DESIGNING SUSTAINABLE URBAN TRANSITIONS TO ACTIVE MOBILITY

COPENHAGEN AND BARCELONA

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ABSTRACT

This thesis report compares the state of active mobility in Copenhagen and Barcelona, analyzing the policies, infrastructure, and social environment behind the active mobility state in both cities. The research employs the Multi-Level Perspective (MLP) theory to understand the complex dynamics involved in the transition towards active mobility. It develops a conceptual framework, the "Active City," which includes three dimensions: policy environment, social environment, and streetscape. The framework is used to assess the current state of active mobility in both cities and identify areas for improvement.

The report finds significant differences between Copenhagen and Barcelona in their approaches to active mobility, and it highlights the importance of a holistic approach to active mobility that considers the local context, political environment, and social acceptance.

To support a sustainable transition towards active mobility, the report proposes interventions for both cities as niches of transformation under the MLP theory, which can help build momentum for active mobility by challenging the current dominant socio-technical regime and improve the livability and sustainability of both cities.

The report concludes that by learning from each other's experiences and best practices, Copenhagen and Barcelona can accelerate their transition towards sustainable urban mobility and create healthier, more livable cities for their residents.

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I would also like to thank Sílvia Casorrán, former head of the Bicycle Office of Barcelona's Metropolitan Area Council for her valuable insights provided through the interview carried for this project, and the planner from Copenhagen, who requested to remind anonymous.

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1. Introduction

In recent decades, the global urban landscape has undergone significant transformations, driven by a growing recognition of the need for sustainable and health-promoting modes of transportation. The climate emergency that the planet lives under has brought cities to come up with adaptation and mitigation policies and interventions and to re-think urban life in all aspects, from the redesign of urban spaces integrating nature and greenery as a resilience measure to the introduction of sustainable modes of transportation in the city as a way to decarbonize urban mobility.

Among the most impactful and widespread strategies for cities to enhance their urban sustainability is the promotion of active mobility, specifically walking and cycling, and the development of car-free urban environments. This Sustainable Cities Master thesis explores the promotion of these strategies through the lens of the Multi-Level Perspective (MLP) transition theory, using Barcelona and Copenhagen as case study cities.

Encouraging active mobility can lead to a reduction in traffic congestion and noise pollution, creating a more pleasant urban environment for everyone and enhacing the livability and urban health of a city. Additionally, these modes of transport are cost-effective for individuals and municipalities, as they require less investment in infrastructure compared to road maintenance and expansion needed for motor vehicles. With the correct urban planning, active mobility has the potential to become the main transport modal of a city, overcoming the motorized traffic regime and reducing it to a minimum expression on the urban landscape. This means transforming a city in which cars and motorized vehicles have to adapt to citizens and bicycles, and never viceversa. A city made in a human scale, which has phased out the car regime that once dominated all the streets and conditioned urban life at all levels.

Conceiving Copenhagen's and Barcelona's urban mobility as a socio-technical regime, this thesis explores the role of cycling and walking in this regime by analyzing it through a developed conceptual framework, which provides an analysis of the state of active mobility in the two cities. Sequentially, the results from the analysis are consolidated an interpretated from an MLP perspective, exploring how certain policies and interventions could boost active mobility in two cities to a dominant role in the regime.

In conclusion, a city in which its citizens live on a human-scale environment fosters connectivity, sustainability, and well-being. Cycling and walking have the potential to play a transformational role in the urban life of cities like Copenhagen and Barcelona and by prioritizing these modes of transport, cities can create healthier, more vibrant communities that are resilient in the face of environmental and social challenges. Embracing active mobility is not just a step towards better health and cleaner air; it is a stride towards a more equitable and sustainable urban future.

2. Literature Review

This chapter aims to illustrate the research on the available literature and knowledge about the field which this thesis looks into, this being the planning of active mobility in cities and standards to measure its development, while also looking into the Multi-Level Perspective theory and its appliance in sustainable urban transitions. The Literature Review chapter embodies the research work behind the first stage of this thesis, in which relevant papers and knowledge was mainly searched through gateways as Aalborg University's digital library *Primo* and Google Scholar, and other ones have been suggested by this thesis' supervisor. This chapter includes the ones selected as most relevant papers among all the ones that have been read through this first phase of the research.

These articles and papers cover three key topics: urban cycling, pedestrianization and car-free policies, and sustainable urban transitions. At the same time, these three main areas of research have been investigated through papers and articles that specifically cover this in Copenhagen and Barcelona, studying specific case studies in these two cities.

Through the literature research phase, a gap of any internationally recognized or standardized framework to measure the state of active mobility was found. This means that no framework could be identified to measure the state of 'cycling or walking friendliness' of a city, for what research on these three mentioned outlined themes was carried. In addition, the relevant published articles that helped both inspiring or construction the developed conceptual framework of this thesis are shortly explained in this Literature Review chapter.

The International Transport Forum's report *Improving the Quality of Walking and Cycling in Cities* explains the challenges of transition from car-centric urban environment to more pedestrian- and cyclist-friendly spaces, emphasizing the need for policies that go beyond infrastructure to address social broader issues that negatively impact the promotion of active mobility in cities. (ITF, 2024)

Relevantly for this thesis, based on a comparative study between a Northern and a Southern European city, *The ABC of Mobility* by Prieto-Curiel and Ospina explores the complex dynamics of mobility patterns in regions around the world, providing insights into the distinct modal shares and mobility behaviors. (Prieto-Curiel & Ospina, 2024)

Lastly, Kahlmeier S et al. (2021) define a score methodology based on the Physical Activity Through Sustainable Transport Approaches (PASTA) Index to assess the evaluate the friendliness of the policy environment for walking and cycling promoting in cities, including the social, policy and planning context. Meanwhile, the Copenhagenize Index is a scoring point built by this consultancy firm, dedicated to assessing urban cycling policies to municipalities across Europe, through which the firm assesses yearly over 600

cities over 600,000 inhabitants and a bicycle modal share above 2% and presents an annual scoring. These two sources are the base of the conceptual framework used by this thesis to analyze the state of active mobility, and it covers the gap found on an international standard to measure this on an urban environment.

Urban Cycling

In the book *Cycling for Sustainable Cities*, by Ralph Buehler and John Pucher, the authors explore the multifaceted role of cycling in fostering urban sustainability. The book provides an in-depth analysis of how cycling can contribute to reducing carbon emissions, improving public health, and enhancing the livability of urban environments. Buehler and his co-authors present case studies from various cities around the world, illustrating successful strategies and policies that have promoted cycling as a viable mode of transport.

Another relevant paper on the urban cycling field is the George Liu's PhD thesis *Designing the Cycling City: Towards a User Perspective of Cycling Space*. This Thesis from Eindhoven's University of Technology provides three frameworks for understanding cycling, which served as an inspiration for the conceptual framework developed in this MSc thesis. Liu (2021) also presents empirical studies observed from the cycling experience perspective, which the author considers key to develop good cycling infrastructure.

Lastly, the paper *Researching cycling innovations: The contested nature of understanding and shaping smart cycling futures* by Marco te Brömmelstroet et. Al includes five reflections extracted from a research project on cycling innovations in the Netherlands. The relevance of this paper not only relies on the the light shed on the complexities of researching on urban cycling but as how cycling is portrayed as a socio-technical regime in transition.

Pedestrianization and car-free cities

On the pedestrianization and re-thinking of public space in favor of people against cars, the industrial PhD Thesis from Robert Martin *Points of Exchange: Spatial Strategies for the Transition Towards Sustainable Urban Mobilities* stands out as the most relevant paper to this thesis research. In his research, Martin explores the potential of architect's spatial knowledge and visualization methods to propose a vision for a car-free Copenhagen, focusing on its mobility and providing valuable visible material.

Another relevant document that has inspired is the *Manifesto for the Good Bench* (Bynon & Rishbet, 2015), which state a series of principles to design, distribute and plan for benches as inclusive walking infrastructure, highlighting the importance of these

elements in the urban landscape as they foster social interaction and inclusivity in our cities.

Sustainable Urban Transitions

The Environmental Innovation and Societal Transitions (EIST) is a journal that focuses on understanding and addressing sustainability transitions in various sectors, including transportation in urban development. In this journal, *The role of design in sustainable transitions: The case of mobility in Greater Copenhagen*, Valdemarra Pineda et Al. envision the future of Copenhagen's mobility through their involvement in the project 'A Coherent Transport System for Greater Copenhagen 2050'.

Another highlighted paper is *Design for Sustainable Transitions: Origins, Attitudes and Future Directions* by Gaziulusoy and Öztekin, in which a complete overview of the design for sustainability transitions is presented and the role and impact of this emerging field on research is examined.

3. Theory and Methodology

This chapter identifies elaborates on articles and research to establish the theoretical key concepts and definitions essential for constructing the Conceptual Framework presented herein, which forms the basis for analyzing the current state of Active Mobility in Copenhagen and Barcelona. Subsequently, the methods employed in this thesis to analyze the two cities within this conceptual framework are presented later in this chapter.

3.1. Research Question and Subquestions

The core of this thesis research relies on a comparison study that analyzes the state of active mobility in Copenhagen and Barcelona. From this point, what follows is a study which pursuits to reflect the key considerations that the municipal governments should take into account to support a sustainable urban transition of their respective cities' urban mobility towards a model that will be based on active mobility as a way to create a healthier urban life. Therefore, the main research question and sub questions are the following:

How can Copenhagen and Barcelona act to support a sustainable transition of its urban mobility?

a) ***How do both cities compare in terms of Active Mobility?***
b) ***Which policies and interventions are needed in both cities to achieve a successful sustainable urban transition to an urban mobility model based on Active Mobility?***

3.2. Theoretical Framework

This subchapter aims to define key concepts to understand this research and create a theory framework with the different sources that back up this Thesis.

Sustainability and cities

One classic widely accepted and known definition of sustainability is "the development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs". This definition was introduced in the Brundtland Report by the World Commission on Environment and Development in 1987. (Haijan et. Al, 2021)

In the context of cities and urbanism, Sachs et. al (2019) in *Six Transformations to achieve the Sustainable Development Goals* defines the concept of sustainable cities and communities through its *Transformation 5* as urban environments that prioritize economic productivity, social inclusivity, and environmental sustainability. A sustainable

city ensures access to essential services such as water supply, sanitation, waste disposal, and energy for all residents, **promoting health and well-being**. Sustainable cities feature infrastructure that supports public transportation, **walkability, green spaces, and resource-use efficiency, fostering a high quality of life**. They prioritize resilience and adaptation to climate change and other challenges, addressing vulnerabilities and promoting sustainable practices. By promoting compact, safe, and healthy settlements that minimize land conversion and enhance resource-use efficiency, sustainable cities create inclusive, safe, resilient, and environmentally sustainable communities that contribute to the achievement of multiple Sustainable Development Goals, including those related to sustainable cities and communities, clean water and sanitation, affordable and clean energy, industry, innovation, infrastructure, climate action, and life on land. (Sachs et al., 2019)

Relationship between Health and Sustainability

The first key concept to determine and understand its importance is **Health**, and its consequent relationship with **Sustainability**. This is very important as this research puts the emphasis on studying transitions from an unsustainable model of urban mobility to one that is sustainable by promoting health among its citizens, differing from main urban planning directions that merely focus on decarbonizing mobility and achieving zero net goals and carbon neutrality in cities. Therefore, it is key to understand why promoting Health through planning and promoting improved Active Mobility embodies the concept of Sustainability itself.

In *Transforming cities for sustainability: A health perspective,* Crane et. Al (2021) emphasize the interconnectedness between health and sustainability in cities, highlighting the need for integrated approaches to address both needs with a focus on the synergies between these concepts. They discuss the importance of framing and unpacking city-level transformation to achieve significant improvements in both urban health and environmental sustainability. Moreover, the authors propose a definition of a "healthy sustainable city" as one that enables all people, communities, and natural systems to thrive now and into the future, acknowledging the complexities of the city's physical, social-economic, and ecological dimensions within the broader biophysical region and planetary context.

Furthermore, the article underscores the mutual benefits that can be derived from addressing health and environmental goals simultaneously in urban settings. It advocates for a planetary health approach that integrates actions to promote and protect the health of populations with the state of natural systems on which health ultimately depends. Crane et. Al (2021) suggests that transformational change in cities should involve multi-scalar processes across city sectors to meet the scale, speed, and form of change required, incorporating mechanisms such as strengthening city governance,

technological and social innovations, sustainable urban planning, infrastructure development, and social behavior change supported by evidence-driven policies.

In the context of sustainable development and the 2030 Agenda, the relationship between health and well-being and their interconnectedness with urban transitions is one of the main area of focus. In the research paper *Six Transformations to achieve the Sustainable Development Goals,* Sachs et. Al (2019) touches upon the dynamics between sustainability and health, emphasizing the importance of promoting healthy behaviors, preventing diseases, and addressing social determinants of health to achieve long-term sustainability. By exploring the synergies between health promotion, environmental sustainability, and social cohesion, the research underscores the benefits of integrating health considerations into urban planning and development strategies. Through an analysis of the linkages between health, sustainability, and urban transitions, Sachs et. Al (2019) provides valuable insights for advancing sustainable development goals and creating healthier, more resilient communities for current and future generations.

Therefore, it is key to understand that the relationship between Health and Sustainability is not only proven by many research papers but also fostered under the **United Nations Development Goals** (UN SDGs) for 2030, providing a universal framework for governments, policy makers and research studies.

United Nations Sustainable Development Goals

The UN SDGs are a set of global goals designed to address various social, economic, and environmental challenges worldwide. These goals aim to end poverty, protect the planet, and ensure prosperity for all by 2030. The SDGs build on the success of the Millennium Development Goals (MDGs) and encompass a broader scope, covering areas such as health, education, gender equality, and climate action. With 17 goals and 169 targets, the SDGs provide a framework for sustainable development at both the national and international levels. The implementation of the SDGs requires collaborative efforts from governments, organizations, and individuals to create a more equitable and sustainable future for all.

To understand a sustainable urban transition towards a city that aims to promote good health and well-being among its citizens by planning Active Mobility, SDGs 3 and 11 and its correspondent targets are to be regarded as the bond between the correlation between sustainability and health under the context of urban transitions.

Goal 3: Ensure Healthy Lives and promote well-being for all at all ages

Figure 1. SDG 3

SDG 3 aims to ensure healthy lives and promote well-being for all at all ages by addressing a wide range of health issues. Among other issues, the goal focuses on universal health coverage, substance abuse prevention, road safety, and environmental health. SDG 3 seeks to improve the overall health and well-being of individuals worldwide, and it is streamlined through nine different targets, each one with several indicators associated to them. Three of these indicators are considered relevant for this research:

> **3.4.** By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being. Indicators are:
>
> - 3.4.1 Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease.
> - 3.4.2. Suicide mortality rate.
>
> **3.6.** By 2020, halve the number of global deaths and injuries from road traffic accidents.
>
> - 3.6.1. Death rate due to road traffic injuries.
>
> **3.9.** By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.
>
> - 3.9.1. Mortality rate attributed to household and ambient air pollution.

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

Figure 2. SDG 11

SDG 11 focuses on making cities and human settlements inclusive, safe, resilient, and sustainable. The goal targets the provision of safe, accessible, and sustainable transport systems, enhancing inclusive and sustainable urbanization, and reducing the adverse environmental impact of cities. By emphasizing the importance of urban planning and

management, SDG 11 seeks to improve the quality of life for all, particularly for vulnerable populations such as women, children, and older individuals. Its relevant targets and indicators for this research are the following:

> **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 disability and older persons.
>
> **11.3.** By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.
>
> - 11.3.2. Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically.
>
> **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
>
> - 11.6.2. Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted).
>
> **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
>
> - 11.7.1. Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities.
> - 11.7.2. Proportion status and place of occurrence, in the previous 12 months.

Defining Active Mobility

Prieto-Curiel & Ospina (2024) define Active Mobility as any mode of transport that require physical effort, such as walking, cycling and other alternative modes used for short-distance trips that involve some form of physical activity. These costs are characterized as low-cost, environmentally friendly, beneficial for physical health, and suitable for commuting to nearby destinations within neighborhoods. According to the article, some of the health benefits associated with active mobility include a reduction of air pollution and road accidents, as well as increased physical activity during commutes. Additionally, reducing car dependency through active mobility can lead to a net gain of urban green areas, new spaces for social interactions, and even a positive impact on retail stores' sales.

Active Mobility in this Thesis research is therefore primarily conceived as walking, using a standard bicycle or any other Personal Mobility Vehicle (PMV) that needs to be powered through human physical effort. Vehicles as electric bicycles enter this category as they

reduce the physical need to cycle and can be regarded as an inclusive tool to expand the use of bicycles.

Multi-Level Perspective Theory for Sustainable Transitions

This Thesis research will mainly base its core theoretical framework under the Multi-Level Perspective (MLP) to understand the complex dynamics of sustainable urban transitions and the key concepts presented by it. The second research sub question brings the need to find a solid and recognized theory as a framework to conceive the concrete actions that the cities need to apply and design a first draft of a sustainable urban transition towards a city that bases its urban mobility in active methods.

The MLP is a transition theory developed within the field of innovation studies, synthesizing concepts from **evolutionary economics** (including technological trajectories, regimes, niches, and speciation), **sociology of technology** (which examines how innovations are socially constructed through interactions among engineers, firms, consumers, and policymakers), and **neo-institutional theory** (which explores how actors are constrained by shared beliefs, norms, and regulations). Therefore, the MLP theory offers a framework for analyzing transitions in socio-technical systems.

The MLP theory defines transitions as non-linear, long-term, and large-scale systematic transformations that are characterized by changes in technological, cultural, behavioral, policy, and infrastructural dimensions that deviate from established regimes. These changes can lead to shifts in practices, rules, and norms within a socio-technical system, ultimately influencing the trajectory of the transition towards a new state. This is the reason why this research has chosen MLP as its core theoretical framework, as urban mobility can be regarded as a socio-technical regime in transition that complies with all the characteristics defined by the MLP, and it can help providing an answer to the research question by defining the socio-technical regime of mobility in Copenhagen and Barcelona and identifying niches of transformation that would enable this sustainable transition to move forward.

The MLP theory emphasizes the dynamic interactions between different levels and the emergence of opportunities for innovation and change within socio-technical systems, and defends that transitions are the result from the interplay of multiple developments at three analytical levels: niches, socio-technical regimes, and the socio-technical landscape. These concepts are defined by Geels (2012) as:

1. **Niches of transformation**: they represent the locus for radical innovations. These are spaces where new technologies, practices, or ideas emerge and develop, challenging the existing regime. Examples of niches in sustainable urban transitions can be R&D laboratories or subsidized demonstration projects. Niches gather momentum when visions and expectations become clearer and widely embraced, when diverse learning processes align to form a stable configuration

(referred to as a 'dominant design'), and when social networks expand (with the involvement of influential actors, enhancing legitimacy and attracting greater resources to niches). (Geels, 2012a)

2. **Socio-technical Regimes**: the established practices and associated rules that govern a particular system, the alignment of existing technologies, regulations, user patterns, infrastructures, and cultural discourses. These regimes are characterized by **stability**, **lock-in mechanisms**, and **path dependence**, which can hinder the adoption of radical alternatives. Niches and novelties must compete with the elements that conform a socio-technical regime, such as the technologies that benefit from well-developed systems around them.
   In existing socio-technical regimes, innovation is mostly incremental because of lock-in mechanisms and path dependence.
   In the field of transport and mobility there are multiple regimes coexisting, including the Active Mobility one, which is defined by this research as a **subaltern regime** from the dominant auto-mobility regime. (Geels, 2012a)

3. **Socio-technical Landscape**: represents the broader context within which niches and regimes operate. It includes urban layouts, political ideologies, societal values, beliefs, and concerns. Changes at the landscape level, such as shifts in policies, societal values, or technological advancements, can create pressure on the existing regime and open opportunities for new innovations. (Geels, 2012a)

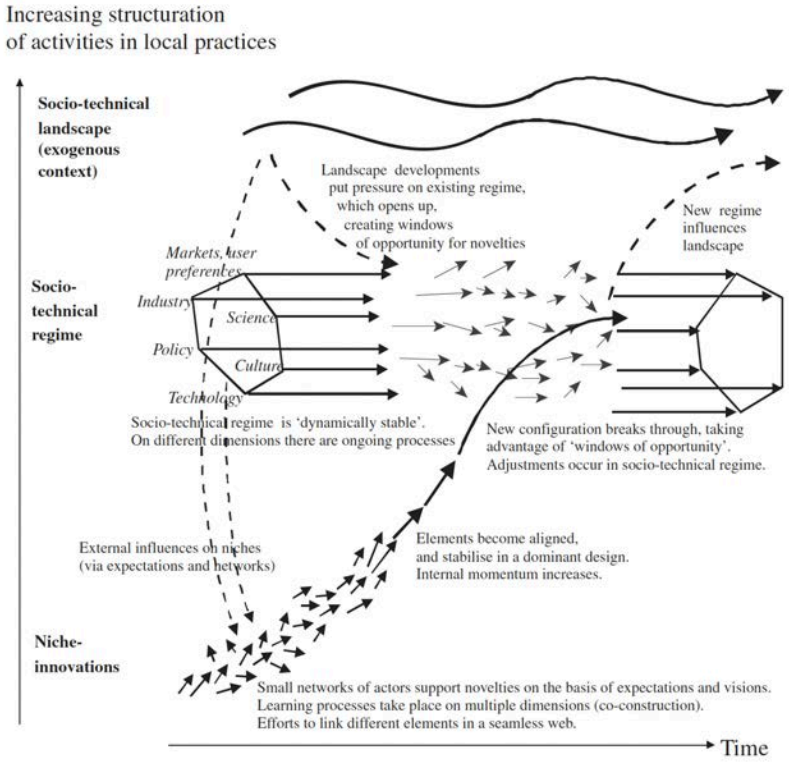

Figure 3. Multi-level perspective on transitions (Geels, 2012a)

4. **Subaltern regimes**: refers to a secondary or alternative system within a socio-technical context that coexists alongside a dominant regime. They represent niche areas or smaller market niches that operate within the broader socio-technical landscape. These subaltern regimes may include modes of transportation, technologies, or practices that are not part of the dominant regime but cater to specific user groups or serve particular purposes, such as cycling or walking (Geels, 2012).

The MLP emphasizes the dynamic interactions between the first three defined levels in driving transitions. Niche-innovations build momentum internally, changes at the landscape level influence the regime, and destabilization of the regime creates windows of opportunity for niche-innovations.

In applying the MLP to the analysis of sustainable transitions, it is important to recognize that it is not a definitive solution but rather a heuristic framework that guides attention to relevant questions and issues. The MLP's temporal orientation focuses on explaining processes over time, while its spatial dimension, though less elaborated, also plays a role in understanding transitions.

3.3. Conceptual Framework

The conceptual framework of this Thesis is named the 'Active City'. It is an essential part of this research the establishment of a satisfactory definition of the urban model that will later be used to design the sustainable urban transitions for Copenhagen and Barcelona and explore a potential partnership between them to reach the 'Active City' model. Therefore, the aim of this conceptual framework is to both serve as a measurement tool on the state of active mobility of Copenhagen and Barcelona and as a vision of a city in which this subaltern regime has become the dominant one.

As a research conceptual framework, the 'Active City' is built upon a series of variables that relate between each other and that contribute to support this. These concepts are widely exposed in the Theoretical Framework part of this research and related as variables in this chapter.

Defining the 'Active City'

The Active City model is constructed as the study's conceptual and analytical framework, given the research gap found on an international standard to define a city model that plans its urban mobility around the idea that active mobility should occupy the center of priority, and the rest of modes are there to support this. This model needs to be pinned down and further defined in different levels to serve as a functional future socio-technical regime under the multi-level perspective theory.

For that, this research has defined the Active City combining the parameters presented by the Copenhagenize (Copenhagenize, 2019) and the PASTA Index (Kahlmeier et al., 2021) and different research papers, which are stated below in each one of the parameter's explanation.

The Active City conceptual framework is based in the following three dimensions: social environment, streetscape and policy environment.

Policy Environment: constitutes the political and regulative framework that provides the adequate administrative framework for a city based on active mobility to exist. Its defined variables under the Active City conceptual framework are based on the Copenhagenize and PASTA Index. The parameters included in this dimension are **Advocacy, Urban Planning** and **Politics**.

Social Environment: represents societal parameters that shape the behavior of the inhabitants of an Active City towards its active mobility patterns. Just as the policy environment, its parameters are based on the Copenhagenize and PASTA Index. The parameters included in this dimension are **Perception of Safety**, **Accessibility and Inclusivity** and **Culture and Social Acceptance.**

Streetscape: comprises the urban layout that shapes and conditions the active mobility patterns in a city. The parameters included in this dimension come partly from the Copenhagenize and PASTA Index and from other research papers, meanwhile the dimension itself has been abstracted from the Copenhagenize Index. The parameters included in this dimension and the theory their based on are:

- **Infrastructure and Facilities**: defined combining the first two parameters of the 'Streetscape Parameters' dimension of the Copenhagenize Index, the key infrastructure and facilities explained in Table 1 have been developed based on the *Cities for People* book from Jan Gehl (Gehl, 2010) and the Navarrete-Hernandez P., Laffan K. *A greener urban environment* research paper (Navarrete-Hernandez & Laffan, 2019), which explains why green infrastructure development has been included under this parameter.
- **Strategic Public Transport**: this parameter measures the level of intermodality offered by the public transport network of the city. It is inspired by the findings in *Intermodal connections between cycling and public transport – A Stockholm case study* (Birkholz, 2009).
- **Low Motorized Traffic:** included as 'Traffic Calming' in the Copenhagenize Index, this parameter is conceived by this research based on (Nieuwenhuijsen & Khreis, 2016), where the benefits of car-free policies are displayed and linked to an increase of active mobility and better physical and mental health, aligning it directly with the Active City principles.

- **Digital Infrastructure and use of data:** not included in none of the previously mentioned Indexes, this last parameter has been given by (Reggiani et al., 2022) in *Bicycle network needs, solutions, and data collection system,* where these group of students from TU Delft explain the importance of data collection and digital infrastructure on building bike-friendly cities.

The Active City can be regarded as a non-existing socio-technical regime and landscape that is nothing more than a vision but could become the dominant socio-technical regime if the three dimensions that conform it would be aligned (Geels, 2012). The synergies between dimensions rely on this conception given by the MLP Theory, as the social and policy environment can be regarded both as part of the socio-technical regime and the general landscape, meanwhile the Streetscape parameters can be considered the core part of the socio-technical regime.

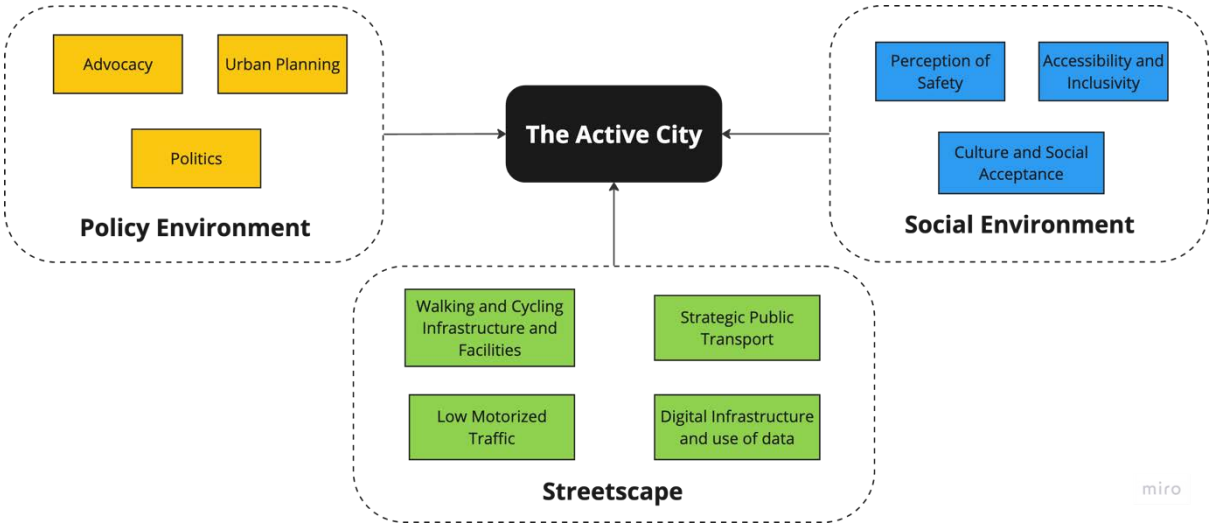

Figure 4. Conceptual Framework 'The Active City' overview

The Active City

Social Environment

1. Culture and Social Acceptance

- Cycling and walking has been fully reestablished as the main mode of transport among regular citizens, and not only a part of society. Cyclists and pedestrians are part of the urban landscape and the core of urban mobility.
- Widespread social acceptance exists among the community about urban cyclists and pedestrians. Drivers respect them and are fully aware of their priority in the urban landscape.
- Cyclists and pedestrians are not considered an urban tribe or profiled ideologically anyhow, as cycling and walking are intersocietal.

2. Perception of Safety

- Cycling and walking are regarded as absolutely safe modes of transportation from any given point to the city to any destination at any time. Users do not think they are performing an activity that carries on a certain risk, especially those who identify as women or minority groups.
- Cyclists count with the adequate parking infrastructure and overall feel safe against bicycle theft.

3. Accessibly and Inclusivity

Walking and cycling are accessible and inclusive to the whole society, including people from all ages and genders. In the Active City, people from all ages and genders cycle and walk safely. The main two indicators of this parameters are:

- Gender balance exists among cyclists and pedestrians; the infrastructure and social environment allows compatibility between active mobility and age equality – especially among pedestrians.
- Cargo bikes are a common and accepted sight in the city. A significant amount of goods transport is carried out using bicycles, and families have access to various brands for private use. Facilities such as parking and wider cycle tracks to accommodate cargo bikes are prevalent. The local logistics industry utilizes bikes for last mile transport. (Copenhagenize, 2019).

Streetscape Parameters

4. Infrastructure and Facilities

In the Active City, there is a high level of protected and separated bicycle infrastructure on a high-quality and well-maintained network that covers all the city. At the same time, all streets and parts of the city are equipped with sidewalks wide enough to walk comfortably.

- Connectivity exists among all the cycling network.
- A network of cycle highways connects the city to its metropolitan area.
- Bicycle racks are available in all the city.
- Successful Bikeshare alternatives exist.
- Green infrastructure is installed in most of the streets and used to enhance and promote walkability experience.

5. Digital infrastructure and data

The municipality collects data from cyclists and pedestrians to better understand mobility patterns and identify areas of improvement of the infrastructure. Modern modelling tools and digital infrastructure are used efficiently by the municipality.

6. Low motorized traffic

The development of cycling and walking infrastructure has been developed to the detriment of car and motorized vehicles infrastructure, reducing these vehicles to a minimum expression in the city. In consequence:

- The Active City maintains its levels of PM 2.5 under the WHO's limit of 5 µg/m3. (World Health Organization, 2021)
- The Active City is pedestrianized and prioritizes cyclists and active mobility over cars and motorized vehicles.

