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Research Proposal on Sustainable Mobility in Europe

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Master in Management of Services and Technology

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Department of Marketing, Operations and General Management

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“Instead of always evolving the automobile, we should be looking at how we design mobility differently in the future”

Hans-Peter Dürr

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Acknowledgment

This chapter is dedicated to all the people, who, directly or indirectly, contributed to the realization of this milestone. This thesis marks the end of my academic journey, and it is with great satisfaction that I dedicate this section to the people who have been with me throughout this whole process.

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Disclaimer: This thesis has employed ChatGPT, an AI language model, exclusively for language correction purposes. The model was used to improve grammar, spelling, and syntax in the manuscript. All content, ideas, analysis, and conclusions presented in this thesis are the sole work of the author, and the use of the AI tool did not influence the development of the research, the interpretation of data, or any intellectual decisions. The author assumes full responsibility for the accuracy and integrity of the academic content.

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Resumo

Os crescentes desafios ambientais, sociais e económicos impostos pelo setor dos transportes tornaram a mobilidade sustentável uma prioridade na Europa. O Pacto Ecológico Europeu visa reduzir as emissões de transporte em 90% até 2050, mas a transição para o transporte sustentável enfrenta barreiras significativas, incluindo infraestrutura subdesenvolvida, adoção lenta de tecnologias e resistência comportamental.

Este estudo utiliza uma estrutura de tomada de decisão híbrida, com base em conjuntos *fuzzy* de imagem, para avaliar estratégias de transporte sustentável em toda a Europa, com foco na adoção de veículos elétricos, expansão do transporte público e integração de sistemas multimodais. A pesquisa destaca o papel das tecnologias digitais, como IoT, IA e Mobilidade como Serviço (MaaS), na otimização das redes de transporte e redução das emissões.

A equidade social, a acessibilidade e os impactos na saúde pública também são analisados, proporcionando uma visão abrangente das complexidades da mobilidade sustentável. Os resultados oferecem recomendações práticas para acelerar a adoção de soluções de transporte ecológicas em diversas regiões europeias.

Palavras-chave: Mobilidade Sustentável, Pacto Ecológico Europeu, Veículos Elétricos, Tecnologias Digitais, Transporte Público, Mobilidade como Serviço.

JEL Classification System:

O18 - Urban, Rural, Regional, and Transportation Analysis; Housing; Infrastructure

Q01 - Sustainable Development

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Abstract

The growing environmental, social, and economic challenges the transportation sector poses have made sustainable mobility a priority in Europe. The European Green Deal seeks to reduce transportation emissions by 90% by 2050, but the transition to sustainable transportation faces significant barriers, including underdeveloped infrastructure, slow technological adoption, and behavioral resistance.

This study employs a hybrid decision-making framework using picture fuzzy sets to evaluate European sustainable transportation strategies, focusing on electric vehicle adoption, public transportation expansion, and multimodal systems integration. The research highlights the role of digital technologies such as IoT, AI, and Mobility as a Service (MaaS) in optimizing transport networks and reducing emissions.

Social equity, accessibility, and public health impacts are also examined, providing a comprehensive analysis of the complexities of sustainable mobility. The findings offer practical recommendations for accelerating the adoption of eco-friendly transportation solutions across diverse European regions.

Keywords: Sustainable Mobility, European Green Deal, Electric Vehicles, Digital Technologies, Public Transport, Mobility as a Service.

JEL Classification System:

O18 - Urban, Rural, Regional, and Transportation Analysis; Housing; Infrastructure

Q01 - Sustainable Development

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Contents

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Index of Figures

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Glossary

EV - Electric Vehicle

MaaS - Mobility as a Service

AV - Autonomous Vehicle

ITS - Intelligent Transportation Systems

IoT - Internet of Things

EEA - European Environment Agency

EU - European Union

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1. Introduction

In recent developments in Europe, the concept of sustainable mobility is increasingly coming to the front, partly because there is an urgent need to mitigate the increasing natural, cultural and economic problems. With its rich geography and bustling cities, Europe is at the forefront of developing new modes of transportation built with people and the environment in mind. The following provides a broad background to the topic, including its relevance, the study's aims and the research questions, while presenting relevant ideas and models from the relevant literature.

1.1 Problem Statement and Context

In Europe, the transportation sector faces the central problem of being one of the most damaging in terms of greenhouse gas emissions, air pollution and public health contamination. However, some policies, such as the European Green Deal and similar initiatives, aim to reduce transportation emissions by 90% by 2050. Moreover, the existing infrastructure often provides minimal or no inclusion, as many groups still prefer that people move around in buses or other vehicles, which leads to the exclusion of communities (Road Transport, 2024). The tendency to switch to time-limited mobility solutions is reinforced to some extent by the ability to take environmental, economic and social aspects into account. The current situation calls for innovative decision-making frameworks to navigate the complexity of infrastructural, behavioral, and policy-related barriers, ensuring the successful implementation of sustainable transport strategies across Europe (Kirchherr et al., 2023).

1.2 Scope Definition and Research

The transportation sector in Europe is at a critical crossroads due to its significant contribution to greenhouse gas emissions, air pollution, and public health concerns. Despite policies like the European Green Deal, the transition to sustainable mobility is hindered by inadequate infrastructure for electric vehicles, the slow pace of technological adoption, and persistent social and behavioral resistance to alternative modes of transport, such as cycling and public transit. Furthermore, there is a pressing need to address social inequities in access to sustainable transport options, particularly for marginalized communities (Qadir et al., 2024).

The critical challenge of accelerating the adoption of sustainable transportation solutions in Europe by employing a hybrid decision-making approach under picture fuzzy sets is emphasized. This method enables a comprehensive evaluation of transportation strategies by incorporating various criteria and addressing the complex nature of decision-making. By considering infrastructural, social, and economic barriers, the approach provides a nuanced framework to identify and prioritize effective solutions. It aims to overcome obstacles such as inadequate infrastructure, public resistance, and high costs by offering a structured evaluation supporting sustainable transportation initiatives' development and implementation. Ultimately, the goal is to enhance the adoption of eco-friendly transportation options while navigating the multifaceted challenges associated with their deployment (Bakioglu, 2024).

1.3 Objectives and Research Questions

The primary aim of this research is to explore and address the multifaceted challenges arising from the implementation of sustainable transportation solutions in Europe. Given the complexity of transitioning to environmentally friendly transport systems, it is essential to consider the various infrastructural, technological, and behavioral barriers that are currently hindering progress. This study seeks to assess the opportunities available for overcoming these challenges, focusing on the effectiveness of existing policies, such as the European Green Deal, which plays a pivotal role in shaping the future of sustainable mobility across the continent (Papadakis et al., 2024).

Another crucial objective is to investigate the transportation strategies, broader social and environmental impacts. This involves analyzing how initiatives to improve sustainable mobility affect public health, air quality, biodiversity, and social equity, particularly in marginalized communities. The effectiveness of interventions, such as expanding electric vehicle infrastructure and public transit systems, will be thoroughly examined to understand their potential benefits.

Finally, the research aims to develop actionable strategies to accelerate the adoption of eco-friendly transportation modes. By proposing innovative solutions that integrate infrastructural improvements, policy reforms, and social interventions, the study seeks to promote greater use of sustainable transport options such as cycling, electric vehicles, and public transit across diverse regions of Europe.

Considering these objectives, the research is guided by four key questions:

RQ1. What are the key components of sustainable transportation in European cities and regions, since 2020, and how have they evolved?

RQ2. How have European cities and regions implemented sustainable transportation solutions, and what measurable outcomes (e.g., reduction in emissions, increased public transport usage) have these efforts achieved?

RQ3. What are the primary obstacles (e.g., financial, regulatory, public acceptance) hindering the transition to sustainable transportation in Europe, and what strategies (e.g., policy reforms, community engagement) can address these challenges effectively?

