels, 2011). Figure 5.1 interprets these three MLP levels with the relationships connecting them. Some adjustments, inspired by explained criticisms in Geels (2011), are applied to the MLP theory in this project.

To give more attention to power and politics, to incorporate constructivist approaches (Genus and Coles, 2008) and to "show concern for actors and alternative representations that could otherwise remain silent" (Geels, 2011, p.29), the actor-network theory is incorporated.

MLP has been criticised for not stating how broad the regime level should be. Geels argues that the "regime notion is an analytical concept that can be applied to empirical topics of different scope" (2011, p.31). In case of this project, regime level is the current

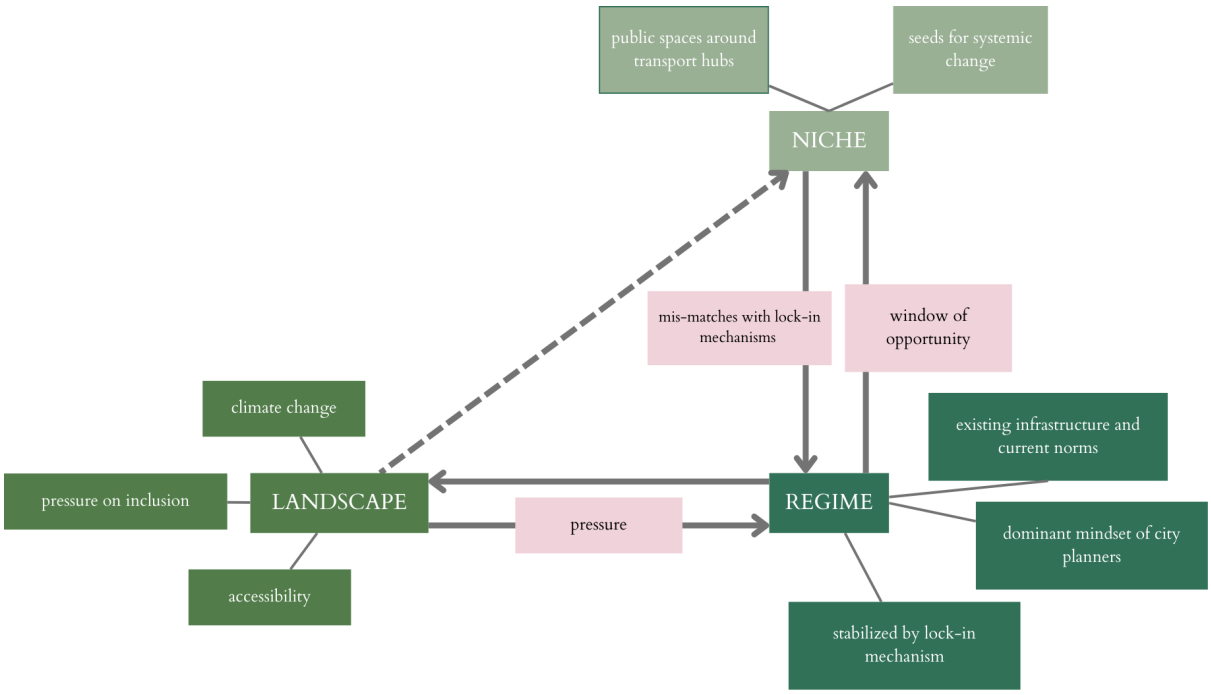


Figure 5.1: MLP levels, connections and relationships based on Geels (2011), created by the authors

state of the public space around the Lyngby Transport Hub, with the dominant mindset of planners, existing infrastructure and current norms.

Similarly, MLP faced criticism toward the landscape level, stating that it works as a residual category. Thus, Van Driel and Schot (2005) (in Geels (2011)) developed a three-level typology of landscapes: factors that do not change (the climate), rapid external shocks (war, inflation), long-term changes in certain directions (demographic changes – population ageing). To answer criticisms that MLP is biased towards bottom-up change models (Geels, 2011), Geels and Schot (2007) created a typology of transition pathways. For this project, the De-alignment and re-alignment type is useful:

> "*If landscape change is divergent, large and sudden ('avalanche change'), then increasing regime problems may cause regime actors to lose faith. This leads to de-alignment and erosion of the regime. If niche-innovations are not sufficiently developed, then there is no clear substitute. This creates space for the emergence of multiple niche-innovations that co-exist and compete for attention and resources. Eventually, one niche-innovation becomes dominant, forming the core for re-alignment of a new regime.*" – Geels and Schot (2007, p.408)

The *landscape change* in this case is the need to act against climate change, to push transitions toward active mobility and to make public spaces accessible and inclusive. These pressure leads to the current regime to deteriorate and *de-align*. New niche innovations – solid bike and pedestrian infrastructure, green infrastructure, accessible features – can emerge and co-exist until *re-alignment* occurs around one innovation and the rise of a new regime.

Main takeaways for this project

Niche – the public space around transport hub in Lyngby where the Framework is developed

Regime – state of the public spaces around transport hubs, with the dominant mindset of planners, existing infrastructure and current norms

Landscape – need to act against climate change, transition toward active mobility, inclusive and accessible public spaces

The pressure of landscape level can influence actors in the regimes. Innovations in the niche can influence regimes.

5.1.1 Multilevel Design Model

Joore and Brezet's (2015) Multilevel Design Model (MDM) combines a structure of hierarchical system levels with a cyclic iterative design process consisting of four phases: Reflection, Analysis, Synthesis, and Experience (Joore and Brezet, 2015). To understand how the framework emerged, these four phases are implemented at the niche level in which the Framework is set.

Phase		Actions/Description at Niche Level (Lyngby Transport Hub Thesis)
Reflection	Perceiving Problems/Opportunities	Initial activities of identifying the strengths and shortcomings of LTH through workshop, survey, user interviews
Analysis	Defining Requirements/Objectives	Defining criteria for the Framework: Social Factors, Environmental Factors, Wayfinding & Navigation, Accessibility, Active Mobility Infrastructure.
		Using expert opinions, user needs, SDG targets
Synthesis	Generating Solutions/Concepts	Further developing the Five Concepts (Social Factors, Environmental Factors, Wayfinding & Navigation, Accessibility, Active Mobility Infrastructure)
Experience	Simulating/Testing Outcomes	Getting feedback from municipal planners from both LTK and Roermond

Figure 5.2: MDM phases implemented in the specific niche level

5.2 Actor-Network Theory

Actor-network theory (ANT) is a theoretical approach that treats both human and non-human actors as equal participants in a network of relationships (Latour, 1996). It seeks to understand how these actors interact and influence each other, shaping the network's structure and actions (Latour, 1996). ANT extends the definition of an "actor" or "actant" beyond humans to include non-human entities (Latour, 1996).

ANT will help the project by creating a dynamic and interactive research process, as knowledge is developed through the interaction with local actors in Lyngby. Rather than analysing urban development from the outside, ANT will be testing and shaping regenerative solutions in practice (Tofteng and Husted, 2012).

The "network[s]" in ANT are heterogeneous, made up of all sorts of different things mixed together. It includes both human actions (social) and non-human material elements[1] (Murdoch, 1998).

ANT challenges dualisms[2] such as nature/society, actor/structure, and local/global – rather than treating these concepts as separate and opposing forces, ANT explores how they are interconnected and mutually constitutive within networks (Murdoch, 1998).

According to ANT, spaces can be shapes by prescription or negotiation. **Spaces of prescription** are network environments where translations are effectively accomplished, and the network is stabilised with entities aligned. These spaces often involve standardised links and relations, making actions predictable and controlled from a centre. In spaces of prescription, networks may be imagined as scripts that prescribe the roles that other elements in the network are expected to play (Murdoch, 1998). **Spaces of negotiation** are network environments where actors have some autonomy to act independently from the network's prescriptions (Murdoch, 1998). Components of the network continually re-negotiate with one another, form variable and revisable coalitions, and assume ever-changing shapes. Spaces of negotiation are fluid, interactional and unstable (Murdoch, 1998). It is important to note that prescription and negotiation are two sides of the same coin and cannot exist without the other –

[1] "*...that is, ANT seeks to analyse how social and material processes (subjects, objects and relations) become seamlessly entwined within complex sets of association*" (Murdoch, 1998, p.359)

[2] dualisms were already mentioned in the mechanistic vs. ecological worldview in Section 3.3, ANT thus agrees with the ecological worldview in coupling those dualisms together and exploring their interconnection

Concept	Description
Actors (human)	Passengers, staff, local residents, urban planners, business owners.
Actants (non-human)	Trains, tracks, platforms, lighting, security cameras, ticket machines, waiting rooms, signage, the station building, nearby buildings, and the surrounding environment.
Heterogeneity (social and material elements)	How do material elements (actants) influence the behaviour of social elements (actors)? How does the design of the platform impact passenger flow and waiting times? How does signage influence navigation and accessibility?
Translation	The process through which elements are shaped to behave according to the network's needs.
Space of Prescription	Network environments where translations are effectively accomplished, stabilizing the network with entities aligned.
Space of Negotiation	Network environments where actors have some autonomy to act independently from the network's prescriptions.

Figure 5.3: Key Concepts in Actor-Network Theory for Urban Spaces

spaces can be shaped by both prescriptive elements (design, regulations) and negotiation (how people actually use the space) (Murdoch, 1998). **Translation** in ANT is about how ideas, people, or objects change as they move through a network (Murdoch, 1998).

Table 5.3 shows the key concepts of ANT and how these concepts will be used in the project.

Main takeaways for this project

Spaces of prescription – dangerous areas, e.g. perrons close to the train tracks, bus stops, light rail stops

Spaces of negotiation – green areas, waiting areas further from the public transport vehicles

5.3 Nudge

Nudge theory was developed by Thaler and Sunstein (2021) as an approach to policy making and choice architecture. It offers policy makers an effective way to influence citizens' behaviour without restricting their freedom of choice.

> "*A nudge is any aspect of the choice architecture that alters people's behaviour in predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not taxes, fines, subsidies, bans, or mandates. Putting the fruit at eye level counts as a nudge. Banning junk food does not.*" – Thaler and Sunstein (2021, p.8)

There is no neutral design when speaking about architecture or urban planning (Thaler and Sunstein, 2021). Every choice of a design an architect or urban planner makes is eventually going to influence the choices of the users – and even small details potentially perceived as insignificant can have huge impacts on people's behaviour (Thaler and Sunstein, 2021). There is no way to create a perfect urban plan, but design choices can be made with beneficial effects (Thaler and Sunstein, 2021).
Thaler and Sunstein introduce their movement *libertarian paternalism*, meaning that "people should be free to do what they like" (libertarian aspect) and that it "is legitimate for choice architects to try to influence people's behaviour in order to make their lives longer, healthier, and better" (paternalism aspect) (2021, p.4-5).
Although the definition of paternalism in Cambridge University Press (2025) may appear excessive in democratic societies, ultimately, someone must make the design choices that influence others.

> *"thinking or behaviour by people in authority that results in them making decisions for other people that, although they may be to those people's advantage, prevent them from taking responsibility for their own lives"* – Cambridge University Press (2025)

In their book, Thaler and Sunstein (2021) mention concept used by their coworker Daniel Kahneman. The concept understands brain as two separate systems – the automatic one and the reflective one. Figure 5.4 shows the main differences between these two systems. Hansen and Jespersen (2013) developed a Framework based on Nudge theory by Thaler and Sunstein (2021). This Framework divides nudges into four types – Transparent Type 1, Transparent Type 2, Non-Transparent Type 1, Non-Transparent Type 2. Type 1 aims

Automatic	Reflective
uncontrolled	controlled
effortless	effortful
associative	deductive
fast	slow
unconscious	self-aware
speaking mother tongue	speaking another language

Figure 5.4: Overview of the differences between Automatic and Reflective Systems, adapted from Thaler and Sunstein (2021)

to affect automatic system (without involving the reflective one), type 2 aims to affect reflective system. Figure 5.5 shows the main characteristics of the four types.