7. Strategic Public Transport

Public transport needs to promote intermodality with cycling to be strategic, as this combination can provide a door-to-door solution that meets individual needs while promoting a healthier and greener mode of transport (Birkholz, 2009), supporting active mobility and making it easy for citizens who choose for intermodality to commute. Public transport supports intermodality through:

- Bicycles parking at rail stations and bus stops.
- Provision for taking bikes on board trains and buses.
- Public bikes and rental facilities strategically placed near public transportation stops.

Policy Environment

8. Advocacy

There is a history of strong civil advocacy to encourage cycling and walking through public campaigns, which keeps politically active until the present days to ensure the maintenance and progression of the Active City. This advocacy has or has had political influence to enforce the Active City principles.

9. Urban Planning

The urban planning of the Active City is a key parameter to promote active mobility. A well-planned city, in which facilities are close enough to residences, can give place to a city based on active mobility as citizens would have everything close enough to walk or cycle to their destinations, having public transport as a support method in case they need to travel further distances. Moreover, the city has a dedicated planning office for bicycle and/or walking infrastructure and their recommendations are taken seriously.

10. Politics

There exists political consensus on a national, regional and municipal level to maintain the Active City model and empower people to choose Active Mobility. The Active City model is not at risk, no matter who governs the municipality.

- General political consensus exists on promoting active mobility and developing the infrastructure for it.
- Administration procedures facilitate the promotion of active mobility.

Table 1. The Active City framework table

The urban transition that Copenhagen and Barcelona would have to promote in order to achieve a model of city that complies with the definitions of the ten parameters defined by 'The Active City' would be a transition in which a subaltern regime – cycling and walking – would overturn and substitute the existing socio-technical regime based on motorized transport, becoming the dominant one. Therefore, the new mobility regime based on Active Mobility would comply with the characteristics of a classic socio-technical regime defined by the MLP theory and be dynamical stable. The alignment of the three dimensions (policy environment, social environment and streetscape) would be the base of the establishment of this new regime, converting the old one in a subaltern regime that would cohabit with the dominant one (Geels, 2012).

Active Mobility counts with a significant advantage to any other possible subaltern regime that wants to become dominant: it is not based on any expensive technology, but rather a very simple one that has already existed for centuries (Geels, 2012). It would neither require a substantial change in user practices, as most of the citizens would not need to start learning how to move on a new brandly invented vehicle. The main challenges for this sustainable transition would rely on the implementation of favorable regulation – and all the process behind it – and the building of the adequate infrastructure, which would not simply be more bicycle lanes or paths.

A sustainable transition that would replace the current dominant motor vehicle regime would require a systemic change on the streetscape parameter and bring planners to re-think the paradigm that we have lived under since the introduction of cars in cities. The urban layout understood as normal, where the motorized traffic circulates through the middle of the streets and pedestrians and perhaps bicycles adapt to it and circulate on their correspondent sides should be re-thought.

3.4. Methodology

Research Design

In this chapter, the research design to provide an elaborated answer to the Research Question of this study is presented through the different methods followed, organized as different research steps.

The research design of this Thesis research can be outlined through the following key steps:

1. **Creation of the Active City Conceptual Framework**
   The research study begins with the development of the Active City conceptual framework through different sources, primarily the PASTA and Copenhagenize Index, as detailed in chapter 3.3.
   The need for the development of a conceptual framework organized in different parameters grouped in three dimensions comes from the gap found on any

internationally recognized framework that would fit the research framework of this study, which is defining a city that bases its urban mobility in active mobility.
This framework serves first as a guiding tool for the subsequent analysis of Copenhagen and Barcelona and later as the future socio-technical regime that will base the design of the sustainable urban transitions of both cities.

2. **Municipal Documents Analysis in Copenhagen and Barcelona**
As a first analysis and assessment of the state of active mobility and urban mobility in general in both cities, an analysis of current data and plans is carried.
This is a previous step to the research analysis of this Thesis and serves this study to gain an understanding of the policy environment and plans that shape both municipalities, as well as the directions set by these municipal documents and the ambitions of both cities. Moreover, the communication clarity of these documents is examined as it determines the ability of each municipality to express their respective plans and future actions.
The analyzed documents are Barcelona's Urban Mobility Plan 2024 and Copenhagen's Mobility Report 2023, *Cykelfocus* 2024 and Bicycle Account 2022.

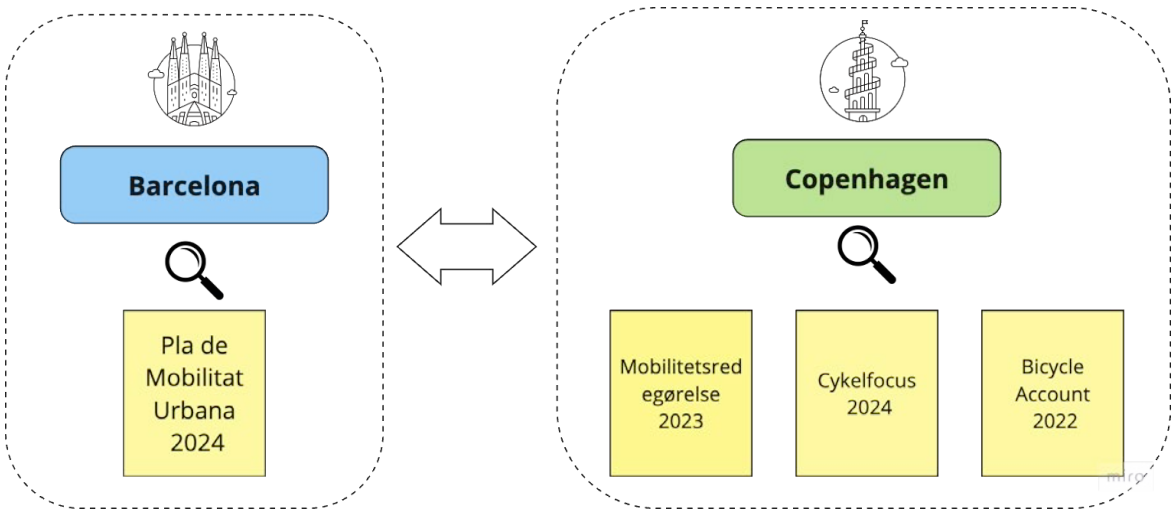

Figure 5. Illustration of municipal plans

Moreover, a comparison table of basic city information including demographic figures is presented to provide a stronger comparative analysis of the cities and expose key figures that will serve to gain understanding of urban life of both cities.

3. **Analysis through the Active City Framework**
Utilizing the Active City framework, the study conducts an analysis of Copenhagen and Barcelona parameter by parameter within each of the three dimensions: policy environment, social environment, and streetscape. This analysis allows for

an evaluation of the cities' sustainability efforts and identifies areas for improvement. Data collection is carried in the following way:

- **Policy Environment:** document analysis, literature research and interviews. The core of this part are the interviews carried to main actors in both cities are carried to obtain information and provide a valuable insight from experts from both cities.
- **Social Environment:** online surveys to citizens of Copenhagen and Barcelona.

  The surveys, responded by 154 citizens of Barcelona and 106 of Copenhagen, address questions on cycling and walking culture in both cities, presenting very similar questions adapted to both respective contexts in order to provide comparable results and outcomes that determine the conception that regular citizens have on cycling and walking as urban mobility options and for this research to be able to extract conclusions.

  No other criteria has been applied to circulate the surveys than residing in Copenhagen or Barcelona (and their metropolitan areas), and the samples obtained can be considered random and an attempt to represent the heterogeneous population of both cities.
- **Streetscape:** site visits, interviews, surveys and research.

  The four parameters conforming the Streetscape dimension are assessed through an analysis of the data extracted from the municipal documents and other diverse sources such as the interviews, analyzing with real data how do Copenhagen and Barcelona perform and stand in each one of these. Site visits have been done in both cities to produce photographic material and compliment the analysis of the streetscape and its active mobility, and the surveys conducted in both cities determine the level of satisfaction and therefore the effectiveness of the cycling and walking infrastructure in both cities.

The experts in each cities interview through this Thesis research are:

- **Anonymous Copenhagen Planner**. Interviewed on the 19th of April 2024, interview transcript can be found in Annex. This person was involved in the Bicycle Program of the City of Copenhagen, and asked to remain anonymous.
- **Sílvia Casorrán**, former Head of the Bicycle Office of Barcelona's Metropolitan Area council (2015-2021). Interviewed on the 23rd of April 2024, interview transcript can be found in Annex.

This part of the research is the one that provides an answer to the first research subquestion '*How do both cities compare in terms of Active Mobility?*'.

4. **Sustainable Transition Design**

   Once the analysis of the cities through the conceptual framework is consolidated, all the data is sorted and elaborated to give path to the study of what would be need for a sustainable urban transition to take place and achieve The Active City as a future vision. The three levels that define MLP (landscape, socio-technical regime and niches of transformation) are defined in both cities from a historical perspective, done through article research, and from a present point of view.

   Therefore, this part is constituted as a reflection and synthesis of everything needed for a sustainable transition in Copenhagen and Barcelona based on the replacement of both cities' dominant motorized transport regime for the current subaltern regime of Active Mobility.

   Through the MLP transition theory, this study deducts the niches of transformation that both cities would need to see to achieve the vision of The Active City. These niches represent opportunities for innovative interventions, policies, and actions that can catalyze sustainable urban development in the future.

   The niches of transformation identified are translated into concrete interventions, policies, and actions that the municipalities of Copenhagen and Barcelona can implement to achieve the Active City model. These recommendations are tailored to address specific challenges and leverage opportunities identified in each city.

4. City Basics

Prior to analyze the state of Active Mobility through the given conceptual framework, this chapter aims to present a general overview about Copenhagen and Barcelona, outlining key figures relevant to this research to gain a better understanding of the differences between both cities.

Relevant data to gain a first overview on urban life in both cities is exposed in Table 2, and municipal plans in place are streamlined to provide an analysis on the state of active mobility in public municipal documents by the two respective municipalities.

	Copenhagen	Barcelona
Demographics		
Municipal Population Size	653,554[1]	1,655,956[2]
Metropolitan Population Size[3]	1,363,296[4]	3,303,927[5]
Municipal land area (sq km)	86,4	101,35[2]
Metropolitan land area (sq km)	3,372	636
Municipal density of Population (hab / sq km)	7639	16,339[2]
Metropolitan density of Population (hab / sq km)	412	5094
Economy		
GDP per capita (€)	86,492 (2021)	51,200 (2023)[2]
Gross average income (€ / year)	83,550[6]	33,837[7]
Climate		

[1] (Statistics Danmark, 2023)

[2] (Institut d'Estadística de Catalunya, 2023)

[3] Barcelona: Àrea Metropolitana de Barcelona; Copenhagen: Storkøbenhavn. Data is rounded upwards.

[4] (Statistics Danmark, 2023)

[5] Data from 2021; (Area Metropolitana de Barcelona, 2021)

[6] Data from 2022, translated to DKK to EUR (1=7.4601) (Dyvik, 2024)

[7] Data from 2022 (Ajuntament de Barcelona, 2024c)

Average Temperature (°C)	8.9[8]	18
Rainy Days per year	167[9]	55
Sunshine hours per year	1635[8]	2530
Environment		
Average Annual PM2.5 concentration (µg/m³)	4[10]	17 (2021)[11]
Green spaces (m² / inhabitant)	42[12]	6.64[13]

Table 2. Urban Data - Comparison table Barcelona and Copenhagen

[8] https://en.climate-data.org/europe/denmark/capital-region-of-denmark/copenhagen-23/

[9] https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,copenhagen,Denmark

[10] https://www.aqi.in/dashboard/denmark/hovedstaden/copenhagen

[11] https://www.barcelona.cat/metropolis/en/contents/air-pollution-the-city

[12] https://helenilus.com/2022/08/08/copenhagen-greenground-map-a-green-guide-for-walkers-and-cyclists/

[13] Excluding Collserola Park; (Medi Ambient i Serveis Urbans, 2020)

5. Social Environment

This chapter contains the analysis of the state of the active mobility in the cities of Barcelona and Copenhagen through the Social Environment dimension of the conceptual framework. The three subchapters correspond to the three parameters defined in the previous chapter, allowing the reader to compare the performance of the two cities in each one of the parameters defined in the conceptual framework and contrast the results obtained through this research, based in the two surveys conducted in both cities, the data obtained through the interviews and the rest of sources.

Chapters 6 and 7 are structured in the same way with their correspondent parameters.

5.1. Culture and Social Acceptance

Barcelona is a Mediterranean city that enjoys pleasant temperatures and climate conditions most of the year, with mild winters and hot summers. This prompts a lifestyle characterized by a social outdoors culture that has brought the municipality to rethink and improve public spaces in all districts of the city (Casorrán, 2024). On the contrary, Copenhagen is characterized by much lower temperatures and tough weather conditions, with long, cold and dark winters and mild summers and a rainy climate that does not invite residents to spend time outdoors in the city during the winter months.

Cycling Culture and Social Acceptance

To start analyzing the cycling culture and the place that this active mode of transportation has in both Copenhagen's and Barcelona's urban societies, it is key to look into figures and the modal share of the two cities.

Contrasting data, figures 6 and 7 show very different results to surveyed population in both cities when asked about the frequency of bicycle use to commute in both cities. However, the results obtained show a correlation with municipal figures, that situate cycling in opposite places on the share modal of both cities.

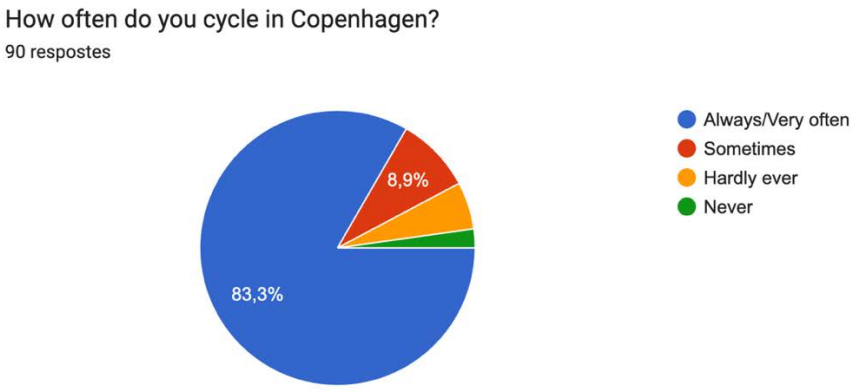

Figure 6. Cycling frequency in Copenhagen (Survey)

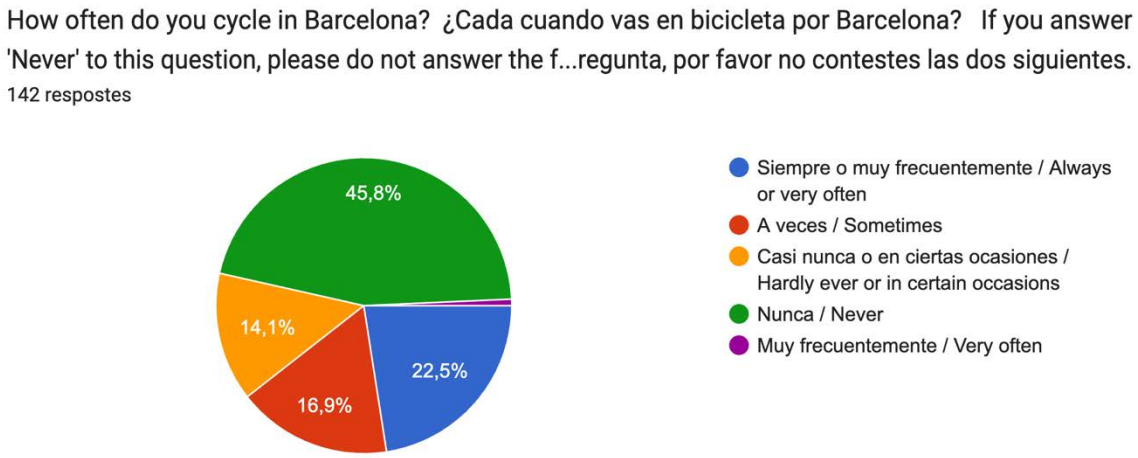

Figure 7. Cycling frequency in Barcelona (Survey)

Less than a quarter of the surveyed sample answered 'Always or very often' when asked about the frequency of cycling in their day-to-day life in Barcelona. On the contrary, almost half of the surveyed claim to never cycle, leaving the rest between sometimes or occasional cyclists.

Survey results show again opposite results in both cities, with citizens answering *I never cycle* being the biggest surveyed group in Barcelona and the same profile in Copenhagen accounting for a small 2.2%. On the contrary, more than 8 out of 10 citizens in Copenhagen claim to *Always* cycle while in Barcelona this group does not reach a quarter of the surveyed citizens.

Both these results and the municipal ones indicate that cycling is a very strong part Copenhagen's lifestyle and culture, while Barcelona results indicate the contrary. Moreover, figures 8 and 9 reinforce the conception of Copenhagen being a society that embraces cycling as part of its culture, while in Barcelona cycling was voted as the second prefered option to move around the city, if 'Private bicycle' and 'Bicing', the municipal shared bike system, are counted together.

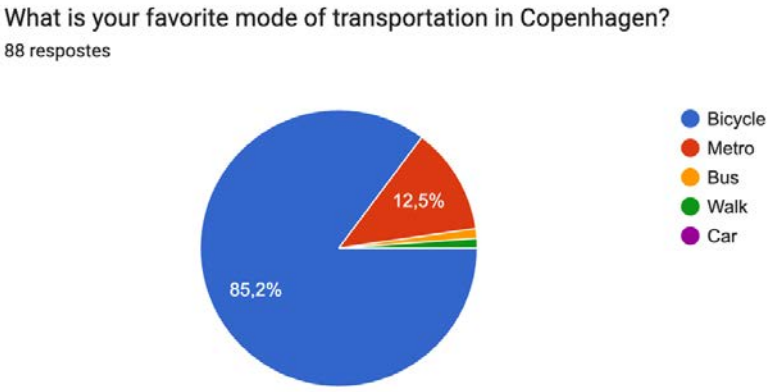

Figure 8. Favorite transport choice in Copenhagen (Survey)

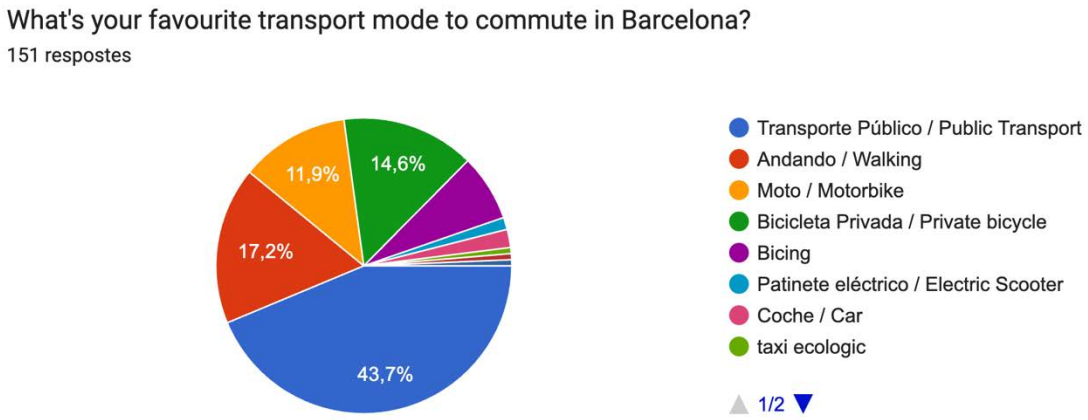

Figure 9. Favorite transport choice in Barcelona (Survey)

Both Copenhagen's and Barcelona's results in figures 3 and 4 are remarkably high, as 'favourite' transport mode does not necessarily mean the most used to commute. More than 8 out of 10 people surveyed in Copenhagen indicated that cycling is their favorite mode of transportation, and almost the 22% of surveyed in Barcelona did as well. This numbers contrast with the official data published by the respective municipalities, that indicate lower cycling rates in both cities.

Despite much lower numbers than in Copenhagen, historic data in Barcelona show an increase on cycling and bycicle ownership, for what it is arguable that Barcelona's cycling culture and social acceptance is also increasing and breaking through the dominant socio-technical car regime.

Figure 10. Bicycle ownership in Barcelona. Black: No; Green:Yes (Chevalier P, 2023)

Regarding the perception of cyclists and their relation to any political ideology or social profiling, results vary considerably in Copenhagen and Barcelona, although most of its surveyed citizens do not see any correlation between cycling and having a concrete idelogy. However, in Copenhagen the opinion ammong the surveyed is divided between those who do not see any political ideology behind cycling and those who see it.

When asked about the concrete political ideology that is associated with cycling, results vary slightly as well. In Barcelona, most of the answers indicate that they see people who cycling as 'left-wing' people mainly, with a few people answering 'green'. In Copenhagen, answers are similar, but with more answers indicating 'green parties' or 'environmentalism'.

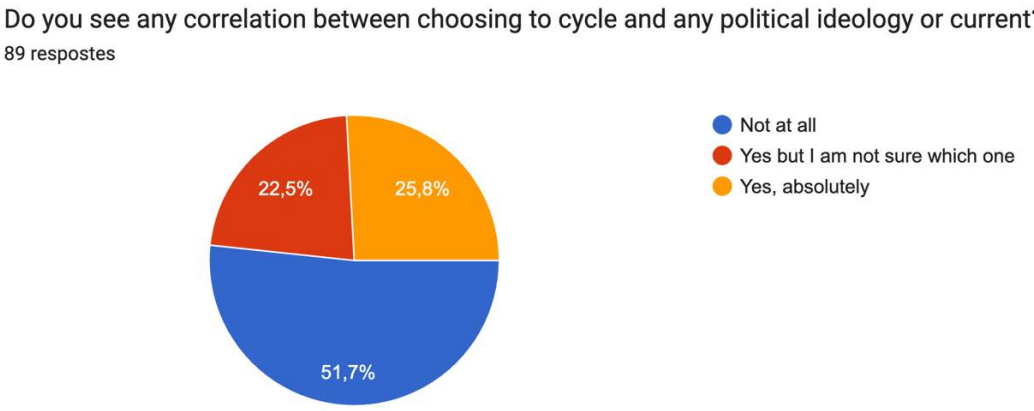

Figure 11. Political ideology correlation with cycling in Copenhagen (Survey)

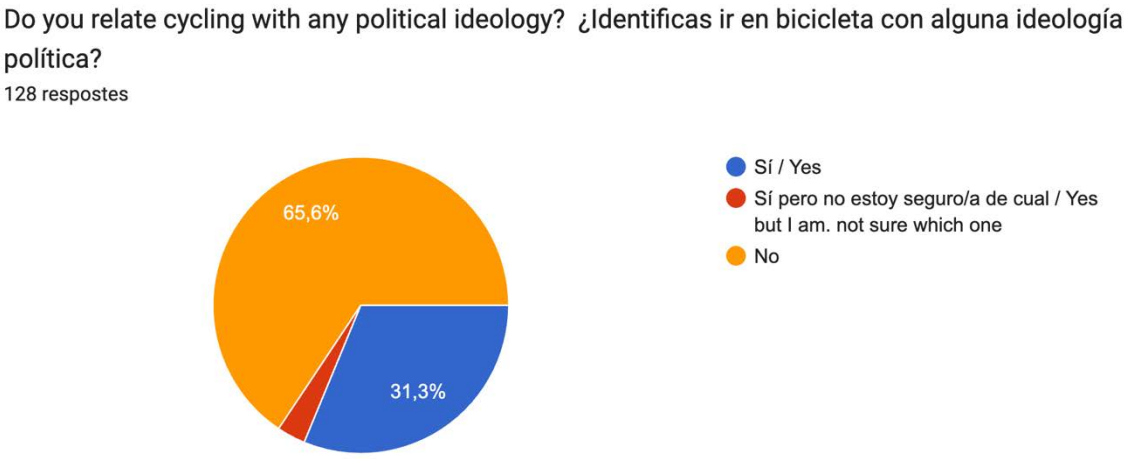

Figure 12. Political ideology correlation with cycling in Barcelona (Survey)

On contrast with political ideology, more people in Copenhagen profile those who cycle with certain urban tribes than in Barcelona, surprisingly. However, the vast majority in both cities do not see cyclists as a any particular urban tribe, indicating a healthy cycling culture.

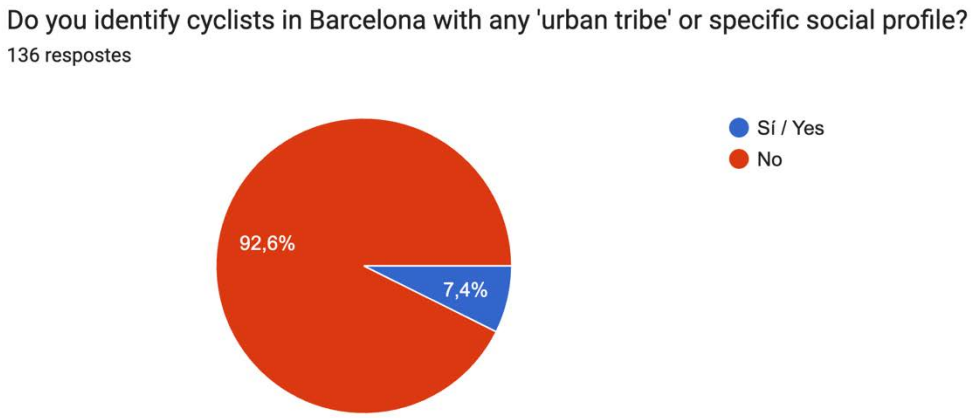

Figure 13. Identification of cyclists with urban tribes in Barcelona (Survey)

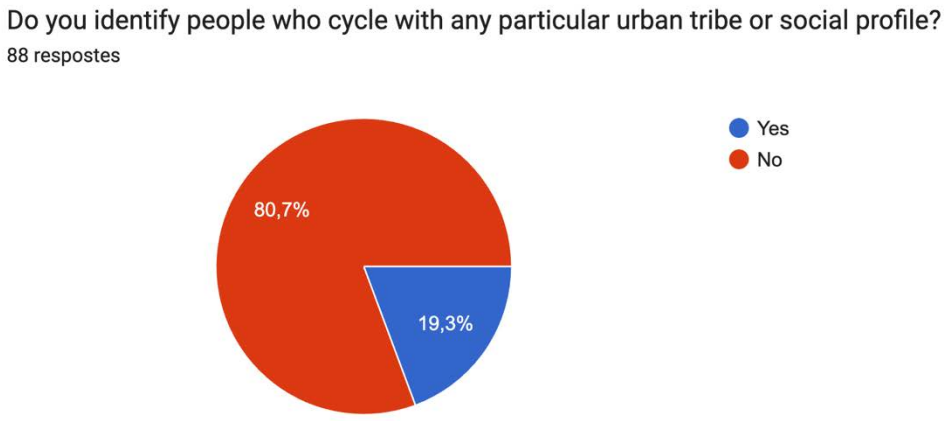

Figure 14. Indentification of cyclists with urban tribes in Copenhagen (Survey)

One answer on the survey where citizens were asked to indicate the social tribe is 'Yes in other cities, not in Copenhagen'. This is a remarkable opinion as it expresses that cycling in Copenhagen is intersocietal and not reduced to one social profile, while in other cities it might be seen like this due to low cycling rates caused by a not well-developed infrastructure that attracts only the ones who cycle due to their ideology and morals. Other answers include 'students', 'sporty' people and 'sustainable' people.

The interviewed Copenhagen Planner, identifies a strong connection between cycling and values that are distinctly Danish. According to Copenhagen Planner, Danes perceive humility and modesty as central to their identity, preferring not to boast or brag. This down-to-earth attitude is reflected in their equitable society, where it is common to see the Prime Minister cycling to work alongside any one else in society. Copenhagen Planner suggests that the bicycle is seen as a democratic means of transportation, embodying simplicity and human scale, in contrast to the exclusivity of expensive sports cars. Cycling is associated with a healthy, modest lifestyle that promotes both physical and

mental well-being. However, she also claims that cycling is *not really an identity here. I wouldn't say that in general, cycling is part of your identity here because it's so widespread. But it's just another element in your daily life like brushing your teeth, right? So you wouldn't, everyone does it, but you wouldn't identify as a toothbrush*. (See Appendix A for full interview transcript)

Copenhagen Planner notes that this cultural overlap was particularly celebrated in the 1930s, as seen in poems, paintings, movies, and novels from that era. She explains that while cycling is widespread in Denmark, it has become so normalized that people do not typically identify as cyclists. This normalization is a key distinction between Denmark and other European countries; even during periods when car dominance increased, cycling remained a common practice. (See Appendix A for full interview transcript)

Copenhagen Planner emphasizes that Denmark never needed to reintroduce cycling as a normal activity because it was never fully marginalized. Factors contributing to this include the municipality's limited financial resources, which prevented the construction of large highways through city centers, and the lack of a national car manufacturer. As a result, cycling has remained an integral part of Danish culture and urban life, helping to maintain Copenhagen's reputation as a leading bicycle city. She claims that '*culturally, we never needed to start all over again telling people that it's normal to cycle. In part because we couldn't afford constructing like huge highways through the city center. We were a very poor municipality in the I think that. And then we don't have a national car manufacturer that might also come into play'* (See Appendix A for full interview transcript)

Walking Culture and Social Acceptance

Walking is another essential part of Active Mobility culture and the vision of the Active City. To analyze the state of the culture and social acceptance of walking in Copenhagen and Barcelona, several questions were conducted through the surveys on overall satisfaction about walking and walkability in both cities, analyzing the main reasons that make citizens choose to walk and identify the main negative aspects that they identify and stop them from doing so.

Figures 15 and 16 show very similar results on a rating scale from 1 to 5 for Barcelona and Copenhagen, giving almost identic median ratings in total, 3.8 for the first and 3.75 for the second. However, more people have voted for low ratings 1 and 2 in Barcelona (8.7%) than in Copenhagen (3.2%), while at the same more than three quarters of the surveyed perceived walking in Copenhagen positively with high ratings 4 and 5, while in Barcelona 64.7% of the surveyed indicated positive opinions.