RQ4. What insights and best practices (e.g., policy frameworks, technology use) can be derived from successful European sustainable transportation initiatives that can inform global sustainability efforts and policies?

By thoroughly examining these objectives and research questions, this study aims to contribute significantly to advancing sustainable transportation practices across Europe. It aims to provide valuable insights for policymakers, urban planners, researchers, and practitioners based on the latest findings and experiences from Europe's dynamic and evolving transportation landscape.

Furthermore, the study offers actionable recommendations and strategies that can drive positive change and foster sustainable mobility solutions.

1.4 Value Proposition

In the domain of imaginative marketable strategies, our sustainable mobility proposition sets out an unmistakable and convincing offer. We design a plan of action that only addresses the ecological and social goals of sustainable mobility and offers financial benefits. Our sustainable mobility proposition is established on the coordination of eco-accommodating transportation arrangements, computerized innovations, and the city wanting to make an extensive, low-outflow versatility environment. Thusly, we mean to diminish the biological impression of transportation and convey cost investment funds and functional efficiencies for partners.

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2. Literature Review

2.1 General Approach

Today, the European transportation industry is at a turning point that affects all three pillars: environmental, economic and social. As one of the biggest emitters of greenhouse gasses, this sector is central to the acceleration of global warming and even to the problem of air pollution. The situation is no different when it comes to persistent issues like motorization, which relies heavily on the burning of fossil fuels. This worsens climate change and negatively affects urban air quality, as revealed by (Lucas & Jones, 2012).

The European Union has recognized these difficulties and responded with political commitments such as the European Green Deal, which aims for a 90% reduction in transport emissions by 2050. This makes the EU's perspective clear, focusing on improving citizens' quality of life by improving public health and making cities greener (Hafner & Raimondi, 2020).

In addition to greenhouse gas emissions, unlike pollution from other sectors, transportation causes pollution and affects people's health in Europe. The health effects of vehicle emissions usually lead to other problems, such as respiratory and cardiovascular diseases. The health effects of vehicle emissions usually lead to other problems, such as respiratory and cardiovascular diseases. Mueller et al. (2015) emphasizes that traffic-related air pollution significantly impacts public health and leads to deaths and illnesses. In addition, there are chronic diseases such as hypertension and heart disease which are indirectly affected by traffic noise, so a change in the system is needed. Such conclusions raise the question and the need for an overarching approach to urban design and transportation development management free from noise and emission control measures (Thomopoulos & Givoni, 2015).

The negative impacts of transportation are not limited to individuals but also affect biodiversity and ecosystems. The construction and expansion of transportation facilities usually lead to the isolation of species through geographical and other anthropogenic changes, endangering biodiversity and compromising ecosystems (Thomopoulos & Givoni, 2015). In the face of territorial barriers, the EU is promoting the development of smart mobility concepts that combat negative environmental impacts and improve the quality of transportation in cities. Several such

EDW and AV technologies have been promoted to play this role and deliver environmental benefits in reducing pollutant emissions and improving the efficiency of transport services. Effective measures such as the use of high-tech devices, including Intelligent Transportation Systems (ITS) and Mobility as a Service (MaaS), are also being used to achieve the goal of improving traffic flow and reducing congestion in anticipation of smarter cities (Waqar et al., 2023).

Economic factors also contribute to the development of sustainable mobility. The latest approaches to transportation systems offer various economic benefits, namely reduced health expenditures related to pollution and passive lifestyles, as well as greater economic diversity due to increased job creation and innovation (Möller et al., 2020). Such sustainable facilities, such as the installation of charging stations for electric cars or the expansion of public transportation networks, not only meet environmental goals, but also boost the economy by creating new sectors and technologies (Hafner & Raimondi, 2020). In addition, specific policy measures, such as the provision of subsidies for low-emission vehicles and incentives for the use of public transport systems, have increased the economic prospects for sustainable forms of mobility and enabled the further merging of the two desired goals (Gössling et al., 2019).

However, a balanced perspective on sustainable mobility will also take social justice into account to ensure that transport systems consider all social classes. The Sustainable Urban Mobility Planning initiative, an outcome of the Commission's focus, aims to improve urban space so that people walk, cycle or use public transport more than private cars (De Vos, 2024). This approach not only helps to mitigate environmental impacts but also promotes social inclusion through equitable access to transportation services, especially for marginalized communities (Lucas et al., 2016). By integrating environmental, economic and social goals, Europe can lead the way in developing a sustainable mobility paradigm that benefits all citizens and contributes to a healthier, more sustainable future.

2.2 Environmental Impact of Transportation in Europe

2.2.1 Greenhouse gas emissions from different modes of transportation

Due to the type of fuel, energy efficiency and operating practices, there are also significant differences in greenhouse gas emissions between the various modes of transportation. Road transport, especially private car and lorry traffic, contributes significantly to emissions due to its

dependence on fossil fuels and the large number of vehicles used. Air travel also plays a major role due to its high fuel consumption, especially for long-distance journeys. Rail transport remains the most efficient form of transportation when electrified, but still consumes more energy than road transport and air travel. Although shipping is essential for international trade, work is also underway to develop emission sources to increase fuel efficiency and minimize pollution. In the review, it is said that each mode of transport offers some challenges. At the same time, there are also opportunities to reduce greenhouse gases emissions compared to the standards of the political authorities (Aminzadegan et al., 2022).

2.2.2 Air quality issues in urban areas due to transportation

There are large, unfavorable impacts of transportation on European emissions that affect air quality in the EU. Motor vehicle emissions fall into the category of toxins that appear to be above the limits prepared by the European air quality standards and are said to include the disruption of medical systems used by various subjects within the medical field. This common issue that affects many medical issues. In this context, Bolan et al. (2024) reports repeatedly emphasize the need toward sustainable mobility to avoid all unforeseen losses, such as health problems associated with air pollution and thus protect public health (Bolan et al., 2024).

Transport affects air quality in urban areas mainly through emissions from motor vehicles. González et al. (2021) emphasizes that some problems with public transport, such as strikes, make it even worse. As shown, the suspension of public transportation forces more people to use private cars, which leads to more congestion and more emissions of air pollutants such as NOx, SO2, CO and PM10, which affects air quality. These reasons are unhealthy, and a reminder of how important adequate public transportation is for preventing air pollution in cities (González et al., 2021).

2.2.3 Impact of transportation on biodiversity and ecosystems

Apart from the severe air pollution problems, the transportation system also contributes to climate change and other related impacts. One aspect that should also be considered here is that the structures built for such activities are increasingly vulnerable to the impacts of climate change. Therefore, strategies that reduce the effects of climate change are needed, as well as strategies that prepare for its effects. These include Thomopoulos and Givoni (2015), who advocate

incorporating climate change into transportation planning. This will ensure that the structure is best able to cope with the stresses and shocks that climate change is likely to bring.

Apart from this, transportation also alters biodiversity and ecosystems through habitat fragmentation, pollutants and the introduction of invasive species. Kim et al. (2024) explores the likely impact of these disruptions on the global climate and systems such as European food, water and health supplies. Although transportation networks are essential for the development and facilitation of various economic activities, they harm the system by disrupting the ecological balance, leading to extinction and affordable ecosystem services. The study, therefore, demonstrates that cost-effective transportation infrastructure and services can be achieved without jeopardizing biodiversity. This includes, for example, a policy for electric cars that promotes lower pollutant emissions, which can harm the ecosystem. This does not preclude incorporating such mechanisms into urban development and transportation policies to prevent the degradation of biodiversity without harming ecosystems (Kim et al., 2024).

2.3 Strategies for reducing carbon footprint in the transportation sector

Numerous strategies aim to reduce the carbon footprint of the transportation sector. One of the most important approaches, for example, is the adoption of environmentally friendly technologies, such as electric and hydrogen vehicles. In addition, it is important to integrate renewable energy sources into transportation systems, such as charging stations for electric vehicles. No less important are the strategies aimed at improving fuel economy, especially through technological upgrades and the development of alternative strategies such as public transportation and car sharing. As Kwilinski et al. (2024) states, these measures are necessary reduce emissions from the transportation sector significantly.