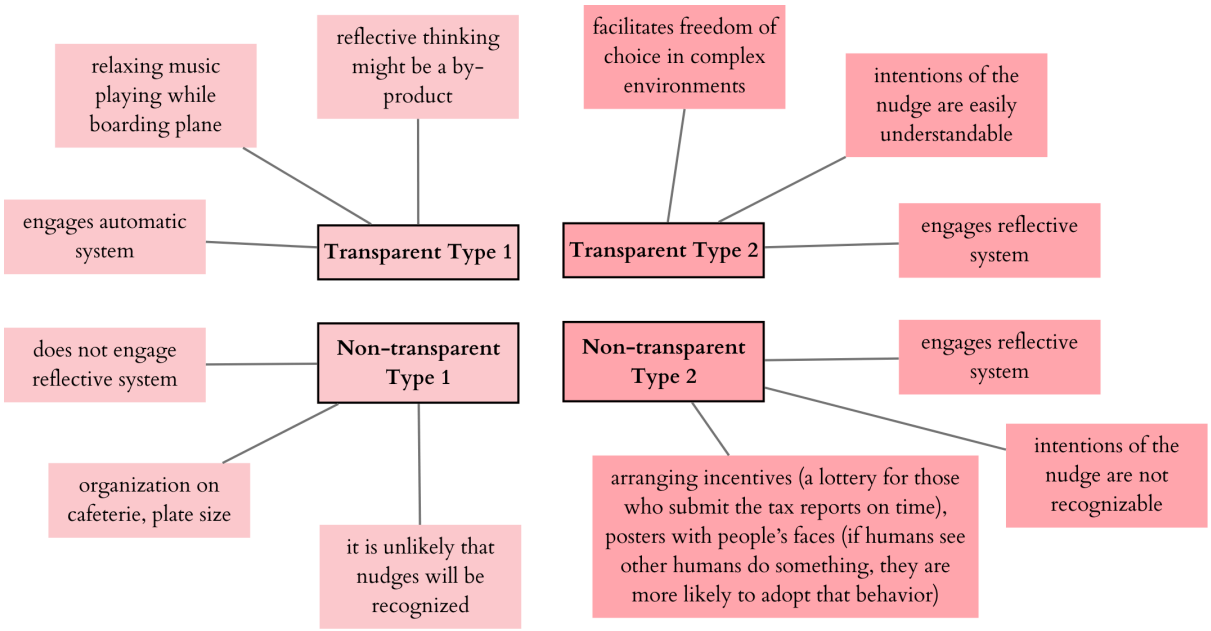


Figure 5.5: Types of Nudges, adapted from Hansen and Jespersen (2013)

Main takeaways for this project

Design choices can be made with beneficial effects (Thaler and Sunstein, 2021). The goal is to use nudges while maintaining the **freedom of choice** of the users.

Transparent Type 2 nudges are used the most, as they facilitate freedom of choice and their intentions are easily understandable.

Transparent Type 1 nudges are also used in smaller quantities.

5.4 Combining ANT and Nudge

ANT and Nudge Theory can be combined by assigning the types of nudges to types of spaces (cf. Figure 5.6). The transparent type 2 nudges work within the flexible spaces of negotiation – a typical example of such nudge is the use of visual illusions in traffic that are obviously made to be noticed (tactile stripes on a road before a pedestrian crossing) (Hansen and Jespersen, 2013). The spaces of negotiation definition says that actors have some independence from the network's prescriptions, so an actor (driver) can choose whether to acknowledge the actant (tactile stripes) or not (Murdoch, 1998).

The stable spaces of prescription can be connected with the other types of nudges – non-transparent type 1 and 2 and transparent type 1. All of these types of nudges create a space of prescriptions – it is unlikely that the nudges' intentions will be recognized which creates a space where actions are predictable and controlled (by the nudges) (Murdoch, 1998).

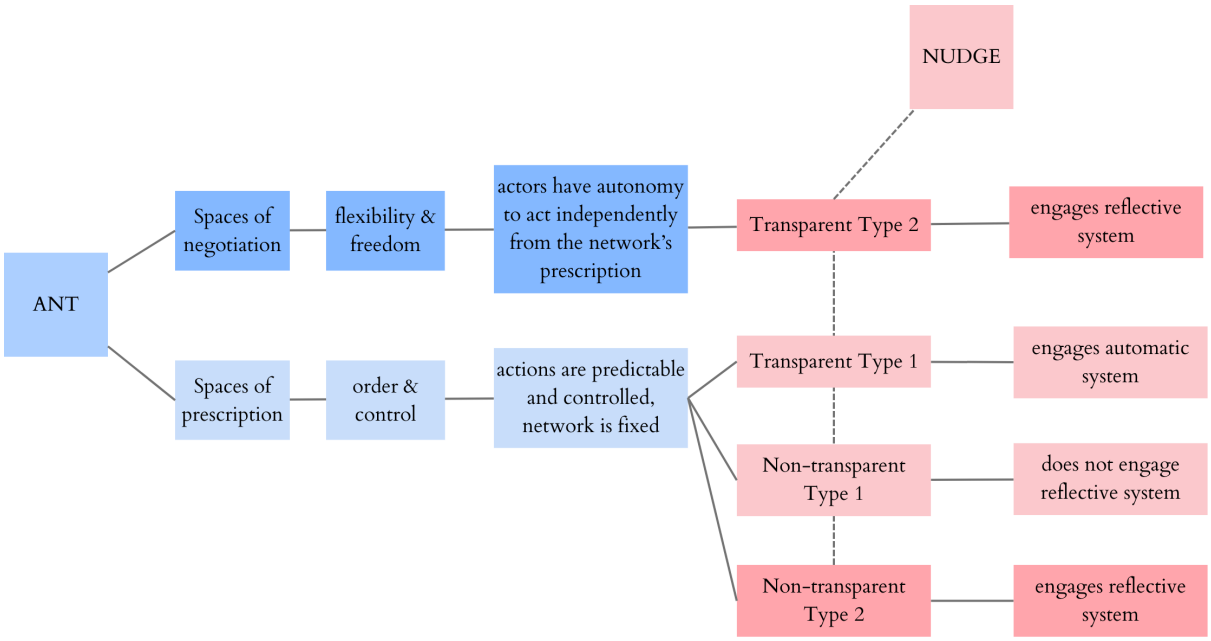


Figure 5.6: Connection between ANT's Spaces of negotiation and Spaces of prescription, and types of Nudges

CHAPTER 6

METHODOLOGY

This chapter introduces the methods and methodology chosen to answer the research questions of the project and the framework developed. The chosen analysis techniques are inspired by the book Applied Urban Design, with the intention of creating an in-depth site analysis (Black et al., 2024). The aim is not only to generate new information and knowledge about the topic, but also to find a practical solution to the societal challenges unfolded in the Problem Orientation (Chapter 2) (Jæger, 2019). The methodological choices in the project were guided by the need for a framework that is both applicable and valid in real-life context. In this context, the purpose of the used methodological tools and their importance to answer the research questions will be discovered.

6.1 Research Design

Figure 6.1 illustrates the steps taken throughout the completion of this project.
The first step was a literature review and the selection of theoretical lenses — Actor-Network Theory and Nudge Theory, supported by the Multi-Level Perspective. Regenerative Development and the Sustainable Development Goals were also explored, as they form the foundation of future urban development. The history and current situation of the Lyngby Transport Hub were examined as well. This literature review was presented in Chapter 3. The second step involved data collection through non-participant observation, behavioural mapping, interviews with experts and users, and an online survey. These methods are presented in this chapter, and the results are outlined in Chapter 7, alongside a site analysis. Following the analysis of the qualitative data and the site, a framework was developed in three phases: pre-development, feedback from Lyngby and Roermond representatives, and the final version.
In the final phase, the main research question, focused on the theoretical lenses, is answered.

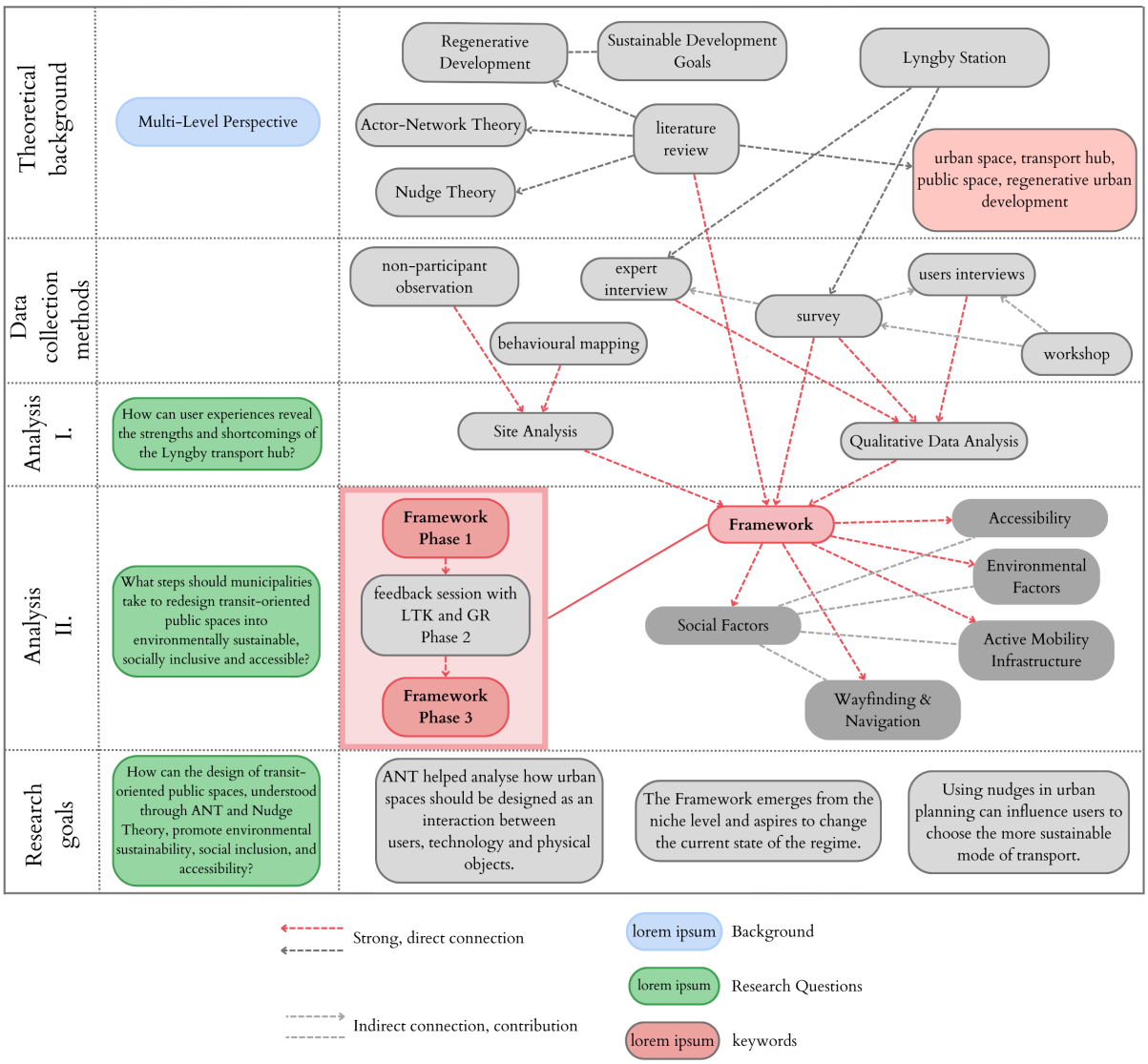


Figure 6.1: Research Design; Appendix 2A

6.2 Conceptual Model

The conceptual model, presented in Figure 6.2, was designed to clarify the process that underlies this project. It incorporates the researched concepts from Chapter 3, framed by relevant theories and SDGs, along with key issues identified during data collection. The process section of the figure outlines the steps and sources involved in redesigning public spaces.

The output represents the ultimate goal of this project – to help municipalities redesign and redevelop public spaces around Transport Hubs – while incorporating components of the chosen theories. Figure 6.3 presents key concepts used in this project, summarizing important insights from the reviewed literature. In the first part of the project's research work, a literature review was used to gain an understanding of the challenges and issues

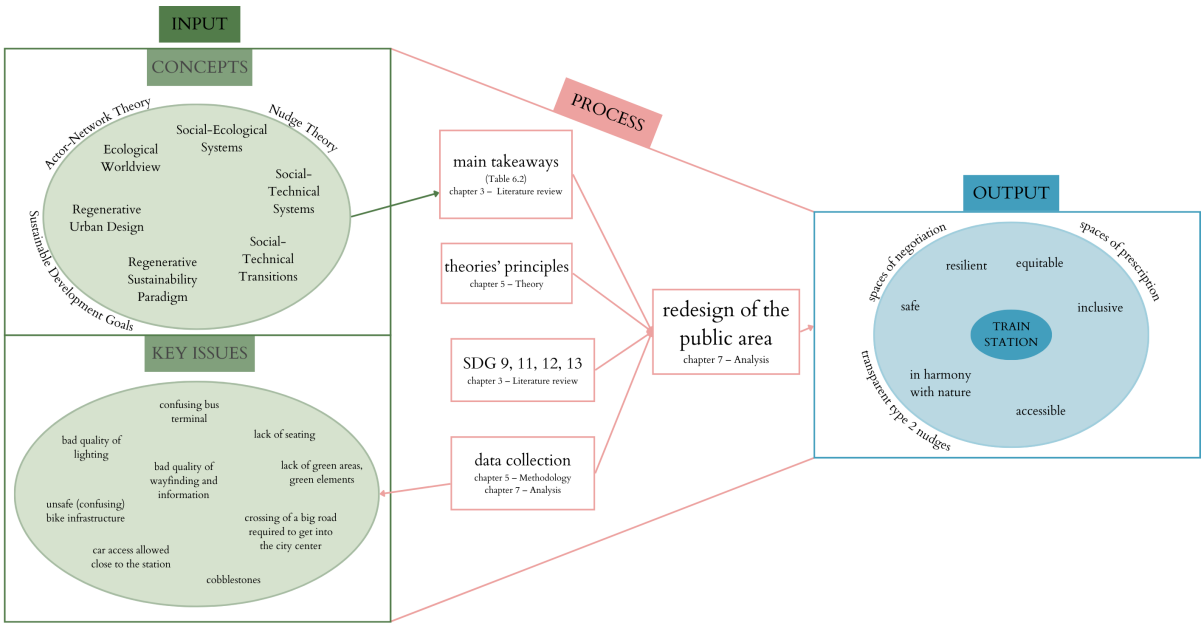


Figure 6.2: Conceptual Model; Appendix 2B

Concept	Description	References
Ecological Worldview	- Interdependent, interconnected network of complex living systems - Multiple relationships between multiple actors - Human as part of nature and co-evolution	Benne and Mang (2015); Mang and Reed (2012)
Regenerative Sustainability Paradigm	"The possibility that human and other life will flourish on the planet forever." Ehrenfeld (2008, p.8) - Regeneration, regenerative design, place, story of place, potential, pattern literacy	Ehrenfeld (2008); Mang and Reed (2012, 2013)
Regenerative Urban Design	- Cities as efficient platforms for promoting regenerative development	de Baro (2022)

Figure 6.3: Main takeaways from previously researched concepts

that transport hubs experience. Search engines such as Google Scholar, Scopus and the AAU library Primo were used. As there gradually became a greater interest and understanding of Lyngby Station as a well-known and popular transport hub, it was decided to prepare a future workshop for DTU students to supplement the project with their opinions and wishes. A survey was created on the Google Forms platform and distributed on social media and at the station. Semi-structured interviews were conducted with an expert TAA from LTK.