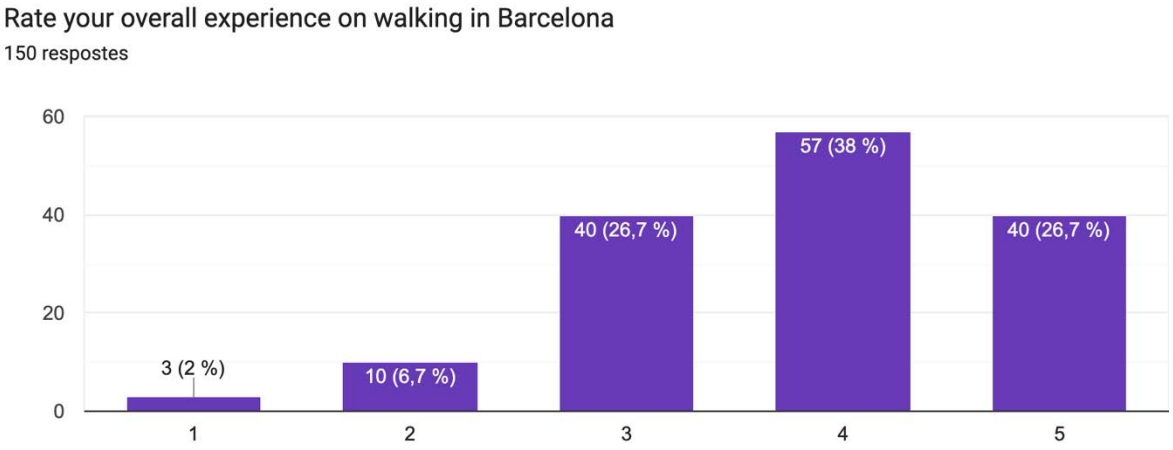

Figure 15. Walking experience rating in Barcelona (Survey)

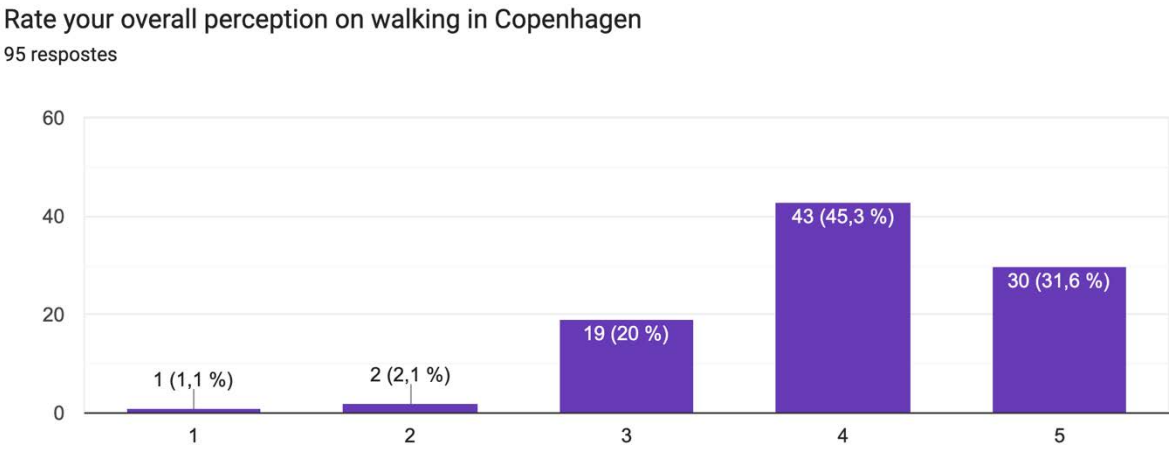

Figure 16. Walking experience rating in Copenhagen (Survey)

Regarding the negative aspects about walking in both cities, the results obtained through the two surveys differ a lot. In Barcelona, citizens identified the excess of cars, air pollution and the lack of green spaces as the main negative aspects about walking in their city, while Copenhageners indicated that the weather was the main negative aspect about walking through the Danish capital, followed by far by a lack of spaces on the sidewalks, caused by these being too narrow and and excess of people.

Table 1 compiles the results obtained through the two surveys, which can be consulted in Appendixes C and D.

%	Copenhagen	Barcelona
Too many cars	8,2	**67,6**
Too many people on the sidewalk	22,4	36,5
Air Pollution	2,4	**62,2**
Too many bicycles	8,2	18,9
Dirty streets	0	28,4
Sidewalks are too narrow	27,1	27,7
Thefts and insecurity	Not included	16,9
The city's weather	**58,8**	3,4
Lack of green spaces	Not included	45,3
Motorbikes parked on the sidewalks	Not included	39,2

Table 3. Survey answers on negative aspects associated with walking in Copenhagen and Barcelona, survey results

Remarkably, people in Barcelona are unhappier than the surveyed ones in Copenhagen about the amount of cyclists on their streets, despite the city having a much lower of modal transport share of cycling than Copenhagen. This can be an indicator of a latent conflict between pedestrians and cyclists in the Catalan capital.

Lastly, according to the surveys carried by this research, Barcelonians would be willing to commute a maximum time of 44 minutes if they had unlimited time to reach their destination, while Copenhageners would only spend 25 minutes. When asked about the maximum time they would be willing to commute walking, the surveyed citizens of Barcelona voted mostly for 30 min while their counterparters in Copenhagen voted for 15 min, indicated a tendency to walk more in the Catalan capital than the Danish one.

This shows that the citizens of Barcelona, despite being able to identify more negative aspects about walking in their city than Copenhageners, have a stronger walking culture than the citizens of Copenhagen, which would rather choose another type of faster transportation rather than walk more than 25 minutes.

5.2. Perception of Safety

In the Active City, cycling and walking are universally considered the safest modes of transportation within the city, offering residents a secure means of travel to any destination at any time. This perception of safety is particularly strong among women and minority groups, who do not feel they are engaging in a risky activity, at any time of the day. Cyclists benefit from well-developed parking infrastructure, ensuring their bicycles are secure from theft, further enhancing the sense of safety and convenience associated with these eco-friendly transportation options.

Perceiving active mobility as safe modes of transportation, with no personal security risks or theft exposure is key to develop a city in which cycling and walking are the main mode of transportation.

Perception of cycling safety

The perception of cycling safety is crucial for encouraging more people to use bicycles as a primary mode of transportation in their cities. When cycling is perceived as a complete safe mode of transportation with no risks attached, citizens can enjoy a healthy cycling environment.

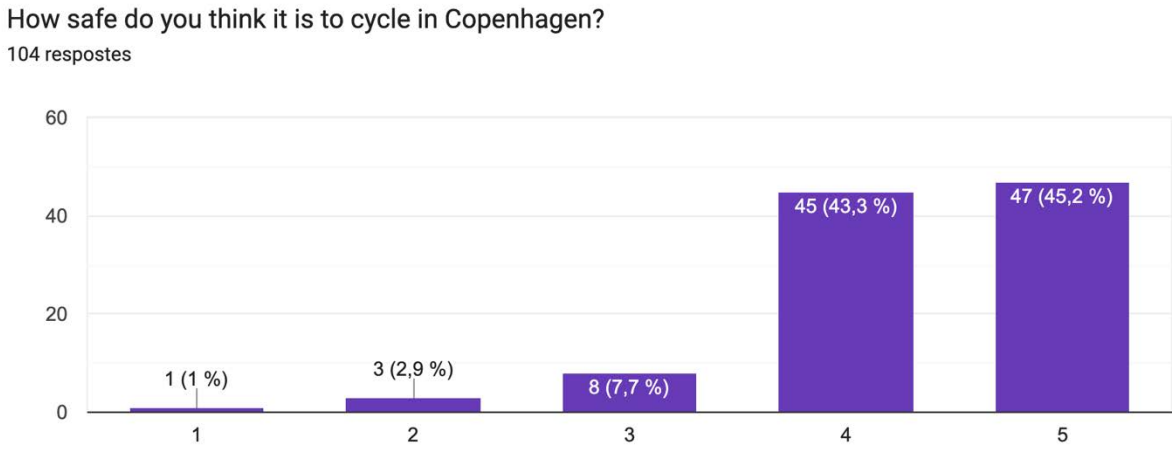

Figure 17. Safety perception of cycling in Copenhagen (Survey)

Through the survey made to citizens in Copenhagen by this research, results indicated a median result of 4.29 on a scale from 1 to 5 to the perception of cycling safety in the Danish capital. The vast majority of surveyed Copenhageners voted high rates when asked how safe they think it is to cycle in Copenhagen, indicating a strong sense of safety in the city.

According to the Bicycle Account 2022, cyclists' rist injury in traffic has decreased after two years of increase in 2018 and 2019, but they did account 55% of all traffic casualties and fatalities (City of Copenhagen, 2022). In 2020 and 2021, the Copenhagen police registered 78 and 99 serious cyclist injuries respectively, while 2022 figures were not reported. These numbers are lower from previous years, as in 2018 when 131 serious cyclists casualties were reported. Now, the municipality aims to see zero casualties in 2025 (City of Copenhagen, 2022). Moreover, the proportion of cyclists in Copenhagen who feel safe was reported to be 79% both in 2020 and 2022, although the municipality aims now to see a figure of 90%. Considering marks 4 and 5 a vote for feeling safe while cycling in Copenhagen, 88.5% of the surveyed through this research's survey perceive cycling as a safe experience, bringing figures close to the municipality's goal.

Moreover, the city of Copenhagen has reached a political consensus to reduce motor vehicle speeds by 10 km/h on the entire municipal network and to reduce speed on

selected roads such as Ågade and Roskildevej to 50 km/h. According to the municipality, lowering motor vehicle speeds leads to fewer serious injuries and fatalities. Additionally, reduced speeds enhance the sense of security for cyclists and pedestrians, and make urban spaces more enjoyable by decreasing acustic pollution (City of Copenhagen, 2022).

According to the Active Mobility survey carried by this research, Copenhageners identify motorbikes on the cycling lane as the main threat to their safety, followed closely by cars. Electric scooters and pedestrians are other reasons identify as dangerous when cycling in Copenhagen.

On the other hand, cycling safety in Barcelona looks different than in Copenhagen.

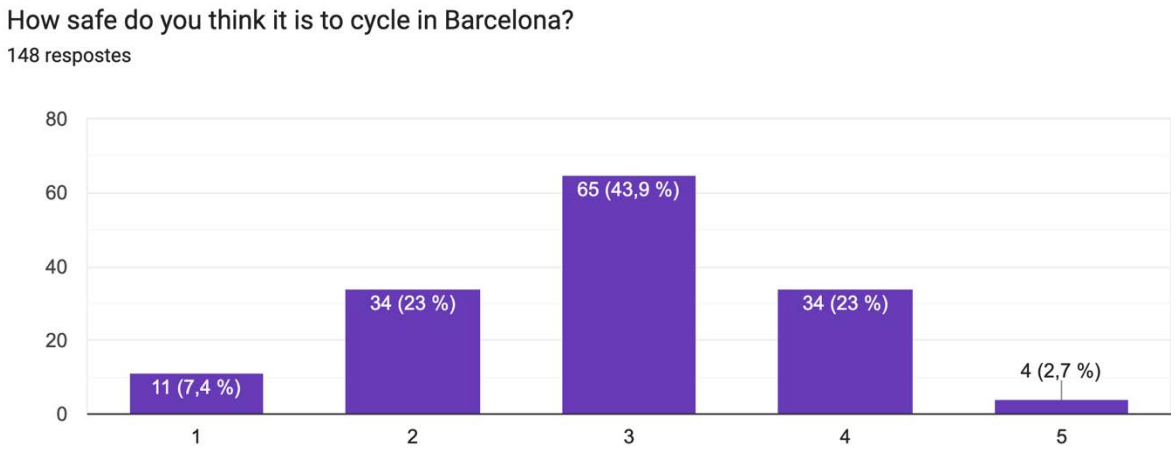

Figure 18. Safety perception of cycling in Barcelona (Survey)

The surveyed sample of Barcelona indicated a balanced answer between those who do not perceive cycling as a safe activity to do in their city and those who think it is, rather a negative than a positive vision about cycling safety in Barcelona, with a median of 2.89 from a 1 to 5 scale.

The main threats to cyclists safety indicated by Barcelonians through the survey are cars, followed by electric scooters and motorbikes. Surveyed citizens also indicated the lack of compliance with traffic rules as a negative element identified with cycling.

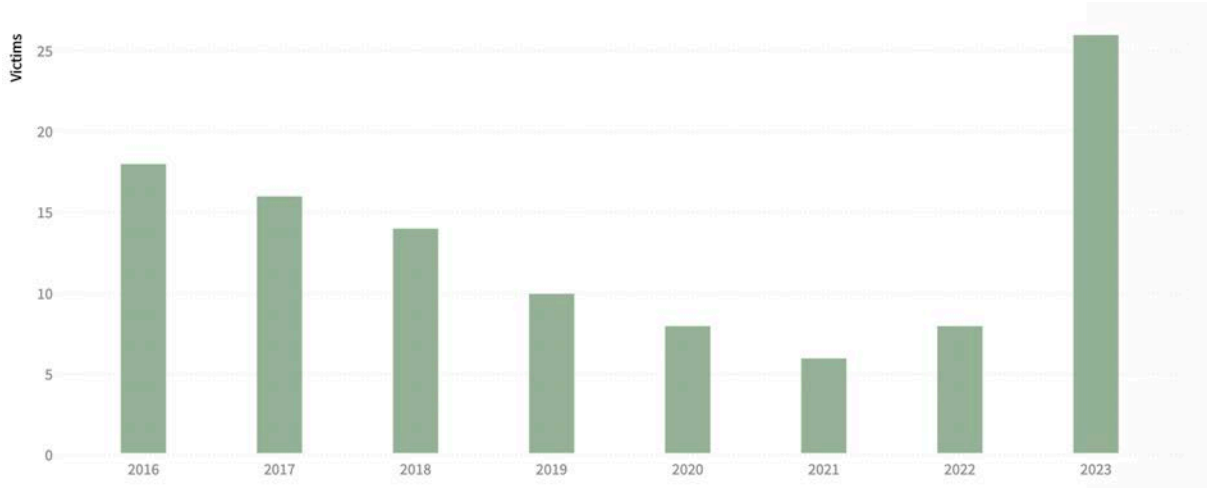

Figure 19. PMV fatalities figures in Barcelona (Barcelona Datastore)

Official figures indicate a sharp increase of fatalities of PMV users in Barcelona in 2023, when a record of 26 citizens lost their life in the cities while cycling or using any other PMV transportation mode. On the previous year, 2022, a decreasing positive tendency was broken, bringing this dramatic increase on the following year. Even considering that electric scooters can now be considered a third of the total PMV mobility in Barcelona (Chevalier P, 2023) this is an alarming tendency and it shows that cyclists in Barcelona are in higher risk that those in Copenhagen, as the number of commuters are much lower in the Catalan capital.

%	Copenhagen	Barcelona
Cars	**67,3**	**82,6**
Pedestrians	32,7	20,8
Motorbikes	**76,9**	**58,4**
Electric Scooters	40,4	59,1
Cargo-bikes	22,1	20,8
Electric Bicycles	19,2	27,7

Table 4. Comparative table of identified risks of cycling in Copenhagen and Barcelona (survey results)

Perception of safety to bike thefts

The perception of safety regarding bicycle thefts can arguably influence the decision to cycle in cities and urban areas. This is a key aspect in the second parameter of the conceptual framework to analyze the state of active mobility and concretely cycling, as the perception of living in a safe city to park your bicycle around can influence crucially the bikeability of the city itself.

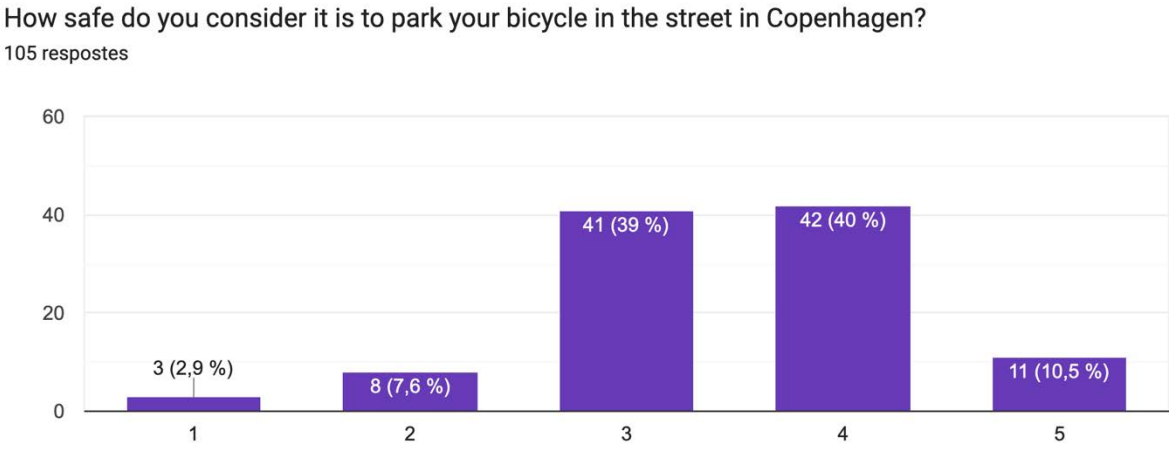

Figure 20. Safety perception on bike parking in Copenhagen (Survey)

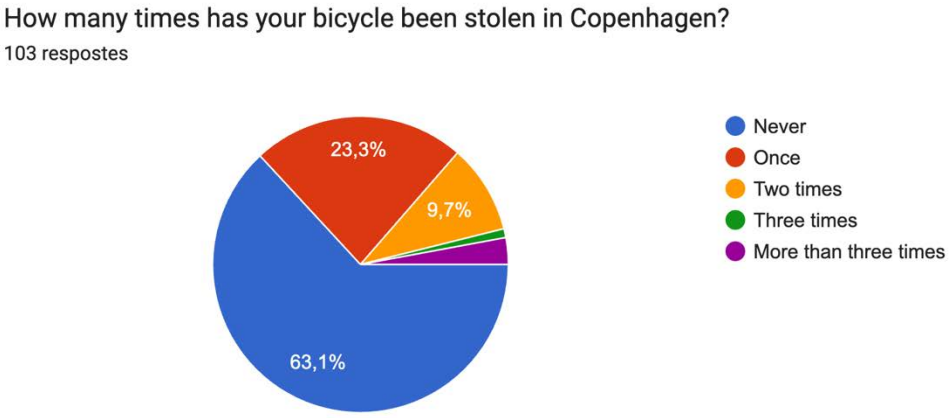

Figure 21. Frequency on bike theft experiences among citizens of Copenhagen (Survey)

Surveyed Copenhageners rated their city with a 3.48 mark from a 1 to 5 scale when it comes safety perception on parking their bicycle in the street. At the same time, almost 4 out of 10 of the surveyed citizens indicated to have lost their bike to burglars at least one time in their lives.

During the first nine months of 2023, over 13,000 bicycles were reported to be stolen in Copenhagen, with only a fraction under 1 percent being found again by the police, setting a ten year record on bicycle thefts in the Danish capital. (Hunter L, 2023)

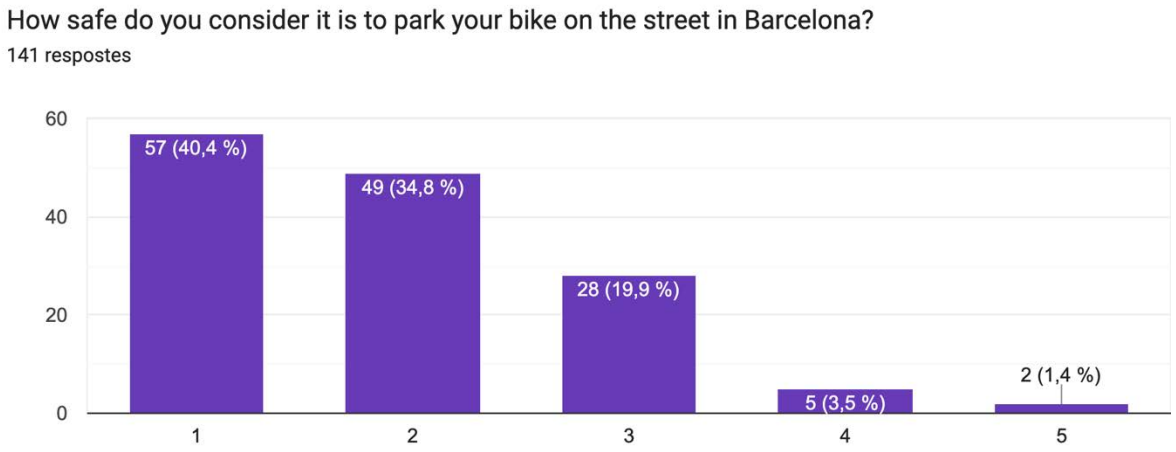

Figure 22. Safety perception on bike parking in Barcelona (Survey)

Safety perception on parking your bicycle in the streets of Barcelona looks very much different than in Copenhagen, according to the surveyed citizens. Residents of Barcelona indicated a negative view when asked if they consider it safe to park their bicycles in the streets, voting mostly for the least favorable view to safety and giving an overall punctuation of 1.9 from a scale of 1 to 5.

In the city of Barcelona, at least two bikes are stolen every day. With 870 thefts in 2021, Barcelona does not rank among the cities with the highest number of bike thefts, but the figure has remained constant for many years, highlighting a problem that is not being taken seriously enough. Additionally, this data only accounts for reported thefts, suggesting the actual number could be higher, and 25 percent of the victims choose to not purchase a bicycle again. (La Vanguardia, 2022)

The most affected districts are Sant Martí, l'Eixample, and Ciutat Vella, precisely the areas with the most bikes parked on the streets. Only 8 percent of stolen bicycles are recovered, and even fewer are returned to their owners. (La Vanguardia, 2022)

Bicycle theft insecurity might be the reason behind why Barcelona is the city in the world with the highest ownership per capita of Brompton bicycles, according to Sílvia Casorrán. Casorrán, former Head of the Bicycle office of Barcelona's Metropolitan Area government sees the success of this London brand type of foldable bicycle due to the insecurity that cycling citizens in Barcelona suffer in their every day lives, and she claims that these bicycles in the urban layout of the city could be key to promote cycling while stronger security measures are not yet implemented by the municipality, as their format allows users to easily bring and store them home and in their offices while they work, allowing them to commute cycling without worrying about their bicycles (full interview transcript can be found in Annex B).

Figure 23. Brompton bicycle in Barcelona (Folding Bikes House, n.d.)

Perception of walking safety

Walking safety perception is crucial for promoting the Active City model. Perceptions of safety significantly influence individuals' decisions to walk in urban areas. If people perceive walking as risky or insecure due to concerns about physical safety, crime, traffic accidents, or harassment, they are less likely to choose walking as a mode of transportation. (ITF, 2024)

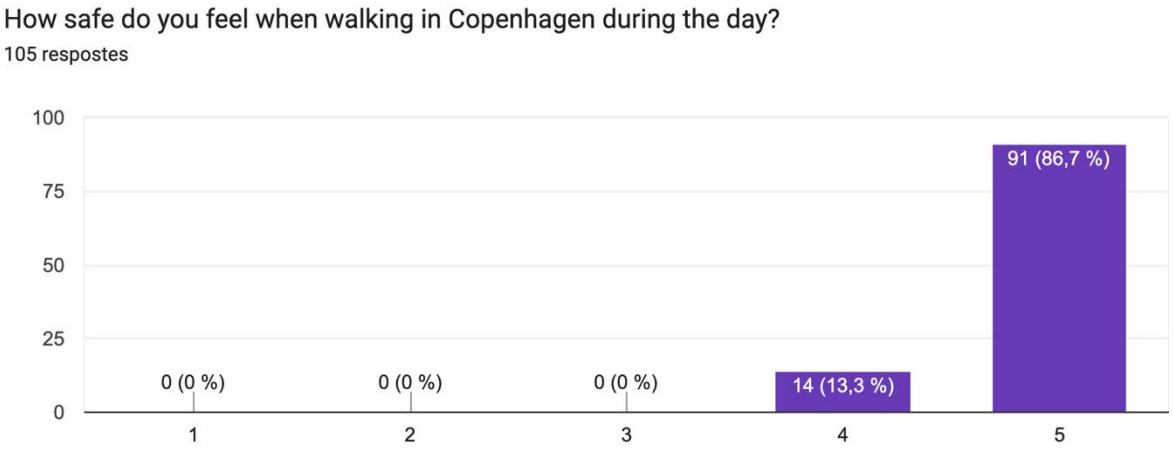

Figure 24. Safety perception of walking in Copenhagen during the day time (Survey)

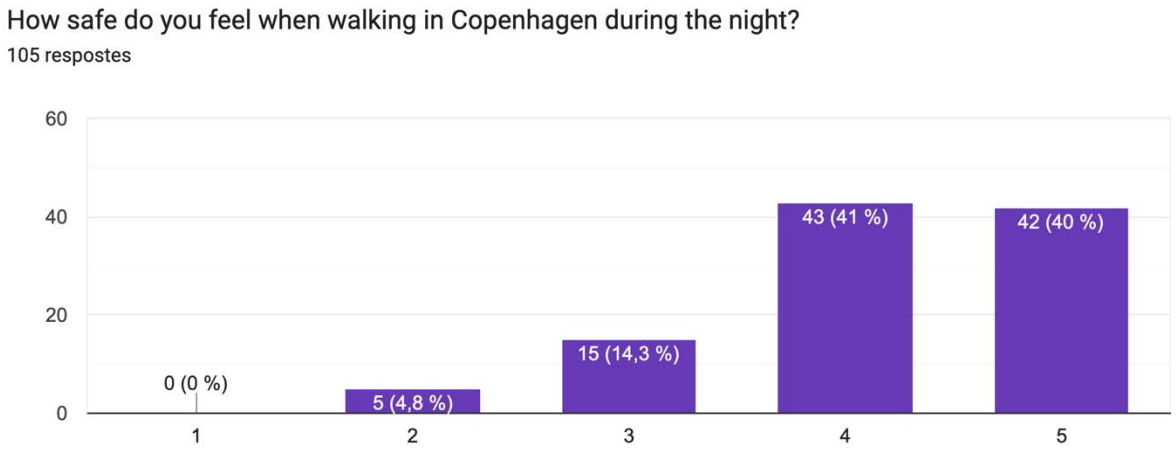

Figure 25. Safety perception of walking in Copenhagen during the night time (Survey)

Walking in Copenhagen is perceived as a very safe experience, according to results obtained through the survey. Citizens indicated a 4.88 mark to walking during the day and a slightly lower 4.16 to walking during the night in Copenhagen, from a scale to 1 to 5.

On top of that, the majority of the surveyed citizens indicated that they perceive all districts of the city as safe areas to walk at night, followed by Nørrebro, Brønshoj-Husum and Bispebjerg being the ones perceived as less safe after this option. The full results can be consulted in Appendix C.

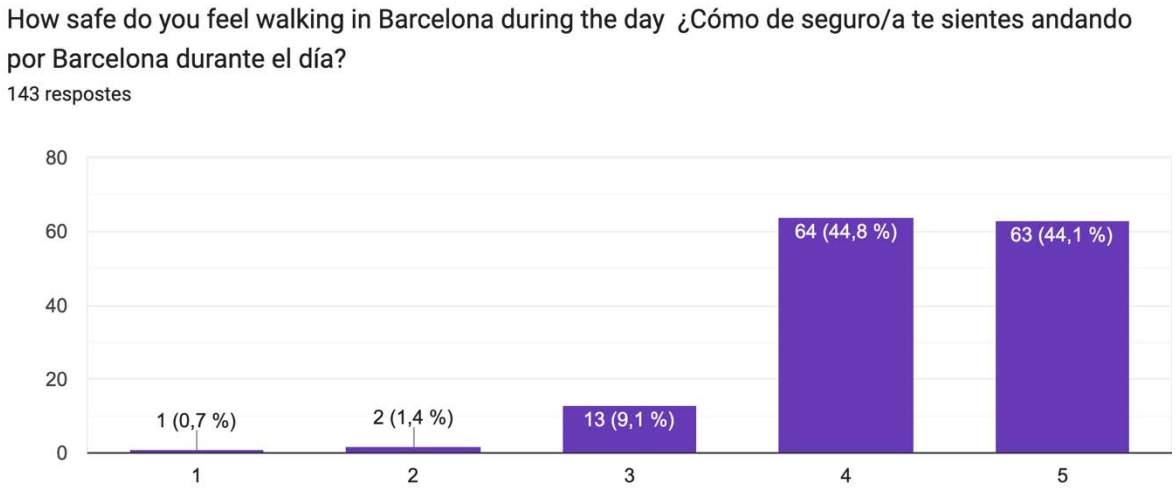

Figure 26. Safety perception of walking in Barcelona during the day time (Survey)

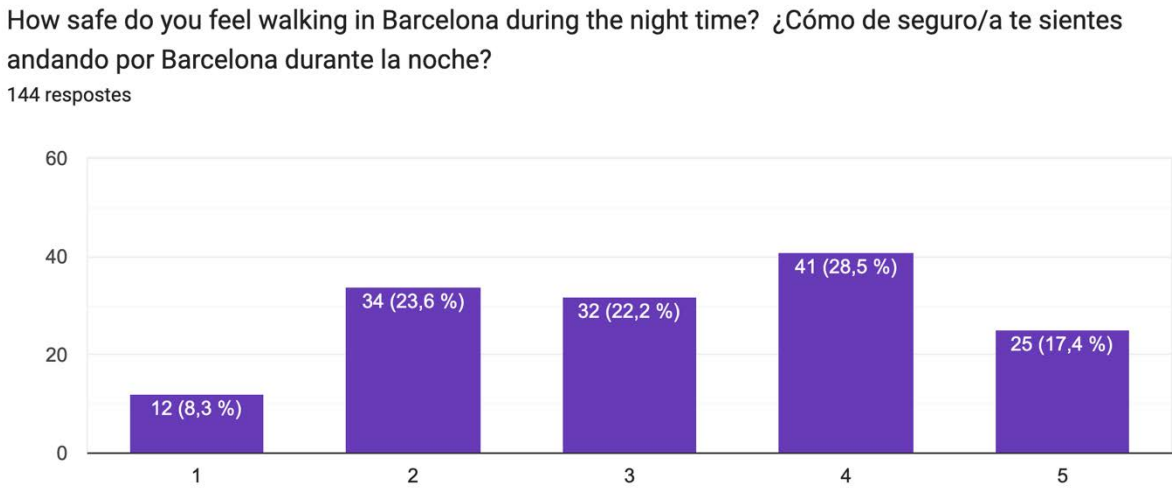

Figure 27. Safety perception of walking in Barcelona during the night time (Survey)

Regardless of walking more than their Copenhagen counterparters, citizens of Barcelona perceive walking in their city as a less safe experience, especially during the night. Walking during the day scored 4.3 and during the night 3.23, in a scale from 1 to 5.

Regarding the districts perceived as more unsafe to walk at night, more than 8 out of 10 of the sample of citizens answered Ciutat Vella (Barcelona's old town and city center) is not perceived as a safe area, followed by the peripherial district of Nou Barris and Sants-Monjuïc. Contrasting with the results in Copenhagen, a very few citizens voted for the option 'None, all of them are safe'. Full results can be consulted in Appendix C and D.

The results obtained by the two surveys show a remarkable contrast between the perception of safety when walking in the two cities, especially walking at night. Barcelona is perceived as less safe than Copenhagen, while citizens of Barcelona still choose to walk more and during more time than Copenhageners.

However, looking into the topic from a gender perspective, the results are alarming. As shown in Figure 19, more than 4 out of 10 women from the survey sample of Barcelona claimed not to feel safe when walking in their city, with only a quarter responding positively when it comes to their perception of safety as women.

Surveyed women indicated that cat-calling and men chasing them while they coming back home at night have been experiences that they have gone through more than once, while other shared other experiences that provide evidence of an on-going problem in Barcelona. Results can be consulted in Appendix D.