To summarize, the question of why transport in Europe can no longer remain as it is today linked to mobility development. Reforming existing transport systems is needed to combat emissions and pollution and protect the environment. Realizing this dream requires more than mere words. Action must be taken to change policy, strategic investment in infrastructure, advances in technological development and a shift in society towards more environmentally friendly practices (“Environmental Noise in Europe — 2020,” 2022).

Furthermore, improving urban design policies to promote the different modes of transportation one chooses can be crucial in the fight against climate change. Providing safe sidewalks, bike lanes, and public transportation has been shown to discourage people from using their cars. Such measures help to reduce car use and traffic congestion and improve air quality. Investing in intelligent transportation systems also helps to optimize road traffic flow, reduce idling times and reduce per capita vehicle emissions (Nieuwenhuijsen, 2020).

In addition, working with governments, communities and industry can help accelerate the adoption of sustainable transportation systems. The private sector offers exceptional opportunities to develop green solutions for innovative transportation systems. Particular attention should be paid to actively involving the population and educating them about the introduction of sustainable transportation systems (Papadakis et al., 2024).

2.4 Economic Aspects of Sustainable Mobility

2.4.1 Cost-benefit analysis of sustainable transportation initiatives

This measure enables Europe's Sustainable mobility to involve both environmental problems and more economic opportunities, depending on policies and innovations. Many mechanisms are available today that aim to reduce greenhouse gas emissions in transportation. This trend is not only a step towards achieving environmental goals but also an economic relief for society, in which the quality of air and the impact of climatic changes on people's health are improved, as outlined by (Afifa et al., 2024).

2.4.2 Economic benefits of investing in sustainable transportation

Implementing the strategic plan for the transition to environmentally friendly modes of transport brings some economic benefits. In the context of linking transport policy to public health and economic development, examines the economic benefits of reduced health costs resulting from increased walking, cycling and use of public transport (Möller et al., 2020).

Beaudoin et al. (2015) state that investments in sustainable transportation bring enormous economic benefits. For example, one of the benefits of modernizing the public transport system is less congestion, which means less time spent on the road and lower costs for vehicles, such as fuel and maintenance. These modernizations save individuals or even companies a lot of money. In

addition, improved transportation infrastructure can potentially increase property values and boost the region's economy by attracting more investment and businesses. Overall, this leads to more efficient transportation systems, which bring long-term economic benefits and more sustainable development (Beaudoin et al., 2015).

2.4.3 Funding mechanisms for sustainable mobility projects

The broader implications for the fate of sustainable mobility in Europe require a comprehensive methodology that coordinates mechanical advances, infrastructural ventures, policy change and social changes in versatility. The blend of these components aims for a future in which transportation is naturally reasonable, economically advantageous, and socially inclusive and contributes to the general flexibility and sustainability of European cities (Möller et al., 2020).

2.5 Innovative Transportation Solutions

2.5.1 Electric vehicles and infrastructure development

As market demand for electric vehicles (EVs) increases, so does the need to improve charging infrastructure. To support this expansion, it is crucial to increase the number of public charging stations and develop innovative technologies for rapid deployment. In addition, integrating EVs into the existing system also involves improvements in grid control and energy consumption due to increasing demand. Smart grid technologies can also help to improve the correlation between EV charging and renewable energy. Haghani et al. (2023) highlights the need for and importance of well-coordinated infrastructure development to promote and sustain the increased adoption of electric vehicles (Haghani et al., 2023).

2.5.2 Mobility services

Mobility as a Service (MaaS) redefines urban mobility by combining different modes of transportation into one service. Ho and Tirachini (2024) mention that it is possible to plan, book, and pay for multiple modes of transportation that permeate the MaaS ecosystem through one interface. The concept of MaaS improves both convenience and flexibility for the end user. This encourages optimal use of public transportation, carpooling, bicycles, and other modes of transportation, leading to reduced use of private vehicles and lower emissions. Research has shown

that multimodal systems can improve mobility in cities by optimizing traffic flows and reducing congestion (Ho & Tirachini, 2024).

MaaS can solve local problems, such as inadequate public transportation in rural areas or traffic congestion in cities, under various circumstances in developing and developed countries. Ho and Tirachini (2024) suggest several conditions without which a successful implementation of MaaS is impossible, such as well-developed digital technologies, a willingness to cooperate with all relevant stakeholders and policies that encourage such developments. Nevertheless, it is a clear case for implementing a MaaS system in combination with a wide range of new inter-user and interdisciplinary practices and concepts (Ho & Tirachini, 2024).

2.5.3 Autonomous vehicles and their potential impact on sustainable mobility

In the cities of the future, autonomous vehicles can be a major step forward in achieving the goals of sustainable mobility. Acheampong et al. (2021) aims to analyze the prospects for the development of AVs in urban transport systems and how they can promote better traffic management and control to reduce congestion and emissions through improved driving behavior and reduced use of private vehicles. In addition, introducing AVs can increase the efficiency of traditional shared mobility services by reducing the number of vehicles off the road and promoting car-sharing and ride-hailing services. However, the study also highlights some political challenges, such as the availability of infrastructure and supporting measures, as well as the attitude of the local population towards autonomous vehicles. Overcoming these challenges is important to ensure that AVs positively impact the sustainability agenda. Likewise, is added that policymakers, urban planners, and technology developers are equally challenged when integrating AVs into the city, as each of these groups has their own aspects that should be balanced to avoid complications (Acheampong et al., 2021).

2.5.4 Integration of traditional and new transportation modes for efficiency

The effective integration of traditional and new modes of transportation is critical to improving transportation efficiency and equity. Ji et al. (2024) emphasizes that the simultaneous use of established modes of transport and new options, such as ridesharing, bike-sharing, etc., will improve the of the system’s overall performance. Cities can contribute by providing convenient connections between modes, improving spatial coverage, and shortening travel times. In addition,

the study points to the need to design transport systems in an integrated way that considers all aspects of regions, whether urban or rural, in transport development. In addition, integrating public transport systems is strengthened by considering timetables, fare structures, and supporting infrastructure to ensure the right choice of systems. It is thus a more coordinated method of dovetailing conventional transport and advanced mobility systems that promote efficient, equitable, and simplified urban transportation (Ji et al., 2024).

These technological advances are gradually coalescing into a comprehensive picture of the future of transportation in Europe that is innovative, progressive, and responsive to the needs of the growing urban population. This emerging pattern can play an important role in protecting the environment and improving the quality of life in European metropolitan areas, thus promoting Europe as a leader in sustainable mobility (Jittrapirom et al., 2017).

2.6 Digital Technologies and Sustainable Mobility

2.6.1 Use of data analytics for improving transportation efficiency

Analyzing data is crucial for transport efficiency in the context of smart cities. By collecting data, e.g. from traffic sensors and GPS as well as social networks, big data can be used to improve transport systems, e.g. by minimizing traffic volumes and supporting traffic management. Smart technologies extend this capability to the centralized monitoring of activity and the ability to create models that make predictions that enable management to make key decisions regarding the flow of traffic, the structures needed to handle a given traffic volume, and the resources required. Identifying patterns and trends from the cities' operational environment helps manage more efficient traffic signals, transit timing constellations, and routing systems. Different data analytics applications were described, but the focus was on developing holistic approaches that integrate all traffic operations data. At the same time, however, there are also problems, such as the impossibility of controlling data handling or the confidentiality of information. To put it in a nutshell, data analytics should be used efficiently to develop urban transportation systems that are safer, more cost-effective and meet the requirements (Ushakov et al., 2022).