6.3 Semi-structured interview

A semi-structured interview format was chosen, as it offers a balance between structure and openness (Kvale and Brinkmann, 2015). This approach enabled respondents to share

their experiences in depth and allowed new, relevant themes to emerge naturally during the conversation. Using this qualitative method provided direct access to key actors and helped generate a deeper understanding of their perspectives, experiences, and local knowledge. Prior to conducting the interviews, an interview guide was developed to ensure a systematic and focused collection of empirical data (Kvale and Brinkmann, 2015). The guide consisted of thematic and exploratory questions tailored to the respondents' expertise and the project's research focus. While structured, the guide was flexible enough to allow for follow-up questions and more fluid conversation, enabling deeper insights (Poulsen, 2019).

6.3.1 Respondents

To gain insight into the development of Lyngby Station, the project includes expert perspectives from individuals directly involved in the planning process. Experts were selected based on an ethnographic interview approach, which emphasizes participants' specialized knowledge of a specific context (Kvale and Brinkmann, 2015). The aim was to understand both the physical and social dynamics influencing the area's transformation. While experts are seen as knowledge carriers, their insights were supplemented with other methods to also capture citizens' subjective experiences and avoid treating expert views as absolute (Kvale and Brinkmann, 2015). LTK was contacted and provided contact information of TAA, an urban planner from the municipality. TAA was directly involved in the development strategy and participated in parallel workshops with local stakeholders, making him a key informant for the study. Additionally, two user interviews were conducted as well. Email addresses were collected at the end of a survey and potential interviewees were contacted. Two of the respondents responded and were able to meet for the interview.

6.3.2 Interview guide

The interview guide for expert interview was developed to gain a deeper understanding of the Lyngby Transport Hub. The main focus was on the Strategic plan that LTK published on its website (*Udviklingsplan for Kongens Lyngby Centrum* – Lyngby-Taarbæk Kommune (2023)), safety and climate resilience. The whole interview guide is presented in Figure 6.4.

EXPERT INTERVIEW
Opening
Can you tell us what your job title is and what you do?
Urban Development Plans
What are the specific plans for the development of the area next to the train station to create a diverse, green and vibrant city centre?
Are there any plans for redesigning Ulrikkenborg Plads?
What implementation solutions have you considered to ensure a strong commercial life and out-of-hours activities?
Mobility, Accessibility & Safety
How do these plans relate to the goal of improving ease and safety of movement in Kongens Lyngby Centrum?
What are the plans for improving safety in the area?
Are the impaired groups and minorities included in the redesign process?
Sustainability & Climate Resilience
How are you going to implement environmental and climate change needs? For example regarding the flooding in the tunnel under the train station.
Do you require recycled materials in renovation and redesign?
What are the plans for developing green and blue infrastructure?
Community Engagement
How does the municipality plan to involve local communities and stakeholders in these development processes?

Figure 6.4: Interview Guide for the Expert Interview

The interview guide for user interview was developed in connection to the chosen theories – ANT, MLP and Nudge, and it was also inspired by the answers from previously conducted survey. The interview focused on spatial navigation, accessibility, sustainability, and the users' needs and preferences. Figure 6.5 presents the full interview guide.

USER INTERVIEW
Opening
1. Can you tell me a little about your typical use of this station or surrounding public space?
2. How often are you here? What are you usually doing (commuting, waiting, meeting someone, passing through, etc.)?
3. How do you usually get to the station, and where do you go afterward?
Section 1: Navigating and Interacting with the Space
4. Can you describe how you usually move through this space? Are there routes or areas you use more than others?
5. Are there specific features (paths, signs, sounds, materials, people) that help guide your movement?
6. Have you noticed anything in the space that "nudges" you — encourages or discourages you — to behave in a certain way? (e.g., taking the stairs, avoiding certain areas, walking in a specific direction)
7. Do you feel that certain parts of the space are clearly "telling you" how to use them — like a path, a bench, or a sign? How do you respond to that?
Section 2: Inclusion, Accessibility, and Negotiation
8. Have you ever had to adapt your path or behavior in this space because something didn't work for you? (e.g., confusing layout, blocked route, lack of seating)
9. Are there areas or features in this space that make you feel especially included, welcomed, or safe?
10. Are there parts of this space you avoid — or that feel uncomfortable, difficult, or even unsafe for you?
11. Have you ever used something in a way it wasn't "meant" to be used? (e.g., sitting on a ledge, using a non-marked path, following others instead of signs)
Section 3: Sustainability & Behavior
12. Do you feel the space encourages people to act in environmentally friendly ways (e.g., walking, recycling, taking public transport)? How?
13. Have you ever changed your behavior in this space because of something subtle — like a sign, symbol, color, or placement of objects?
14. Are there things that make sustainable choices (e.g., biking, walking, using trains) easier or harder here?
Section 4: Reflective & Future-Oriented
15. What's one thing you would change or add to make this space work better for everyone?
16. Do you think the space is designed more for some people than others? Who benefits most from how it is now?
Optional (if relevant for longer interviews):
- If you had to name the most important "actors" (things, people, technologies) that help you use this space, what would they be?

Figure 6.5: Interview Guide for the User Interview

6.3.3 Transcription

The interviews were recorded through the Voice Memos mobile app, which also provided transcriptions. Those were later cleaned up to correct grammatical errors and typos.

6.3.4 Anonymisation

The interviewees are partially anonymous, as only their initials are provided. The transcription and use of their answers was later shared with the interviewees to get their approval.

6.4 Workshop

At first, the coducted workshop was meant to be based on the Future Workshop methodology. However, due to time constraints and lack of participants, improvisation had to take place. Future Workshop is a post-digital research method that encourages participants to use imagination to envision alternatives and create change in their surroundings (Suoranta and Teräs, 2023). The workshop is divided into four phases – **preparation**, **critique**, **fantasy** and **implementation**. Due to time constraints, this workshop lasts only 2 hours, encouraging participants to rely on their first impressions of the case area.

In this project's case, the participants are students from the Technical University of Denmark (Danmarks Tekniske Universitet – DTU). DTU campus is located in Lyngby, and the students often commute to Lyngby, using the Lyngby Transport Hub. As the workshop only had two participants, it was used to gather an overview of the issues, constraints and opportunities that are present at the Lyngby Transport Hub.

6.5 Survey

An online survey was created on the Google Forms platform. It was shared on social media groups, flyers were put up at Lyngby Transport Hub and at Lyngby Library, and people at Lyngby transport hub were asked directly to complete in the interview using a QR code.

An online survey was favored over an on-site survey in hope for higher response rates

Phase	Description
Preparation	This involves introducing the workshop method, deciding on a theme, and preparing the physical space.
Critique	Participants identify and critique problematic aspects of the chosen theme. They brainstorm ideas, often in smaller groups, before coming together to record and organise their criticisms into topics or clusters, using rules like avoiding over-discussion and focusing on quantity rather than quality.
Fantasy	Participants are encouraged to imagine alternative futures, drawing from their frustrations and experiences, without being limited by "obvious facts." They explore utopian solutions, and then choose the most exciting ideas to develop as suggestions.
Implementation	Participants critically evaluate the practicality of the ideas generated in the fantasy phase, considering possible obstacles and actions for the desired future. They present their "utopias" and develop more detailed plans to make them achievable, moving from imagination to practical application.

Figure 6.6: Workshop Methodology Phases

(Van Selm and Jankowski, 2006), and because of the other advantages, such as ease, speed, flexibility, automation, and no costs (Ball, 2019). The aim of the survey was to gather citizens' perspectives on the current state and potential of Lyngby Transport Hub, with a particular focus on movement patterns, mobility, safety, and environmental quality. The target group included local residents, commuters, and regular users of the Transport Hub. The goal was to include a broad range of perspectives from people who interact with the space on a regular basis.

The questionnaire included both closed and open-ended questions on topics such as perceived safety, accessibility, use of green areas, bike infrastructure, and suggestions for improvement. These topics were chosen based on previously conducted workshop with DTU students.

As with many online surveys, there is a potential for sampling bias, particularly in terms of reaching digitally active users or those already engaged with local planning discussions (Ball, 2019). The survey was open from 17th March to 5th April and received a total of 41 responses.

Vælg venligst et sprog: Please choose a language:	
Danish	**English**
Hvor ofte benytter du den offentlige transportknudepunkt (transport station) i Lyngby?	How often do you use the transport hub in Lyngby?
Hvad er årsagen til at du rejser til og fra Lyngby?	What are the reasons you are travelling to or from Lyngby?
Hvilke transportmiddel gør du brug af for at komme til og fra den offentlige transportknudepunkt?	Which mode of transport do you use to get to or from the transport hub?
Hvad er de først tre karaktertræk du tænker på når vi siger “Lyngby station”?	What are the first 3 characteristics that pop up in your head when we say “Lyngby station” or "Lyngby Transport Hub"?
Hvor tryg føler du dig på stationen på tidspunkt af dagen - Morgen (±7:00)?	How safe do you feel at the station during different times of a day - morning (±7:00)?
Hvor tryg føler du dig på stationen på tidspunkt af dagen - Middag (±12:00)?	How safe do you feel at the station during different times of a day - midday (±12:00)?
Hvor tryg føler du dig på stationen på tidspunkt af dagen - Aften (±18:00)?	How safe do you feel at the station during different times of a day - evening (±18:00)?
Hvor tryg føler du dig på stationen på tidspunkt af dagen - Nat (±22:00)?	How safe do you feel at the station during different times of a day - night (±22:00)?
Hvor nemt er det at navigere rundt på stationen, især når du skal skynde dig eller bære bagage?	How easy is it to navigate the station, especially if you are in a hurry or carrying luggage?
Nogen kommentarer til tidligere spørgsmål:	Any comments to previous question
Hvilke faciliteter og service tænker du at du mangler ved stationen som kunne forbedre din oplevelse?	What facilities or services do you think are missing at the station that would improve your experience?
Hvilke områder omkring transportknudepunkter har mest behov for forbedring/renovering?	Which area around the transport hub needs redevelopment/redesign most?
Er der noget specifik du gerne vil have tilføjet eller ændret ved?	Is there anything specific that you would like to see or change at the station?
Hvad er dit køn?	What is your gender?
Hvad er din alder?	What is your age?
Bor du i Lyngby?	Do you live in Lyngby?
Har du nogen bevægelses begrænsninger eller handicap som påvirker din oplevelse af transportknudepunktet?	Do you have any mobility limitations or disabilities that affect your experience at the transport hub?
Hvilke mobilitetsbegrænsninger eller handicap har du?	What mobility limitations or disabilities do you have?
Vil du være villig til at hjælpe os yderligere ved at mødes med os for en mere dybdegående samtale?	Would you be willing to help us further by meeting with us for a more in-depth conversation?
Udfyld venligst din e-mailadresse (i "Other"-muligheden):	Please fill out your email address (in the "Other" option):

Figure 6.7: Overview of the Questions in the Survey

6.6 Behavioural mapping

The following section draws exclusively on Bishop et al. (2024), which provides a comprehensive overview of the topic.

y Behavioural mapping is a structured observation technique used to systematically record people's behaviour and movement patterns in a particular environment. This method observes environmental psychology and captures how actors interact with the physical space. It provides insight into what spatial usage patterns and activity distributions may occur from actors in the selected location. The method is often used in urban studies, environmental planning and post-change evaluations to assess how spaces function and how they can be optimised.

The main purpose of behavioural mapping is to analyse the interactions between people and the environment by identifying the behaviours exhibited as a function of time. Behavioural mapping is a useful method especially in urban and spatial research, as alternative methods can provide different data that may be unreliable due to social desirability, recall errors or lack of awareness of habitual behaviour. Therefore, by directly observing actor behaviour, this research enables authors to document objective and data on how space is used and by whom. However, there are also limitations to behavioural mapping, including the fact that it is not possible to understand the significance of the perception, judgement or motivation of each individual observed using this technique. Therefore, no definitive assumptions can be made as the method can only be used to record what was observed.