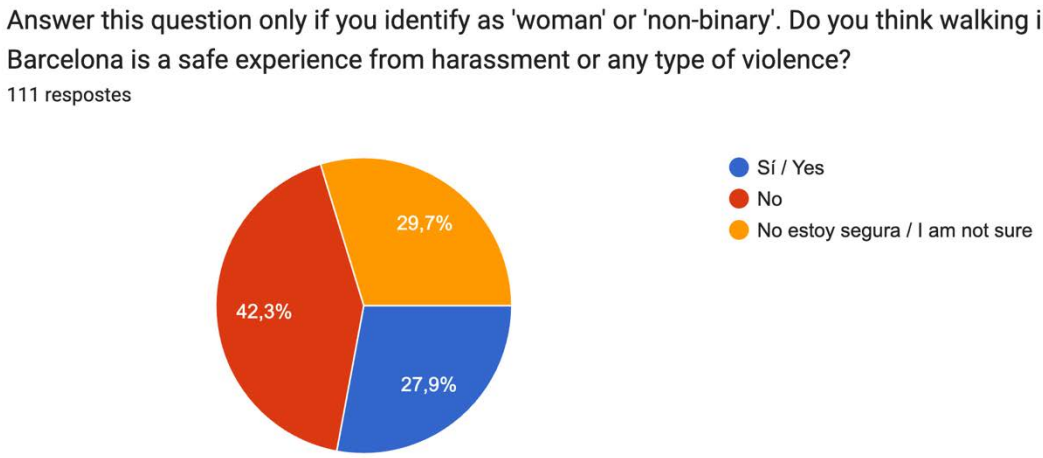

Figure 28. Walking safety perception by women and non-binary people in Barcelona (Survey)

Again, this results contrast with the ones obtained in Copenhagen, where a slightly higher number of women and non-binary people claimed that they see their city as a absolutely safe to walk, although almost half of the surveyed sample of women and non-binary people answered that they feel safe during the day but not necessarily during the night. Worringly, 15 percent indicated that they do not always feel safe walking in Copenhagen, neither the day nor during the night time. Full results with feedback provided on safety-threating experiences by women and non-binary people in Copenhagen can be consulted in Appendix C.

Copenhagen was presented as the safest city in the world by the *Safe Cities Index* report from *The Economist,* while Barcelona ranked 11th on the chart, sharing the position with New York City on this chart. From the five subindexes in which this is built, Barcelona ranked 12th in the Personal Security one, while Copenhagen stood on top again. (The Economist, 2021)

To encourage walking and improve safety perceptions, it is essential to address not only physical safety through infrastructure but also broader societal issues related to social safety. This includes engaging with deeper system leverage points to change incentives, rules, and paradigms within the transportation system. By creating a safe and secure environment for pedestrians, free from various forms of violence, individuals can feel more comfortable and willing to walk in cities. (ITF, 2024)

5.3. Accessibility and Inclusivity

Accessibility and inclusivity play a vital role in promoting active mobility in cities by ensuring that walking and cycling are convenient, safe, and attractive options for all individuals, regardless of their age, abilities, or socio-economic status. (ITF, 2024)

The analysis of the accessibility and inclusivity parameter in Copenhagen and Barcelona in this chapter is solely made through a social perspective and indicators. This parameter is linked to the previous one 'Perception of Safety' and the following one 'Infrastructure and Facilities', as the inclusivity in a city to all social groups can be also determined by how safe they feel and perceive their city and the infrastructure built around them.

Gender Balance in Active Mobility

Planning for women and elderly people is essential to promoting active mobility in cities due to their unique needs and concerns. Safety is a primary issue, as women and elderly individuals often have specific apprehensions about walking and cycling in urban areas. Addressing these concerns through well-lit pathways, clear signage, and safe infrastructure can alleviate fears and encourage more participation in active mobility. For example, well-maintained sidewalks and designated bike lanes can make these activities safer and more appealing. (ITF, 2024)

When it comes to gender balance, there is evidence that women cycle less than men due to a combination of behavioral, psychological, and environmental factors. Research suggests that women perceive cycling as a riskier activity than men and physical route characteristics such as steep slopes can deter women from cycling, especially for commuting purposes, plus infrastructure design that does not cater to the specific needs and safety concerns of women cyclists can also act as a barrier. Other factors contributing to the gender gap in cycling include aversion to long distances, poor weather conditions, and lower confidence in cycling skills. (Battiston et al., 2023)

Moreover, societal norms and cultural perceptions play a role in discouraging women from cycling and walking. Harassment can be a significant deterrent for women when it comes to cycling. Research suggests that concerns about harassment by motorists and other road users can contribute to women cycling less than men. The fear of harassment, whether verbal or physical, can create a hostile environment for women cyclists and impact their sense of safety and comfort on the road. (Battiston et al., 2023)

Therefore, finding gender balance on the active mobility in a city relies both on infrastructure and a secure environment where women feel safe from gender-based harassment

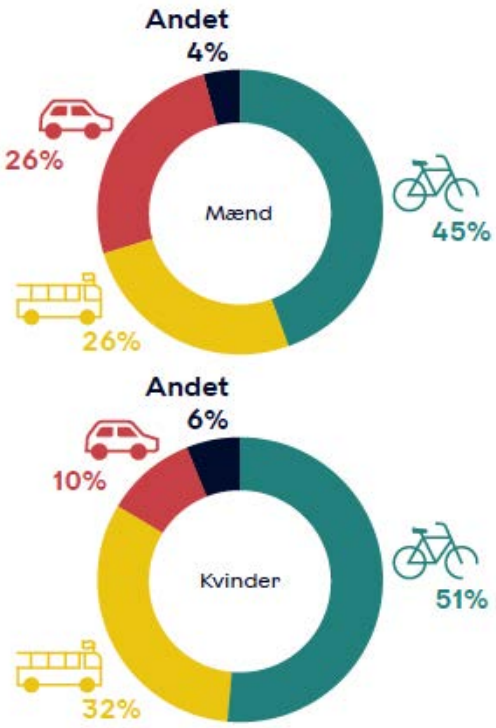

Figure 29. Modal share of mobility in Copenhagen by gender. Men: above; Women: below (City of Copenhagen, 2023)

According to the Mobility Report 2023 annually published by the municipality of Copenhagen, female citizens cycle more than their male counterpart. Women in the Danish not only cycle more, but they also move around with public transport than men, who drive more than double times than them. (City of Copenhagen, 2023b)

This indicates a significant milestone achieved by Copenhagen in promoting gender equality among cyclists and one step further to the Active City vision. This accomplishment signifies a general sense of safety and integration for all cyclists. Copenhagen joins the ranks of a few other cities globally, such as Amsterdam in the Netherlands and Osaka in Japan, which have also achieved notable gender parity in cycling. In Osaka, for example, nearly two-thirds of bike trips are made by women (CEDAR, 2021).

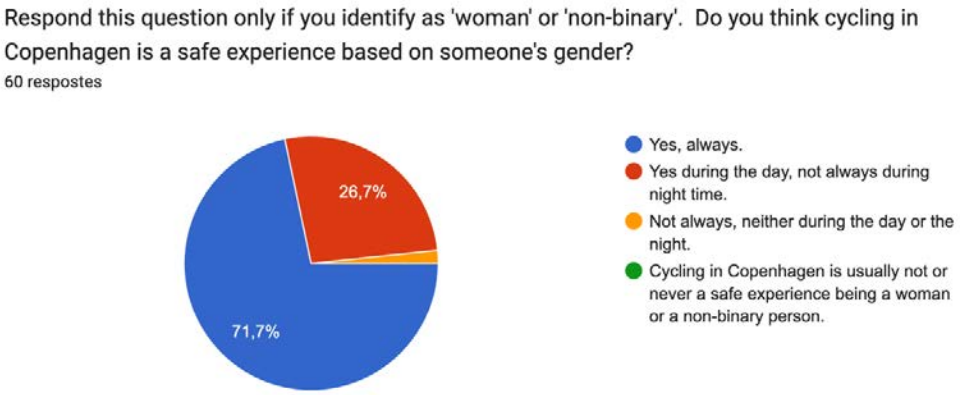

Figure 30. Safety perception of cycling in Copenhagen from a gender perspective (Survey)

Survey results show a general positive perception on women safety from gender-based harassment when cycling in Copenhagen as shown in Figure 30, while in Barcelona answers and results are very similar as exposed in Appendix D.

Nonetheless, Barcelona figures look much different when it comes to gender balance. As shown in the figure below, there is a big disparity between male and female cyclists in the Catalan capital, where around three quarter of the cyclists in 2023 were men. These numbers have been oscilating through the past years, but never close to a point similar to gender equality.

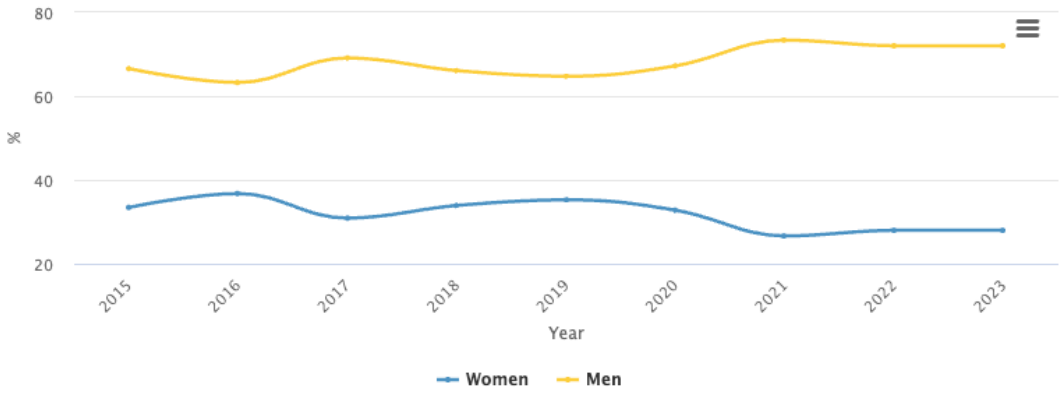

Figure 31. Percentage share of PMV use by gender in Barcelona (Barcelona Datastore)

Barcelona's municipality has been has been taking action to push for a gender equality agenda in the past few years, including in mobility. Under the leadership of former Mayor Ada Colau, the city approved its Plan for Gender Justice 2016 – 2020, which includes different strategic axes that overall aim to promote equality between women and men (Municipality of Barcelona, 2016). This report includes an analysis on mobility patterns of the city from a gender perspective, with similar results to Copenhagen in this regard: women use more public transport and drive less than men, while still cycle much less as well. Moreover, women mainly travel for family reasons and more internally inside the city of Barcelona than men and also they carry more trips more often and closer by (Municipality of Barcelona, 2016).

Furthermore, the municipal plan claims that women have a higher perception of insecurity, which affects their mobility and can even lead to its limitation, as well as constrain the right to enjoy the public space and a social life (Municipality of Barcelona, 2016). For that, the plan includes management mechanisms both for the implementation of the plan and its monitoring and evaluation, and a strong focus on training and mainstreaming awareness to improve preventive action against gender-based harassment and violence in urban public space (Women4Climate, 2019) to work towards a city in where women feel safe when walking and cycling.

However, there is one positive indicator pointing to a solution that could balance the cycling gender gap in Barcelona: there is gender parity in the city's public bikeshare

system, Bicing: 48 percent of users are women and 52 percent of users are men (Women4Climate, 2019), although this does not necessarily mean that usage and number of trips per year are similar.

Cargo-bikes

There is an increasing awareness among both transportation users and planners that many urban deliveries do not require large, powerful vehicles like cars or trucks. Instead, they can be effectively and efficiently handled by bicycles. Lightweight cargo bikes, capable of carrying up to 250 kg, are already widely used in various cities and offer a reliable, fast, and cost-effective method of delivering goods. Maximizing the use of cargo bikes and reducing reliance on heavy vehicles can significantly benefit carbon emissions, air quality, street safety, and urban space utilization. However, there has been relatively little focus on the factors that make certain routes more suitable for cargo bikes than others. Thoughtful consideration of these factors by transportation planners can encourage the rapid growth of cargo bike transport. (Liu, 2022)

Cargo-bikes are therefore an indicator of a strong cycling culture (Copenhagenize, 2019), as these vehicles require good cycling infrastructure and policies that promote its use to transport both goods and people around the city. They hold the potential to substitute cars for everyday use in urban settings, specially among households with children, making families less reliant on cars (Inserra, 2021).

Figures from 2009 showed that in Copenhagen, 6% of all households in the city owned at least one cargo bike. 25% of families with two or more children had a cargo bike and 50% of all Copehageners with a cargo bike used it to transport children. On top of that, studies show that only 2% of Copenhagen cyclists found cargo bikes as obstacle

s and had a negative view on them. Moreover, 22% of cargo bike owners in the city had the bike instead of a car and 24% used their cargo bikes as a supplement to their car. (Copenhagenize, 2009)

In 2022, figures indicated that Copenhageners owned approximately 40,000 cargo bikes, doubling the number of ownership achieved just two years ago, in 2020. (City of Copenhagen, 2022)

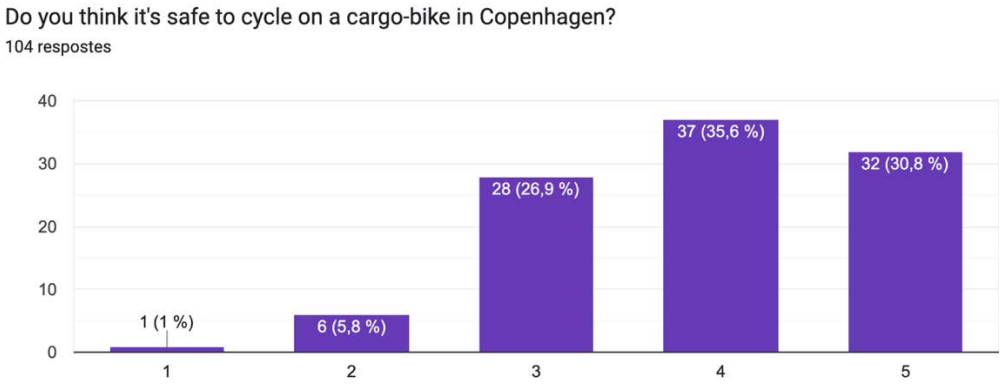

Figure 32. Safety perception on cargo-bike riding in Copenhagen (Survey)

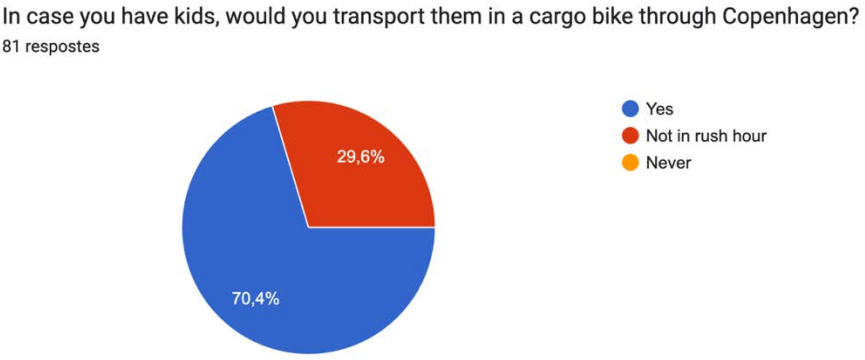

Figure 33. Transport of kids with a cargo-bike trust rate, Copenhagen (Survey)

Surveyed Copenhageners perceive cycling with a cargo-bike as an overall safe experience, and none of them answered that they would never transport their children in one in their city. These results, in which safety when cycling with a cargo-bike is valued with a 3.89 mark on a 1 to 5 scale, show a recognized sign of a strong and healthy cycling culture (Copenhagenize, 2019).

Moreover, several companies operate cargo bike delivery services in Copenhagen: Chainge, founded in 2019, uses electric cargo bikes to deliver goods the last kilometers to customers, reducing van traffic. BY-EXPRESSEN, an independent and cooperatively-owned company, has revived its old name and employs cargo bikes for deliveries. The Danish postal service and DHL also utilize cargo bikes for post and small parcel deliveries in Copenhagen's inner city. (Danish Design Review, 2021)

Figure 34. Family cycling on a Christiania cargo-bike in Copenhagen (Mellbin, 2012)

Barcelona's results show to be different again from Copenhagen. Figure 35 shows a Barcelonians having a more negative perception about cargo-bike cycling in their city, voting for a median 2.4 mark on a 1 to 5 scale, indicating a low trust on the safety of these cycling devices in their city.

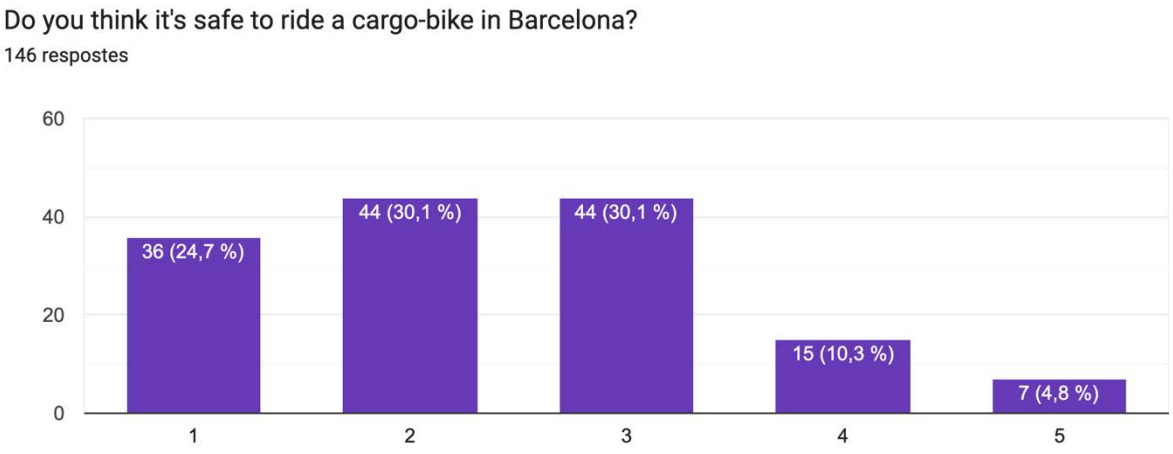

Figure 35. Safety perception on cargo-bike riding in Barcelona (Survey)

However, cargo-bikes have recently started circulating through the streets of the Catalan capital. Courier companies as *CargoBici* have started to made their way through the urban ecosystem of Barcelona. This companyoperates a sustainable last-mile logistics service using their own electric cargo bikes for deliveries. They have strategically located microhubs across the city for cross-docking, fulfillment, and reverse logistics operations. Cargobici's cargo bikes are designed for industrial use, electric, versatile, agile, and stable, with modular parts and boxes of different temperatures. They offer real-time data collection through their own SaaS tool, providing transparency to clients with visibility and traceability of shipments in real-time. Cargobici aims to transition towards a more efficient and sustainable urban distribution model, focusing on reducing carbon emissions in the last mile delivery operations in Barcelona (CargoBici, n.d.).

Figure 36. CargoBici couriers in Barcelona (CargoBici, 2024)

6. Streetscape

The streetscape of a city plays a crucial role in promoting cycling and walking. Well-designed streetscapes that prioritize pedestrian and cyclist needs create safer and more enjoyable environments for non-motorized travel. Features such as dedicated bike lanes, wide sidewalks, ample lighting, and green spaces encourage residents to opt for healthier modes of transportation as cycling or walking. Furthermore, attractive and accessible streetscapes can reduce traffic congestion and pollution, enhance social interactions, and boost local businesses by making streets more inviting and navigable. By fostering a culture of walking and cycling, cities can improve public health, decrease their environmental footprint, and create more vibrant, livable communities.

This dimension of the conceptual framework explores how the urban infrastructure of a city, from digital infrastructure to its public transport system, conditions active mobility in Copenhagen and Barcelona.

6.1. Infrastructure and Facilities

Cities can promote active mobility by developing infrastructure and facilities that support both cycling and walking. A well-planned cycling infrastructure includes a network of bike lanes, bike-friendly traffic signals, and secure bike parking, making cycling a safe and convenient option for residents (Liu, 2022). Walking infrastructure should feature wide, well-maintained sidewalks, pedestrian crossings, and traffic calming measures to ensure a pleasant and safe experience for walkers.

In this parameter from the defined conceptual framework, the cycling infrastructure and network from Copenhagen and Barcelona is evaluated, as well as walking infrastructure, greenery and the bikeshare alternatives. These are the indicators defined in the conceptual framework, from which the infrastructure of cities is evaluated.

This subchapter is organized in different sections that aim to divide the infrastructure and facilities that provide the opportunity to citizens in Copenhagen and Barcelona to actively commute through their cities. These are the cycling network, bicycle parkings, walking infrastructure, greenery and bikeshare alternatives. Each one of these urban elements is evaluated through the criteria established in the conceptual framework defined in section 3 of this report.

Cycling network

Copenhagen

The cycling network of a city is considered by this thesis research all the routes designated by the municipality in with bicycles and other PMVs can circulate in a city. This include bicycle lane, paths, streets where bicycle transit is allowed and pacified streets, and urban elements that are part of the cycling experience.

Copenhagen's cycling network is claimed to be one of the best ones of the world by the municipality (City of Copenhagen, 2023a).

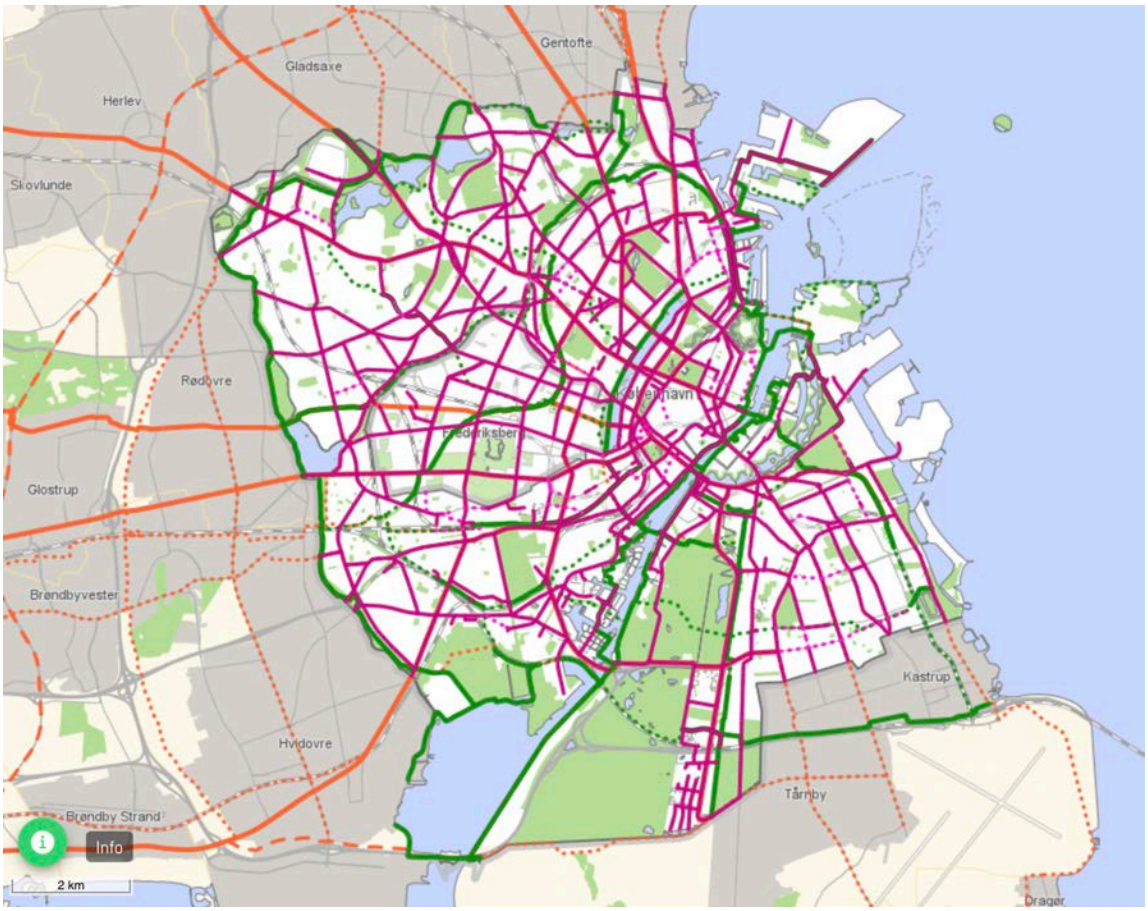

Figure 37. Map of Copenhagen's cycling network. Pink: cycle path along the road; Green Cycle Route'; Orange: Vision plan for 'Super Cycle paths' (City of Copenhagen, 2024b)

In 2022, the city of Copenhagen counted with 388 km of cycle tracks, 33 km of cycle lanes, 65 km of Green Cycle Routes and 60 km Cycle Superhighways. These figures are the results of an investment plan that has brought the municipality to spend a total of 0.84 billion DKK from 2012 to 2022 (City of Copenhagen, 2022).

The municipality distinguishes three types of cycling routes in Copenhagen's streets:

- Cycle path along the road (**PLUSNet**): describes Copenhagen's main network where the highest volumes of bicycle traffic are present or expected. The minimum PLUSnet width of 2.8 m ensures comfort, safety and flow for different

types of cyclists. This width ensures that a commuter cyclist can overtake a cargo bike or a parent and child cycling side by side. Thus, the overall goal is to make it possible for everyone to cycle at a pace that suits them on the majority of the central cycle network. Part of this network overlaps with the 'Super Cycle Paths'. (City of Copenhagen, 2023a)

- **Green Routes**: routers for cyclists and pedestrians that run through green spaces, along the harbour and on less busy roads. These routers have both transportation and recreation purposes. The green cycle routes are an experimental alternative to cycling and walking along busier roads. (City of Copenhagen, 2023a)
- **Super Cycle paths**: cycle paths designed for commuting across municipal boundaries and over longer distances, where a high standard of cycling infrastructure must be ensured. (City of Copenhagen, 2023a)

Figure 38. Example of Super Cycle Path in Inner Ring Route on Enghavevej (City of Copenhagen, 2023a)

The classification is understood under the 'Finger Plan' that shapes Copenhagen's road planning from the outskirts of the city to the city center, explaining why Super Cycle paths are differentiated than normal ones. Moreover, the municipality integrates cycling in streets that do not fall in neither of the three categories above. In general terms, the following cycling infrastructure is identified to create these routes and adjecent streets:

- Bike paths (*Cykelstier*): streets with higher volumes of 2500 motorized vehicles per day should always incorporate a bike path with a physical separation from pedestrians and cars. (City of Copenhagen, 2023a)
- Bike lanes (*Cykelbaner*): marked cycling area at the same level as the roadway. The bike lane is marked with a wide, continuous edge line and bicycle symbols at a distance of approx. 100 m and after side roads and intersections. The beginning and end of the bike lane to the mixed traffic lane is designed by continuing the bike lane in a 15-20 m long wedge-shaped bike lane. (City of Copenhagen, 2023a)

- Bike streets (*Cykelgader*): bicycles and cars circulate on the same way, where bicycles have priority and have to cirulate on the same direction as motorized vehicles. (City of Copenhagen, 2023a)
- Bi-directional bike lanes: cyclists travel in both directions separated by a dotted center line. The municipality is against building those along the road, and plans them to have no stops along the way. Examples can be found in bridges and tunnels. (City of Copenhagen, 2023a)

The very first cycle track in Copenhagen was established in 1905 with the primary purpose of providing cyclists with a smooth surface and protection from cars. This marked the beginning of dedicated cycling infrastructure in the city. the mid-20th century, nearly half of the present cycle tracks in Copenhagen had already been established, with cycling peaking between 1945 and 1950. During this period, major streets like Nørrebrogade saw a high volume of cyclists, influencing traffic dynamics in the city. (Jensen, 2013)

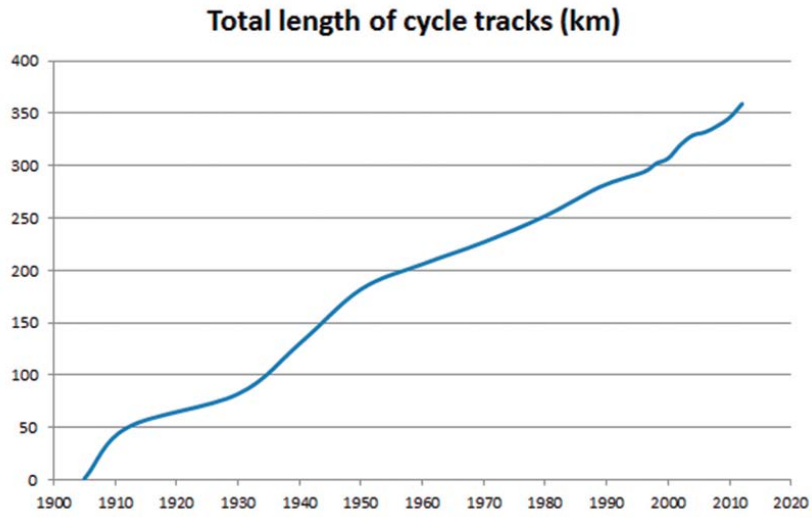

Figure 39. Development of cycle tracks in Copenhagen (Jensen, 2013)

According to Copenhagen Planner, former head of Copenhagen's Bicycle Program, Copenhagen's approach to promoting cycling has involved creating a differentiated network adapted to different needs and preferences. The main network features segregated bicycle tracks along all major roads, ensuring that cyclists can travel safely and directly to their destinations without detours. This principle follows the logic that people should have safe bicycle infrastructure where they would naturally travel. Overlapping this network are green bicycle routes, which serve as recreational greenways with slower speeds and a safer, more relaxed atmosphere. Copenhagen Planner remarks that Copenhagen could further enhance its cycling infrastructure by focusing on the sublayer of residential streets, integrating traffic calming measures and other strategies to make these areas more inclusive for cyclists, even though segregated infrastructure

might not be feasible. This would create a more finely meshed network, utilizing back alleys and smaller connections to ensure coverage and accessibility for all cyclists (Appendix A, interview with Copenhagen Planner).

When it comes to satisfaction with Copenhagen's cycling network, Copenhageners indicated in 2021 a level of 68% of satisfaction with the cycle track maintenance. Through the survey carried out by this research (see Appendix C), higher levels of satisfaction were indicated, with 93% of the surveyed sample indicating a positive mark of 4 or 5 on a scale from 1 to 5 when being asked about their level of satisfaction with Copenhagen's cycling network.

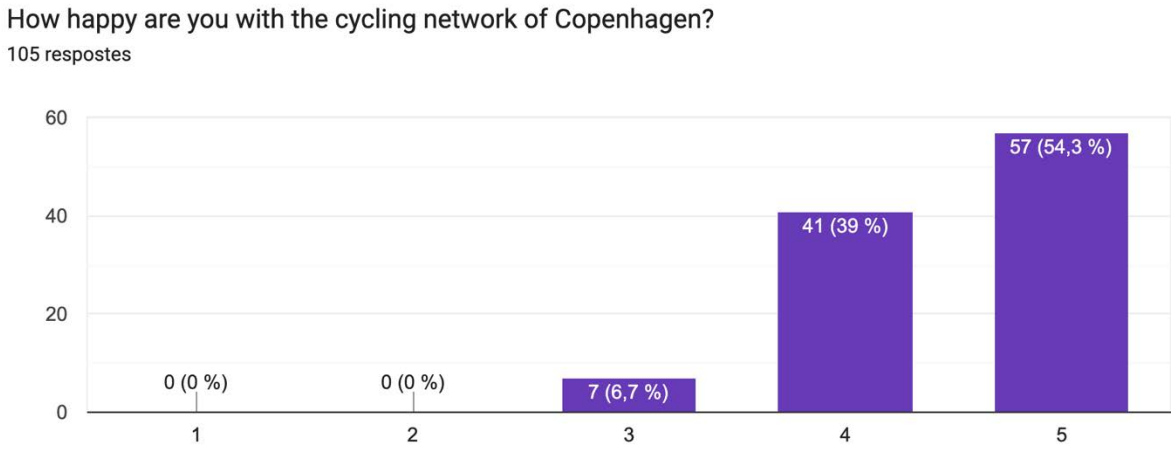

Figure 40. Level of satisfaction with Copenhagen's cycling network (Survey)

Survey results show that more than half of the sample thinks that 'Some intersections don't make sense', followed by cycling lanes being too narrow and cars circulating too close as main identified problems with the cycling network of Copenhagen (see Appendix C).