2.6.2 Intelligent transportation systems for traffic management

Intelligent transportation systems (ITS) are one of the systems used for traffic management in smart cities. This article explains how smart technologies such as IoT, AI and big data analytics control

and monitor traffic to avoid congestion. With intelligent traffic signals, smart traffic systems help transportation networks manage daily changes in traffic quickly and efficiently. They also enable faster detection and response to incidents that cause traffic delays. This increases road safety. ITS also helps promote a sustainable environment by encouraging healthy traffic flow to determine minimal gas and pollutant emissions. It is important to integrate ITS into urban design and planning to create efficient, fast and environmentally friendly transportation systems in the cities of the future (Elassy et al., 2024).

2.6.3 Mobility apps and platforms for seamless travel experiences

Mobility as a Service (MaaS) is recognized as a key area within the components of digitalization and sustainable urban mobility, where the focus is on service rather than vehicle ownership. Companies offering a surface transportation network or MaaS provide integrated and customized travel methods that combine multiple modes of transport such as public transport, cabs, apps and bicycles (Wong et al., 2020).

By incorporating new technologies, users can combine different modes of transportation, plan their trips and manage them as effectively as possible. The appeal of these platforms is that they are easy to use and offer effective ways to travel using different modes of transportation. On the other hand, there is the feedback that accepting these mobile applications has to do with a fascination for technology and trust in the community. The adoption of mobility apps is motivated by building trust and the effective and desirable design of services that also improve travel satisfaction and experience (Elassy et al., 2024).

2.6.4 IoT applications in transportation for real-time monitoring and optimization

IoT applications in transportation are crucial for real-time monitoring and optimization of transportation systems. IoT devices such as sensors and cameras can be used in urban areas to collect traffic data continuously. Combined with deep learning techniques, this data is processed to provide real-time insights into traffic conditions, enabling more effective traffic flow and congestion management. IoT-powered robotics further enhances the system by enabling dynamic adjustments such as traffic signal timing and detour suggestions based on real-time data. This approach not only improves traffic efficiency but also increases safety, as incidents can be quickly detected and responded to. Thus, IoT in transportation offers significant potential to optimize

urban mobility, reduce delays and create smarter, more responsive transportation networks (Kheder & Mohammed, 2024).

In summary, digital technologies offer extraordinary potential for realizing sustainable mobility in Europe. However, their effective coordination depends on overcoming the technical, administrative and social challenges associated with such significant changes. By overcoming these challenges, Europe can take full advantage of digital innovations to create an efficient, sustainable and user-center mobility system for the future (Cohen et al., 2020).

2.7 Policy and Planning for Sustainable Mobility

2.7.1 Sustainable Urban Mobility Planning

Tackling the far-reaching traffic problems in metropolitan regions requires sustainable urban mobility planning. To achieve this goal, effective planning must consider environmental, social and economic factors to achieve the goals of building resilient transport systems. A comprehensive approach is needed that combines public transport, active transportation and targeted measures that discourage excessive vehicle use. Stakeholder involvement also plays an important role in this process. Through public participation and cross-sectoral input, cities can develop mobility solutions that are acceptable and usable. It is also noted that proper urban mobility planning also requires strong governance structures and, above all, a strategic vision to promote sustainability. Such an integrated approach makes it easier for cities to reduce emissions, improve accessibility and increase the overall quality of urban life (Carvalho et al., 2023).

2.7.2 Regulatory frameworks for promoting sustainable transportation

Urban Mobility Plans (SUMPs) are meant to drive the agenda to change the way mobility is practiced in cities. The frameworks promote a radical shift towards more intensive and diverse use of public transport, cycling and walking. The emphasis on multimodality in transport planning is not just on providing options for private transport but on developing integrated transport networks that work in the urban environment. According to Michelini et al. (2023), the development of SUMPs needs to involve stakeholders, as this enables the consideration of different needs and aspects in the development of mobility measures.

2.7.3 Public-private partnerships in sustainable mobility projects

Public-private partnerships (PPPs) are very important for implementing and promoting sustainable mobility projects. Stakeholder consultation, follow-up, and bid evaluation should include sustainability requirements so that each project is assessed on its environmental and social benefits. Because PPPs combine public and private sector resources, they can promote the construction of infrastructure that will ensure sustainability in the future, including modern public transportation systems and the development of smart cities. The proposed bid selection model helps decision makers to focus procurement on bids that meet sustainability performance criteria so that implemented projects meet strategic urban mobility objectives and economic returns. This treats the phenomenon of public transport modernization approaches as three-dimensional and multi-layered, increasing the effectiveness of PPPs in solving the complex issues of transport and mobility and leading to sustainable urban centers (Dolla & Laishram, 2020).

Financial motivations and existing laws play a major role in encouraging movement towards sustainable transport. Instruments such as congestion charges, low emission zones or incentives for purchasing environmentally friendly cars are used to promote best practices among individuals and companies. The EU strives to use these methods to balance economic and environmental concerns in a way that makes such decisions cost-effective and practical (Zeiske et al., 2021).

2.8 Barriers to Sustainable Mobility

2.8.1 Social and behavioral barriers to adopting sustainable transportation

Social and behavioral barriers are among the factors that explain why communities struggle to adopt sustainable modes of transport. Mosca et al. (2024) reason that commuting behavior before and after commuting and users' self-assessment are important for the acceptance of transport behavior. Even when people can choose more sustainable options, their social norms, habits and the assumption that switching from a private car is inconvenient create barriers to this change.

These barriers can be particularly relevant and personalized travel plans can help by overcoming these barriers through appropriate persuasion and offers that meet the needs of the individual. Research in this area seeks to understand better how psychological and social factors influence people in their efforts to use sustainable modes of transportation. To change behavior

over time, interventions must address both the practical and the emotional side (Mosca et al., 2024).

2.8.2 Infrastructure challenges for implementing sustainable mobility solutions

One of the economically controversial parameters is the dissatisfaction with the high construction and operating costs of the infrastructure supporting other modes of transportation associated with the construction of the metro. The infrastructural challenges are one of the main problems in implementing sustainable mobility solutions. To use big data for smart mobility, the existing infrastructure must be significantly improved, e.g. through smart sensors, networks and data centers. These technological changes require significant initial investment and planning for compatibility with existing systems. It is also particularly complicated to combine several different data sets into one system, as it involves questions of data and so on. Even these data-intensive infrastructures do not exempt the existing infrastructure from high-speed analytics and synthesis requirements on the spot (D'Alberto & Giudici, 2023).

Addressing these issues is necessary to create advanced and sustainable transportation networks with maximum impact from Big Data. D'Alberto and Giudici (2023) emphasizes that removing these infrastructural barriers is crucial for effectively adopting smart mobility concepts.

Furthermore, the EU bureaucratic framework consists of many layers, and this multi-layered structure creates an additional polycentric pluralistic polity where local and public interests support each other and policy implementation fails and leads to delays (Mattioli et al., 2020).

2.8.3 Political and institutional barriers to policy implementation

Such cultural and institutional barriers tend to consistently be behind the curve, especially within new mobility service landscapes that straddle the Scandone concept of cultural and institutional barriers and technological advances, such as MaaS, autonomous vehicles and the rest. On the other hand, these new innovative concepts may be associated with legal and regulatory barriers within the current legal framework and regulations that make their socio-technical integration into existing mobility systems difficult (Pangbourne et al., 2018).

2.8.4 Equity considerations in sustainable mobility initiatives

Equity considerations are essential in the formulation of sustainable mobility initiatives. Tammaru et al. (2023) point out that while green solutions such as electric vehicles are driving major political changes and success in securing ‘green’ infrastructure is paramount, social issues also need to be addressed for such chairs to have the best reach. Basic urban transport should be equitable and not promote the further marginalization of disadvantaged socio-economic status groups and disregard their access to green transport that is meant for all. Equity should be addressed as it exacerbates existing inequalities and social segregation and deprives the vulnerable society of the opportunity to enjoy the attributes of green mobility (Tammaru et al., 2023).