Behavioural mapping aligns with this perspective by linking observed behaviour:

- Specific locations (e.g., areas with high or low activity levels).
- Physical environmental features (e.g., seating areas, green spaces, pathways).
- User demographics (e.g., children, women, elderly, people with disabilities).
- Temporal variations (e.g., behaviour changes across different times of the day or week).

By mapping these relationships, authors gain empirical insights into spatial use, supporting the development of data-driven urban planning strategies.

Behavioural mapping typically follows a structured approach consisting of the following

steps:

1. **Preparing a site plan:** A detailed floor plan or spatial layout is created to define observation zones and ensure accurate documentation.
2. **Defining behavioural categories:** Activities of interest are categorized, such as walking, sitting, socializing, or interacting with infrastructure.
3. **Developing a sampling plan:** Decisions are made regarding observation timing and frequency, ensuring representative data collection.
4. **Standardizing observation procedures:** Observers record behaviours systematically, reducing subjectivity and ensuring consistency.

6.7 Non-participant observation

In non-participant observation studies, the main approach is that the researcher does not engage or interact with the people being observed – the researcher can be considered an outsider. The role of the researcher is to observe behaviours, interactions, and environmental patterns passively and unnoticed (Kawulich, 2005). The decision to choose this method is because it is commonly used in urban studies. According to that non-participant observation method is also used cause it was decided that it would support the previously mentioned method, behavioural mapping, to collect objective data from the case area.

Non-participant observation methods are often used to overcome social desirability bias (SDB) issues that can occur when conducting self-report methods. SDB is a tendency for individuals to want to represent themselves in a favorable or socially desirable way instead of acting or responding based on their own characteristics or views. This bias can affect the validity of self-report measures and is one of the reasons why some researchers favour non-observational methods when possible (Kawulich, 2005). In this case, it is debatable how the subjects could react in a different way even though they knew they were being observed, but for the sake of validity it was decided to keep it professional and stick to the methodological approach. Another advantage of using non-participation is that the researcher does not need any approval or requirement from the participation because they were not directly involved (Cooper et al., 2004).

The observation was focused on following objectives:

- Activity
- Starting time
- Finishing time
- Age group
- Gender
- Alone or accompanied
- Location
- Other remarks

6.8 Literature Review

The purpose of the literature review is to identify and assess the existing academic literature on public space near transport hubs[1].The literature review investigated which literature studies have analysed people's experiences of transport hubs and which elements should be taken into account in urban design – with the intention of improving accessibility, safety and sustainability (Knopf, 2006). It was essential to include literature that highlights studies conducted in different geographical and contextual contexts. The intention was to gain a nuanced understanding of the varied challenges and opportunities that public spaces around transport hubs can hold in relation to implementing sustainable solutions. In the context of the ambition to develop a framework that can be applied in municipal contexts other than Lyngby.

The literature review was conducted according to the Principle of 'Minimizing bias in systematic reviews' (Okoli and Schabram, 2009).

When conducting a literature review, it is important to determine which of the often large sources comes from original research studies with an opaque methodology (Knopf, 2006).

6.8.1 Literature search strategy

Four databases were used for finding literature: Google Scholar, Primo (Aalborg University's search engine), Sage Journals and Scopus.

An informal time frame was applied in order to focus on the most recent publications,

[1]Brand et al. (2021); Grindsted et al. (2024); Tuvikene et al. (2023); Tran and Hyeong (2023)

prioritizing the latest updated literature available.

In the first step, the keywords ('urban space', 'transport hub', 'areas close to train station', urban space next to transport hubs', 'public space, train') were defined (Okoli and Schabram, 2009). Next step required exclusion of articles not relevant for the focus and scope of the project (Okoli and Schabram, 2009). Initially, literature focusing on urban space in general was assessed, and the decision to narrow the scope down to public spaces around transport hubs was taken later.

6.9 Generative Artificial Intelligence use

Generative AI language model ChatGPT by OpenAI (2025) was used in this project for LaTeX codes generation, fixing grammar errors and helping with structure of the chapters. DeepL Translator (DeepL SE, 2025) was used to translate written text from Danish to English. Additionally, NotebookLM: AI powered Research Assistant (Google, 2025) was used in the first phase of reviewing and comparing scientific articles. All contributions were critically evaluated, revised and edited by the authors.

CHAPTER 7

ANALYSIS I.

The first analysis addresses the first sub-question by drawing on qualitative data, including interviews and survey responses. The site – Lyngby Transport Hub – is further examined through non-participant observation and behavioural mapping. These methodologies are employed to identify the strengths and weaknesses of the Lyngby transport hub. The insights gathered form the basis for the development of a Framework, further introduced in Chapter 8.

Sub-Question 1

How can user experiences reveal the strengths and shortcomings of the Lyngby Transport Hub?

7.1 Site Analysis

To answer the first sub-question of how the users experience reveal the strength and shortcoming of the Lyngby Transport hub, site analysis was done to gain a deeper understanding of the case area's patterns and environment. Literature on public spaces linked to transport hubs was reviewed, specifically focusing on the Lyngby Transport Hub. The literature provided valuable insights into the challenges train stations and surrounding areas face, which was considered in the Framework's development.
The exciting and unique thing about transport hubs is that the areas are active almost all hours of the day and night (Strandbygaard, 2021). It was necessary to identify how the case area at Lyngby Transport Hub functions in both its busy and quieter hours.

7.1.1 Passenger Numbers and Role of Lyngby Station

As mentioned in the Problem Orientation, Lyngby Transport Hub is one of the busiest stations in Denmark (Passagertal.dk, 2025). The Danish Transport Authority's OD-

matrix (Origin-destination matrix) presents annual number of journeys made on Danish national railway lines and train stations in 2019 (Trafikstyrelsen, 2020). However, these figures exclude journeys made only in the metro or on non-state railways. The Danish Transport Authority's OD matrix describes the total journey from the first boarding to the last disembarkation. This means that a journey from A to B is counted as one, regardless of the number of changes along the way (Trafikstyrelsen, 2020). Empirical data from the Danish Transport Authority support the picture of how busy the Lyngby Transport Hub is.

The year 2019 was chosen to look at, as both numerical data on passenger numbers and boarding figures are available. Lyngby Station belongs to the Hillerød line served by both S-train lines A and part of E (Passagertal.dk, 2025). In 2019, 13,285,574 passengers travelled the line from Jægersborg towards Lyngby station, and 10,190,305 passengers travelled from Lyngby to Sorgenfri (Trafikstyrelsen, 2020). It is not possible to read individual travel relations, as the map only shows the number of travellers on sections and at stations. To put the number of passengers on the state railway lines in perspective, Lyngby Station is located on the line that is considered to be the second most active (Trafikstyrelsen, 2020). The Danish Transport Authority's data collection shows that in 2019 there were 3,308,822 boardings at Lyngby Station. 'Boardings' is defined and counted as every time there is a change of means of transport in the form of bus, train and/or metro, where the number of passengers is counted as one, regardless of how many means of public transport are used during the journey from A to B (Passagertal.dk, 2025).

7.1.2 Fingerplan and Future Light Rail

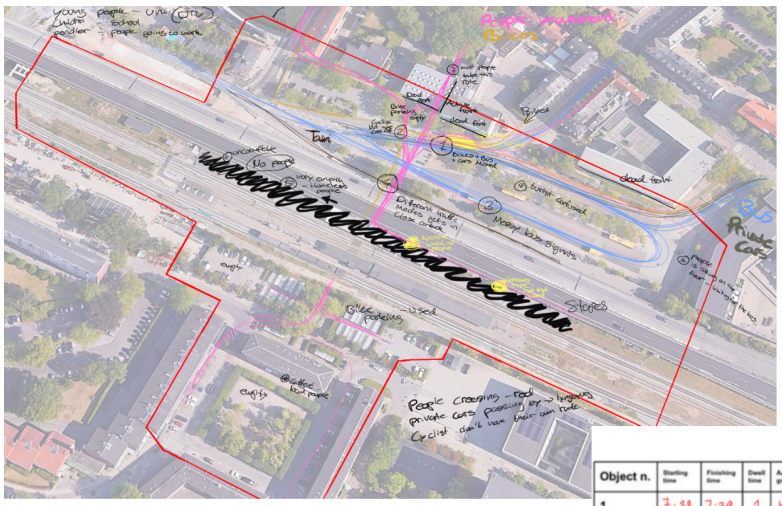
Lyngby-Taarbæk is one of the 34 municipalities that are part of the National Planning Directive for metropolitan area planning – Fingerplan 2019 (Erhvervsstyrelsen, 2019). The purpose of Fingerplan 2019 was to prepare an overall framework for physical planning in the metropolitan area in Denmark. The focus is to concentrate housing, trade, businesses, public institutions, etc. around a well-developed infrastructure in the cities covered by the Fingers, as well as to take into account areas between and outside the Fingers covered with green wedges, smaller urban communities and agriculture (Danish Planning and Rural Development Agency) (Erhvervsstyrelsen, 2019). Lyngby belongs to Hillerød Finger along with other stations such as Hillerød, Lillerød, Birkerød,

Holte, Farum, Værløse, Bagsværd, Virum and Sorgenfri (Erhvervsstyrelsen, 2019). Having Lyngby Transport Hub as part of the Fingerplan can support the site analysis, as the Fingerplan includes rules and plans that must be complied with for the different cities and stations to be part of it (Erhvervsstyrelsen, 2019). It is also important to take into account that the functions of the case area must also be seen and understood in a larger context. According to the latest counts from the Danish Transport Authority, in 2024 there were 3,725,853 boardings on the Hillerød Line at Lyngby Station, which places the station among Denmark's ten busiest stations (Passagertal.dk, 2025). Furthermore, several reports indicate that the use of public transport should increase in the coming years (Solá et al., 2017). For the Lyngby Transport Hub, this will also be a reality that the area must take into account (Lyngby-Taarbæk Kommune et al., 2023). Lyngby is part of the project for a future light railway that will run from Ishøj to Lundtofte. It is expected that between 13 and 14 million passengers a year will use the light rail, which should result in more people having a change at Lyngby transport hub (Lyngby-Taarbæk Kommune, 2025).

7.1.3 Behavioural Mapping, Observation and Movement Patterns

Through a combination of behavioural mapping and non-participant observation, an understanding of how the case area functions at different times and how the area is used by whom has been achieved. Behavioural mapping has been an important methodological tool in the site analysis in order to get a systematic overview of how the area is actually used and the users' movement patterns - and not just how it is designed to work (Marušić and Marušić, 2012). At the same time, non-participant observation was chosen, where the authors took a withdrawn and non-interacting role when observing the area (Cooper et al., 2004). Using non-participant observation, the authors recorded who uses the area, how they move, where they stay, and how they react to their surroundings (Cooper et al., 2004). Figure 7.1 illustrates which registrations, notes and mappings were made of the case area to be analysed. Repeated observations have been carried out over time, where movement patterns for the different means of transport have been manually written and drawn on a map of the area. Through behavioural mapping, it became clear that there are hardly any people staying for long

periods of time in the area around the station. Users move quickly through the different transport modes, such as train, bus, bike and shop. This indicates a weakness in the area's ability to support longer stays, social interactions and breaks. In addition, it was possible to identify patterns of passage and so called 'desire lines' (Pacetti et al., 2012). The method showed that most users follow very specific routes – especially when travelling to and from the tunnel, the majority chose to cross the pedestrian zone and then turn right through the shopping arcade. Therefore, there was minimal variation in the way people moved. Except for those who chose to walk behind the arcade, which is illustrated with the pink string on the map. The informal desire lines reveal how people cross roads and paths where it is not intended, where it can be inferred and revealed where clearer and more intuitive infrastructure is missing. The intersection of bus lane, pedestrian crossing and cycle path was the main area that was rated as unsafe and problematic. In addition to this, a conflict was also observed between pedestrians, cyclists, private motorists and the bus terminal due to their intersecting movement patterns. This creates uncertainty for pedestrians and cyclists. One participant in the future workshop described an incident where a private car followed a bus and failed to notice them crossing near the pedestrian crossing—though fortunately, the driver stopped in time to avoid an accident. This confirms the uncertainty of mixing lanes for both buses and private motorists, where one might think that during rush hour periods both parties want to get through quickly. Mixing these modes of transport together also creates a traffic jam, as some drivers might use Jernbanepladsen as a through route to save time by not driving on Hovedgade in Lyngby. At the same transition between station and bus terminal, there was no signage or other clear markings informing users which buses go where, or which roads lead to where. It is therefore possible to argue that there is a design weakness and lack of separation of traffic modes. Using both behavioural mapping and non-participant observation, it was possible to categorise the users of the area. There was a clear majority of young and adult commuters who had very similar everyday movement patterns during rush hour periods. A small number of older users were observed to use the area differently by utilising the arcade's shopping facilities. A number of children and young people were also observed using the bus as well as the older generation. Despite the bike path and bicycle parking at the transport hub, minimal numbers of cyclists were observed in the area. This could be due to the



Lyngby Station Observation

Object n.	Starting time	Finishing time	Dwell time	Age group	Gender	Alone/ Accomp.	location	activity	remarks
1	7:38	7:39	1	45	M	al	T/M	shopping	bus
2	7:40		1	45	M	al	FoS	crossing road (on foot)	bike
3	7:41		1	40	W	al	FoS	— " —	bike → parking
4	7:42		1	25	W	3	FoS	crossing 1st on bike	
5	7:44		/	40	W	al	FoS	walk to train	
6	7:49			15	M	4	FoS	bike from train	on a sidewalk
7	7:52			30	M	1	FoS	BIT	fixing a bike

Figure 7.1: Behavioral Mapping, Appendix 3F

fact that people who would use bicycles feel it is too complicated and unsafe to navigate around the area. In addition, the observations showed that many users avoided staying in the shopping arcade, even though it is designed to provide passage and potential seating in the form of benches. The closed, dark and slightly unsafe character of the area made it uninviting, which is not visible in the floor plans for the area.