Barcelona

The Catalan capital counts with nearly 1150 kilometers of cycling routes, including bike lanes, 30 km/h streets, traffic-calmed areas, and other infrastructure designed for cycling (Municipality of Barcelona, 2023b), conforming a cycling network that has expanded considerably the past years.

From 2015 to 2019, the city removed about 3000 car-parking spots to increase the total length of bicycle lanes from 116 kilometers to 209 kilometers, almost doubling the network of lanes in just four years (Wilson, 2022).

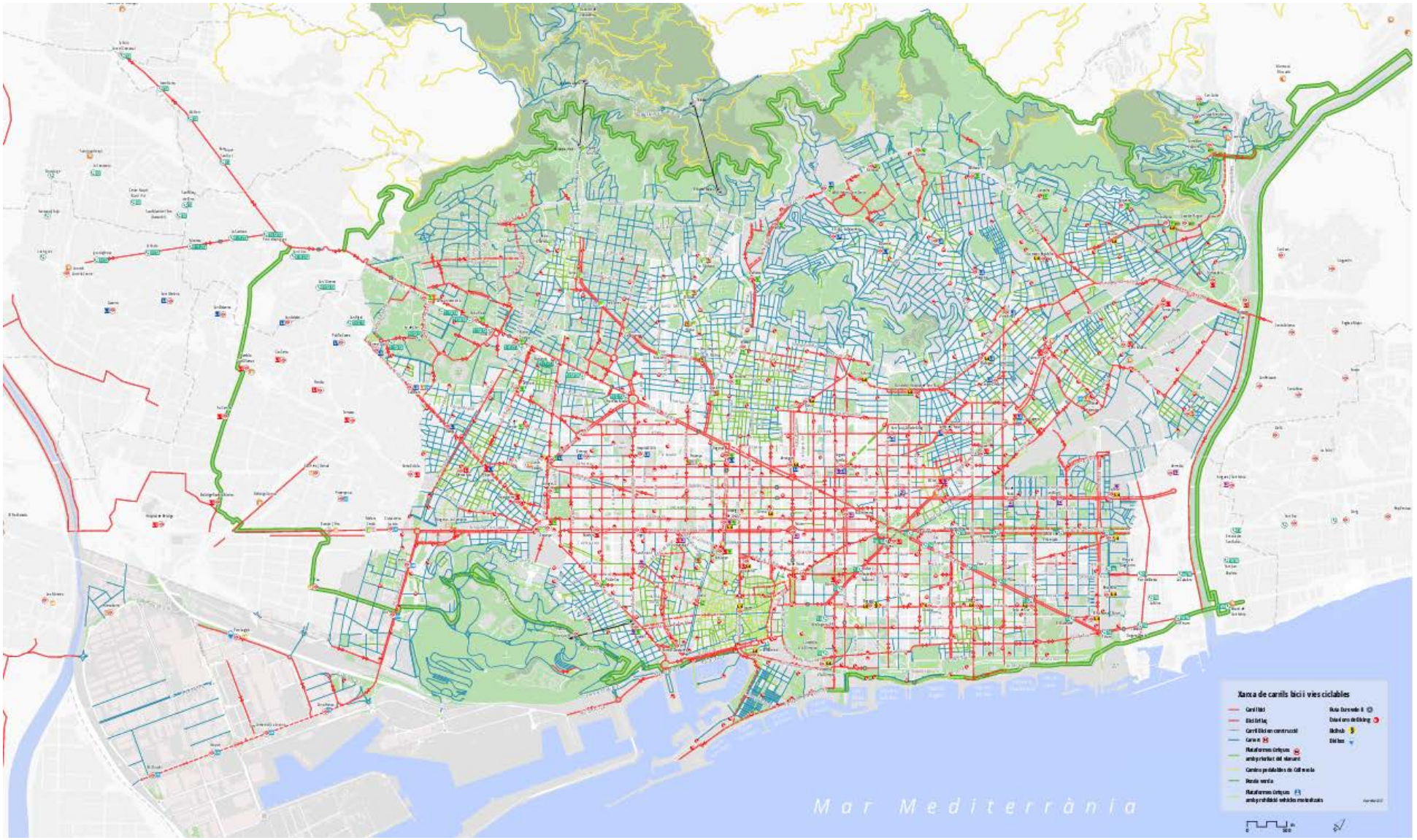

Figure 41. Map of Barcelona's cycling network (Municipality of Barcelona, 2023b)

Analyzing the cycling network of Barcelona, three types of cyclable streets can be distinguished:

- **Regular streets with a cycling path**: streets with motorized traffic and in which Personal Mobility Vehicles (PMV) can circulate on the designated cycling lane. It is worth pointing out that in Barcelona, the direction of circulation on these paths is not necessarily the same as the one motorized vehicle have on the same street. (Ajuntament de Barcelona, 2022)
- **'Cycling Streets' or Zone 30**: streets with pacified traffic in which the circulation of cyclists is promoted, since the traffic of automobiles has its speed limited to 30 km/h. On these streets, bicycles must circulate in the direction of traffic road and have priority over the movement of other vehicles, but no on pedestrians. Circulation is not allowed in two directions. (Ajuntament de Barcelona, 2022)
- **Pedestrian areas with a single platform**: streets under a 20 km/h speed limit, inner streets of superblocks and green axes: these zones of reversed priority are areas or streets where the traffic conditions of vehicles are restricted in favor of pedestrian traffic. In these areas, PMVs enjoy priority over the rest of the vehicles, but not over them pedestrians, and can travel in both directions of the road. (Ajuntament de Barcelona, 2022)

When it comes to the perception of this relatively newly developed cycling network, the surveyed sample expressed a medium level of satisfaction with it. Most citizens voted for 3 on a scale from 1 to 5, with more indicating a rather negative punctuation than those voting for a positive one. Results can be observed on the figure below.

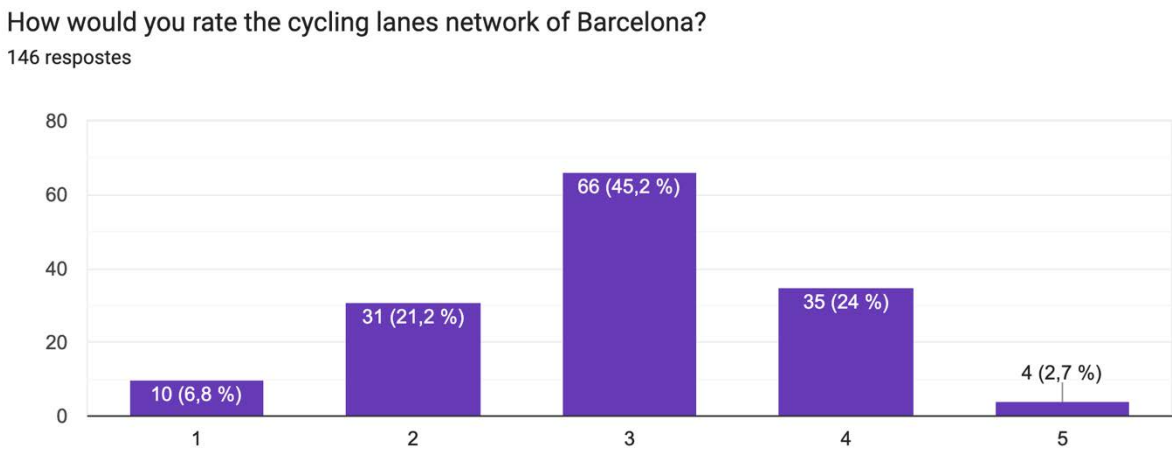

Figure 42. Level of satisfaction with Barcelona's cycling network (Survey)

Surveyed citizens were critical when asked about identifying problems with the cycling network of their city. More than 7 out of 10 complained about lanes lacking good interconnectivity, while more of the half vote for 'Bike lanes are too narrow'. Moreover, more than 4 out of 10 expressed that the bidirectional lanes, such as those built in

Passeig de Sant Joan or Avinguda Paral·lel are dangerous, and that the plastic separators between the lanes and main road are perceived as dangerous. Full results can be consulted in Appendix D.

Sílvia Casorrán reaffirms her commitment to making the entire metropolitan area bike-friendly, with every street accessible for cyclists: *I am not giving up on my goal, which is to make the entire metropolis pedalable, any street*. She highlights that while quick networks are essential, any street should be pedalable. Casorrán explains that from the public sector, a team was created to coordinate project initiatives, although most projects are outsourced. Initially, they managed both the project planning and the direction of the work. Often, they collaborated with the City Council, which would contract the projects, showcasing two typical scenarios. In one, subsidies were given to municipalities, with technical support and valued reports provided internally or contracted out, allowing the municipality to handle the executive project and the construction. However, technical coordination was always maintained from within her team, following minimal guidelines approved during the project phase, such as minimum widths and pavement types. (Appendix C, interview with Sílvia Casorrán)

Currently, these guidelines are under review, mentioning that many projects initiated through participatory budgeting, like the bike lane project at Plaça Catalunya, are currently on hold. Despite these challenges, the overarching goal remains to enhance and expand the city's bike infrastructure. (Appendix C, interview with Sílvia Casorrán)

Bicycle Parking

Bicycle parking facilities play a crucial role in promoting cycling as a sustainable and convenient mode of transportation in cities. Providing secure and convenient bicycle parking facilities encourages more people to choose cycling as a mode of transportation. Cyclists are more likely to use their bikes for commuting, running errands, or recreational purposes if they have access to safe and reliable parking options at their destinations. Proper bicycle parking facilities, such as bike racks, lockers, or secure parking areas, help prevent theft and vandalism of bicycles. By offering designated parking spaces with adequate security measures, cyclists can feel confident leaving their bikes unattended while they engage in other activities. (ITF, 2024)

Bicycle parking infrastructure needs to be available in all parts of the city to comply with the Active City vision, having racks and other facilities everywhere and available where they are needed, both in commercial and residential areas. (Copenhagenize, 2019)

In Copenhagen, the availability of bicycle parking spaces is a key focus area for the city's urban planning and transportation strategies. The municipality conducted citywide mapping to assess the current status of bicycle parking, revealing that there were 180,000 publicly available bicycle parking spaces with 200,000 bikes parked in 2017.

Despite this, there was still free capacity in 45% of the bicycle parking areas, indicating a need for more efficient utilization and expansion of bicycle parking facilities. To address the growing demand for bicycle parking due to the city's increasing population and the projected rise in bicycle traffic, the City of Copenhagen has implemented a Priority Plan for Bicycle Parking 2018-2025, which outlines initiatives to construct between 26,000 and 71,000 new bicycle parking spaces based on different levels of ambition. The goal is to increase capacity where it is most needed and to enhance accessibility by addressing issues such as bicycles being parked outside stands due to varying usage patterns and improper stand locations. (Cycling Embassy of Denmark, 2018b)

Moreover, Copenhagen set up 4400 bicycle parking spaces over 2021 and 2022 (City of Copenhagen, 2022)

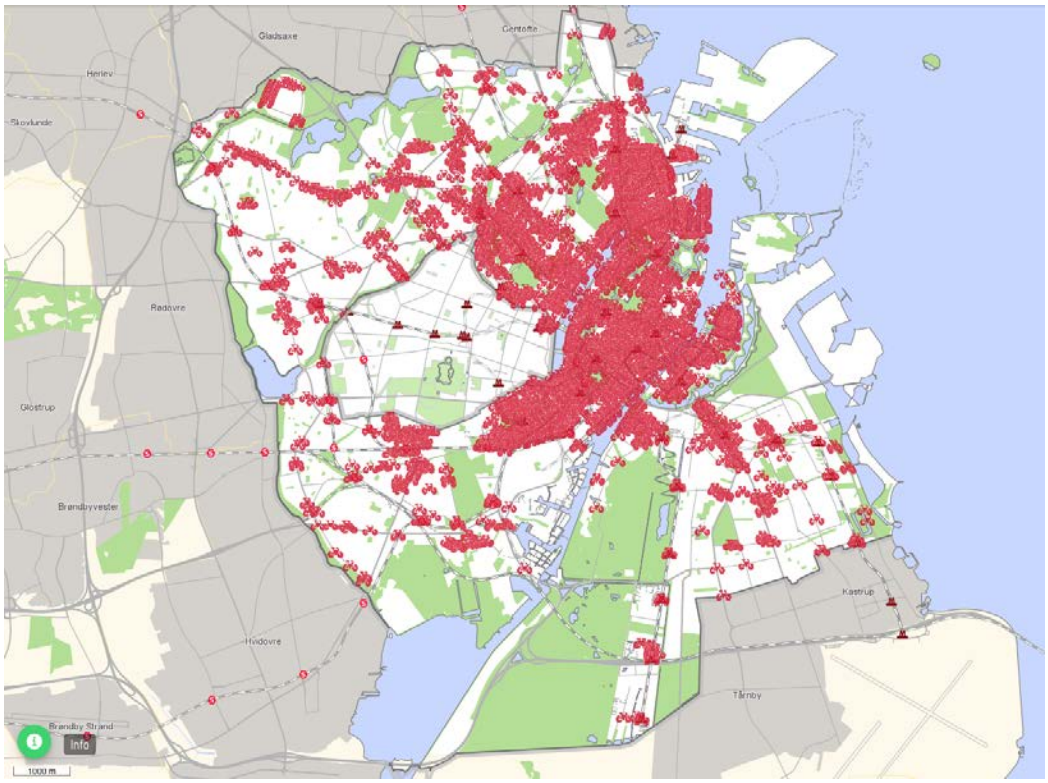

Figure 43. Overview of bicycle parking municipal locations (Cykelsativ) in Copenhagen (City of Copenhagen, 2024b)

When it comes to bicycle parking infrastructure in residential buildings, more than three quarters of the surveyed sample in Copenhagen indicated to count with a dedicated space to park their bicycles safely at home. This shows a positive indicator, as Copenhageners do not have to be concerned on the safety of parking their bicycles while they do not use it, as this would be a negative factor on bicycle use in the city.

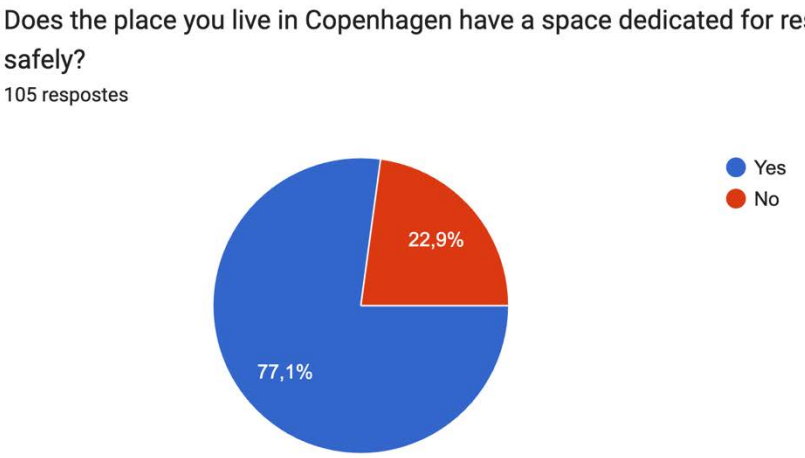

Figure 44. Safe parking space for bicycles availability among Copenhagen residents (Survey)

The city of Barcelona has also made steps further when it comes to bicycle parking facilities, specially those that offer secure parking to cyclists. According to municipal data, s of today, there are 18,000 bicycle anchoring points distributed throughout the city. These anchoring points are in the form of bicycle parking facilities across the city, where cyclists are recommended to anchor their bicycles whenever possible (Open Data BCN, 2024).

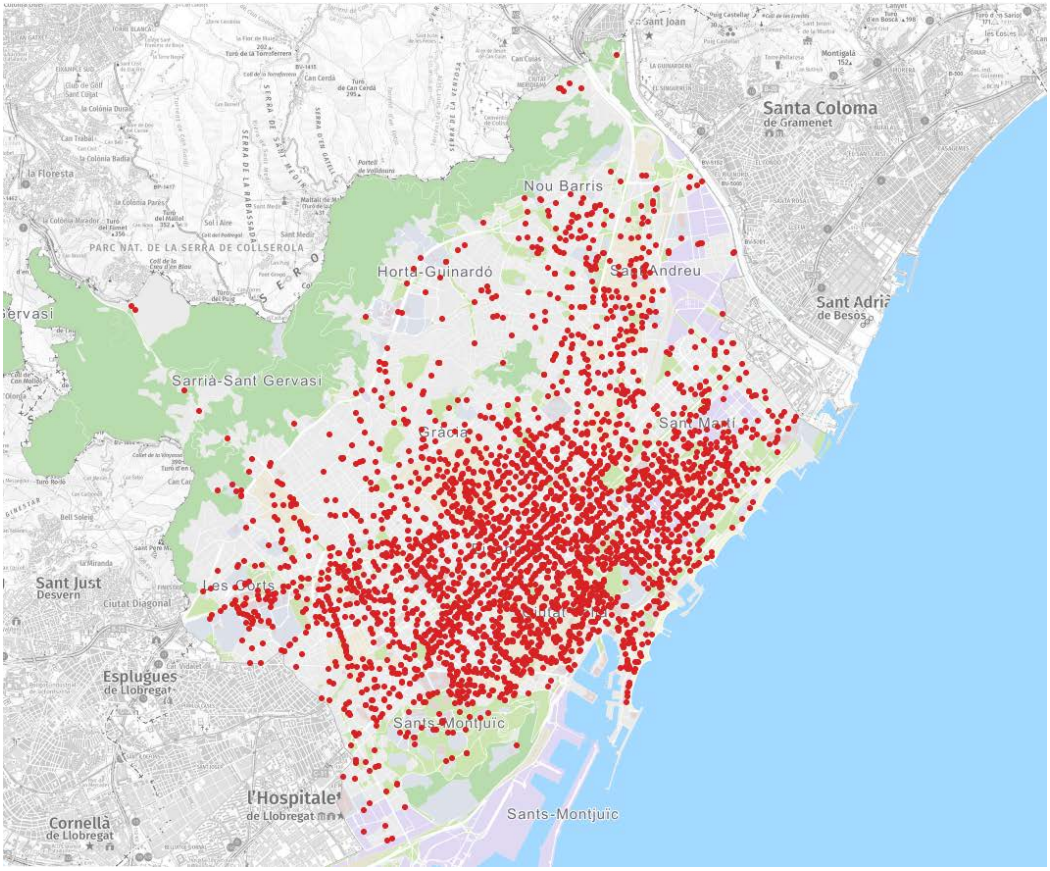

Figure 45. Overview of municipal bicycle parking locations and racks in Barcelona (City of Barcelona, 2024)

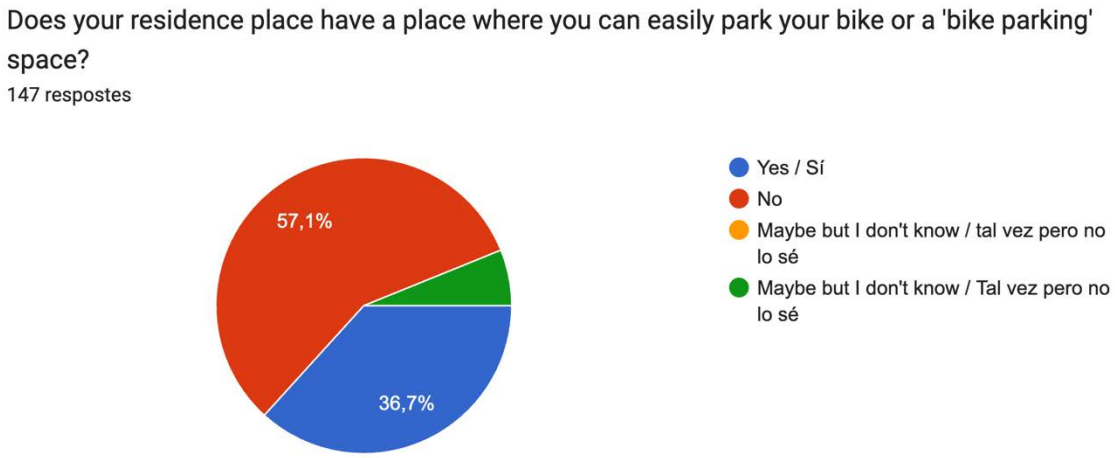

Figure 46. Safe parking space for bicycles availability among Barcelona residents (Survey)

Unlike Copenhageners, most of Barcelona residents do not count with any facility to park their bicycles safely at home. The urban model predominant in Barcelona and its urban continuum is primarily composed of dense urban blocks with multi-family housing typologies, often lacking associated parking spaces for private vehicles. This characteristic of the city's urban form notably impacts mobility patterns on many levels. While it contributes to increased use of public transport and active mobility, it also indirectly encourages scooter use, as they are easier to store within households than conventional bicycles. In this regard, bicycles face more challenges related to home parking due to the space they require and destination parking due to security concerns (Chevalier P, 2023).

In 2022, the Catalan capital doubled the number of secure parking spaces for bicycles, giving place to a metropolitan network of secure parking facilities. Six new so-called 'Biciparks' have created around 300 spaces, with more than 200 registered users and an average occupancy rate of 75% (B:SM, 2022).

A notable type of parking in the metropolitan area of Barcelona is *Bicibox*, a public network of free and secure parking spaces for bicycles and scooters distributed across the different municipalities in the metropolitan area of Barcelona. Compared to 2022, the number of parking points has increased from 186 to 196, an increment of 5%. These parking facilities can be of different types, as shown in the following figure, but all of them offer a protected parking space for bicycles or scooters for a maximum period of 48 hours during the week and 72 hours on weekends. The parking of scooters in Biciobox has been allowed since the prohibition of bringing electrified PMVs on public transport, which came into effect on February 1, 2023. (Chevalier P, 2023)

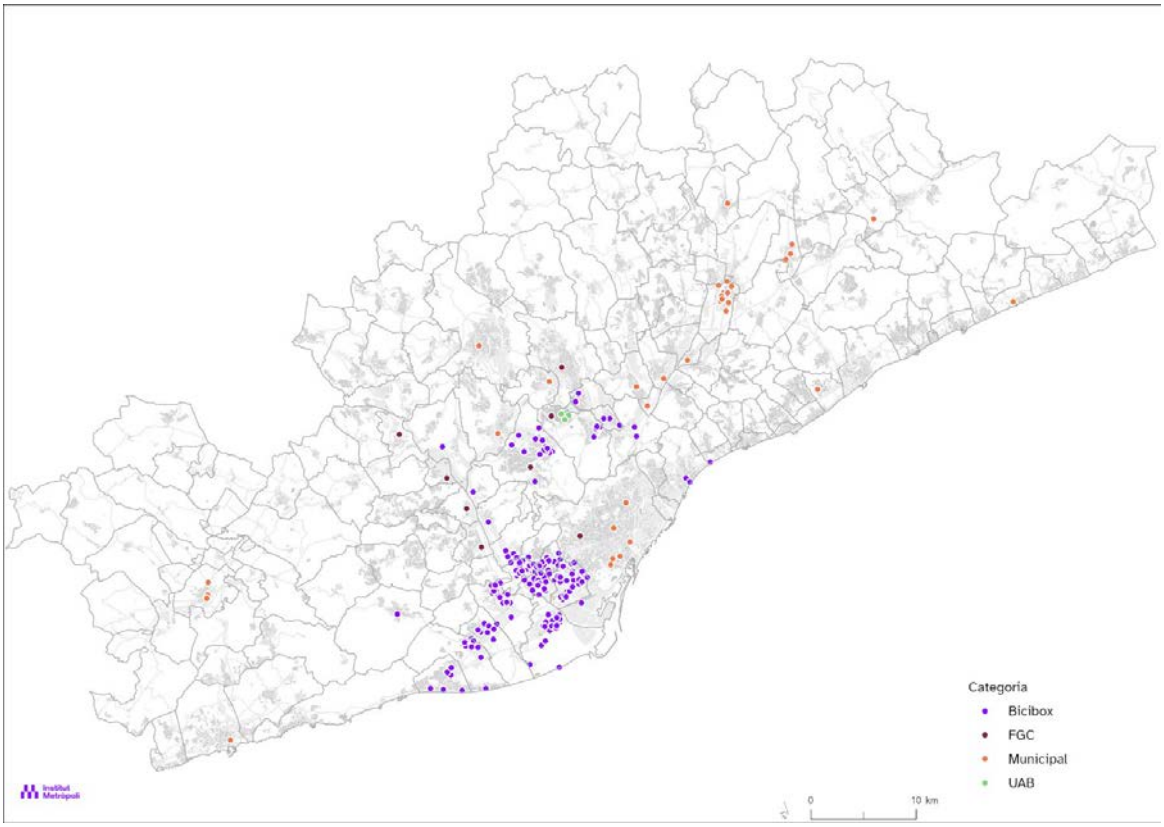

Figure 47. Safe public parking points for bicycles in Barcelona Metropolitan Area (Chevalier P, 2023)

Notably, Figure 48 shows a scarcity of safe parking facilities within the municipal boundaries of the city. When asked about safe bicycle parking, Sílvia Casorrán stated: *this is one of the main challenges we face today. Unlike the metropolitan area, Barcelona does not have a safe bicycle parking policy. At the AMB there is the BiciBox and secure car parks such as those in Gavà and Badalona*.

Given the issue on safe bicycle parking facilities inside the city of Barcelona, Sílvia Casorrán mentioned:

'I think that every block in the city of Barcelona should have a municipal bike park in a commercial space, since we have more and more expensive bikes and we need safe spaces to park them.'

In fact, this idea from Casorrán, which could be considered a potential niche of transformation to promote the urban transition to the Active City model, is already taking place in the Catalan Capital. CUBIC (*Cooperativa d'usuàries de la bicicleta*) refers to a cooperative of bicycle users in Barcelona that aims to provide more facilities for cycling in the city. Through their Park&Bike initiative and for a 20 euros yearly subscription, they offer parking spaces in ground floor offices, and reparation workshops for users.

Figure 48. CUBIC's safe parking space in Gràcia district, Barcelona (EmabProjects.com, 2024)

Furthermore, other private initiatives that offer safe bicycle parking are starting to emerge as new niches of transformation in Barcelona, such as VadeBike, which offers a network of intelligent bicycle parking stations that operate through a real-time technological platform. VadeBike offers not only a safe system against bicycle theft, but also provides a space to store a helmet, contributing to cyclists' safety (VadeBike, 2024).

Figure 49. VadeBike safe bicycle parking facility in Plaça Espanya, Barcelona (Self Made)

Walking infrastructure

The urban infrastructure built around to provide walkability to a city and encourage citizens to walk varies a lot. From well-connected and wide-enough sidewalks to benches, these urban elements provide the opportunity to citizens to commute by walking through the streets, and creating more vibrant and livable spaces.

Through the designed conceptual framework, these subchapter is focused only on the analyzing benches in the urban layout of Copenhagen and Barcelona.

Benches are valued as public, egalitarian, and free spaces, functioning as a vital social resource, especially for those marginalized from other communal environments. They offer flexible and affordable places to spend time and contrast positively with crowded or lonely home situations. Benches accommodate both solitude and conversation, promoting inclusivity in urban environments. (Bynon & Rishbet, 2015)

Designing comfortable and accessible benches alongside various facilities fosters interest and legitimacy in using public spaces. Feeling safe is essential, and visible, frequently used spaces with multiple seating options enhance security. Resting on benches can be restorative for mental health and promote local walking. (Bynon & Rishbet, 2015)

The city of Copenhagen, through the municipality's Health and Care Administration, carried out in 2019 a study on the city's age-friendliness, focusing on the wishes and needs of the elderly in the city's spaces. More than 300 seniors citizens expressed their opinion through municipal surveys, which lead the municipality to install 500 benches all around the city, observable in Figure 51. (City of Copenhagen, 2024a)

The new benches have been designed with armrests, a backrest and an even surface all the way to the bench, not made by stone of concrete as it would be too cold to site on in the winter months. (City of Copenhagen, 2024a)

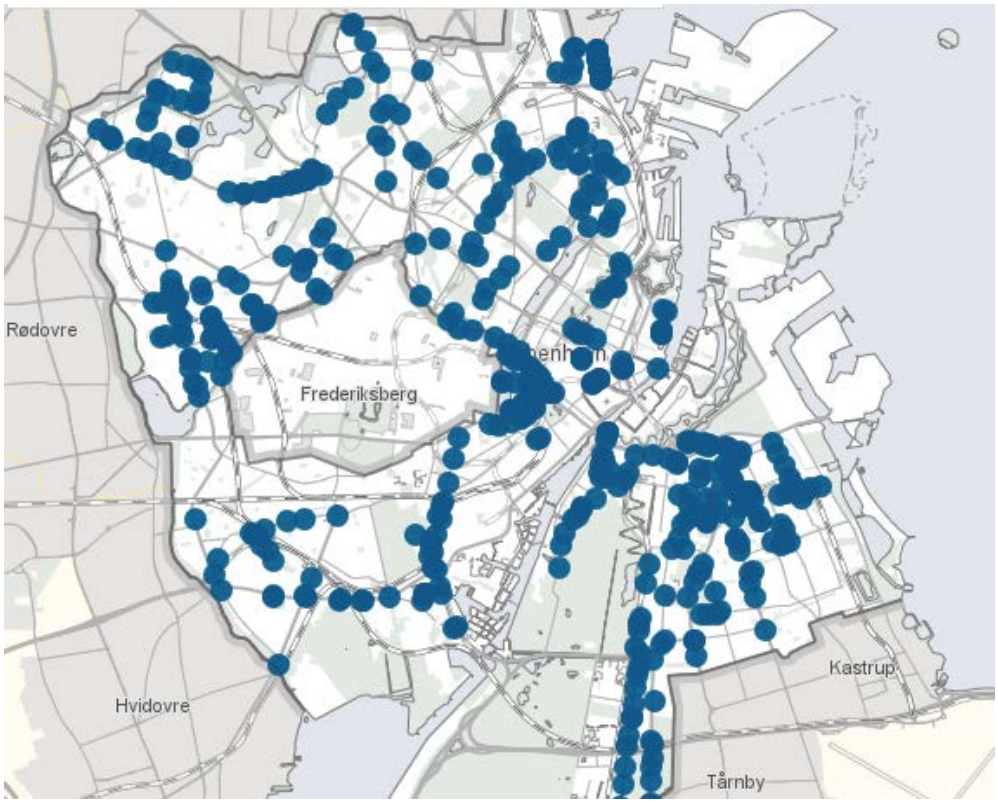

Figure 50. Map of elderly-friendly benches in Copenhagen (City of Copenhagen, 2024a)

When asked about her general overview about walkability in Copenhagen, Copenhagen Planner expresses a rather negative opinion about the topic:

I think that the strong focus on cycling has to some extent overshadowed walking.