They pointed to controversial clients whose application could exacerbate the problem of inequality among citizens in an urban area. They targeted these groups by creating policies that equalize balanced inequalities such as finances in the provision of services and facilities. It is argued that incorporating equity principles into sustainable mobility initiatives will help achieve a fairer and more equitable outcome for cleaner urban transport (Tammaru et al., 2023).

To promote an inclusive, sustainable mobility paradigm, the above-mentioned interconnected barriers should be addressed in the European Union holistically, combining technology, strategy, culture and policy. Everything that minimizes the transition should be done simultaneously and in a coordinated manner to ensure that the ambition of a transition to sustainable mobility is not just a goal but can be achieved given the different economic contexts in Europe (Mattioli et al., 2020).

2.9 Future of Sustainable Mobility in Europe

2.9.1 Emerging trends in sustainable transportation technology

Several emerging trends in sustainable transportation technology are shaping the future of urban mobility. One of the most important is the increasing use of electric vehicles, which represents an important step towards reducing greenhouse gas emissions and eliminating the use of fossil fuels. Another important trend that is emerging is the adoption of self-driving cars, which are intended to improve safety, reduce traffic and increase the efficiency of transport systems. The development of smart infrastructure is also on the rise, with the Internet of Things (IoT) and big data analytics being used in real-time traffic management systems and optimized transport routes. In addition, the steady increase in combined transport systems that use different environmentally friendly modes

of transport is improving how people move around cities. Barceló (2019) also emphasize how important it is that these technological trends are complemented by various policy measures to promote technological progress and supporting a greener transport future. All in all, these trends are leading to more sustainable, efficient and resilient urban mobility solutions.

2.9.2 Long-term sustainability goals for European transportation systems

The need for long-term sustainability goals for European transport systems is crucial to achieving carbon neutrality. Khurshid et al. (2023) emphasizes that achieving these goals will require significant advances in technology and policy. European transport systems must increase the uptake of electric and alternative fuel vehicles, expand public transport services and allocate resources to sustainable transport. The article highlights that the reduction of carbon emissions using renewable energy sources and the introduction of smart mobility can be pursued in addition to the measures already implemented. It also calls for a unified policy among EU member states to achieve faster progress and avoid regional disparities. The current starting point is certainly commendable. However, the article notes that the pace of progress needs to be accelerated given the financial and technological barriers to achieving carbon neutrality targets by 2030 (Khurshid et al., 2023).

On the one hand, these top-down goals of the SUMP seem to be broken in the way most urban transport systems are planned. On the other hand, the development of sustainable urban mobility plans is fundamental to contemporary traffic management. It contributes to the implementation of an urban transport policy based on sustainable transportation principles. Such SUMPs are promoting the use of multimodal transport systems and increasing the share of more active modes including walking and public transport and therefore are contributing to urban sustainability more broadly (Mladenovič et al., 2022).

2.10 Social Impacts of Sustainable Mobility

2.10.1 Accessibility and Equity in Transportation Services

Access and discrimination or equity in providing transportation services are the subject of a more sophisticated analytical examination. In this section, the effects of time-dependent accessibility on different population groups are examined using geostatistical methods to explore the geography of transportation equity. Using Lorenz curves and Gini coefficients, Raza et al. (2023) attempt to determine the degree of equity in access to public transportation and to show the distribution of

public transportation services among different population groups. This approach illustrates the efficiency of access to transport systems and thus helps to segment the services provided compared to the demand satisfied (Raza et al., 2023).

Sustainable mobility aims to ensure a transportation system that is accessible to the entire population, especially the most marginalized segments of society. This is important because it promotes social equity and minimizes barriers to key resources such as employment, education, and healthcare (De Vos, 2024).

Geographic inaccessibility is a major challenge for many marginalized communities, and these researchers suggest that this problem can be addressed by targeting or investing in certain aspects of transportation infrastructure. Pereira et al. (2016) argue in their analysis of equity and accessibility in transportation planning that disadvantaged groups who face the most significant challenges in using transportation systems need to be considered in coverage. For example, increasing public transport provision in areas where it is currently inadequate can reduce journey times and ensure that potential users have access to crucial activity locations. This would clearly enable upward mobility for all social classes (Pereira et al., 2016).

2.10.2 Policy Implications

Public policies that improve equity in access to and use of transportation services often require substantial funding for public transit and the provision of credit and financial assistance to disadvantaged customers. Such measures also prove crucial in balancing inequalities across different social classes, as they ensure that transportation systems are not only for a specific wealthy class in the community (Pereira et al., 2016).

They not only change the level of accessibility but also the inclusivity of the transportation system, which is effective in reducing the level of social exclusion and increasing the level of social interaction in the community (Lucas & Jones, 2012).

2.10.3 Health Benefits of Active Transportation Modes

Active transportation, such as walking and cycling, not only allows people to get from one place to another but also has excellent health benefits and promotes people's well-being (Barajas &

Braun, 2021). This mode of transportation is an essential aspect of a sustainable mobility policy, as it causes less damage to the environment and promotes health (Mozos-Blanco et al., 2018).

Dynamic transportation reduces the likelihood of non-communicable diseases such as obesity, cardiovascular disease and diabetes. People who use bicycles and walk as part of their daily activities significantly improve their health, as these are strenuous and energy-consuming activities that are integrated into the members' daily work. This mainly benefits urban areas where a sedentary lifestyle is the norm and exercise are difficult to achieve (Mozos-Blanco et al., 2018).

As mentioned above, the shift towards increased use of active transportation brings various benefits for personal and public health. In this context, the prevalence of chronic diseases and mental health problems will decrease as people move more through activities such as jumping and cycling. In addition, promoting active transportation in communities reduces the population's need for medical and health services. This not only encourages people to be physically active, but also expands the facilities and resources of society towards a more health-conscious and healthier society (Mizdrak et al., 2023).

2.10.4 Social Inclusion and Community Engagement in Transportation Planning

It is recognized that social inclusion must be addressed for the transition to sustainable mobility to succeed. In this context, it is important to ensure that transport systems reach all parts of society, including the less advantaged members. Such inadequacies would internalize major disadvantages and prevent potential benefits from being maximized. In contrast to most urban environments, inclusive policies improve the urban integration of societies and ensure that all people, regardless of their socio-economic status, benefit adequately from sustainable mobility (Remme et al., 2022).

Transport equity focuses mainly on older people, people with disabilities and people on low incomes, who are generally underserved in the provision of transport systems. There is a growing recognition that social inclusion must be at the heart of transportation planning to strengthen community and social cohesion by minimizing geographic isolation (Lucas et al., 2016).

New ways of thinking about active travel start by considering a more comprehensive range of options, including different types of e-scooters and e-bikes that will improve the quality of the distance travelled. Cities that promote these different active travel methods will appeal to a broader

range of age groups and encourage more people to incorporate active travel into their lifestyles. This broader perspective simultaneously reduces the disease burden as the population becomes more active and promotes social interaction and inclusion as people participate more in community activities (Cook et al., 2022).

2.10.5 Social Cultural Considerations in Promoting Sustainable Mobility Behaviors

Transport behavior is influenced by individuals' values and psychological characteristics. Understand how preferences and social factors, such as travelling with companions, influence transportation choices to formulate effective transportation programs. All these concepts have evolved into sustainable mobility measures and have been shown to increase the acceptance of alternative modes of transportation among residents. Mapping the different socio-technical factors related to the acceptance of targeted measures or schemes would allow for more effective engagement of the target group (Arroyo et al., 2020).

Different countries worldwide have different responses to transportation, and it is this response that can either enhance or dampen the chances of adopting a culture of sustainability. In other European countries, such as Germany and the Netherlands, where cycling is more accepted and acculturation is encouraged, people use this mode of transportation much more frequently than in other regions of the continent. This acceptance is reinforced by extensive infrastructure and supportive measures that make cycling accessible and attractive (Sovacool & Griffiths, 2020).