However, despite the above mentioned challenges, the observations also revealed some strengths of the area's planning, such as the fact that most bus stops were sheltered and quiet, and that the connection between modes of transport is relatively short and efficient – even if it is unsafe.

7.1.4 Spatial Weaknesses and Lack of Safety

Throughout the observations, it was clear that people did not stay for long periods of time and that the area was very much characterised as a transit area. Hardly anyone sat down, took breaks or used the space as a social space. This lack of 'quality of stay' could be identified as a weakness, due to a lack of recreational value and social inclusion. The observations also confirmed the lack of natural surveillance, referred to as 'eyes on the street' in certain parts of the area (Strandbygaard, 2021). Without that, the area can quickly feel empty and unsafe, especially in the darker hours of the day (Brown et al.,

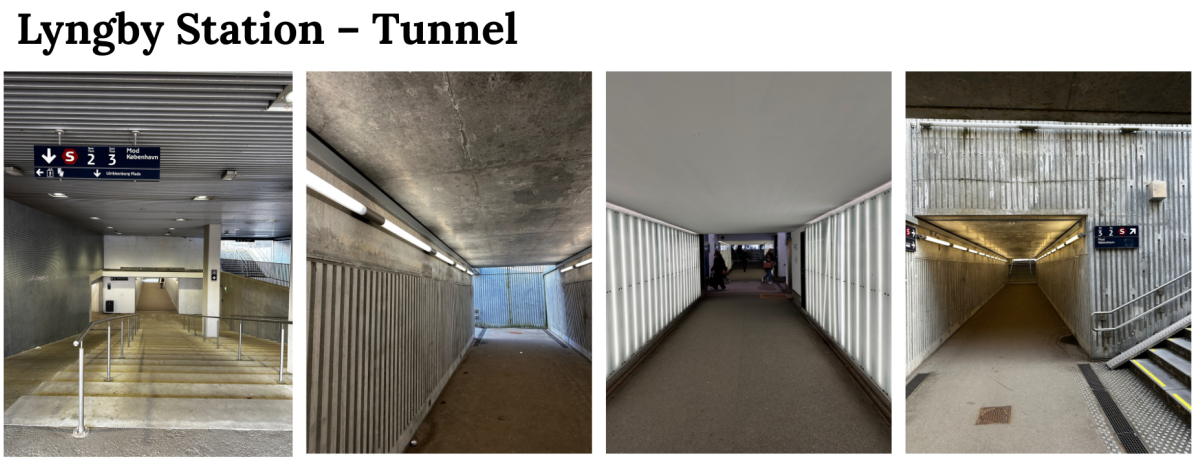


Figure 7.2: The Tunnel at Lyngby Transport Hub

2008). Especially in and around the tunnel and the shopping arcade, there was a lack of lighting, active facades and clear sightlines to make the urban space feel safe, vibrant and more inclusive around the station.

Conclusion

By combining behavioural mapping and non-participant observation methods, it has been possible to identify both strengths and weaknesses in Lyngby Transport Hub. By focusing on how user behaviour provides an honest and undisturbed picture of how the area is used, as well as which weaknesses and strengths could be identified in relation to accessibility, safety, clarity and recreational value.

Summary of the Site Analysis

Site analysis is an important part of the project as it helps to understand how transport hubs in cities (both in general and in the case area) function and interact with the actors and actants.

Role of the Station: Lyngby Station is considered to be the second most active station on the A and E line (Hillerød line) of the S-Train system (Trafikstyrelsen, 2020), and one of the 10 busiest stations in Denmark (Forbrugerrådet Tænk, 2019a).

Fingerplan and Light Rail: The Finger Plan for Copenhagen includes Lyngby as one of its 'Fingers,' designating it as a well-developed urban area with a concentration of housing, businesses, and public institutions (Erhvervsstyrelsen, 2019).

Methods: The methods used for site analysis were behavioural mapping and non-participant observation. These methods provided an overview of how the transport hub and the area around it works, how it is used, how the actors and actants behave and influence each other.

Spatial Weaknesses and Lack of Safety: The area of the transport hub does not feel very safe, as it lacks natural surveillance, for example quality lighting and active facades.

7.2 Qualitative Data Analysis

This section introduces the qualitative data collected from an expert interview with the urban planner TAA from LTK, survey and user interviews with two users of the Transport Hub in Lyngby.

7.2.1 Expert Interview

The expert interview was conducted on the 19th March 2025. Figure 7.3 summarizes the main questions and points discussed. Mostly, the focus was on the area that spreads from the train rails to Lyngby Hovedgade.

The most burning issue is the "searching-for-a-parking-spot" traffic. LTK therefore wants to build a new parking facility on the Jernbanevej. To create a better, easier and safer environment for cyclists, LTK plans to potentially make Lyngby Hovedgade a

one-way road (south to north) and leave one side of the road for a bike lane. TAA acknowledges the confusing layout of the bus terminal and agrees that it is in need of redesign, however, it is also partially Movia's responsibility. Therefore, the next steps relating to the bus terminal must be consulted with Movia as well. As Lyngby Transport Hub is used by many people during all times of the day, safety is one of the major priorities. LTK would like to have mixed functions of buildings around the transport hub, to enhance the "eyes-on-the-street" principle.

The current development follows a strategic plan approved in late 2023, developed through an architectural competition and political workshops. While the plan is not legally binding, it sets out six urban strategies that guide future development. Citizen feedback was indirectly integrated through public input gathered by competing design teams. LTK is also exploring sustainability measures, such as the reuse of existing cobblestones and the preservation of mature trees where possible. Furthermore, wayfinding and navigation around the station are recognised as problematic and will be addressed in coordination with Movia. Another important aspect is climate adaptation: the station area is part of the wider KALC project, which includes plans for underground water tunnels to prevent flooding, especially in the tunnel under the tracks.

The expert interview with TAA provided valuable insight, highlighting that it is not always effective to test experiments or implement changes solely at the niche level. In the context of larger urban spaces, addressing challenges often requires coherent, integrated solutions that align with broader objectives (Solá et al., 2017). When municipalities want to design public spaces, they should not only focus on individual projects, but rather see them as part of a broader systematic transition. In addition, smaller pilot projects in areas such as green stormwater management, biodiversity-enhancing planting or inclusive urban design can act as niches that challenge existing urban design at the regime level. But to create lasting change, those niches need to be underpinned by political support, which must resonate with the broader landscape of societal goals, such as the UN Sustainable Development Goals (Geels, 2011; Fleming et al., 2017).

The expert interview transcript is available in Appendix 4A.

Topic/Question	Answer + Quotes
Information about the strategic plan	A strategic plan was approved in autumn 2023, not legally binding but guiding development. It was created via competitions and workshops with politicians. **Quote (line 25-26):** "It doesn't regulate the area. It's a strategic plan... comprised of a strategy, six urban strategies."
Information about the current traffic situation	High car traffic caused by search for free parking, even though parking capacity is high. **Quote (line 53-54):** "People search for the free parking spaces and that generates a lot of traffic."
New parking facilities – why?	To simplify parking and reduce search traffic; funded partly through a light rail loan. **Quote (line 38-40):** "We got money from the light rail company as a loan to be able to build a parking structure."

Figure 7.3: Expert Interview Preview; Appendix 3A

7.2.2 User Interviews

Two user interiews were conducted on the 22nd April and 1st May respectively. The first respondent, MVL, is male, Swedish, traveling to Lyngby from Malmö. The second respondent, BMH, is a Danish woman traveling to Lyngby from Birkerød.

Both respondents agreed that the front of the station – whether it is the close car traffic, finding the right bus stop, or crossing the road – can be confusing and frustrating. MVL would like to see a new tunnel built under the car road, while BMH would move the traffic further from the train station itself. Both would like to see a better wayfinding system.

Transcript of the interview with MVL is available in Appendix 4B. Interview with BMH was not recorded, but detailed notes were taken.

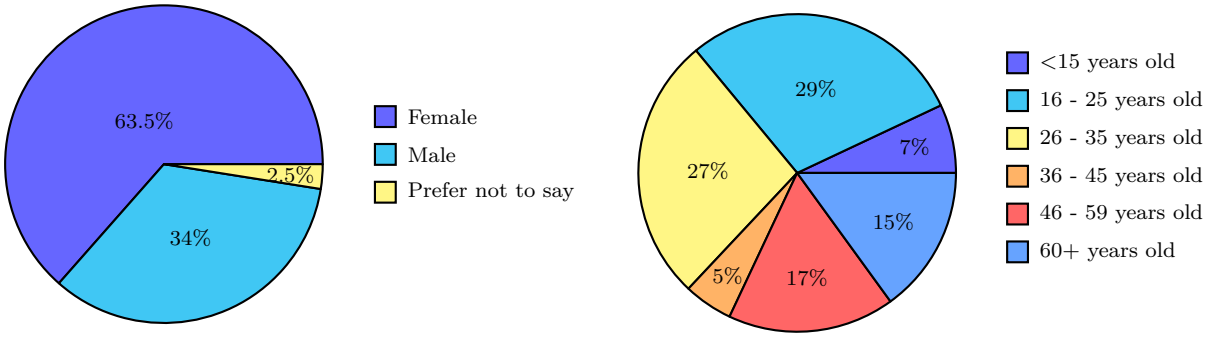
Topic	MVL	BMH
Typical Use	Takes bike to Malmö station → train to Copenhagen → S-train to Lyngby → uses second bike to reach DTU. Reverse in the afternoon.	Shopping. From Vesterport to Lyngby and then to Birkerød.
Frequency	Every weekday since August 2022	A few times per month, usually weekends
Time of Use	~8:35–8:55 in the morning, ~16:35 in the afternoon. Sometimes later on Mondays or for leisure travel.	Similar daytime hours; occasional off-hours for events.

Figure 7.4: User Interviews Comparison Preview; Appendix 3B

7.2.3 Survey Analysis

Identified Users of the Transport Hub

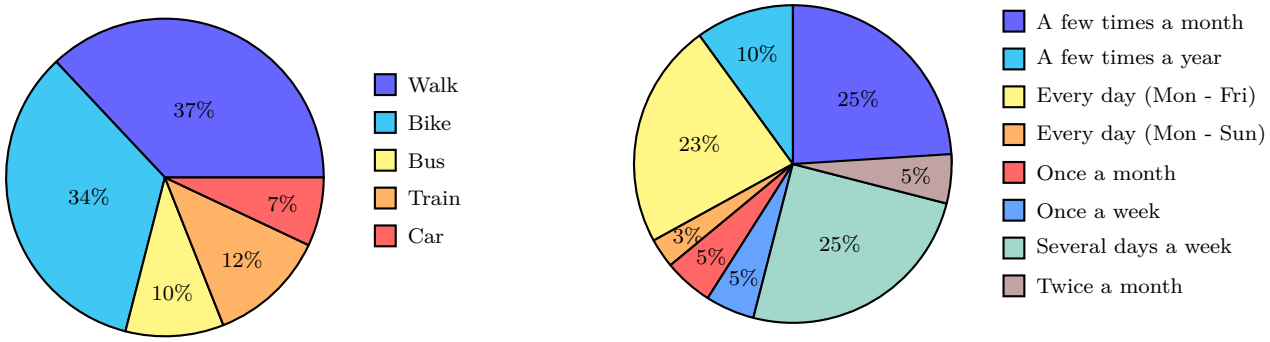
The survey was conducted with 41 respondents, with a significant proportion being women. The age group of respondents predominantly ranged from 16 to 35 years old.



(a) Gender (b) Age

Figure 7.5: Demographic Distribution of Survey Respondents

In terms of transportation to Lyngby Transport Hub, most respondents either walk or bike. Bus, train, and car use were less common among the participants. The majority of respondents reported using the hub several times a month or on workdays.