I think that Copenhagen could definitely do better in terms of walking conditions and it hasn't, we don't have a walking strategy, for example. Like other cities have I mentioned, Vienna and Helsinki as two examples.

Though the Mobility Report 2023's modal share portraits walking as the biggest transport share, there is no mention on walking or pedestrianization interventions, as nothing regarding benches is mentioned either. (City of Copenhagen, 2023b)

Barcelona's approach to walkability and benches installation differs than Copenhagen, as the city's urban deisng prioritizes pedestrians and aims to create a more inclusive city that serves the needs of diverse users. (Alonso Ruiz, 2021)

The municipality publishes an inventory of urban furniture placed in public spaces yearly, in which the 27 types of benches findable in the city are exposed, with their name, provider and picture (Municipality of Barcelona, 2023a), among other elements as fountains or signals.

Remarkably, during the Poblenou 'Superblock' pilot project, more than 300 benches were installed, increasing public space for pedestrians with 75% of the area previously occupied by cars now freed up for benches, cycle lanes and public space. (Bravo, 2023)

Sílvia Casorrán highlights Barcelona's commitment to walkability and accessibility, positioning it as one of the most walkable and accessible cities in Europe and the world. According to Casorrán, the city has consistently prioritized creating an environment that is navigable for everyone, including those with disabilities. While some metro stations are still undergoing accessibility improvements, significant progress has been made, with ongoing efforts to address any remaining issues. (See Appendix B for full interview transcript)

Casorrán emphasizes Barcelona's attention to the needs of both wheelchair users and visually impaired individuals. The city is well-equipped with tactile pavements and podotactile indicators at crossings and other key points, ensuring that visually impaired pedestrians can navigate safely and independently. Additionally, traffic lights with acoustic signals aid those with visual impairments, enhancing their ability to move through the city with confidence. Casorrán points out that these thoughtful installations, though often unheralded, demonstrate Barcelona's dedication to accessibility. The city's efforts set a high standard and serve as a model for other cities aiming to enhance walkability and inclusivity. (See Appendix B for full interview transcript)

Critically, Casorrán also reflects on the main problems that pedestrians have nowadays in Barcelona, refering to a poor enforcement of municipal laws and compliance of regulations when it comes to motorbikes parked on the sidewalk:

I think there is still a lot of work to be done, 'enforcement' needs to be done to protect pedestrians. Action must be taken on sidewalks plagued by motorbikes, for example, or access from terraces to public spaces such as Rambla del Poblenou. We need to protect more, there are very 'soft' measures. Then in certain districts like Horta-Guinardó, with slopes and mini sidewalks where there are still light poles.

With the issue of motorbikes, in Barcelona we have a problem with compliance with the regulations, we do not enforce them and this can be considered prevarication.

Greenery

The integration of green infrastructure in urban environments plays a crucial role in promoting sustainable modes of transportation such as cycling and walking. Green elements in streetscapes not only enhance the aesthetic appeal of urban areas but also contribute to creating healthier and more livable cities. Research has shown that the presence of greenery in urban streets positively influences the valuation of streets for cycling activities, indicating a strong connection between green streets and the promotion of cycling as a sustainable mode of transportation. Similarly, green infrastructure has been associated with increased physical activity levels, with green spaces and natural environments encouraging walking and cycling among urban residents. (Nawrath et al., 2019)

Copenhagen is renouned by its big urban parks, with Copenhageners enjoying a median of 42 square meters per citizen (Ilus, 2022). However, Ms Copenhagen Planner argues that urban greenery in the Danish capital could be improved, as it usually is not part of the streetscape where pedestrians, cyclists and others circulate:

So it could definitely be better, but it could also be worse the same you can say for like trees and greenery. Copenhagen is quite a gray city compared to any other, even northern European cities

And there have been political ambitions to plant 100,000 more trees.

On the other hand, in Barcelona Sílvia Casorrán emphasizes the challenges and efforts in maintaining urban parks, noting that while the city has numerous small parks distributed throughout various networks, the most significant issue lies in the Eixample district. Casorrán explains that the Municipality faced criticisms for centralizing investments in the Eixample district, but it is essential to understand its unique context. Eixample is the most populated district, boasting the highest economic activity and mobility, yet it suffers from a severe lack of urban green spaces, with less than two square meters of green per person compared to the city average of around seven square meters. (See Appendix B for full interview transcript)

This deficiency in green space contributes to several problems, including higher pollution levels, increased noise, more pronounced heat island effects, and greater industrialization. Casorrán underscores that these factors combine to make the Eixample one of the most challenging areas in terms of urban living conditions, thus justifying the focus on enhancing its green infrastructure and overall livability. (See Appendix B for full interview transcript)

Moreover, Casorrán highlights the importance on greenery and trees to develop the cycling network of Barcelona in the upcoming years. Bringing the climate emergency as the main reason, she opposed the construction of a bidirectional cycling lane in the middle of the street in Passeig Maragall as it was not possible to cover this infrastructure with greenery and shadow, as she claimed that it wouldn't be usable by cyclists due to torrid conditions in the hot months. The newly constructed, and still on process, bidirectional bike lane in Meridiana Avenue is a good example of including greenery on the development of cycling infrastructure. (See Appendix B for full interview transcript)

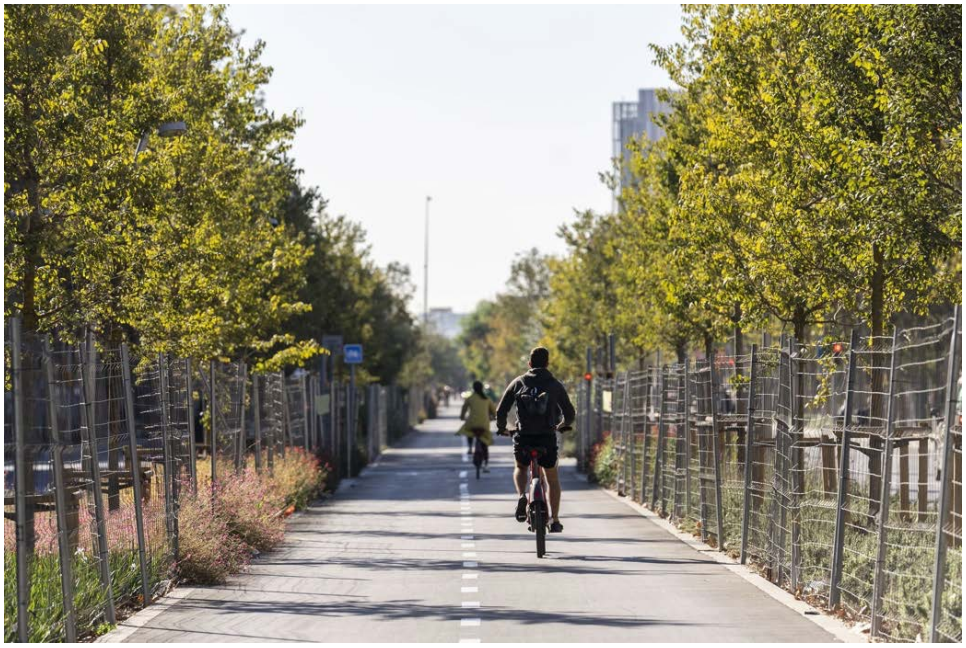

Figure 51. Meridiana Avenue new bidirectional bike lane (Nuñez, 2024)

Bikeshare alternatives

Bikeshare alternatives play a crucial role in promoting cycling in cities by providing convenient, affordable, and sustainable transportation options for residents and visitors. These systems offer a range of benefits that contribute to the growth of cycling as a viable mode of urban transport.

In Copenhagen, most of the citizens cycle with their own personal bikes, as survey results show in Figure 53. Only less than a five percent of the sample claim to use shared bikes as their main bicycle in Copenhagen.

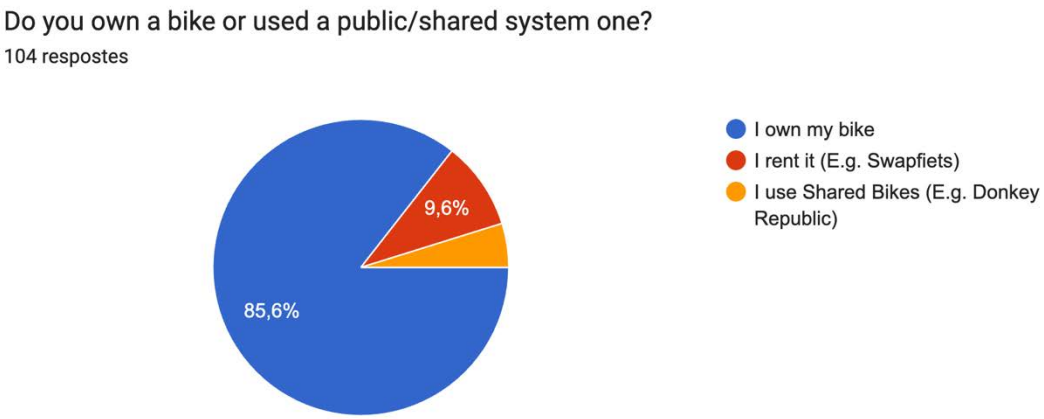

Figure 52. Typology of bike used and ownership in Copenhagen (Survey)

Among bikeshare systems in the Danish capital, Donkey Republic stands out from the rest. Founded in 2016, this system was born in Copenhagen and has made its way to

other big European cities, Barcelona among them, registering over one million trips per year only in Copenhagen. Donkey Republic promotes itself as a sustainable solution for visitors and tourists to explore the city with bicycle. (Donkey Republic, 2024)

Notably, Copenhagen does not count anymore with a municipal bikeshare system. Bycyklen was a public bikeshare scheme that was founded in 2017 until it declared bankrupcy in December 2022, as subsidies from municipalities and DSB became unavailable. (Bycyklen, 2023)

In Barcelona, the bikeshare niche is dominated by Bicing, the municipal bikeshare system administrated by the municipality. With more than 519 stations distributed around the city Bicing counted with a total of 7100 mechanic and electric bicycles and 148,177 users registered in 2023. Every month, 736.65 kilometers are cycled in Barcelona through this service, with more than 1.2 million trips done monthly as well. (Bicing, 2024)

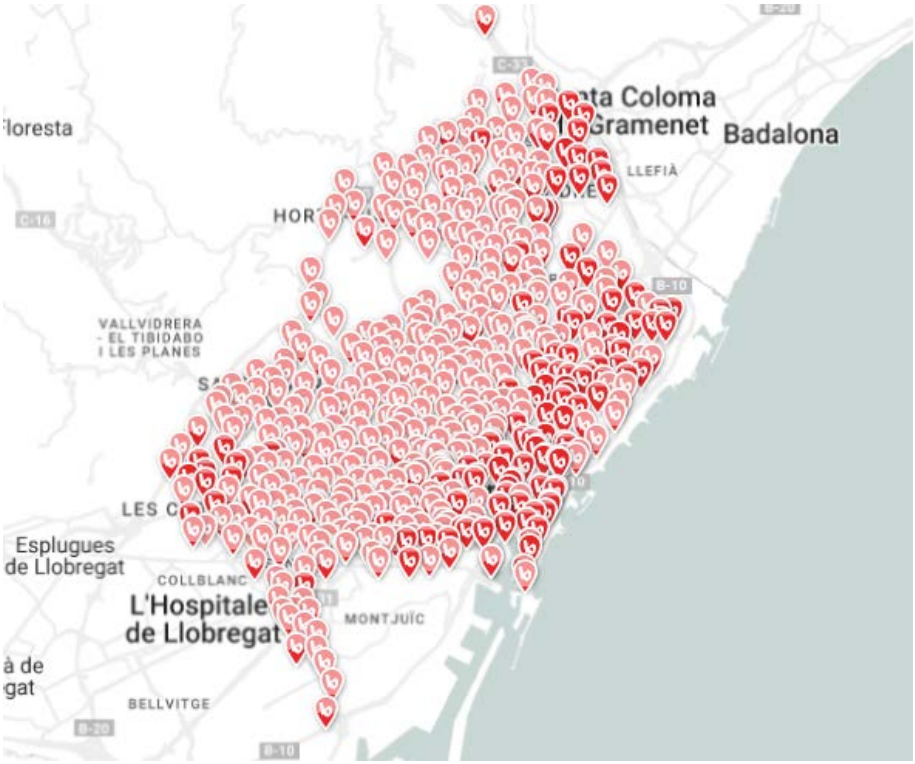

Figure 53. Bicing stations map in Barcelona (Bicing, 2024)

Sílvia Casorrán calls Bicing in Barcelona the beginning of the city's 'cycling revolution', being the main niche of transformation in Barcelona than unleashed the development of the city's cycling network:

Mayor Pasqual Maragall was the one who brought it up for the first time and I think that Bicing in 2007 was a great revolution. Bicing came hand in hand with the introduction of parking zones, and Bicing led to 100,000 people registering there in the first year as the pass cost €6. Suddenly you had a lot of people moving around the city by bike and the City Council had to invest in bike lanes. So it could be said that Bicing was what later led

to the deployment of the cycling network, as it had to accommodate all these new cycling users in the city.

The level of satisfaction with the Bicing service among surveyed citizens who hold a membership is medium, with an average mark of 2.95. This could be attributed to low levels of maintance of the bikes and stations, as well as uneven distribution among bikes around the city during peak times.

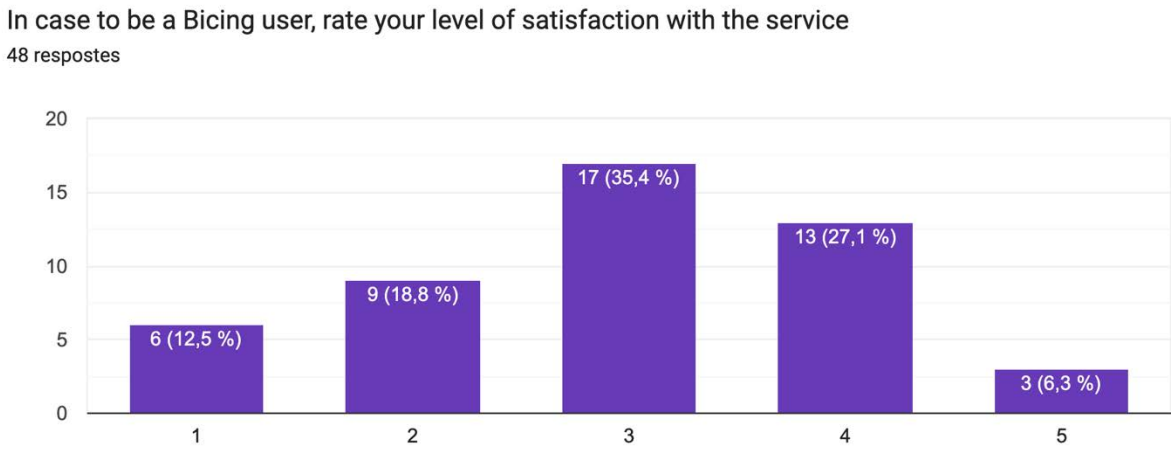

Figure 54. Satisfaction level of Bicing users in Barcelona (survey)

Still, according to the *Bicycle and Eletric Scooter Mobility in Barcelona's Metropolitan Region* report, Bicing bicycles plays only a 2 out of 10 fraction on the bicycle and PMV ecosystem of Barcelona, as shown in Figure 56.

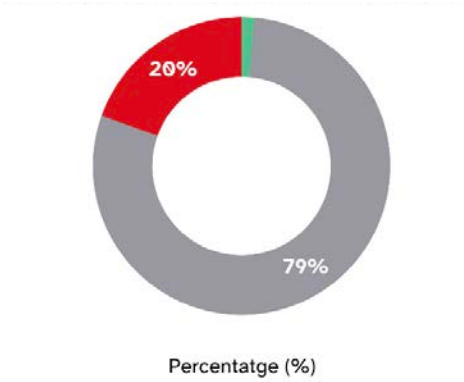

Figure 55. PMV trips according type of bicycle. Grey: private bike; Red: Bicing; Green: Other bike share systems (Chevalier P, 2023)

Furthermore, the introduction of the Bicing bike-sharing system in Barcelona has been linked to a reduction in premature mortality among its users. Health impact assessment studies have demonstrated that shifting from private car journeys to public or active transportation, such as Bicing, leads to significant health benefits due to increased physical activity. Bicing has contributed to reducing the disease burden, particularly

benefiting public health through the promotion of regular physical exercise and the associated improvements in overall health outcomes (Nieuwenhuijsen & Khreis, 2016)

Other bikeshare systems besides Bicing operate in the Catalan Capital, such as Donkey Republic and Bolt, whose target are mainly tourists and visitors who choose to explore the city using its newly developed cycling network.

Figure 56. Bolt and Donkey Republic bikes parked in Barcelona (Self Made)

6.2. Digital Infrastructure and Data

Data collection systems are key in promoting urban cycling by providing essential insights and fostering a safer, more efficient, and inclusive cycling environment. These systems offer valuable data on cyclists' usage patterns, helping urban planners optimize infrastructure and plan for future developments. By identifying high-risk areas through incident data, cities can implement targeted safety improvements, such as new bike lanes and traffic calming measures. Continuous monitoring of cycling initiatives allows for the assessment of their impact, ensuring effective policy and investment decisions. Furthermore, data-driven strategies enable evidence-based decision-making, tailored to meet cyclists' needs. Data collection systems are crucial for creating supportive urban cycling environments that encourage more people to choose cycling as a mode of transportation.

The digital infrastructure and data process models defined by this parameter of the conceptual framework refer to all the sensors and infrastructure installed in a city to model bicycle and pedestrian traffic, as well as the data treatment processes behind that the municipality takes to improve cycling infrastructure and safety.

The City of Copenhagen has developed a traffic model called COMPASS (Copenhagen Greater Area Model for Passenger Transport) to model how changes in the road network or transportation prices affect routes and mobility patterns. COMPASS simulates weekday daily traffic for the four modes of transport: car, bicycle, walking and public transport, as well as a combination of the four modes of transport, called combination trips.

Developed in 2017, COMPASS models scenarios for years 2025 and 2035 and it operates in all Copenhagen's Metropolitan area. The model is based on the Open Street Map (OSM) network and it is programmed to detect bicycle congestion, linking cycle volumes to the road network to adjust intersection capacity, and as there is no data readily available to describe the correlation between bicycle and car flows at inteseection, the model is complemented by VISSIM. (Vuk et al., 2022)

Regarding COMPASS and traffic data treatment in Copenhagen, Copenhagen Planner remarks that the model can only calculate politically approved projects for the future: '*we have a Danish state that plans on widening highways in the capital region. We don't have politically approved mega projects for cycling. It is something that is being decided upon, year by year*'.

Portable sensors *MetroCount* can be observed around the city, where strips are displayed on the road where both bycicles and cars circulate.

Figure 57. Portable traffic sensor in Indre By, Copenhagen (Self Made)

Figure 58. MetroCount sensor in Vesterbro, Copenhagen (Self Made)

Besides the traffic model COMPASS and the use given by the city, there is other remarkable data and digital infrastructure that makes Copenhagen a better cycling city. Copenhagen uses traffic-controlled signal systems to prioritize cyclists and ensure their safety and convenience. Thermal detection is the recommended solution by the municipality, with the purpose to agilizice their journey and provide a green light before reaching the stop line or extend their green time without having to stop (City of Copenhagen, 2023a).

Another example is the Green Wave (Grøn Bølge) bicycle traffic management system. In streets with a large amount of cyclists, such as Nørrebrogade, the municipality plans the so-called 'green waves', in which cyclists receive a green light at several consecutive intersections at a given speed on a given stretch of road. (City of Copenhagen, 2023a)

Figure 59. 'Green Wave' sign (City of Copenhagen, 2023a)

Barcelona also counts with digital infrastructure behind its cycling network. There are a total of 371 bicycles loop sensors installed in the city, from which the municipality obtains cycling data (Open Data BCN, 2024).

Figure 60. Map of bicycle sensors location in Barcelona (Open Data BCN, 2024)

The municipality publishes data obtained through some of these sensors in the municipal Open Data website, as shown in figures 62 and 63.

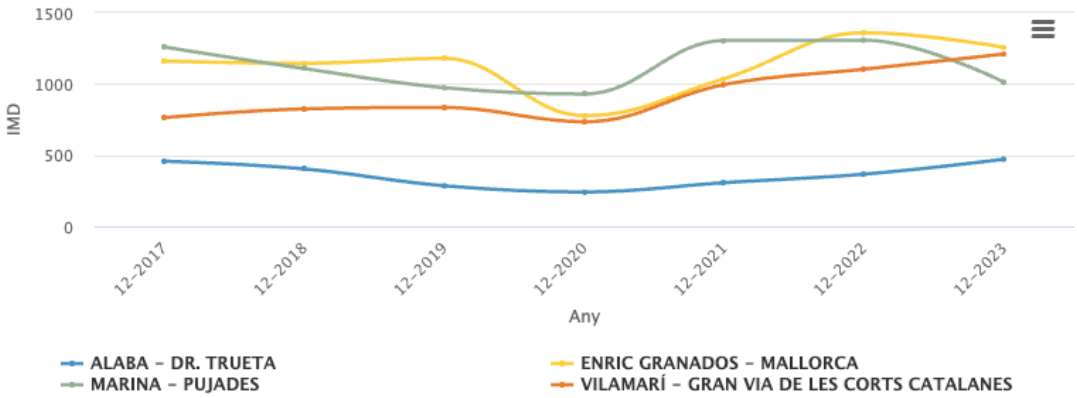

Figure 61. ADT for sea-mountain bicycle lanes in Barcelona (Open Data BCN, 2024)

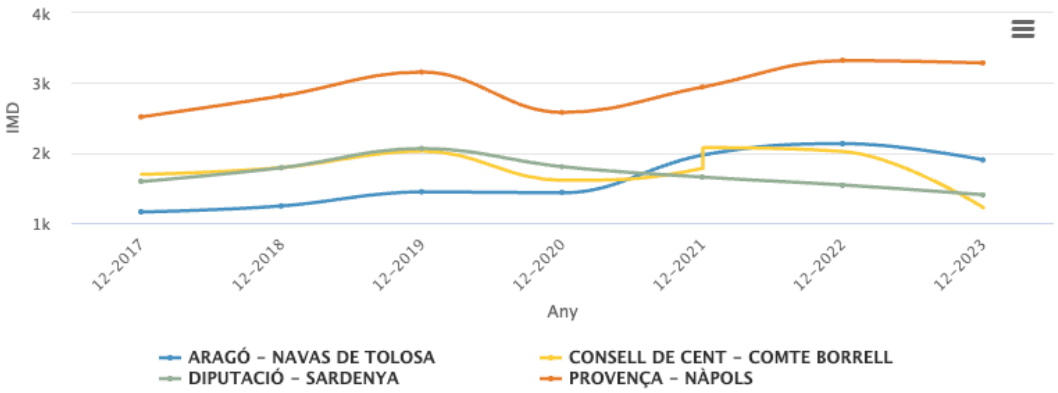

Figure 62. ADT for transversal bicycle lanes in Barcelona (Open Data BCN, 2024)

'Transversal' bycicle lanes in Barcelona are more used as they go a long a less steep route than the ones placed on the 'sea-mountain' direction. Bicycle lane in Consell de Cent street has been virtually removed as its been pedestrianized under the Green Axis plan.

The municipality of Barelona has been using the traffic model PTV Visum since 2018 (PTV Group, 2019), but there is no evidence that the municipality has integrated cycling and PMV traffic from the city's cycling network into the model and that the municipality uses the cycling data to improve the city's cycling infrastructure.

6.4. Low Motorized Traffic

Traffic calming measures in cities can lead to a reduction in accidents, as evidenced by the congestion charge implemented in London, which resulted in a substantial decline in traffic incidents. Implementing traffic calming strategies can also help reduce traffic-related air pollution, noise, and urban heat island effects, potentially leading to lower rates of premature mortality and morbidity. In fact traffic calming initiatives create opportunities for increased active mobility, which have significant positive impacts on public health by promoting physical activity and reducing greenhouse gas emissions (Martin, 2021). This is the reason why this parameter of the conceptual framework takes PM2.5 concretation as an indicator of the state of active mobility in cities, as it affects it directly.

Moreover, the design of the urban environment to limit car use, such as Barcelona's Super Blocks, can contribute to 90 min/week of physical activity (Martin, 2021), being the reason why the implementation of these policies is also a key indicator of this paramter from the developed conceptual framework to analyze the state of active mobility in Copenhagen and Barcelona.

PM2.5 level indicators in Copenhagen and Barcelona vary substantially. In Copenhagen, the average annual PM2.5 concetraiton is 4 $\mu g/m^3$ (AQI, 2024), while in Barcelona is four

times higher, reaching a level of 17 μg/m^3 in 2021 (Garriga Mas, 2021). This is bad news for the Catalan Capital, as the World Health Organization (WHO) guidelines stablishes an annual average concentration threshold of 5 μg/m^3 for a city to be considered to have a healthy air quality (World Health Organization, 2021).

These findings contrast with the policies implemented in both cities. Copenhagen has attempted to reduce the speed limit in some parts of the cities to 30 kilometers per hour, while Barcelona has implemented the Super Blocks and Green Axis program, to pedestrianize streets and reduce traffic in the city, among the most notorious measures.

Copenhagen Planner mentions the project of reducing speed limits to 30 kilometers per hour across the whole city, but refers to an important structural impediment: the local police has to approve these speed reductions. Claiming that resistance exists from the police side, she also mentions that national legislation might block the project as well, as it states that the speed limit should be 50 kilometers per hour. On top of that, she adds:

So it's part of a trial now that we have been allowed to experiment with lower speeds. But we have a quite rigid framework that limits the extent to which municipalities can actually do traffic coming in Denmark, which is not the same in many other countries where local governments have more influence over um over the the speed limits. But I definitely think there is a huge potential in not only prioritizing the segregated infrastructure, but create shared spaces or solutions like bicycle streets for low speeds and traffic islands and the circulation plans like you see it in several Belgian cities such as Ghent and Leven um where you don't need the bicycle tracks because you can mix in a in a safe environment.

Copenhagen Planner also compares Copenhagen with the Netherlands, where she claims that more restrictive car policies have been taken place:

It's not like Copenhagen is a car city and we just managed to similarly have a lot of cyclists as well. And you can also see it in the way we, we plan for the infrastructure. It's really would focus on segregating the different modes. So we have these curb separated bicycle tracks because we have a lot of car traffic that goes really fast. So the bicycle traffic is almost replicated. There's a mini copy of the car traffic where the cyclists also go quite fast when you compare to maybe the Netherlands where you also have widespread cycling, but it's a little bit slower because the city centers have been traffic calmed. You know, traffic will be maybe 30 kilometers an hour instead of 50 which we have here in Copenhagen. And some Dutch cycling experts have criticized Copenhagen saying (...) it's just like a semi nice bicycle city because you have never done anything about the cars.

Full interview transcript can be read at Appendix A.

On the other hand, Barcelona has caught the attention from planners around the world for the Super Blocks program. This consist in the creation of car-free streets that allow the development of more green spaces, bike lanes, and pedestrian areas. It is an urban planning strategy that aims to create a more liveable and sustainable city by reducing air and noise pollution, promoting active transportation and social interaction, taking advantage of the urban layout that shapes the Eixample district. (Ajuntament de Barcelona, 2023).

In the Poble Nou neighborhood of Barcelona, the introduction of superblocks has led to a radical transformation of public space. Public areas have doubled, motorized traffic has been more than halved from 2,218 to 932 trips per day, and the space occupied by cars has decreased by 48%. Pedestrian areas have increased by 80%, and green spaces have nearly doubled. Additionally, the number of shops has risen by 30%, from 65 to 85, and traffic accidents have become almost non-existent, illustrating the significant benefits of this urban planning strategy. (IAA Mobility, 2024)

Furthermore, Barcelona recently introduced a new program called Green Axis, which involves the transformation of certain streets into pedestrian-friendly spaces with a focus on greenery, social interaction, and local commerce. These streets, known as green axes, are designed to prioritize pedestrians and create vibrant, green spaces within the city. The Green Axis initiative aims to enhance the urban environment, promote sustainable mobility, and improve the quality of life for residents by providing accessible and attractive public spaces for leisure, social activities, and community engagement. The program includes the creation of new green hubs, squares, and tree-lined avenues. (Ajuntament de Barcelona, 2022)

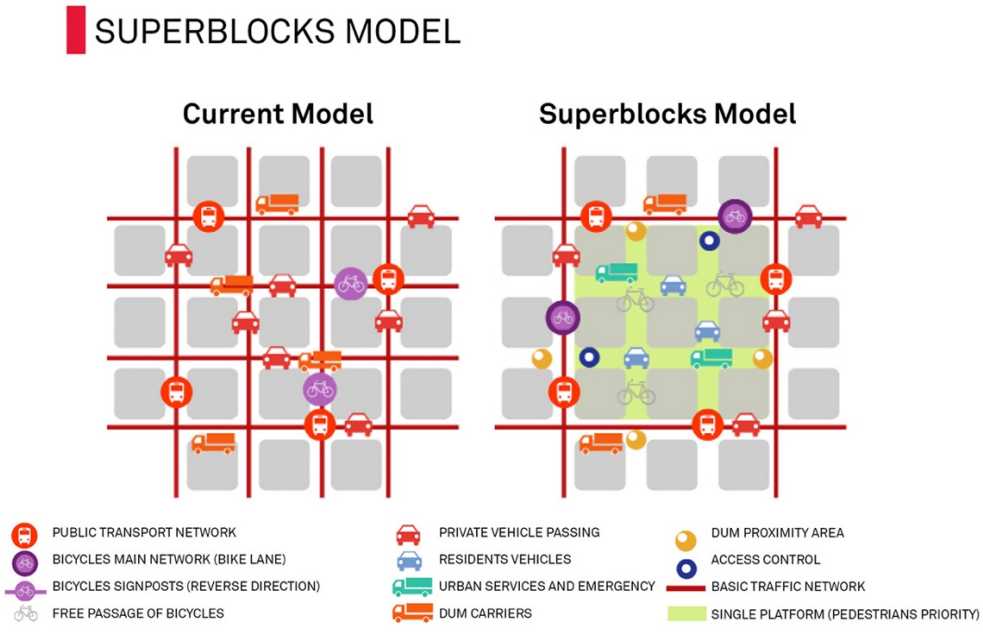

Figure 63. SuperBlocks replanning graphic (Ajuntament de Barcelona, 2023)

Barcelona citizens who were surveyed through this research project, indicated validating results to the Green Axisproject: more than a quarter feel they walk more since the implementation of the project, as survey results in figure 65 show.