On the other hand, in countries where the car is seen as a status object, it can be more difficult to encourage the use of a bicycle or other more sustainable modes of transportation such as cycling (Heinen et al., 2011). Therefore, such cultural principles that lead individuals to focus on using the car as their primary or even sole means of navigation.

2.10.6 Behavioral Change

The increasing mobilization of the population requires strategies that consider the cultural capital of different population groups. Such approaches must be implemented primarily with the audience in mind, i.e. their knowledge, beliefs and experiences. For example, in countries where cultural capital tends to be more collectivist, marketing sustainable mobility through mass events and culturally polite advertising would work better. Without these proverbial 'lenses', it is unlikely

that a better understanding of the context will enable the design of more effective campaigns for sustainable forms of mobility (Quaglione et al., 2019).

This context-specific cultural understanding was also necessary to overcome barriers such as safety, comfort and social acceptance of the behavioral. By familiarizing policymakers with cultural behaviors, they will find effective ways to advocate for transportation options that promote them and are likely to be used over longer periods of time (Gössling et al., 2019).

2.11 Final Remarks

The transition to sustainable mobility in Europe has focused on a key endeavour that is highly relevant to solving Europe's environmental, economic and social problems. There are clear and immediate reasons for concern about the current use of fossil fuels in transportation and the associated greenhouse gas emissions, including climate change, air quality and respiratory diseases, which raise health concerns (Lucas et al., 2016). Some of the policies, such as the European Green Deal, provide a broad direction with prudent improvements that will help to achieve these goals, especially about the need to introduce new technologies in transportation. These measures are ushering in real change on the European continent and helping to develop new solutions needed to ensure sustainability in the future (Hainsch et al., 2022).

Innovative approaches - electric vehicles, shared mobility services and other ways of getting around the city significantly impact on reducing emissions and optimizing resource consumption. Further improvements through the application of digital technologies, including Intelligent Transportation Systems (ITS) and Mobility as a Service (MaaS), that enable reduced congestion and a seamless journey for users, complemented these efforts and technologies. These and other innovations are helping to create a new transportation paradigm in the European context that incorporates advanced technologies and aligns with Europe's broader environmental and economic interests (Jittrapirom et al., 2017).

Nevertheless, the goal of sustainable mobility has limits and is not easy to achieve. Techno-sociological, political and cultural factors influence the process of implementing sustainable transportation. Working within these parameters means that policy, technology and culture must be

combined in tackling the problems. By fostering such collaboration with stakeholders, Europe can overcome the barriers to sustainable mobility (Heinen et al., 2011).

In summary, sustainable mobility is one of the key elements of the European response to climate change and the improvement of public health and economic resilience. Efforts aimed at reducing transportation's impact on carbon emissions, improving air quality and ensuring social inclusion are crucial for a sustainable future that benefits all European citizens (Tsavachidis & Petit, 2022).

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3. Methodology

This chapter describes the study's step-by-step process and explains why and how certain methods were found suitable. The study follows an exploratory approach using a case study design. This means that the researcher can investigate certain things at a low level as part of her research and try to find different patterns, findings and questions.

3.1 Research Design

This is a quantitative cross-sectional design, which is appropriate as the data collection will take place at a single point in time to determine the state of sustainable mobility in Europe. The reason for the cross-sectional design is to gain quick insights into the perceptions, attitudes and practices of a population in relation to sustainable transportation on this one occasion.

A quantitative method was chosen for this research, which makes it easier for the researcher to collect and analyze numerical data in an orderly fashion to find some patterns, relationships between variables and some general trends. This method is optimal for a study that wants to get an overview of the situation in the sustainable mobility field, as the respondents come from different areas and their answers are merged to get an overview of the matter.

3.2 Survey Instrument

The primary instrument used to collect data was a questionnaire created specifically for this research study. The questionnaire was created after an extensive review of the literature to cover all necessary aspects of sustainable mobility. It was divided into five sections covering different facets of the topic, namely:

3.2.1 General Information

In this section, information was collected on personal characteristics such as respondents' age and their place of residence. Emphasis was also placed on the age and geographical distribution of respondents, as it is worth exploring the demographic characteristics of respondents concerning their comments to determine how these would affect their understanding of sustainable mobility. The age differentiation helps to understand the framing of each age group concerning mobility, and

the geographical aid reveals the aspect of regional differences in the uptake and challenges of mobility.

3.2.2 Perceptions and Attitudes

This section assessed respondents' overall perceptions of promoting sustainable mobility in their city or region. This was supplemented by questions designed to assess current satisfaction with ongoing activities and existing problems associated with the identified activities. These questions are important to assess how well the population accepts the measures in sustainable mobility and how efficient the instruments and measures used are.

3.2.3 Environmental and Economic Impact

This section looked at the perceived impact of transportation in different locations in terms of environmental and economic factors. An attempt was made to assess greenhouse gas emissions and certain challenges such as air pollution and to assess the extent to which existing measures are suitable for changing the emissions profile of the transportation sector.

3.2.4 Innovative Solutions and Policy

This section pursued to capture respondents' views on the most effective transportation solutions and policies that could accelerate progress on sustainable mobility. It also examined how conventional and modern transportation systems can be combined and the status of multimodal transport systems in Europe.

3.2.5 Future Perspectives

The final part of this research aimed to determine the trends and key aspects of transportation systems for their effective and sustainable development over a long period of time. It sought to identify the perspectives that can contribute to achieving long-term goals regarding policy and innovation.

All questions in the survey were carefully crafted to ensure that they were clear and relevant to the target audience. Closed-ended questions were included in the survey for statistical analysis, while some open-ended questions were added for additional opinions and suggestions that did not fit into the given options.

3.3 Characterization and Sampling Method

The study employed a purposive sampling method, deliberately selecting participants who are Siemens employees based in Europe. This approach was chosen to ensure that the sample accurately reflected the target demographic within the organization.

It is important to note that this study was not aimed at general users or consumers. Instead, it was conducted exclusively within Siemens and focused on employees from two specific departments: IT and Finance. This targeted approach provided a more nuanced understanding of perspectives within these areas of the company.

3.3.1 Target Population

The target population consisted exclusively of Siemens employees based in Europe, specifically those working in the IT and Finance sectors.

3.3.2 Sampling Rationale

The sampling rationale for this study is based on the purposive sampling method, which was chosen to ensure the inclusion of participants who meet specific criteria relevant to the research objectives. The study focused on Siemens employees in Europe, deliberately selecting individuals from the IT and Finance departments. This purposeful selection was designed to capture insights from professionals within these critical areas, ensuring that the sample accurately reflects the target demographic within the organization.

3.3.3 Sample Size and Composition

The final sample consisted of 70 respondents from different parts of Europe, such as Western, Eastern, Northern and Southern Europe. The purpose of covering the regions was to ensure that diverse experiences and practices were captured, reflecting the different variations of sustainable mobility across the continent.

3.4 Data Collection

A survey was used as data collection tool as it was less costly, less time-consuming, simpler and covered more topics and geographical areas. The survey was conducted via Outlook and Teams.

3.4.1 Distribution Channels

The survey was distributed to respondents based in Europe. The aim was to target respondents from several countries that were difficult to reach in Europe.

3.4.2 Response Rate

Around 95 per cent of the target population stated that they had responded to the survey, which is very good. This response rate was attributed to the effective administration of the survey through the company's channels and a well-designed questionnaire that made efficient use of respondents' time.

3.4.3 Ethical Considerations

Ethical guidelines were strictly followed throughout the data collection process. All participants were informed of the study's purpose and the voluntary nature of their participation. Furthermore, the survey was designed to ensure anonymity, with no personally identifiable information being collected. This approach aimed to encourage honest and uninhibited responses, particularly on sensitive topics like barriers to implementation or policy effectiveness.

4. Analysis of the obtained ED Results

4.1 General Information

4.1.1 Age Distribution

The 18-29 age group comprised 14% (10 participants) of the respondents. representing younger professionals who are likely to bring fresh ideas and a strong commitment to sustainability, having grown up in a period where environmental awareness is a high priority.