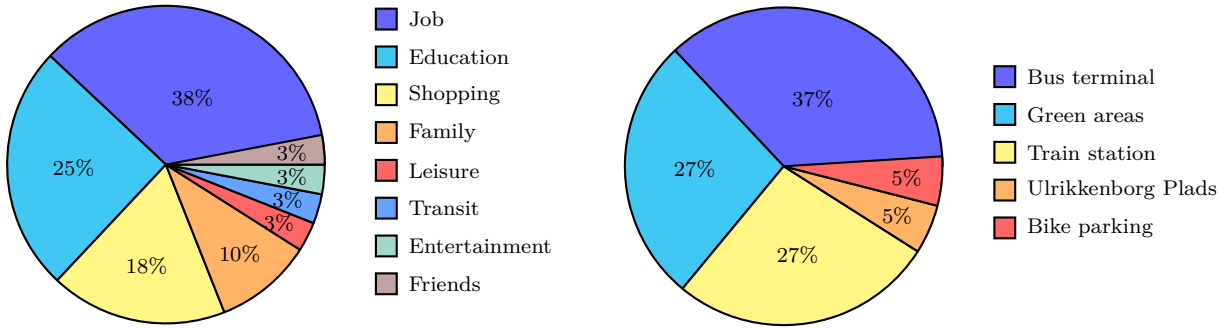
(a) Modes of transport (b) Frequency of visits

Figure 7.6: Survey Data on Transport and Visit Frequency

When asked about the main reasons for using Lyngby Transport Hub, most of the respondents mentioned commuting to work, school, or shopping. Regarding potential improvements, respondents highlighted the bus terminal, green spaces, and the train station as areas most in need of redevelopment or redesign.

Feelings of Safety

The feelings of safety distributed by gender and time of the day are shown in Figure



(a) Reasons of visits

(b) Areas that need redesign most

Figure 7.7: Survey Data on Visit Reasons and Areas for Redesign

7.8. No correlation was found between gender and the feeling of safety using the Mann-Whitney U statistical test. The charts below indicate a slight tendency towards feeling somewhat unsafe at night for both genders.

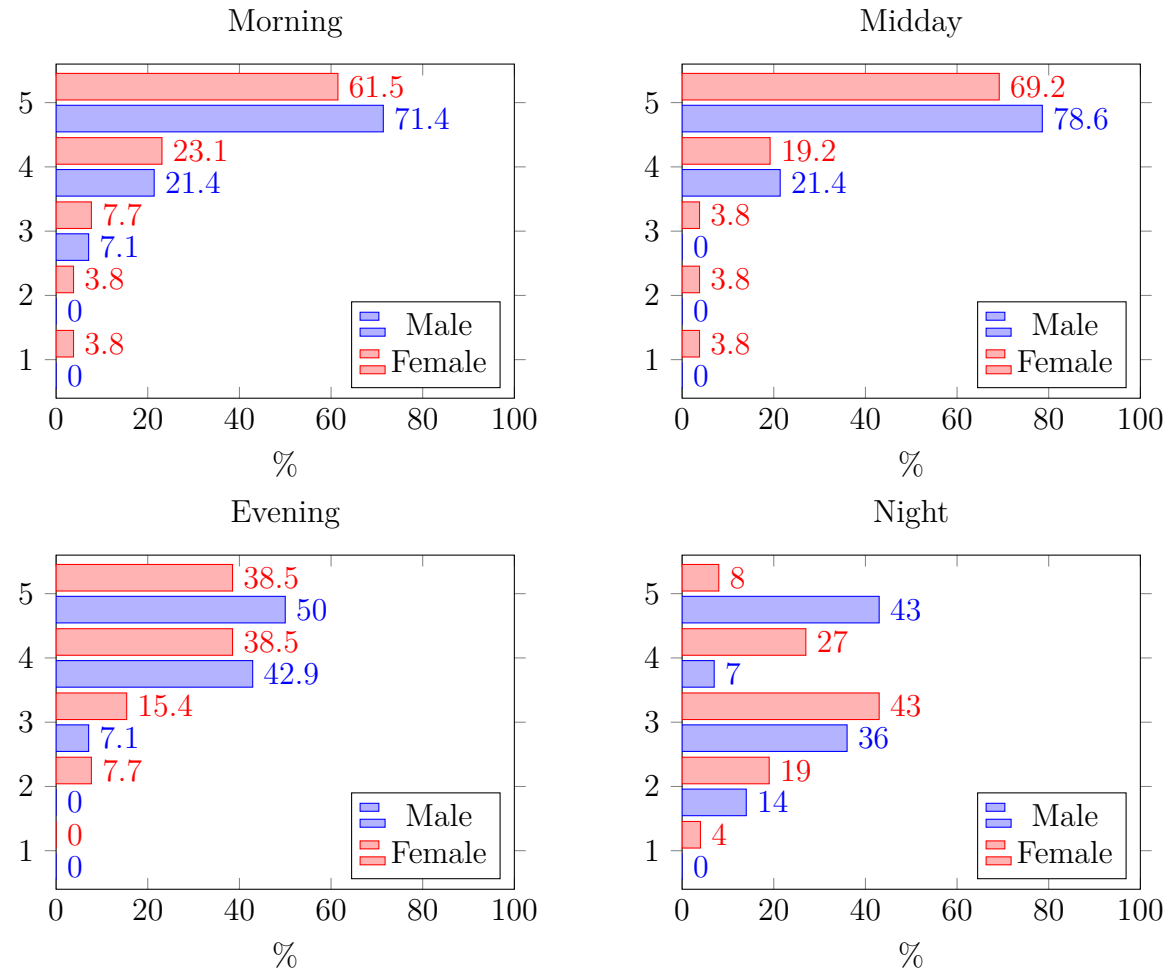


Figure 7.8: Comparison of Perceived Safety at Different Times of the Day; Y axis scale: 1 – very unsafe, 5 – very safe

Open-ended questions results

The survey contained these open-ended questions:

- What are the first 3 characteristics that pop up in your head when we say “Lyngby station” or ”Lyngby Transport Hub”? – Figure 7.9
- How easy is it to navigate the station, especially if you are in a hurry or carrying luggage? – this was a Likert scale question with a possibility to add comments
- What facilities or services do you think are missing at the station that would improve your experience?
- What facilities or services do you think are missing at the station that would improve your experience?
- Is there anything specific that you would like to see or change at the station? – Figure 7.10

Answers were divided into categories – in figure 7.9 the categories were distinguished by one word which was repeated (e.g. boring, messy, old); in figure 7.10 the categories were distinguished by a similar topic mentioned in the answers (e.g. navigation and wayfinding, facilities and services). The survey confirmed that users of Lyngby

Word	Quote(s)	Category	Categories Summary
Chaotic	"Chaotic, lack of signs, transport", "Chaotic, slightly worn, busy", "Chaotic, big, boring", "Messy"	Crowding and Chaos	Describes the feeling of being overwhelmed by the large number of people and chaotic organization. Key words: chaotic, busy, unsafe.
Busy	"Really packed in the morning", "Lots of people, always some transport going", "Full of life", "Many people", "Busy, crowded"		
Unsafe	"Dark, busy, unsafe (in the evening)", "High chance of bike theft, even in the basement with surveillance", "Unsafe"		
Transport	"Fast change of transport", "Good connections to bus and train", "Large pedestrian crossing"	Positive Features (Transport)	The station's strong connections to various modes of transport are seen as a key benefit.
Punctual	"Punctual"		
Flexibility	"Flexibility and large"		

Figure 7.9: Respondents’ Comments Preview – Open-Ended Question number 4; Appendix 3C

transport hub expressed a clear sense of insecurity and disorder in the area. A majority of the respondents described the area as chaotic, messy and busy (Appendices 3C, 3D), indicating that the existing urban space does not sufficiently support safe and intuitive

mobility. This is particularly critical in the transition between modes of transport, where the design of the bus terminal was highlighted as difficult to navigate and understand which bus goes where. The respondents expressed a clear desire for

Category	Comments	Conclusion
Navigation & Wayfinding	Now it is very easy since I already know where the busses/trains I'm interested in go from but I remember it was quite challenging when I didn't know it or when I take a bus I usually do not take.	Many users find navigation difficult, especially for first-time or infrequent visitors. There is a clear need for improved signage, maps, and more intuitive wayfinding systems to help people locate the correct platforms and bus stops. Even those familiar with the station note that the layout is confusing without prior knowledge.
	It's very easy because I know the station very well.	
	Very poor signage about which buses run where	
	Hard to find the right bus station	
	Which track should I take, up or down?	
	It can be difficult to find the right bus.	
	There are a lot of signs, but from a distance it is impossible to find your way around as a new or non-regular user.	
	Better overview of buses, proper toilets, more attractive shops/restaurants along Lyngby station, *some green areas (there is a lot of asphalt)*	
	It would be good with some bigger signage or a possible map showing where each bus stop is and in which direction.	
	Easier way to find your bus	
	A little more green and better navigation info in the bus terminal	
	A guide or better directions	
	Several check-in and check-out stands + very clear signs about which tracks lead where.	
	It can be difficult to find your way around the different bus stops and know which direction they are going.	
	Better bus signage	
	A map of bus stops	

Figure 7.10: Respondents' Comments Preview – Open-Ended Questions number 10, 11, 13; Appendix 3D

improvements that would facilitate orientation and enhance the overall experience of the place. In particular, the need for clearer signage and visual clarity were emphasized as key solutions, showing that the space currently lacks legibility and intuitive movement patterns. These elements are crucial to ensure accessibility and usability in a complex transport space.

Furthermore, several respondents reported that they regularly cross roads without pedestrian crossings or ignore traffic signals, pointing to serious disconnections between design intent and actual user behaviour. This supports a diagnosis of the site as a fragmented zone with weak connections between the different modes of transport, where the design in practice does not support safe transition zones. At the same time, many emphasised the desire for green spaces, highlighting a lack of recreational zones in the area – something that could also contribute to both climate resilience and longer dwell time.

Figure 7.11: Road Crossing, Bus Terminal and Exit from the Trains at Lyngby Transport Hub

Answer to Sub-Question 1

How can user experiences reveal the strengths and shortcomings of the Lyngby transport hub?

Several qualitative data collection methods, such as observations, behavioural mapping and semi-structured interviews, were used to explore the shortcomings and strengths of Lyngby Transport Hub. Mostly, the respondents mentioned crowds, chaos, lack of navigation signs, bad aesthetics and mess. However, the positive characteristics included punctuality of the trains, access to several stores right at the station and convenient location of the Transport Hub.

Neither the survey nor interviews have revealed any strong feeling of unsafety, although some respondents mentioned they are scared of a bike theft or they feel endangered by the dense private traffic.

CHAPTER 8

ANALYSIS II. – FRAMEWORK

This chapter presents the outcome and the ultimate goal of the project, and the answer to Sub-Question 2 – Framework developed as a tool for municipalities which wish to enhance the social and ecological sustainability in the public spaces located around transport hubs. As this Framework is developed mainly as an urban design tool, political or economic factors are not included, as these can vary from municipality to municipality.

The main purpose of the Framework is to collect the important objectives, variables, strengths and shortcomings that influence public spaces. The reason for that is to visualize how they relate and interact with each other to create a strong usable Framework independing on the scale of Municipality. The Framework shall help municipalities during research and planning processes to come to coherent solutions.

Sub-Question 2

What steps should municipalities take to redesign public spaces around Transport Hubs into environmentally sustainable, socially inclusive and accessible?

8.1 Feedback from the Municipalities

The Framework was developed in three phases. In the first phase, it was pre-designed based on a literature review, site analysis, and qualitative data (Chapter 7 – Analysis I.). In the second phase, the Framework was presented to representatives from the Lyngby-Taarbæk and Roermond Municipalities. Finally, the third phase incorporated feedback received from both municipalities to refine and strengthen the Framework.

Organisation

The following sections dive deeper into the concepts. Firstly, the basic characteristics of the concepts are introduced, followed by checklists – questions that municipal planners

should ask themselves to characterize the public space. These questions can be asked both before and after the design process. Asking them before will allow to gain an overview of the public space, while asking them after will help with evaluating the design proposal. The Framework is available in Appendix 5.