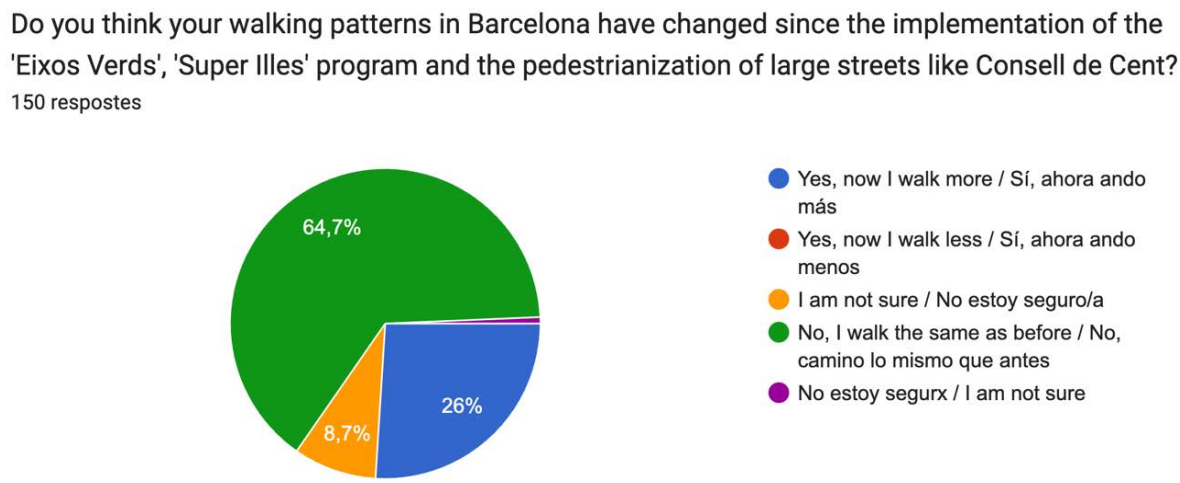

Figure 64. Change of walking patterns since the Green Axis plan implementation (Survey)

Figure 65. Consell de Cent street after its reurbanization (Self Made)

Sílvia Casorrán shares a very positive view on the SuperBlocks program, in which she participated to:

the great virtue is that it eliminates you with a passing motorized vehicle. And that's it. And you do it without forbidding, because in the end you won't forbid, you simply complicate, make it difficult for the car to go straight. It's the one you avoid through traffic. And that's the key. And it's kind of like super easy conceptually, for me, it's great, because you're not even putting up physical barriers.

you're not forbidding, you're simply telling them 'well, if you want to get here, then you'll have to make a little more detour, or to get out' Or if you want to go straight here, then, I mean, you're only welcome in this space if you have something to do here. That, if you live here and you have to download, yes, but then if you are just passing by then no. And that's it, I mean, for me this is fantastic.

6.3. Strategic Public Transport

This parameter evaluates the compatibility of public transport with active mobility in a city, and how this is designed to promote it through intermodality.

Bicycle parking facilities at transit stations, bus stops, and other transportation hubs facilitate multi-modal trips by allowing cyclists to combine cycling with public transport. Easy access to bike parking encourages transitions between cycling and other modes of transportation, promoting sustainable and efficient travel options. Well-designed bicycle parking facilities contribute to the overall aesthetics of urban spaces. Architecturally pleasing bike racks, shelters, and storage solutions can enhance the visual appeal of streetscapes and public areas while promoting a bike-friendly environment. (ITF, 2024)

Copenhagen counts with bicycle parking facilities at tran stations and other transit hubs, making it convenient for cyclists to park their bikes and continue their journey by train or metro. Moreover, DSB, the national Danish train operator made it free to bring bikes on board in 2010 (Cycling Embassy of Denmark, 2018a).

Copenhagen Planner comments on the relationship between public transport in Copenhagen and cycling:

I don't know when it was but with the development of the metro lines and all of that, there will be less cyclists

She remarks that the COMPASS model, which only operates through approved projects, predicts a decrease on cyclists due to the expansion of the metro lines of Copenhagen.

Moreover, the consultancy *Copenhagenize,* specialized in urban cycling, conducted a critical study on the construction of the Metro Rin, claiming that its construction would

be translated into a 2.8% drop of cyclists in the city. The firm carried a mobility study to test the efficiency of the public transport system of the city, showing results that indicate that cycling is faster most of the times to reach your destination within municipal borders, and critizing the investment on the Metro Ring, claiming that this funds could have gone to develop better cycling infrastructure (Copenhagenize, 2023).

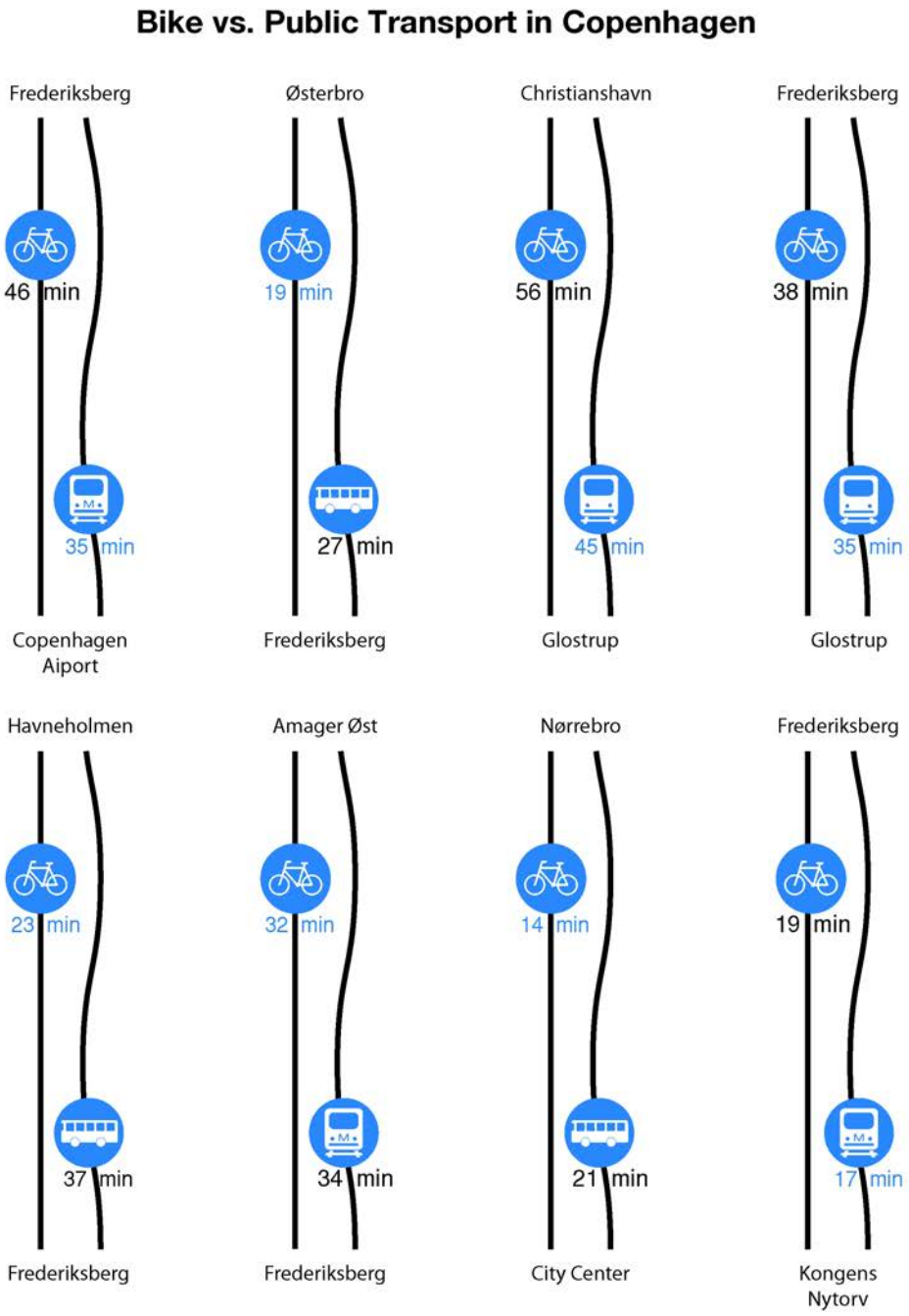

Figure 66. Copenhagenize experiment results (Copenhagenize, 2023)

Barcelona's public transport system allows bicycles except in buses, in which users can only access with a bicycle if it is foldable, as a Brompton bike. Schedules exists for metro, and the municipality recommends not to attempt if there is congestion, and trams have designated areas for bikes, without presenting schedule restrictions to passengers who choose for the intemodality between cycling and public transport. (Ajuntament de Barcelona, 2024a)

Regarding intermodal bicycle parking in railway stations, there are six railway public transport stations that have incorporated secure parking solutions less than 100 m during 2022. These are the FGC stations of Igualada, the stations of Rodalies from Barberà del Vallès, Montgat and la Llagosta, Hospital de Sant Joan Despí TRAM station | TV3 and the Provençana Metro station. (Chevalier P, 2023)

Some stations of interurban trains, like Plaça Espanya, count now with a designated area of bicycle parking undergrown, where users can also borrow tools and pump their bicycle's wheels.

Figure 67. Bicycle parking station with repair tools in Plaça Espanya station, Barcelona (Self Made)

7. Policy Environment

7.1. Advocacy

In Copenhagen, the development of the city as a cycling haven has been influenced by key advocacy movements and events. The oil crisis in 1973 and subsequent car-free Sundays highlighted the potential of alternative transportation modes. Cyclists' demonstrations in the late 1970s, organized by the Danish Cyclist Federation, demanded more cycle tracks, leading to the establishment of the first cycle track along Nørrebrogade in 1982. These advocacy efforts, along with the mainstreaming of cycling and the establishment of the Copenhagen Cycling Strategy, have been instrumental in making Copenhagen a cycling-friendly city. The city's commitment to cycling infrastructure and safety continues to inspire other cities worldwide to prioritize cycling as a sustainable mode of transportation. (Jensen, 2013)

Copenhagen Planner explains that the historical development of Copenhagen as a city for cyclists began with cycling as a common mode of mass transportation from the early 1900s until the post-World War II era. Cars began to dominate in the 1950s, although this shift occurred later in Denmark compared to other countries. The 1970s and 1980s saw public protests, the rise of the environmental movement, and initiatives like Car-free Sundays due to the oil crisis. Gradually, politicians and public offices in Copenhagen embraced these changes, fostering a more cyclist-friendly city. (See Appendix A for full interview transcript)

When asked about nowadays advocacy movements in the Danish capital, Kastrup highlights the Cycling Embassy of Denmark as one of the main organizations that pushes for a cycling-friendly agenda in the city, and a cyclist federation that is over a hundred years old tha continuously lobbies for more cycling. However, she claims that advocacy is not very visible in Copenhagen:

in my opinion, it's not that visible, it's more or less implied.

Full interview transcript with Copenhagen Planner can be consulted in Appendix A.

In Barcelona, Silvia Casorrán emphasizes the strong relationship between the City Council and various entities, which she considers very positive. Casorrán highlights the significance of the 1998 Pact for Mobility, which provided a platform for entities and governments to collaborate on mobility issues. According to her, there is constant dialogue between the City Council and organizations such as PTT, *Catalunya Camina*, and Ecom. These groups are organized into smaller working groups to tackle specific topics. Casorrán mentions that Twitter was a powerful tool for coordination in the past, with a group called Bici BCN serving as an informal platform for collaboration. As the city prepares to update its Urban Mobility Plan (PMU), Casorrán explains that the cycling advocacy groups are coordinating their efforts to submit proposals and messages to the

City Council for inclusion in the new document. Additionally, a group called *Totes amb Bici* is working to align its efforts with the European Bicycle Declaration, while also engaging in community-based activities. Casorrán's words highlight the importance of collaboration between local government and civil society organizations in shaping urban mobility policies and promoting cycling in Barcelona. (See full interview transcript in Appendix B)

Moreover, it is worth to highlight BiciHub as a notorious advocacy actor in Barcelona. BiciHub is a reference center for the world of bicycles, serving as an incubator for ideas, projects, and alliances focused on implementing sustainable mobility solutions. The project, promoted by Biciclot, aims to transform Barcelona into a more inclusive, solidary, and ecological city that promotes sustainable mobility, particularly cycling. BiciHub's activities include events and reflections on social and solidarity economics in the district, as well as other initiatives that contribute to the development of sustainable mobility in Barcelona. (BiciHub, 2024)

Linked to BiciHub, there is Cubic Coop, a non-profit cooperative in Barcelona that works to improve the experience of using bicycles in the city with initiatives as Park&Bike, mentioned earlier when refering to safety bicycle parking.

7.3. Urban Planning

The Urban Planning parameter of the conceptual framework evaluates both the urban distribution of goods and services that allow a city to follow somehow the 15-Minutes city concept, and takes into account the existence of dedicate office to plan bicycle and walking infrastructure.

Evaluating the urban distribution and estimation of compliance with the 15-Minutes city paradigm is done by evaluating the mobility patterns and the urban layout.

Surveyed citizens in Copenhagen and Barcelona indicated almost the same median result when they were asked about the maximum amount of that that they would be willing to cycle before shifting to another type of transportation: 34.3 minutes in Barcelona, 35.21 minutes in Copenhagen. Citizens from Barcelona voted mainly for the 30 minutes while Copenhageners voted for 40 minutes, with a less even even distribution. When it comes to walking, results for Barcelona are 44 minutes while in Copenhagen go down to 25 minutes (See Survey results in Appendix C and D).

Arguably, most of the basic needs in both of the cities can be reached within the times that citizens expressed to be willing to cycle or walk, proving that at some extend, both cities count with a dense and compact layout that allow its citizens to reach their basic needs within 15 minutes or less. Copenhagen Planner defends that *Copenhagen is relatively dense and has multifunctional districts*.

When it comes to planning offices for cycling or walking, Copenhagen Planner talks about the Cycle Superhighway secretariat, a collaborative effort initiated by the City of Copenhagen to address the need for stronger regional planning coordination. Copenhagen Planner explains that the secretariat is a joint venture between 30 municipalities, co-financed by the region and the participating municipalities. With a small team of around five employees, the secretariat is based within the City of Copenhagen's mobility unit, allowing for close collaboration with the dedicated cycling professionals in the city. (See Appendix A for full interview)

The secretariat's primary role is to coordinate the Cycle Superhighways project, which focuses on commuter cycling. Copenhagen Planner notes that there are also regional employees working on cycling-related initiatives, such as the Regional Bicycle Account, which collects cycling data for the entire region, and projects related to cargo bikes. However, the main resources and coordination efforts are centered within the Cycle Superhighway secretariat. (See Appendix A for full interview)

Copenhagen Planner mentions the "finger plan," a regional planning tool that integrates the recreational and main commuter cycling networks with the overall urban planning of the region. This holistic approach ensures that cycling infrastructure is developed in alignment with the region's growth and development plans. (See Appendix A for full interview)

Copenhagen Planner suggests adding a brief mention of the Cycle Superhighway concept, which aims to create direct, comfortable, and safe routes for commuter cyclists across municipal borders, prioritizing their needs above all else. This addition would provide context for the secretariat's role in implementing and coordinating this ambitious regional cycling initiative. (See Appendix A for full interview)

The Bicycle Office of Barcelona’s Metropolitan Area that Sílvia Casorrán used to lead, plays a similar role to Copenhagen’s Supercycle Highway Secretariat, in which they coordinate cycling infrastructure projects with the diverse municipalities that conform the metropolitan area. Casorrán exemplifies the work done from the AMB and the often difficulties found in cycling infrastructure projects:

Well, in each municipality the urban design is different. We have a bike path that is a continuous connection. But each municipality, each section, is a different story. That is, even with the fact that it is a joint project, each municipality tells you something different. Then the complexity, just with a project that has already been done together, imagine when you try to coordinate... Make the bike lane here, do I don't know what, give priority to pedestrians...

(See Appendix B for full interview)

7.4. Politics

This last parameter of the conceptual framework inspects the existing political environment around active mobility, which ultimately shapes the city's urban landscape and decision-making towards developing more infrastructure and applying the right policies to push for cycling and walking, eliminating path-dependences and lock-in mechanisms from the political side.

In the Active City vision, there is a broad political consensus across national, regional, and municipal levels to residents to choose active mobility options like cycling and walking, with administration procedures that enable the efficient implementation of active mobility initiatives, ensuring the continued advancement of sustainable transportation solutions regardless of which party governs the city. (Copenhagenize, 2019)

In Copenhagen, Copenhagen Planner is confident about the political consensus existing in the city to promote cycling, acknowledging that while there is a general political consensus supporting cycling, challenges arise when it comes to reallocating space from cars to make room for bicycle infrastructure. Copenhagen Planner notes that '*of course, when it comes down to removing car parking, to make room for bicycle track, you will see a political divide as in any other place'.*

However, Copenhagen Planner emphasizes that there is a broad agreement that cycling should be prioritized and given its rightful place in the city's transportation system. She states, '*But there is a general buy in that cycling should have it, have its place'.*

Copenhagen Planner recognizes that the specific allocation of space between different modes of travel can be a point of contention, stating, "And you can always discuss how much of that space should be taken from cars or other modes of travel and that will cause political divides".

Despite these occasional disagreements, Copenhagen Planner firmly believes that "*there is a general consensus that everyone should support cycling.*" This sentiment reflects the strong political will and public support for promoting cycling as a sustainable and efficient mode of transportation in Copenhagen. In the interview, she shared the following anecdote as an example:

environmental mayor (...) was supposed to to be in the panel, but then she couldn't go. And another politician from the city council had to replace her and he is from the Conservative Party. So like quite right wing. And he was up there on the stage, like really owning making status as a leading cycling city, saying that no matter our political agenda that we agree on cycling, the Conservatives might be a little more slow for like accelerating change than the, than the environmental socialists. But we do agree that cycling is definitely part of the solution just to give you an example of how like of course,

you can find differences in political prioritization, but in general, it's perceived as a common good like on a par with public transport

Full interview can be read in Appendix A.

In Barcelona, Sílvia Casorrán shared during her interview the procedures behind decision-making in the city, and how administration can be complex and impeding to push for bigger reforms:

The municipal meetings to build new bike lanes in Barcelona are usually very complex, there are many interlocutors. You have districts, firefighters, city police, urban green, waste management, who don't want to pick up trash from the bike lane and don't want the bike lane on the right. Last term, we had to agree and negotiate because the waste department refused to let the workers pick up the rubbish from the bike path. One of the companies that collect waste and its occupational hazards department were against workers having to collect litter from the cycle path because they considered it dangerous. They even considered installing traffic lights there. They blocked meetings for months.

Moreover, she sheds light on the internal workings of the City Council, mentioning the significance of the 'Rep' reports prepared by each technical team. Casorrán explains that these reports, categorized as A, B, C, or D, play a crucial role in project approval. An 'A' rating indicates a project is flawless, while a 'B' signifies minor issues that need addressing for approval. Conversely, a 'C' rating is negative and can impede project approval, requiring all services to provide at least a 'B' rating for progress. Casorrán highlights the intricate negotiations and challenges that often arise, leading to project delays or cancellations, as exemplified by the case of the Fabra i Puig cycle path.

Lastly, Casorrán expresses her fear that the new municipal government that took place in Barcelona last year, lead by Mayor Jaume Collboni, will cancel the Superblocks program as they have cancelled the budget for it: '*I think the new Mobility Plan will not even mention the SuperBlocks or the Green Axis'*. This illustrates a lack of political concensus on the development of walking infrastructure and redesign of public spaces that has put Barcelona in the center of urban planning model for the past years.

8. Analysis Consolidated Information

This chapter is solely dedicated to present the detailed information from the analysis through the conceptual framework in chapters 5, 6 and 7 in one table.

		Copenhagen	Barcelona
Social Environment	**Culture and Social Acceptance**	Cycling is the **favorite** transportation mode by far. Cyclists are not related to any specific ideology.	Cycling is **not spread** among the general population and it is not the favorite mode of transportation. Cyclists are not perceived as a social group or profiled in general.
		Copenhageners identify the **weather** as the main con about walking in their city, with narrow sidewalks as the second identified problem, and are **less likely to walk** long distances than Barcelonians.	Barcelona identifies **air pollution** and **too many cars** as the main walking problems, followed by the lack of green spaces in the city. However, they are **more likely to walk** long distances than in Copenhagen.
	Perception of Safety	Cycling is perceived as a **very safe**. Cars and motoribikes on the bike lans are seen as the main threat.	Cycling is perceived a rather an **unsafe** mode of transportation, while bicycle fatalities skyrocketed in 2023.
		Walking is perceived as **completely safe** during the day, and very safe during the night.	Walking is perceived as generally safe to walk during the day, medium safe during the name. Most **women** do not feel safe walking during the night.
	Accessibility and Inclusivity	**Gender Balance** among cyclists, more women cycle than men. Women feel safe cycling. Copenhageners own approximately 40k cargo bikes, while ridigin a cargo-bike is generally perceived as safe.	**No Gender Balance** among cyclists: 75% of cyclist are men. Gender balance in *Bicing* service as an indicator that women want to cycle. Riding a cargo-bike is not perceived safe, but they are starting to appear in the urban landscape.
Streetscape	**Infrastructure and Facilities**	**Cycling Network***:* expanded through all the metropolitan area, with high satisfaction rates among citizens. **Bicycle Parking:** facilities in expansion, but there is a need to build more. Almost a quarter of the population don't have a safe space to park their bikes at home. **Walking infrastructure:** need for more benches and wider sidewalks. **Bikeshare alternatives:** no municipal service existing	**Cycling Network:** medium-low satisfaction. Bike lanes are too narrow and bidirectional bike lanes have dangerous intersections. **Bicycle Parking:** municipality building racks. Most resident don't have a safe space to park their bikes. Safe parking spaces built around the metropolitan area but a few within the municipality. **Walking infrastructure:** apply regulation on motorbikes on the sidewalks, and access to terraces. **Bikeshare alternatives:** *Bicing* as a successful niche of

		anymore. Donkey Republic as a strong bikeshare alternative.	transformation, giving path to the development of cycling infrastructure.
	Digital Infrastructure and data	**COMPASS** traffic model developed by the municipality, integrating cyclists and pedestrian in the modell. Portable bike counters and sensors can be seen around. The municipality uses data infrastructure to provide cyclists a better experience, as with the Green Waves.	**PTV Visum** as the traffic model used by the municipality, but no certainty if cycling and walking are integrated into the traffic model. 371 bike sensors installed around the city, from which the municipality obtains cycling data.
	Low motorized traffic	**PM2.5** average levels **under** WHO limit. Reduction speed projects due to legislation and police.	**PM2.5** average levels **well above** WHO limit. Superblocks and Green Axis as projects to reduce car pollution in the city, increasing walking commutes.
	Strategic Public Transport	**Intermodality** with cycling is promoted with bicycle stations in public transport hubs and no costs policy to bring your bike in S-trains, which have designated spaces.	**Public transport** reigns as the main transport modal. New bicycle parking stations in metropolitan area starting as a new niche of transformation, promoting intermodality.
Policy Environment	**Advocacy**	No strong advocacy movements to promote cycling and walking visible nowadays. Long history of advocacy movements after WW2.	Strong relationship between the City Council and various entities. BiciHub and Cubic highlighted, associations pushing the city council successfully to promote cycling and walking.
	Urban Planning	Favorable dense and compact neighbourhoods that allow active mobility. Cycle Superhiway Secretariat as a planning entity for cycling infrastructure.	Favorable dense and compact neighbourhoods that allow active mobility. Density much higher than in Copenhagen. Bicycle Office of Barcelona's Metropolitan Area as a planning entity for cycling infrastructure.
	Politics	Political consensus on cycling, regardless who governs the city. Political divide on applying car-free policies and removing parking spaces.	No political consensus on cycling or car-free policies, these projects depend on who governs the Municipality. Cycling projects and infrastructure expansion are hard to approve as procedures involve agreement from all departments.

Table 5. Analysis Consolidated Information Table

9. Sustainable Transition Design

This chapter aims to draft a sustainable transition based on the Multi-Level Perspective (MLP) sketch. Based on the analysis done through the three dimensions of the Active City conceptual framework, this chapter defines the MLP parameters that shape a sustainable transition, and that provide an understanding of the state of active mobility in Copenhagen and Barcelona through the MLP lenses.

The chapter is structured in three parts: definition of the general landscape that shapes the active mobility of both cities, analysis of the evolution of the mobility socio-technical regimes in both cities and the identification of current lock-in mechanisms that prevent the expansion of active mobility and lastly, a proposal of new niches of transformation that would defy the current regime and put pressure on it.

9.1. Landscape

In MLP theory, the landscape represents the broader context within which niches and regimes operate. It includes urban layouts, political ideologies, societal values, beliefs, and concerns. Changes at the landscape level, such as shifts in policies, societal values, or technological advancements, can create pressure on the existing regime and open opportunities for new innovations (Geels, 2012).

Common landscape

Copenhagen and Barcelona are European cities, belonging to different regions in the continent. Both Copenhagen and Barcelona are multi-cultural and dynamic cities with income disparities between them that along with different climate conditions, they shape different lifestyles that condition on a landscape level different specific contexts in each city.

However, a common socio-technical landscape exists, and it is based on the membership of both Denmark and Spain in the **EU** and the **Climate Change** emergency that the world lives under, as well as the on-going conflicts that affect socio-economic life in Europe and global movements towards sustainable urban mobility. This affects the cities in similar ways, as both cities are required to adapt and contribute to their respective national goals towards sustainability and compliance with the policies under the **European Green Deal**.

A new element in the common landscape of the two cities is the **European Declaration of Cycling**, a landmark agreement signed in April 2024 by the European Parliament, Council, and Commision. This EU policy initiative recognizes cycling as a strategic priority and commits the EU and member states to develop and strengthen cycling policies at all levels of governance, recognizes cycling as one of the most sustainable and healthy forms of transport and calls for increasing safe and coherent cycling infrastructure across Europe (Cycling Industries Europe, 2024). This can arguably be regarded as a change in

the common landscape level of Copenhagen and Barcelona that can create pressure on the existing regime in both cities.

A proof of this common landscape is the existence of EIT Mobility 'Innovation Hubs' and headquarters in both cities. EIT Urban Mobility is an initiative of the European Institute of Innovation and Technology (EIT), which is a body of the European Union. EIT Urban Mobility focuses on creating livable urban spaces by engaging cities and citizens, implementing new mobility solutions, and reclaiming public space for public use (EIT Urban Mobility, 2024). This organization operates in the Nordic countries through its 'North Hub' in Copenhagen and in Southern Europe through its 'South Hub' in Barcelona, pushing for regional transformative ideas that could potentially be regarded as niches of transformation under the MLP framework.

In addition, technological advancements in both cities have brought Copenhagen and Barcelona to hold the category of 'Smart Cities'. Barcelona fosters the Smart City World Expo annually, where the Copenhagen Connecting project from the Copenhagen Solutions Lab won the World Smart City Award in 2014 (Nielsen, 2014), exemplifying one of the main technological aspects of the common MLP landscape from both cities.

Copenhagen

The specific MLP landscape of the city of Copenhagen is defined by this being the capital and most populated city of the of Denmark, one of the main urban hubs of the Nordic Countries and a capital of EU Member State.

One important element to highlight on Copenhagen's landscape is the city's plan to become **Carbon Neutral by 2025**. This ambitious plan declared in 2012 has shaped the direction of policies and has given the Danish capital international recognition and a significant branding boost, attracting talent and investors to the city, which ten years after launching the plan declared that it was not viable anymore (Christiansen & Hougaard, 2022).

Barcelona

Barcelona is the second largest city of Spain and its main port on the Mediterranean coast and the fourth most visited city in Europe in 2022 (Schmidt, 2023), which received over 12 million tourists in 2023 (Ajuntament de Barcelona, 2024d).

On a landscape level, the political context of Barcelona through the past years has been shaped by the Catalan independentist movement and the political turmoil caused and the election of housing activist Ada Colau as Mayor of the city in 2015 who stayed in power for eight years conditioning the city's trajectory and mobility politics, and was elected due to a strong campaign against mass tourism (Estirado et al., 2015), under the Anti-austerity movement in Spain.

The climate crisis has hit Barcelona and conditioned urban life at some extend, especially since 2022 when a severe drought started taking place in all Catalonia, bringing the municipality to apply water restriction measures affecting citizens and urban greenery (Congostrina & Velasco, 2024).

9.2. Socio-technical regimes

Copenhagen and Barcelona share a common socio-technical regime dominated by motorized traffic, which shapes all aspects of urban mobility in both cities.

Cars were introduced in European cities in the late 19th century, while the first significant wave of car adoption took place in the early 20th century. After World War 2, cars became affordable and mass-production brought this new dominant socio-technical regime in power, transforming cities and their urban layouts to accommodate car infrastructure.

Looking at ownership rates in both cities, on one hand, Copenhageners owned in 2022 142,400 cars (City of Copenhagen, 2023b). Car ownership rate in 2022 was approximately of 215.75 cars per 1000 habitants.

On the other hand, Barcelona tops the list of European cities with a higher density of cars, 5855 for each km^2, with an uneven distribution of ownership among districts, due to wealth differences. (Vivas & Navarro Soler, 2021). In 2022, Barcelonians owned 493.4 motorized vehicles per 1000 habitants, primarily distributed as 287.6 cars and 131.7 motorbikes per 1000 habitants (Ajuntament de Barcelona, 2020).

These figures provide solid evidence that cars and motorized traffic can be considered as the dominant regime in both cities, but the in the whole socio-technical regime of urban mobility in both cities, other subaltern regimes exist. One of these is public transport, which in Barcelona is a stronger subaltern regime than in Copenhagen due to its expansion, history and daily commuting trips. Another **subaltern regime**, which is the one that this research investigates, is the active mobility one, conformed by bicycles, pedestrians and other types of micro-mobility who complete it and provide a healthy alternative to the dominant motorized regime.

From a MLP perspective, cycling and walking could be regarded as different subaltern regimes that together conform a subaltern regime that aspires to overlap and substitute the motorized traffic dominant one, bringing this one down to the category of subaltern, adapting to a new urban reality in which motorized traffic should adapt to active mobility by transforming the streetscape and the social and policy environment.

Historical Perspective and regime evolution

Copenhagen

Cars were introduced in Copenhagen as part of a postwar economic recovery and urban development. Following World War 2, there was a significant increase in car ownership,

especially in Copenhagen's suburbs (Henderson & Gulsrud, 2019), although compared to many other European cities, the car boom came later to Copenhagen, not setting foot until the 1960s (Jensen, 2013), where cars and motorized traffic become the dominant socio-technical regime of Copenhagen's urban mobility. During the 1950s, streets like Nørrebrogade were still dominated by cyclists, which still could be considered the dominant regime as they outnumbered cars and controlled the flow of traffic (Jensen, 2013), as economic recovery efforts included raising revenue for the welfare state through high taxation on cars, fuel, and other parts of the car system. Nevertheless, the Danish Social Democratic Party and other political parties endorsed the construction of motorways in Denmark, believing that they would boost economic growth and underwrite the expansion of social welfare, preparing the country to enter to a new mobility socio-technical regime as the United States previously did. This support for car infrastructure contributed to the influx of cars into Copenhagen, particularly from the suburbs, leading to a shift in the city's transportation landscape towards greater reliance on automobiles (Henderson & Gulsrud, 2019).