Understanding the age diversity of respondents is crucial for contextualizing their perspectives on sustainable mobility. The survey revealed a strong representation of professionals aged 30-39, who comprised 36% (25 participants) of the total. This age group is often at the prime of their careers, bringing a combination of experience and innovative thinking to the table, making them influential in shaping future transportation strategies.

Participants aged 40-49 years comprised 29% (20 participants) of the respondents. This group has significant experience and often holds decision-making roles within their organizations.

The remaining 21% (15 participants) of respondents were aged 50-65 years, representing seasoned professionals with deep knowledge and experience.

The following figure 4.1 represents the above hypothesis regarding the Age Distribution.

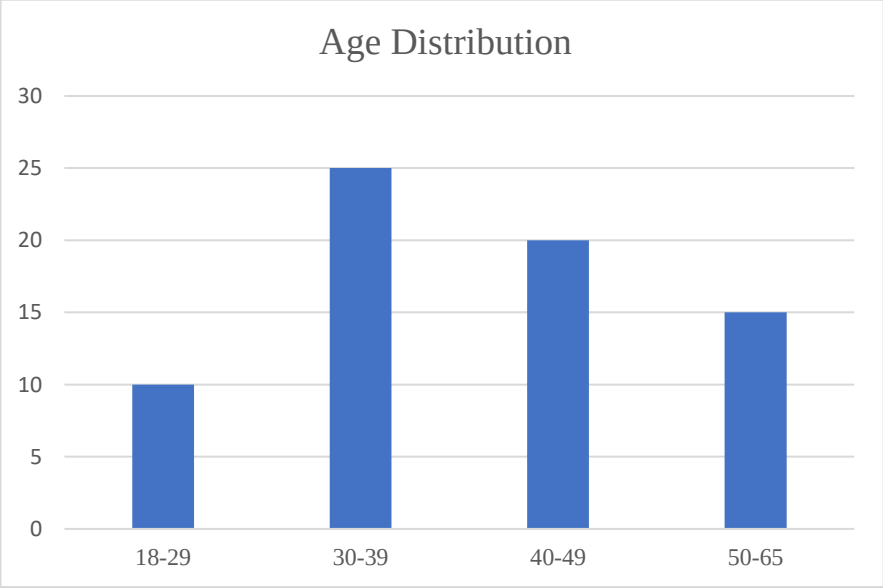

Figure 4.1. Age Distribution

4.1.2 Geographic Distribution

Geographic diversity among respondents is crucial for understanding regional variations across Europe. The survey showed that 74% (52 participants) were from Western Europe, reflecting the higher number of respondents living in that region. The predominance of participants from Western Europe likely reflects the demographic composition of the survey sample.

Northern Europe accounted for 17% (12 participants) of the respondents, again reflecting the regional distribution of the sample. The representation of participants from Northern Europe corresponds to where they live rather than any other considerations.

Eastern and Southern Europe, with 3% (2 participants) and 6% (4 participants) of respondents, respectively, represent the regions with the lowest number of participants in the survey.

The following figure 4.2 represents the above hypothesis regarding the Geographic Distribution.

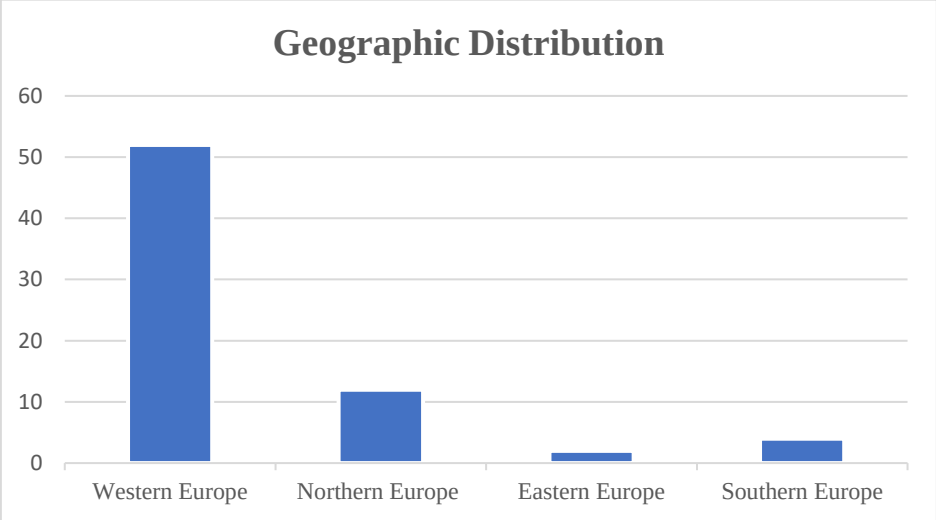

Figure 4.1. Geographic Distribution

4.2 Perceptions and Attitudes

4.2.1 Overall Progress of Sustainable Mobility

The survey also sought to determine whether respondents were satisfied with the overall progress of sustainable mobility in their cities or regions. The majority, 54% (38 respondents), rated progress as good, meaning that efforts are being made and great progress has been made in integrating

sustainable elements into city transport planning. Such a rating is significant as cities have made improvements in the use of public transport, cycling, and low-emission vehicles.

However, 32% (22 respondents) rated progress as 'mediocre', indicating some remaining barriers and recognizing that while there are good intentions, there is still much to do to achieve the targets set. Some of these respondents may be thinking of the relatively slow pace of change, particularly in areas where there is likely to be public resistance or political inertia hindering the adoption of new technologies/approaches.

Only 10% (7 respondents) rated progress as 'excellent'. This may suggest that while much progress has been made in some specific regions, such as Copenhagen or Amsterdam, more must be done to ensure that this is the case across Europe. The 4% (3 respondents) who rated progress as low probably come from countries where the promotion of sustainable mobility approaches was particularly difficult due to social, political and economic factors, public resistance and the like.

The following figure 4.3 represents the above hypothesis regarding the Overall Progress of Sustainable Mobility.

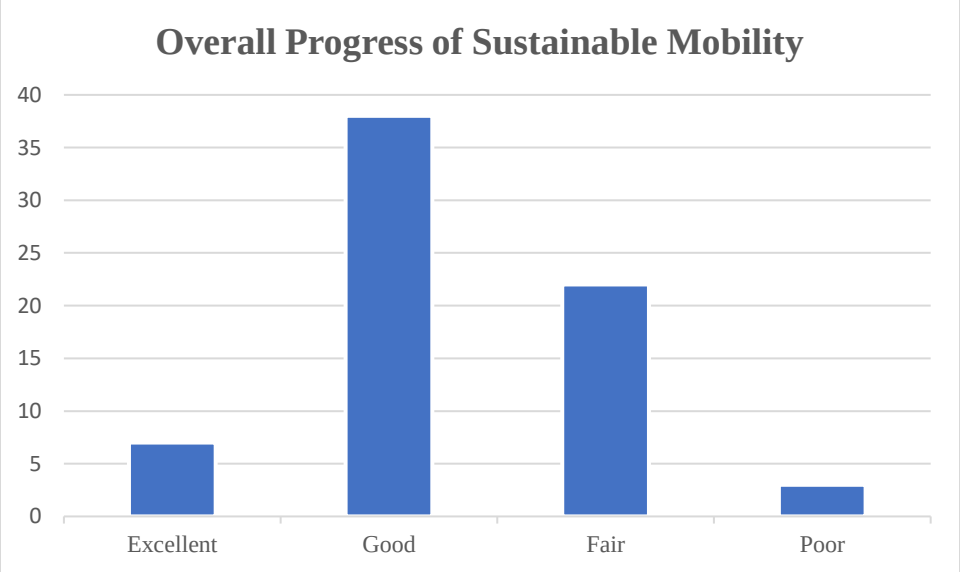

Figure 4.2. Overall Progress of Sustainable Mobility

4.2.2 Significant Barriers to Implementation

Recognizing the challenges in implementing this change is important to identify potential areas where appropriate action is required. The most cited obstacle about these barriers was financial,

mentioned by 33% (23 respondents). This represents the high costs associated with developing and implementing a sustainable mobility system, from the investment required to set up public transport systems, electric vehicle charging stations and bike lanes to the day-to-day expenses of operating and maintaining the systems. Addressing this challenge may require creative financing methods such as public-private partnerships, cherry bonds or foreign aid.