8.2 The Five Concepts

The Five Concepts function as the main pillars of the Framework, and they are based on the SDG targets and the topics mentioned in the survey and interviews. Figure 8.1 illustrates the interconnection of all the concepts, with the Social Factors overarching all the others. Figure 8.2 presents the relevant SDG targets, expert opinions and user

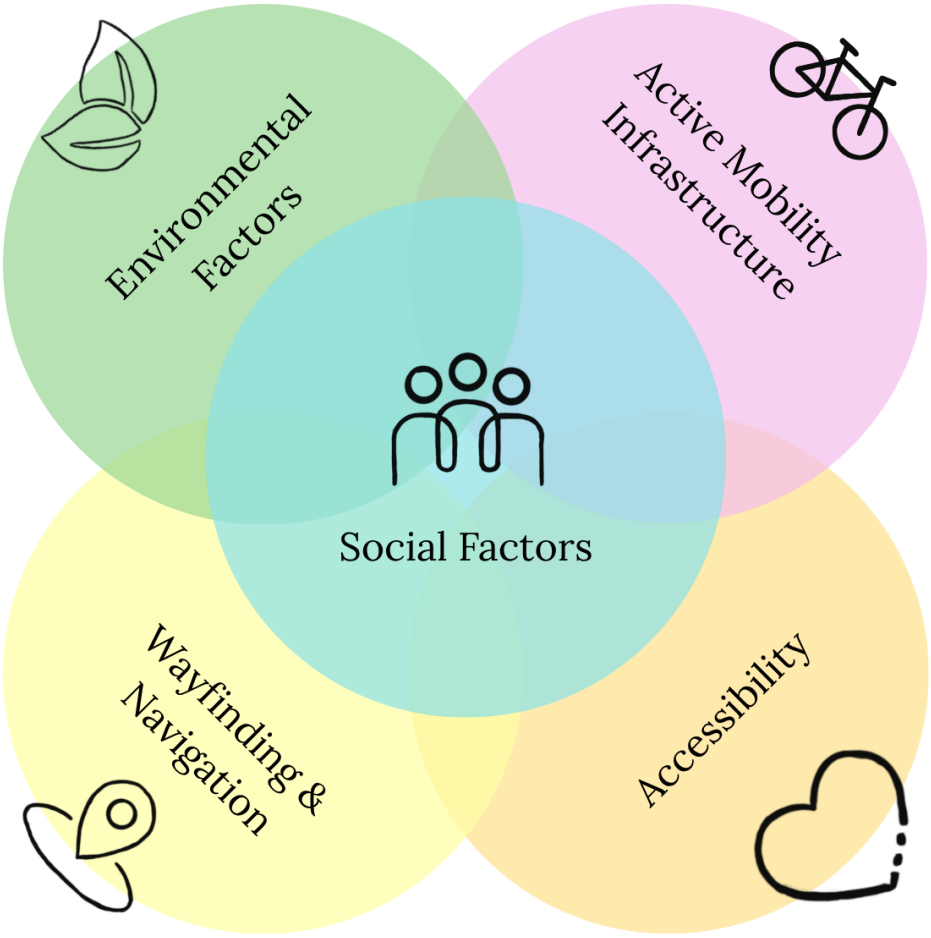


Figure 8.1: The Five Concepts

opinions. Four out of five concepts are directly related to at least two of the SDG targets. However, the concept of Wayfinding and Navigation was developed only as a response to the users' needs, as it was mentioned in both the survey and interviews regularly.

Evaluation of The Five Concepts How were the concepts developed?		Social Factors	Environmental Factors	Wayfinding & Navigation	Accessibility for Impaired People	Active Mobility Infrastructure
SDGs	**9.1** Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	☑	☐	–	☑	☑
	11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels	☐	☑	–	☑	–
	11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	☑	☐	–	☑	☑
	11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	☑	☑	–	–	–
	11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	☐	☑	–	☐	☐
	11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	☑	☑	–	☑	☐
	12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	☑	☐	–	☐	☐
	13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	☑	☐	–	☐	☐
Other sources	**User Interviews**	–	–	☑	☑	☑
		–	–	lack of navigation and signs	inaccessible for VIPs	(un)safe environment for pedestrians and cyclists
	Expert Interview	☑	☑	☑	☑	☑
		Safety is a concern, especially at night. Future plans will include better lighting, more activity, and ground-floor functions.	Green areas to be made more cohesive; blue infrastructure focuses on the Fæstningskanalen and underground water catchment.	Confusing layout of the bus terminal; redevelopment will focus on making it clearer and more efficient. Poor signage and wayfinding noted; improvements will be included in future redevelopment.	The organizations connecting impaired people join discussions and development planning	Plans to implement a one-way street with a bike-priority lane, especially on the sunny side.
	Survey	☑	☑	☑	–	☑
		(un)safe environment for pedestrians and cyclists	People want more green spaces, benches, and shelters.	lack of navigation and signs	–	(un)safe environment for pedestrians and cyclists

Legend	
☑	directly related
☐	indirectly related
–	unrelated

Figure 8.2: Development of The Five Concepts; Appendix 3E

8.2.1 Social Factors

To create safe and inclusive public spaces around transport hubs, it is important to acknowledge a number of social factors. The public space should be accessible to all, which will strengthen the sense of community and promote quality of life for both current and future generations. An urban space that incorporates different living and activity zones that cater to different age groups and social needs helps to harmonise the area. Elements such as seating, gathering places, art and culture can support both spontaneous and planned activities, while promoting a sense of local belonging.

The “eyes on the street” principle is important for promoting feelings of safety. Active facades, minimised blind spots, windows from shops and cafés and any local cultural art can contribute to enhanced safety. Moreover, good and well-placed lighting plays a key role for the safety, orientation and navigation throughout the whole day and night. Finally, it is important that the open space is equipped with necessary and accessible facilities such as toilets, waste bins, water fountains, waiting shelters and bicycle parking. These elements not only support the practical use of the space but also contribute to creating a more inclusive, comfortable, and user-friendly environment.

Checklist:

- Are public spaces accessible and inviting to all demographic groups?
- Do design elements support informal and formal social activities?
- Are spaces perceived as safe during all times of the day and night?
- Are there zones for sitting, gathering, playing, or relaxing for all age groups?
- Do materials, art, and symbols reflect the local community and cultural diversity?
- Are residents involved in the design or redesign process of the space?
- Is lighting placed to support both orientation and perceived safety?
- Are essential facilities (toilets, water, waste disposal, shelters) provided and maintained?

The Social Factors Concept was developed based on all the SDG targets, expert interview and survey responses.

8.2.2 Environmental Factors

Greater role of current climate challenges should enhance the importance of environmental factors of urban planning. Green urban planning can strengthen connections between nature and city and promote climate resilience. Green areas mitigate noise, air pollution, flooding and heavy rainfall consequences. Connecting green areas into green corridors is an efficient way of creating connected, accessible areas for recreation, while mitigating urban heat island effects. Trees, shrubs and flowerbeds can contribute to better aesthetics and biodiversity, creating micro-habitats inside busy areas.

To reduce energy consumption, solar panels, LED lighting and motion sensors should be installed around the transport hubs. Those interventions would contribute to greater feelings of safety and inclusion.

Checklist:

- Is vegetation (trees, shrubs, flowers) integrated to promote biodiversity and reduce pollution?
- Are green elements used to manage stormwater and mitigate flood risk?
- Are energy-efficient solutions (LED lighting, solar panels) included?
- Are green corridors or ecological connections to other green areas considered?

- Are there noise and air pollution buffers, such as trees, green walls or berms, near roads?

The Environmental Factors Concept was developed in both direct and indirect relation to all the SDG targets and as a response to expert interview and survey answers.

8.2.3 Wayfinding & Navigation

Effective wayfinding and intuitive navigation are crucial elements in the design of public spaces at transport hubs, as they support safety, accessibility and cohesive movement of users. Design solutions that support natural orientation without necessarily relying on signage alone should be prioritised. Open spaces should therefore be designed in a way that users can 'read' the space intuitively - where visual cues in the form of paving, placement of lampposts, art on roads and walls, etc. can help guide movement and orientation through the area. Particularly important features such as ticket machines, bicycle parking, lifts, toilets and access to platforms should be placed and designed so that they are clearly visible and accessible. Colour coding and numbering systems can help with quick orientation in complex traffic environments. Likewise, pictograms that are easily recognisable for most people of different ages can also be helpful. Gateways from different modes of transport should be obvious and well-marked to avoid confusion and unnecessary detours. In addition, information boards and signage should be placed logically in relation to the users' directions of movement and zones of stay both from short and long distances. Creative solutions such as visual pavement markings or artistically designed signs contribute to local identity and also act as navigation for the urban space.
Checklist:

- Is the space visually "readable" without relying only on signs?
- Are key functions (toilets, ticket machines, platforms, elevators, etc.) visible and easy to locate?
- Are ground markings, textures, or material shifts used to guide movement?
- Is lighting used to support navigation—both day and night?
- Are signage and information boards placed at logical locations (e.g., decision points)?

- Are pictograms or universal symbols used consistently to support non-verbal understanding?
- Are colour codes or number systems used to distinguish transport zones or routes?
- Are transitions between transport modes intuitive, well-marked, and barrier-free?
- Is the navigation system tested with a diverse group of users (age, language, ability)?
- Are elements of wayfinding integrated into the overall design and materials of the space?

As mentioned earlier, the Concept of Wayfinding and Navigation is not directly or indirectly related to any of the SDG targets. However, the lack of signage and confusing navigation were consistently mentioned in survey responses and user interviews, and have been identified as the most critical issue by LTK.

8.2.4 Accessibility

Sufficient accessibility of a place is an important factor of inclusion and well-being in cities, and transport and mobility plans should prioritize it. Accessibility describes the potential of a person to interact in spatially dispersed activities, and it refers to the 'ease' with which can the activities be reached (Guzman et al., 2023; Pot et al., 2021). However, accessibility is still measured by the experience of an 'average' user, as that is still the "reflection of the population's travel needs" (Guzman et al., 2023). Nevertheless, public spaces and transport hubs must be accessible to everyone, and it helps impaired persons (whether visually or physically impaired) feel safe, independent, and included. Accessibility for impaired people enhances equality, inclusion and overall well-being. Creating an equal and inclusive environment must be prioritized by stakeholders, policymakers and communities, as it supports diversity, empathy and embraces dignity of each individual (Pineda, 2024).

Checklist:

- Are all key access points usable without assistance?
- Is navigation supported by multiple sensory inputs (visual, tactile, auditory)?
- Are contrasting needs (e.g., of wheelchair users and visually impaired users) balanced and tested?
- Is feedback collected from impaired users regularly and acted upon?

- Are updates to infrastructure tied to inclusive design standards?

The Accessibility Concept is related, either directly or indirectly, to most of the SDG targets (with one exception), and it was mentioned during the expert and user interview.

8.2.5 Active Mobility Infrastructure

To promote active mobility among citizens, municipalities must prioritise the development of safe, accessible, and well-connected infrastructure . Walking and cycling are not only sustainable modes of transport, but also play a key role in improving public health (improved physical fitness, reduced cardioovascular risks), reducing environmental impact, and enhancing the overall efficiency of the urban transport system (Michel et al., 2024).

A well-designed active mobility network should include dedicated and protected bike lanes, pedestrian-friendly streets, and convenient connections to public transport (Timmons et al., 2024). These networks must be continuous, clearly marked, and integrated with other forms of mobility to support seamless travel across the city. Where space allows, fully separated bike paths provide a higher level of safety and encourage more people – regardless of age or cycling ability – to choose cycling over driving (Timmons et al., 2024).

Ultimately, the goal should be to make walking, cycling, and public transport the simplest, most logical, desirable and attractive choice for daily movement (Michel et al., 2024). This requires strong policy commitment, citizen engagement, and thoughtful urban design that reflects the needs of all users.

Another important characteristics of cycling and walking as modes of transport is the social connectivity, the constant opportunity to interact with the surroundings and other commuters (Te Brömmelstroet et al., 2017). During active mobility travelling, people can deeply experience the place around them, which lead to higher sense of belonging and ownership (Te Brömmelstroet et al., 2017).

Checklist:

- Are walking and cycling routes physically separated from motor traffic where possible?
- Are paths wide enough for diverse users (wheelchairs, strollers, cargo bikes)?

- Are resting spots (benches, shade, drinking water) regularly available?
- Is signage and wayfinding clear and available for all users?
- Are repair stations or support services (e.g., pumps, tools) available in strategic locations? Are pilot projects or temporary trials used to test and refine designs?

Active Mobility Infrastructure is indirectly related to some of the SDG targets, and importantly, it was mentioned during expert interview, user interviews and in the survey as an important factor.

Answer to Sub-Question 2

What steps should municipalities take to redesign transit-oriented public spaces into environmentally sustainable, socially inclusive and accessible?

To transform transport hub areas into more environmentally sustainable, socially inclusive and accessible, municipalities should work strategically and holistically.

The **social factors** are the common foundation that binds the other concepts together. This means that the municipalities should promote urban spaces that invite people to stay, interact and use them in a variety of ways – for children, young people, adults and the elderly. By integrating active facades, safe spaces and green meeting places, safe and inclusive environments are created where citizens feel ownership and cohesion.

Environmental factors should be considered as an integral part of the physical design, as green elements not only address climate challenges but also contribute to biodiversity, improved air quality and aesthetic value. Here, green infrastructure can serve as both a functional and recreational element in public spaces. **Wayfinding and navigation** are crucial to passengers' experience of the place. As it is important to ensure clarity and safety, intuitive and clear signage that creates a more harmonious flow in the movement pattern of passengers should be implemented. It will support the movement and orientation of citizens, especially in complex traffic junctions. It is crucial to promote **active mobility** by prioritising pedestrians and cyclists in urban design. This involves creating safe, direct and attractive routes between stations, city centres and residential areas, as well as clear separation between different modes of transport. An active mobility strategy not only contributes to health and sustainability, but also strengthens the social dynamics of urban space. **Accessibility** should be a guiding principle throughout the physical environment. The municipality should ensure universal access for all, regardless of age, ability or chosen mode of transport. As mentioned in the Framework, lighting, established rest zones and ensured access to facilities such as toilets and waiting areas will create an urban space that is safer and more pleasant to spend time in.