The 1970s marked a tipping point for Copenhagen and the on-going car-centered urban planning in the Danish capital. At the beginning of the decade, there were significant protests against proposed motorway expansions, and at the same there was a financial crisis that limited the ability of both the national government and the City of Copenhagen to fund extensive car infrastructure. These constraints preserved much of the city from being overrun by cars, maintaining a more human-scale urban environment. Later on, the 1973 oil crisis served as a wake-up call and a change in the landscape that provide evidence of the benefits of reduced car usage and created pressure on the established regime. The crisis led to the introduction of car-free Sundays, which acted as a new niche of transformation and demonstrated how pleasant and livable the city could be without heavy car traffic (Jensen, 2013).

Figure 68. Cyclist demonstration in Copenhagen in the 1980s (Jensen, 2013)

Moreover, in this changing context, the Danish Cyclist Federation organized demonstrations in the late 1970s, demanding better infrastructure for cyclists. This movement gained substantial support from ordinary citizens, leading to the establishment of dedicated cycle tracks along major streets like Nørrebrogade in 1982. These protests acted to destabilize the dominant regime to create a window of opportunity for this niche of transformation with the shape of new cycling infrastructure. (Jensen, 2013)

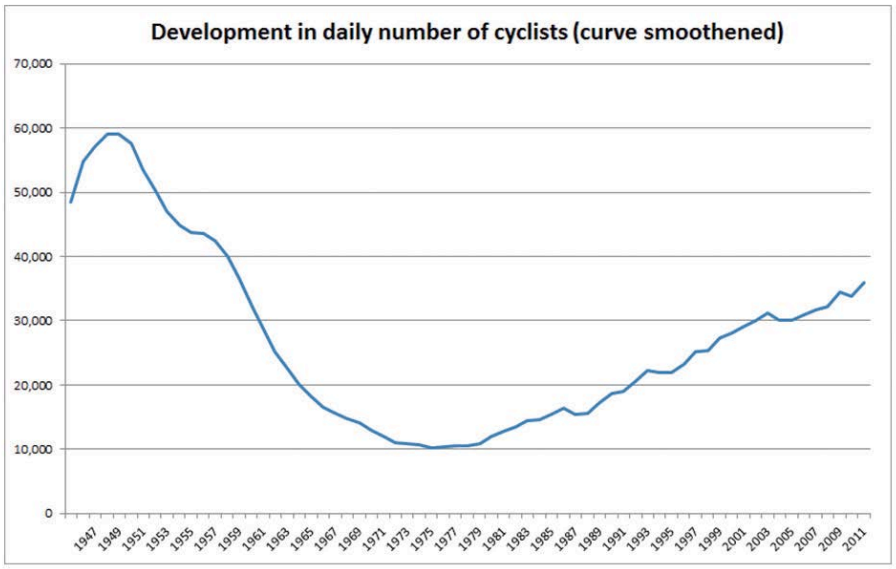

Figure 69. Bicycle trips in Nørrebrogade throughout the years (Jensen, 2013)

The 1990s and early 2000s saw a gradual but steady expansion of cycling infrastructure in Copenhagen, despite financial constraints. As Figure 70 shows, the cycling subaltern regime started emerging as a solid alternative to car use in Copenhagen, while initiatives like the Bicycle Account, introduced during the Car Free Cities conference in 1996, and the Cycle Track Priority Plan of 1997, institutionalized the commitment to improving conditions for cyclists and creating momentum. By 2005, cycling infrastructure had become a significant issue in local politics, with election campaigns for the Copenhagen City Council focusing on enhancing cycling conditions for the first time (Jensen, 2013).

The development of the metro as an another subaltern transport regime is believed to be destabilizing the cycling subaltern regime, as COMPASS projects a decrease of cyclists in Copenhagen (see Appendix A). This shows the complex dynamics within the sub-atern transport regimes, and it might indicate that the substitution of the dominant car regime might have to come with the co-existence of two current sub-altern regimes which together can overlap the dominant one.

Barcelona

The city of Barcelona as we currently know it started with the development of the Eixample district by Idelfons Cerdà, as an attempt to expand the city beyond the old city walls. Cerdà conceived the plan in the mid-19th cetury, well before the rise of the

automobile, and he envisioned a city based on community living, where people could interact on wide streets and in interior public gardens in each block, where transportation of people and goods would not dominate public space. The mobility plan for the Eixample district, planned by Ildefons Cerdà, was revolutionary for its time and was not specifically designed for cars. In fact, the Eixample district was developed in the mid-19th century, before automobiles became common. Cerdà's plan was focused on creating a more organized and modern urban layout to address the challenges of overcrowding and unsanitary living conditions in the old city of Barcelona (Martí et al., 2010).

The 1920s saw a boom in passenger car registrations in Barcelona, driven in part by the 1929 Universal Exhibition (SEAT, 2019), and after years of a landscape defined by the Spanish Civil War, the post-war era and the end of World War 2, came the founding of SEAT in 1953 (SEAT, 2019), as Spain's national car manufacturer. With the headquarters situated in the outskirts of Barcelona, SEAT consolidated the automotive sector in Spain, provided jobs to a developing society from a post-war era, establishing a strong dominant regime dominated by car in all aspects of life.

With a strong metro system that dates from 1920s with on-going lines in development, Barcelona never had a strong cycling culture as Copenhagen did before World War 2. The 1973 oil crisis did not bring protests in Barcelona like in Copenhagen. Back then, the landscape of both cities looked very much different, as Denmark just joined the EU (European union, 2024) and Spain was still leaving under the repression of general Francisco Franco's dictatorship, a landscape that was about to change. Under this circumstance, no windows of opportunity could open in Barcelona as public protests and gatherings were banned under severe consequences, creating a general oppresive lock-in mechanism in which the socio-technical regime.

When democracy was restablished in Spain, Barcelona saw an urban transformation given by the 1992 Olympic Games, which gave birth to the modern nowadays Barcelona, redeveloping the seafront and the restoration of historical buildings and streetscape (Smart Cities Dive, 2024). The Olympic Games modernized Barcelona, but they did not have any negative impact on the dominant motorized socio-technical transport regime. In fact, they helped consolidating with the construction of the ring roads, in part to accommodate part of the traffic that the Eixample district suffered. In a normal day, traffic in Eixample district can reach 350,000 vehicles, while the traffic in the two city rings ('Rondes') can reach 241,000. (Vivas & Navarro Soler, 2021)

Barcelona has lived under a very strong dominant car and motorbike traffic socio-technical regime, with a public transport sub-altern regime who supports successfully the mobility in the city. In Barcelona's case, cycling and walking can not be regarded as both sub-altern regimes as in Copenhagen, only the last one being able to hold this category.

Cycling in Barcelona can still be considered a niche of transformation, with the introduction of th municipal bikeshare system Bicing creating a window of opportunity in 2007. All the cycling network development in the city started after the gradual introduction of the service, which did not cover the entire city when it was first introduced. This niche pressured the regime and made the municipality realize about the need to accommodate this new element into the urban layout of the city, re-shaping the streetscape of the city.

Moreover, another important niche of transformation that Barcelona has seen during the past years was the Super Block program, and the pedestrianization of steets under the Green Axis program. These important niches of transformation were opened by the municipal government of Ada Colau, which pushed for an ambitious agenda on transforming urban spaces, and made the Super Blocks program a central axis of her governance program. The Super Blocks program has already changed the car regime in Eixample district, and has oppened a new window of opportunity as citizens now enjoy

Another niches of transformation opened by the election of Colau are initiatives as 'Obrim Carrers' (We Open Streets), which is a 'Car-Free Sundays' initiative that prohibits car traffic in principal streets of the city of Gran de Gràcia and Sants, dominated by car traffic during regular days. This initiative provides 58,600 m^2 of public space to pedestrians every Sunday (Obrim Carrers, 2024), putting pressure on the dominant socio-technical car regime by creating social change and providing citizens the opportunity to experiment how Barcelona would be if the Active City vision was enforced.

Figure 70. Gran de Gràcia street on a car-free Sunday (Obrim Carrers, 2024)

Moreover, the pedestrianization of key streets that are mainly dominated by cars, such as Via Laietana or Consell de Cent, and the expansion of the cycling network are arguably other niches of transformation under the re-design of streets direction that the municipality has taken towards promoting active mobility.

Identifying current lock-in mechanisms

Lock-in mechanisms are processes that reinforce and maintain the existing dominant motor traffic regime and prevent systematic change to happen (Geels, 2012a). This elements under MLP theory applied to the sustainable transition studied by this reseach prevent the development of more infrastructure for active mobility, and the creation of the necessary social and political framework for this changes to happen.

In Copenhagen, the main identified lock-in mechanism is the regulation that appoints the local police as the deciding organism in speed limits, and not the correspondent municipalities. According to interview in Appendix A, police in Copenhagen tend to have a conservative approach on this matter and usually do not allow the municipality to low down speed or pedestrianize streets. This causes years of delay when the municipality takes a car-free direction and wants to reduce traffic or speed in streets, as municipal governments don't count with the competences to decise on this matter and push for an active mobility-friendly agenda. This legislation also impedes the municipality to ban motorbikes circulate through the designated cycling infrastructure in Copenhagen, which is one of the main concerns of cyclists (see Appendix C for survey results).

This legislative framework makes cities very dependent on government initiatives and road standards, which are conservative by nature (Jensen, 2013) and can be regarded as lock-in mechanisms from the current dominant car regime.

Another lock-in mechanism in Copenhagen comes from the lack of political concensus to remove public parking spaces on streets, which could serve the city in many other purposes, as to widen sidewalks or accommodate more cycling paths.

Lock-in mechanisms in Barcelona take a similar shape that in Copenhagen: there is a lack of political concensus on further developing the Super Block program and move forward the agenda of pedestrianization of streets. According to Casorrán, the new government elected in 2023 and lead by the Social Democrats, has cancelled the Super Block program and removed the budget provided for it that Colau's administration assigned it.

According to Casorrán, the complexity of administration under the Spanish system also plays an antagonic role to the development of the cycling infrastructure on Barcelona's metropolitan context, as each municipality has different plans and depending who governs it, will have different interests. (See Appendix B for full transcript).

Remarkably, the new government of Barcelona, lead by Social Democrat Mayor Jaume Collboni, has not pushed for dismantling the Super Blocks program, the Green Axis or any other of the transformations iniciated by his predecesor. One of the reasons might be that he was par

Another considerable and proved lock-in mechanism in Barcelona and Spain is the existence of associations and figures with a very conservative agenda. In 2023, a judge dictated against the newly developed Green Axis of Consell de Cent street right after it was built, dictating that all the new walking infrastructure and pedestrianization needed to be dismantled and the street had to go back to its car dominated past (Márquez Daniel, 2023). The lawsuit against the Consell de Cent project in Barcelona was initiated by Barcelona Oberta, a business association including major retailers and tourism firms, and argued by architect Antonio Acebillo, claiming that the pedestrianization harms local businesses, disrupts the Eixample grid's transportation function, and contradicts the original vision of Ildefons Cerdà. Legally, they argue that transforming Consell de Cent from a "local road" to a pedestrianized area required a modification of the Metropolitan Master Plan (PGM), which the city failed to do, thus violating procedural requirements (Honey-Rosés, 2023). The sentence was dismissed but in 2024, the Green Axis received two other judicial sentence, denounced by the same association, which the municipality will appeal against (RAC1, 2024).

A one common lock-in mechanism from both the car dominant regime in both cities is the development of policies and infrastructure for Electric Vehicles. As cities need to comply with decarbonization goals, Copenhagen and Barcelona's car regime is pushing for a transformation to continue being the dominant one, just by modernizing their infrastructure. In Copenhagen, the municipality is looking to ban fossil fuel vehicles by 2030, which will come with the development of the adequate EV infrastructure (Wenande, 2023) to replace fuel cars, and Barcelona has now a new Electric Vehicle Master Plan, which will also develop further the emerging EV infrastructure in the city and provide subsidies for those who opt to purchase one of these vehicles (Ajuntament de Barcelona, 2024b).

Overlapping the dominant by the subaltern regime

The sustainable transition that Copenhagen and Barcelona should promote to become cities whose mobility is based on cycling and walking should come by an overlap and substitution of the current dominant regime, motorized traffic, by the existing subaltern ones that conform of active mobility.

Strong lock-in mechanisms exist in both cities that prevent these transformations to happen, yet both cities have been taking steps further towards this model. Arguably, Copenhagen has a bigger history of niches of transformation that prevented the dominant car regime to simply eliminate the cycling and walking subaltern regimes,

which were consolidated after the 1970s as so and have been evolving until becoming solid alternatives to motorized traffic, specially cycling in Copenhagen.

Barcelona, on the other hand, did not see strong niches of innovation in mobility against the dominant car regime, but recently windows of opportunities were open by Colau's political agenda, giving place to strong niches of innovation that gained momentum and seem to have stagnated with her departure from the municipality.

To push for this sustainable transition, the defined lock-in mechanisms should be abolished and more niches of innovation should be open in both cities. As transitions are non-linear processes and involve shifts in existing regimes (Geels, 2012b), there is hope that both cities will see a transformation in the upcoming years, in which citizens will take back the public space that belongs to them.

9.3. Proposed new Niches of transformation

For the dominant motorized traffic socio-technical regime to be replaced, new windows of opportunity in both cities should be open to give momentum to new emerging niches of innovation and transformation that would dismantle the regime. These niches come from the active mobility subaltern regime, which can push and put pressure in the dominant car one, and they come as new policies and urban interventions that would give path to this transition and an increase of cycling and walking and a decrease of motorized traffic in the city.

The proposed niches are a derivation of the findings of this project and the analysis done through the Active City conceptual framework.

Copenhagen

Municipal Walking Strategy with a Focus on Elderly and Disabled People

Inspired by Barcelona's initiatives for inclusivity, this strategy aims to improve accessibility for visually impaired and disabled individuals. It includes expanding sidewalks, installing traffic lights with acoustic sounds for blind people, and using podotactile flooring. Additionally, the plan involves building more benches to provide rest areas for the elderly and disabled. This niche would create an increase of pedestrians and people who choose to commute walking, promoting physical and mental health to elderly and disabled people, who would enjoy a more inclusive Copenhagen.

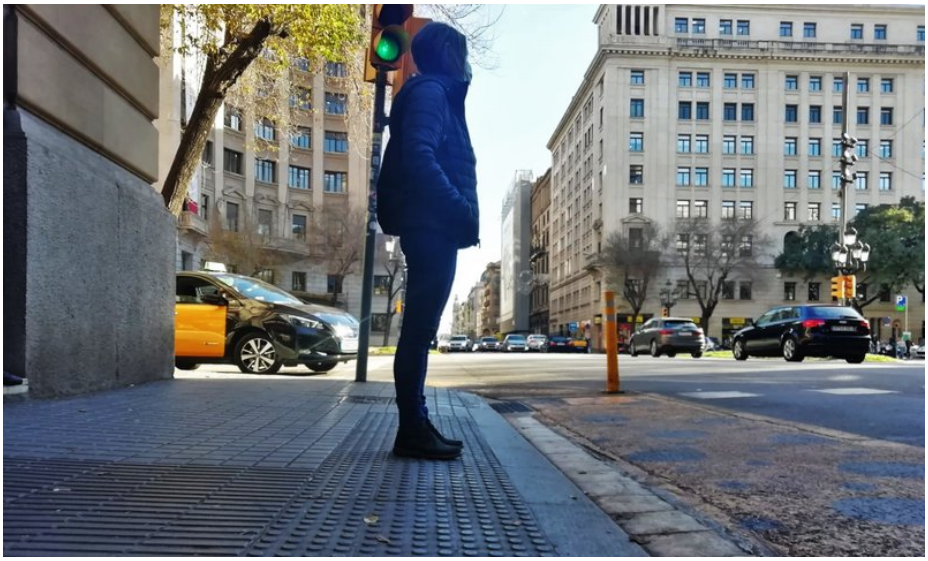

Figure 71. Podotactile floor in Barcelona, indicating the crossing point (J.P., 2021)

Greenery

The political ambition to plant 100,000 trees around Copenhagen is approved and implemented. If more trees were planted in Copenhagen, it could help improve air quality by filtering pollutants and providing shade, creating a more comfortable and pleasant urban environment. In the context of the research paper, increasing tree canopy could also support the city's efforts to promote sustainable and livable urban development as part of its vision for car-free(dom) and sustainable mobility (Martin, 2021).

Figure 72. Vision for a greener Copenhagen (Martin, 2021)

Political Reform for Speed Limit Competences

Advocating for political reform to allow municipalities in Denmark to modify speed limits. Removing this regulatory lock-in mechanism would enable the adoption of car-free policies and tactical urbanism, promoting safer and more livable urban environments. A change on this legislation would be an opening window for car-free policies, but the political will or any citizen advocacy can also be regarded as a niche of transformation pressing this lock-in mechanism.

Cycling Infrastructure

This includes building more parking spaces for bicycles and identifying households that lack safe bicycle storage, so the municipality can install appropriate facilities. Necessary space for these facilities can be repurposed from existing car parking spaces. Additionally, the strategy suggests redesigning some intersections in Copenhagen, taking inspiration from the Netherlands, and focusing on introducing traffic calming measures in residential areas.

Figure 73. Cargo-bike parking that emulates a car in Copenhagen (Copenhagenize, 2009)

Tactical Urbanism

Testing innovative solutions like car-free policies and monitoring their impact on urban life and residents. This approach allows for experimentation and adjustment based on real-world outcomes, fostering a more adaptable and responsive urban planning process. However, this niche of transformation can not succeed if the lock-in mechanism that prevents it to advance, the Danish Road Regulation, is changed or phased out.

Barcelona

Barcelona is currently experiencing the emergence of niches of innovation challenging the dominant motorized traffic regime, just as Copenhagen did in the 1980s. These new windows of opportunity prompted by the protests of the Anti-Austesterity movements at the beginning of the 2010s decade and the political trends that brought Ada Colau to the Mayoralty. Associations as CUBIC, BiciHub or the development of Bicing can be considered niches of transformation, and bring more people to cycle in the Catalan Capital.

The following proposed measures by this research are derived by the findings of the analysis, and are proposed as potential niches of transformation or the reinforcement of existing ones to reinforce cycling and walking as subaltern regimes in Barcelona that can overlap and substitute the existing dominant regime.

Bicing as a Niche of Transformation

Barcelona's cycling landscape can be significantly transformed by **enhancing the Bicing municipal bikeshare service**. Key improvements include investing in more modern bicycle types to enhance service quality and integrating Bicing with the new public transport pass, 'T-Mobilitat', which consolidates all public transport options. Additionally, the expansion of the new Metropolitan bikeshare system should be interconnected with *Bicing*, with infrastructure adapted to support both services. Moreover, incentives from companies to its employees that choose to commute with this new public transport card that integrates *Bicing* could also be regarded as a niche of transformation that would certainly make people cycle more, ask for better infrastructure and put pressure on the dominant car regime.

Expansion of Cycling Network

Keep progressing the cycling network of Barcelona is crucial for the promotion of cycling to favorably influence the social environment of the city and bring more people to perceive cycling as a safe and healthy commuting option. This includes connecting the main city axes with appropriate cycling infrastructure and extending the network across the metropolitan area. For that, Barcelona and its metropolitan area government should also reduce administrative complexity to eliminate barriers, potentially by pushing for **an agreement among all the municipalities**, that would create the necessary political consensus and set an agenda regardless of who governs the diverse municipalities that conform Barcelona's Metropolitan area.

Moreover, on the expansion of its cycling infrastructure, Barcelona would benefit from:

- Developing green infrastructure alongside cycling paths will provide shade and enhance heat resilience.

- A Municipal Cycling Strategy, similar to Copenhagen's Bicycle Account or Paris's Plan de Vélo.

These measures and interventions would provide the niche of cycling in Barcelona the category of subaltern regime, that which time and the right pressure to the dominant regime, could overlapping along walking.

Developing Safe Bicycle Parking Infrastructure

To support cyclists, safe bicycle parking policies need to be developed. Importing the BiciBox system from the metropolitan area into municipal boundaries is a viable option, taking space from car parking areas and placing one at each station. The VadeBike system should be expanded, and initiatives like CUBIC should be subsidized. Consider installing secure bicycle parking facilities in each block of Barcelona to ensure cyclists have safe storage options.

Integrating Cycling in the city's Digital Infrastructure

Integrating cycling into the PTV model, as done in Copenhagen with COMPASS, and using portable sensors can greatly enhance the cycling experience. Investing in more digital infrastructure, such as Copenhagen's Green Waves, can promote cycling by making it more convenient and efficient.

Enhancing Cycling and Walking Safety

Ensuring the safety of cyclists and pedestrians is key to develop the active mobility of Barcelona. This can be achieved by enforcing **better speed limits for cars**, providing a sense of security for cyclists, and **enhancing night-time security** to ensure safety, especially for female citizens.

Measures for intermodality with Public Transport

The renovation of Rodalies trains to include designated areas for bicycles to support cyclists, being inspired by Copenhagen's S-trains. Providing the adequate space and pro-intermodality policies will suppose another strong niche of transformation in favour of cycling in Barcelona.

10. Discussion

This chapter outlines the main reflections from the author of this thesis report that emerge after the analysis and results obtained, and previously to its conclusion. The chapter includes a reflection on the way that the MLP theory and the methods have been applied and how well it fits the context of the project. The results are discussed, and a reflection is as well presented on a potential continuation of this research (...)

The creation of the 'Active City' conceptual framework has provided a good way to measure the state of cycling and walking in a city. The creation of this framework is considered almost as important as the analysis itself and a contribution to this research field, as the first phase of the research was devoted to find the relevant aspects of a city and its society to the state of cycling and walking. The identification of the three dimensions (social, policy and streetscape) contributes on regarding the state of active mobility of a city further than just its infrastructure as cycling lanes or sidewalks, shedding light into other relevant aspects as safety perception by women that are key to unlock the transition that this research looks into. The Active City conceptual framework and the three dimensions and ten parameters in which is built upon could be enforced and further elaborated with tangible indicators that all together could be used as a developed framework to measure the state of 'friendliness' towards active mobility of a city. Therefore, this conceptual framework is considered to be a contribution to the research field and through this thesis, it could give path to further research to be developed and tested by municipalities, similarly to the Copenhagenize Index.

The 'City Basics' chapter was included as an attempt to create a simple portrait of both cities, for readers who are not familiar with more. The table provides a comparative format that allows readers to compare key figures that are relevant to this research and to interpretate the results from the analysis, and aims to illustrate the difference between the two cities. Demographically, Barcelona's municipal population is 2.5 times larger than Copenhagen's, and its metropolitan population is about three times bigger. Although both cities have similar municipal land areas, Copenhagen's metropolitan area is more than five times larger. This results in Barcelona having a municipal population density more than double that of Copenhagen, with its metropolitan density being over ten times higher. In terms of the economy, Copenhagen's GDP per capita is about 40% higher than Barcelona's, and the gross average income is 59% higher, although Danes pay higher taxes than Spaniards. Climatically, Copenhagen is colder and rainier, whereas Barcelona enjoys more sunshine hours per year. Environmentally, Barcelona's air is four times more polluted (in terms of PM2.5 levels), while Copenhagen offers six times more green spaces.

All of this data needs to be considered to provide a good analysis and draft how a sustainable transition towards active mobility would look like, as given these differences,

the cities might need different solutions. Barcelona does not necessarily need to adopt the cyclist city model that Copenhagen promotes, and Copenhagen does not necessarily need to apply the solutions that Barcelona has applied when it comes to pedestrianizations, as their citizens live in different places and countries, with arguably different cultures influenced by very different climate conditions. This is why exporting one model to one of the cities might not necessarily work, as this model needs to be adapted to the particular circumstances. Moreover, the data exposed in Chapter 4 can also help the reader interpretate the reality of active mobility in both cities and the reason behind the different strategies that both municipalities adopt to promote active mobility. One set of missing data in this table are crime rates, which also provide an insight on active mobility culture in both cities. This data was not added as generic crime rates might not be useful enough if not streamlined, for what it was decided to collect this information on safety perception through the surveys.

As an example of how the city basics comparison help understand the reality of active mobility in the two cities, one could argue that cyclists in Barcelona face the problem of hot and humid summers, that do not allow them to reach their destinations without needing a change of clothes, while most of the offices and workplaces do not count with showers or changing rooms. On the same direction, Copenhageners would see as useless for a long time of the year to have their streets pedestrianized and their car parking spaces removed for a space where people just would not use, as climate conditions and cold temperatures during the winter months would not allow it. This does not mean that Barcelona should not develop its cycling infrastructure further or Copenhagen should not strive for the redesign of its streets and spaces and apply more ambitious car-free policies, but successful solutions in one city might fail in other contexts.

The methodology used in this thesis research and the results obtained in survey data and interview transcripts, both in the Appendix, is the contribution to the general knowledge on the active mobility of Copenhagen and Barcelona. The two surveys were planned to be almost identical, although some adjustments were done to adapt them to the specific context of each city, as for instance the answers to the identification of negative aspects about both cities' cycling networks. Identical questions provide identical comparable results conceived as findings of the project that illustrate in a friendly format the difference between the state of active mobility of the two cities. Initially, the idea was to include all of the results and answers of the surveys into the main report, but that would have extended the length of an already long report, filled with these and other figures.

Both surveys results were somehow expected, with a few exceptions. The higher perception rate of Copenhageners of cycling as related to a particular ideology is indeed surprising in a city that claims to be the world's best cycling city. However, the explanation on this result might rely on the sample used in the surveys. Almost 80 percent of the

citizens who responded to Copenhagen's survey are under the age of 30 years old, while in Barcelona this age range does not reach the 25 percent of the entire sample. This could explain why Copenhageners leaned towards more of identifying cyclists as a young, student social profile than citizens in Barcelona, as they were actually identifying themselves as such. Moreover, 7 out of the 10 participants in the survey have lived in Copenhagen for less than five years, which can be regarded as a sample based on 'newcomers' from other places and countries with potentially a weaker cycling culture. This means that these new citizens in Copenhagen still perceive cycling as part of their experience of moving to a 'cyclist city' in which have themselves adopted this new cyclist identity. With time, this identity might end up disappearing to just become part of their normal daily life.

The results can also explain the low rates on cycling in Barcelona, and even more the high rates of walking, as older people tend to walk more in the city. It would have been interesting to reach out to more younger people in Barcelona and older people in Copenhagen, to align the median age of both samples which would provide a better comparative analysis, but time constraints did not allow it.

At the same time, the interviews with Sílvia Casorrán from Barcelona and the anonymous Copenhagen Planner are a core part of the project findings and add great value to the report. The two interviewed planners, which also held very similar positions in their respective cities, shared information that can not be found through classic online sources or articles. A good example of this are the procedures behind the approval of the development of cycling infrastructure in Barcelona, and the specifics about it, or the confirmation about the political consensus in Copenhagen about maintaining and promoting cycling as part of the city's identity.

Once the information is consolidated through the parameters in the conceptual framework, the appliance of the MLP theory comes as a framework to draft how a sustainable transition to a city based primarily on active mobility would look like. The choosing of MLP theory as the theoretical framework of this thesis research was given by the relevance and recognition of this theory to understand sustainable transitions. MLP provides a framework that understands transitions as non-linear processes, which matches with any mobility transition. Moreover, conceiving the mobility of cities as Copenhagen or Barcelona as socio-technical regimes matches with the focus given by this report, which looks into active mobility from different perspectives (social, policy and infrastructure).

Applying the MLP theory has served to answer the second research question of this thesis '*Which policies and interventions are needed in both cities to achieve a successful sustainable urban transition to an urban mobility model based on Active Mobility?',* as these policies and interventions are the identified niches of transformation that can pressure the mobility regime, dominated by motorized traffic in both cities, and overlap it

with the subaltern regime of active mobility. In addition, applying the MLP has served this research on identifying the commonalities between the two cities by looking at their landscape and by defining the socio-technical regime that conforms the mobility of both. Both regimes are similar but not identical, as Copenhagen counts with an active mobility subaltern regime mainly dominated by cycling and Barcelona counts with a subaltern regime mainly dominated by walking, where cycling can still be regarded as a niche of transformation that can soon evolve with walking into a strong subaltern regime. This is the reason why the niches of transformation identified in both cities go in different directions: Copenhagen's niches are policies and interventions that would strive for the pacification of streets and avenues, providing more space for bicycles but also for pedestrians, promoting and enhancing walking, and Barcelona's niches come in shape of interventions towards promoting cycling and unravelling the cyclist city in the Spanish city.

Coming back to the problem formulation, the first research question '*How do both cities compare in terms of Active Mobility?'* is answered through the analysis carried through the conceptual framework, and summed up in Chapter 8, and the second research question is answered in the last part of Chapter 9, where policies and interventions in both cities are identified as niches of transformation through the MLP lenses.

Concluding on this discussion, this research has found that there is a need for further research on the establishment of an internationally recognized criteria or framework to analyze and measure the level of development of an urban society towards active mobility, in which a city that bases almost all of its share modal of transport in active mobility would have the highest rank. Even though this is not empirical data, research on this field would contribute on unravelling cycling and walking in cities around the world and pressuring the dominant regime established with the introduction of cars and motorized traffic in cities, which is already being pressured by the current landscape dominated by the climate crisis. Promoting cycling and walking is not only important to reduce emissions and fight the current climate crisis, but also to improve the quality of urban life and reclaim the space that was once taken out from people and given to cars and motorized traffic.

11. Conclusion

The results of the comparative analysis of active mobility in Copenhagen and Barcelona reveal significant differences in their approaches and progress towards sustainable urban mobility. Copenhagen counts with well-established cycling culture and extensive infrastructure that has made it a global leader in urban cycling. In contrast, Barcelona is still in the early stages of its transition, with a less developed cycling culture and infrastructure but a strong importance given to walking and the redesign of public spaces.

Copenhagen's success can be attributed to its long-term commitment to cycling, supported by consistent political will and investment in infrastructure and born from advocacy movements that changed the course of history, stopping the development of car infrastructure in the city that was stealing public space from citizens. However, Copenhagen's lock-in mechanism still prevents the city to evolve into a more human-scale city, in which both pedestrians and bicycles count with the space that belongs to them.

Barcelona, on the other hand, has lived under a very strong motorized mobility regime during the past decades, but it has witnessed sharper niches on the past years through its ambitious Superblocks plan or the pedestrianization of avenues and spaces which have been redesigned to be given back to its citizens. Nonetheless, the city has seen the contra-action of strong lock-in mechanisms that are currently threatening this on-going sustainable transition that city has embarked in. It is now the time for the citizens of Barcelona to prevent this lock-in mechanisms to protect the car regime and take action as Copenhageners did in the 1970s.

Both Copenhagen and Barcelona can learn from each other's experiences, history of movements and best practices. The successful model of Copenhagen's cyclist city, with the appropriate campaigns and interventions of niches of transformation can be adapted and imported to Barcelona by enhancing and promoting the use of the municipal bikeshare system *Bicing* and its expansion and integration with the public transport card, as one example. Barcelonians can learn from Copenhagen's experience in the 1970s, when Danes set an example to the world by preventing Copenhagen to be overrun by highways and cars on the benefit of a few and mobilize themselves to do not let the system's lock-in mechanism to undo all the progress that has transformed their city into a model of urban transformation. Copenhagen, at the same time, can look both at Barcelona and at their own history to never forget that the cyclist city that its citizens enjoy was once taken away from them, and realize now that it is time to keep pushing for the sustainable transition towards a more human-scale city that would see their streets redesigned and given back to pedestrians, promoting inclusivity with ambitious and sharp niches of transformation as the ones Barcelona has seen during the past decade.

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