CHAPTER 9

ANSWERING THE QUESTION

This chapter answers the main research question through application of the Actor-Network Theory and Nudge Theory.

Main Research Question

How can the design of transit-oriented public spaces, understood through Actor-Network Theory and Nudge Theory, promote **environmental sustainability**, **social inclusion** and **accessibility**?

To answer the Main Research Question, it was essential to first answer the two Sub-Questions – reveal the strengths and shortcomings of the site, and propose solutions that help deal with the shortcomings and support the strengths.

9.1 Use of the theories

Actor network theory is used to acknowledge that the environment is made and influenced by both human and non-human entities. To improve social sustainability, the principles of prescription and negotiation spaces are used to design public space. For improving environmental sustainability, acknowledging the importance of non-human objects in public space is essential for creating a more harmonious and resilient environment.

Nudge theory is used mainly to redesign public areas. Consciously and transparently incorporating nudges into public spaces can steer people towards more sustainable behaviours and help them make better, healthier choices.

Application of ANT

Although people often share the same goal of getting from point A to point B, the analysis confirms that their movement patterns can vary greatly depending on their individual needs (Solá et al., 2017). Therefore, it was crucial to understand the movement in and dynamics of the space through observations and behavioural mapping, simultaneously with the use of ANT, to see how the space was used by human and non-human actors (Latour, 1996).

Non-human actors play an active role in the city network (Latour, 1996; Grønnestad and Nielsen, 2018). Through the survey analysis, it became clear that the urban space lacked physical objects to improve navigation (Carmona, 2019).

Similarly, several studies[1] also revealed that insecurity is often an issue in areas close to transport hubs, and it could be alleviated through various solutions by non-human actors. This led to a focus on 'navigation and wayfinding' and 'environmental factors' as key elements in shaping safer and more sustainable urban environments.

ANT helped to analyse how urban spaces should be designed as an interaction between users, technology and physical objects. By understanding how the networks work, it is possible to create inclusive solutions as a whole, so that the entire system – from mobility to residence – works in practice.

Application of Nudge Theory

Nudge Theory was chosen as a guiding principle because it can subtly influence user behaviour through small but effective design choices (Thaler and Sunstein, 2021). Elements such as paving, planting, and lighting can serve as natural guide tools, helping people navigate urban spaces in a safe and intuitive way. Presence of local art and well-designed building facades plays a crucial role in shaping whether an area feels inclusive and safe. To further support intuitive navigation, the use of color coding and familiar symbols or pictograms can provide a sense of reassurance, as these visual cues are already embedded in users' everyday experiences (Carmona, 2021). Together, these strategies form the foundation for a thoughtfully designed urban environment that nudges the actors toward more sustainable transportation choices.

[1] (Spanjar et al., 2024; Strandbygaard, 2021; Byplanlab, 2021)

The Role of Citizen Involvement

At the same time, it should be mentioned that in order to solve a problem, it is necessary to include the citizens who use the area – they are the experts in this field. That approach to problem solving is the base of design thinking, which is a user-based and solution-based (Han, 2020). To be successful with design thinking, it is important to build empathy with users, to understand the people affected by the problem and to observe the interactions in the product (space) (Han, 2020). The last mentioned step can be connected with the first two phases of the Regenerative Framework mentioned earlier (Chapter 3). Phase 1 states that it is crucial to understand and conceptualize the right relationship to place, understand its history and patterns. Second phase suggests designing a place for harmony within to build a place, not formula (Mang and Reed, 2012).

CHAPTER 10

DISCUSSION

This chapter discusses the Framework in its scope, the influence of MLP, its implications and limitations. Finally, recommendations for further research and action are proposed.

10.1 Single Case Study

Can a framework derived from a single case study – Lyngby Transport Hub – be considered valid and applicable in a wider municipal context?

On one hand, the case study implies a clear local anchoring, ensuring that the Framework is rooted in concrete user experiences and site-specific observations. On the other hand, the intention behind the Framework extends beyond Lyngby Transport Hub, when a literature review of national and international articles and documents has captured common challenges related to public areas around transport hubs that many municipalities both in Denmark and internationally face (Brand et al., 2021). The strength of the Framework lies in its flexibility and principle-based approach. By avoiding narrow solutions and instead formulating overarching strategic directions, it becomes possible for different types of municipalities – regardless of size, economy and physical environment – to adapt and use the insights in their own contexts. This increases the generalisation potential of the Framework, but at the same time raises a relevant criticism about whether the principles are too broad to be operationalised in practice.

Part of the discussion also revolves around whether the Framework should include more concrete guidelines, for example in the form of quantifiable recommendations such as the number of benches per square meter. However, this idea was deliberately rejected, based on the realisation that mobility hubs – like the people who use them – are unique. What creates quality in one place is not necessarily right elsewhere. Therefore, it was instead prioritised to emphasise user involvement and observation as key methods for local anchoring. It is precisely through these qualitative approaches that municipalities

can identify needs, movement patterns and barriers to find the site-specific solutions that would best suit the area under the various concepts.

It is also debatable whether the Framework is more principle-based rather than action-oriented. One can be critical of whether this means that other municipalities might perceive the Framework as being too broad. The municipalities may have issues in considering how the principles should be implemented in their area and whether they have the necessary resources and skills to conduct analyses and user involvement themselves. Here, the usability of the Framework could potentially be strengthened by offering a methodological guide to how observations and involvement processes can be organised without it developing into a one-to-one manual.

A further argument in relation to the generalisability of the Framework is that municipalities follow systematic plans and strategies for their urban areas. These typically include formulations of programmes of requirements and wishes, where the Framework's principles could be integrated or used as an inspiration in the early process and as an assessment list in the mid-final phase. In addition, different project teams will be able to consult the Framework and assess its relevance in the local context, comparing whether these solutions contribute to their existing goals and to new perspectives. Process-wise, there are no obstacles for municipalities to utilise the Framework, as it serves as a free guideline that should not be a replacement for their own municipal and local plans. By using the Framework as a tool, it should not only be tested by designers, but also in practice by users over time, as the potentially implemented solutions will strengthen and gradually adapt the urban area.

Although regenerative urban design is not explicitly included in the framework, its principles form the underlying foundation for the Five Concepts of the Framework. The idea of circularity, co-creation and long-term adaptability are therefore embedded in the Framework. Whether or not municipalities need to understand Regenerative Urban Design can therefore be argued not to be necessary to apply the Framework. However, an understanding of its logic that could support an implementation would still be seen as supplementary knowledge. Similarly, the Framework is inspired by the SDGs, which has ensured relevance across different planning contexts.

A further point of discussion is whether the project should have focused more narrowly on the Lyngby Transport Hub and developed a concrete design proposal. Such an

approach could have provided a deeper contextual understanding and perhaps been more directly applicable to Lyngby-Taarbæk municipality. Conversely, it would have limited the project's broader relevance and ability to contribute to national and international discussions on sustainable transport hubs. The choice to work strategically and reflexively rather than in design detail can thus be seen as both a strength and a weakness depending on the purpose.

10.2 MLP and Urban Transition

MLP provides a structured look at how transition can happen in urban development. Climate change, transition to active mobility, inclusive and accessible public spaces were identified as the macro trends at the landscape level, which influence the potential transition in regime and niche (Geels, 2011). The Framework emerges from the niche level and aspires to change the current state of the regime.

While the Framework at a niche level will function as an experimental tool that supports new practices and local initiatives, it is debatable whether the Framework at a regime level can penetrate and challenge existing municipal strategies and plans, which are often characterised by sector division and standardised solutions in the municipalities. This raises the question of whether municipal planning systems and institutional frameworks are flexible enough to accommodate the holistic Framework. At the same time, it may meet resistance if the political will and capacity are not present. Although looking at the broader landscape trend that embraces climate change creates pressure for change for the implementation of new principles.

10.3 Implications

The proposed approach to urban development planning is not radical or shocking, as it builds on existing concepts of universal design, design thinking, participatory design, and established theories of Actor-Network and Nudge. Both Lyngby-Taarbæk and Roermond have their own strategic plans which more or less apply the proposed concepts (Social and Environmental Factors, Wayfinding, Accessibility and Active Mobility). The Framework brings these ideas together systematically and makes them

more visible and operational as a strategic resource. Comparing the existing plans and strategies of municipalities, the Framework should not be disruptive, but rather adaptive and reflective. It does not reject existing planning paradigms, but adds a new lens that emphasises everyday user perspectives and nature-based thinking. It can complement current practice by encouraging more integrated and interdisciplinary thinking in the earlier stages of planning. The consequence of applying the Framework is thus not a revolutionary shift, but an invitation to rethink priorities and widen the planning lens in a way that is both practical and transformative.

10.4 Limitations

The financial aspect is deliberately left out of the Framework, which opens up a discussion about the balance between flexibility and the practical feasibility of implementing the principles in municipal development. The choice is deliberate in order not to limit the municipalities' use of the Framework, as economic conditions vary significantly from municipality to municipality. However, it is questionable whether the absence of economic considerations weakens implementability in practice. Conversely, the absence of fixed financial requirements supports the scalability and adaptability of the Framework, as many of the initiatives can be implemented on a smaller scale or using recycled materials. The key question is therefore whether the flexibility is a strength in itself or whether it risks leaving too much responsibility to the municipalities without specific budgeting.

Finally, it is debatable whether the Five Concepts in the Framework actually contribute to more citizens choosing public transport over the car. Although this has not been quantitatively investigated, the combination of literature review and site analysis suggests that safety and easy accessibility are of great importance for citizens' transport choices. In this context, it is worth emphasising that the Framework does not promise causal effects, but rather seeks to create the structural conditions for making sustainable transport choices easier and more attractive.

A key point of reflection is that the Framework is deliberately limited to focus only on areas around mobility hubs. This geographical and functional limitation has allowed for a deeper analysis of these complex urban spaces, but it also means that the immediate applicability of the Framework to other types of urban spaces such as residential areas,

parks or shopping streets is limited. It is therefore debatable whether municipalities will be able to apply the principles in broader urban contexts, or whether the Framework in its current form is primarily adapted to transport-related contexts. This is a limitation, but at the same time an obvious potential for further development and adaptation of the Framework in future projects.

10.5 Recommendations

Future research may focus on developing an AI-powered application that would be able to analyze public space based on a photograph and suggest sustainable and equitable solutions.

In addition, it could be relevant in future research or municipal trials to link the Framework with new economic thinking. A concrete suggestion could be to investigate how the Multiple Value Creation model – which emphasises economic, social, and environmental objectives (Koers-Stuiver et al., 2023) – can be integrated into the Framework's principles.

CHAPTER 11

CONCLUSION

This project aimed to explore how public spaces around transport hubs can be designed to promote environmental sustainability, social inclusion, and accessibility.

Two key outcomes emerged from the analyses: a scientific response to the research question, grounded in Actor-Network Theory and Nudge Theory, and a practical tool for municipalities to support future design processes for transport hub environments.

An important part of this project was collecting users' opinions to make the spaces more attractive and nudge users to choose public transport.

By establishing an informal collaboration with Lyngby-Taarbæk Municipality, the project gained an in-depth insight into the challenges and potentials that characterise the area around Lyngby Transport Hub. Through methodological approaches such as non-participant observation and behavioural mapping, knowledge was gained about the function of the area at different times of the day. The site analysis was further qualified through a workshop with DTU students, interviews with planners from the municipality and a survey among daily users, which together have contributed to a nuanced understanding of citizens' experiences and needs.

Their experiences indicate that spaces without functions, life and visibility are perceived as unsafe and exclusionary. These insights emphasise how concrete everyday experiences can serve as valuable indicators of where and how urban spaces should be improved.

The findings highlight the importance of integrating both theoretical insights and real-life experiences into the planning of transit-oriented spaces. By doing so, municipalities can create environments that are not only functional but also socially and environmentally responsive.

Based on this multidisciplinary and multi-layered data base, a principle-based Framework consisting of five concepts was developed. This Framework was designed to support municipalities in their strategic work to redesign areas around transport hubs and was subsequently tested and qualified through feedback from the test municipality

Roermond in the Netherlands.

Furthermore, the project's literature review and analysis of international cases shows that the identified principles can address broader issues in urban development and sustainable mobility. It is therefore suggested that the framework can not only be used in the context of transport hubs, but can potentially be extended and applied in the redesign of other types of public urban spaces such as pedestrianised streets and parks. Thus, the project offers a scalable and adaptive contribution to municipal planning practices, putting sustainability and user perspectives at the centre of urban development.

Although not explicitly mentioned throughout the analyses, regenerative approach to urban development was present in the background of the creative process. Principles of regenerative framework and regenerative design form the basis of the Framework, which aims to be holistic, nature-led and equitable.

The Framework developed in this project is only a starting point. With the rapid advancement of artificial intelligence, it holds potential to evolve into an AI-powered planning tool. The opportunity to redesign public spaces around transport hubs presents municipalities with a powerful lever to advance long-term goals in climate resilience, social equity, and urban livability.

Based on the above, it can be concluded that the project's Main and Sub research questions have been addressed through a comprehensive and methodologically grounded analysis. The study has resulted in the development of a Framework, the implications and applicability of which have been critically considered in the final discussion.

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