30% (21 respondents) indicated technical challenges, suggesting that many technologies are currently being developed in the transport industry. However, the field still faces significant obstacles when deploying these technologies or integrating them into existing systems. Certain topics, such as the construction of charging stations for electric vehicles, the state of technology development for autonomous vehicles and digital mobility services and the corresponding platforms still offer significant opportunities.

21% (15 of the study participants) indicated that there is a need to reconcile the different institutional levels, raise funding and understand how to prepare to implement government policies to promote green transportation. This hurdle highlights the need for strong leadership and sound and coordinated policies supporting sustainable transportation in each country. It also highlights the need for cross-national collaboration and the adoption of best practices in each country.

Public resistance to change was evident at 16% (11 participants). This reveals a gap because even if sustainable means of moving people and goods are provided, they may not be adopted if the intended beneficiaries perceive them as undesirable rather than useful or cheap rather than expensive. To remove this obstacle, we need to tackle corrosion, campaign and demonstrate the benefits, such as saving time, spending less money and optimizing living conditions, to name but a few.

The following figure 4.4 represents the above hypothesis regarding the Significant Barriers to Implementation.

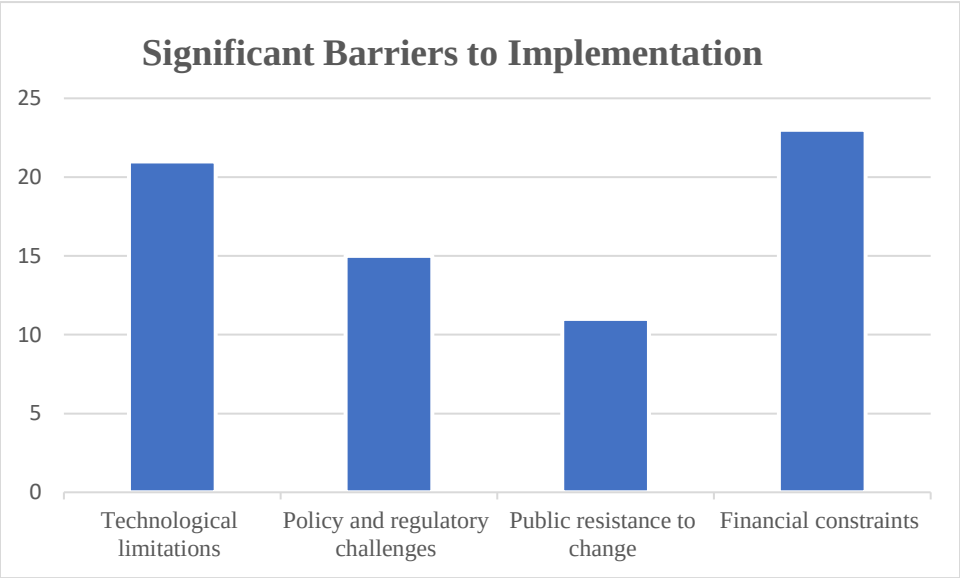

Figure 4.3. Significant Barriers to Implementation

4.2.3 Impact of Digital Technologies

In another way, digital technologies are generally seen as a catalyst for shaping the concept of sustainable mobility, as they offer new perspectives for improving transport systems, reducing emissions and increasing overall user satisfaction.

The analysis also revealed that 41% (29 participants) stated that they would consider the impact of digital technologies on promoting sustainable mobility to be “very significant”. This indicates a high confidence level in the ability to transform the sustainable mobility market with technologies such as artificial intelligence and big data analytics.

However, the other majority, 53% (37 respondents), believe that the impact of digital technologies is significant in most areas of our lives in general and not just in this study. While most professionals consider these technologies important, they tend to think that there is still much work to be done to incorporate them into existing systems.

Only 4% (3 respondents) indicated that the impact is 'moderate', reflecting a degree of caution in the application or pace. Perhaps these respondents are concerned about issues such as the digital gap or all the existing surveillance. Only a small number, 1% (1 participant), do not consider digital technologies to be very important.

The following figure 4.5 represents the above hypothesis regarding the Impact of Digital Technologies.

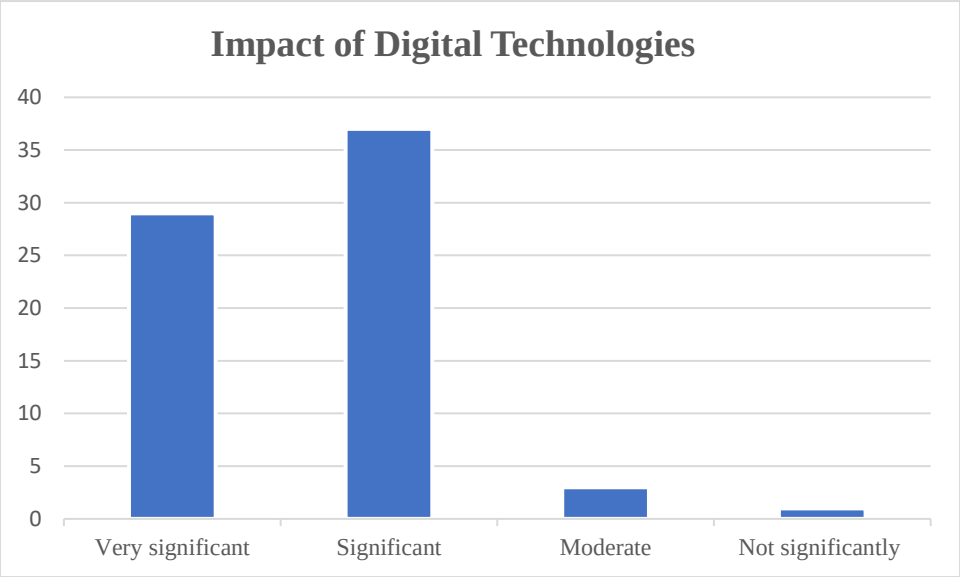

Figure 4.4. Impact of Digital Technologies

4.3 Environmental and Economic Impact

4.3.1 Primary Environmental Impact

The environmental impacts of transportation are a major concern for cities across Europe, particularly in the context of climate change and public health. The survey results reflect this, with 43% (30 participants) identifying greenhouse gas emissions as the primary environmental impact of transportation. This concern is well-founded, as the transportation sector is a significant contributor to global CO2 emissions, and addressing it is critical to meeting international climate targets.

39% (27 participants) identified air pollution as another significant concern, particularly in urban areas where vehicle emissions can contribute to respiratory illnesses, cardiovascular diseases, and other health problems. Efforts to reduce air pollution often focus on promoting low-emission vehicles, improving public transportation, and encouraging active transportation modes like walking and cycling.

14% (10 participants) mentioned noise pollution, a less frequently discussed but still significant environmental impact of transportation. Chronic exposure to high levels of traffic noise has been linked to a range of health issues, including stress, sleep disturbances, and cardiovascular diseases. Reducing noise pollution often involves measures such as the adoption of quieter vehicles, soundproofing, and urban design that reduces traffic density.

4% (3 participants) noted the impact on biodiversity, which reflects concerns about the disruption of ecosystems and habitats due to transportation infrastructure. This includes the fragmentation of wildlife habitats by roads and railways, as well as the effects of pollution on water bodies and soil. Efforts to mitigate these impacts often involve the design of wildlife corridors, the use of sustainable materials, and the minimization of land use for transportation projects.

The following figure 4.6 represents the above hypothesis regarding the Primary Environmental Impact.

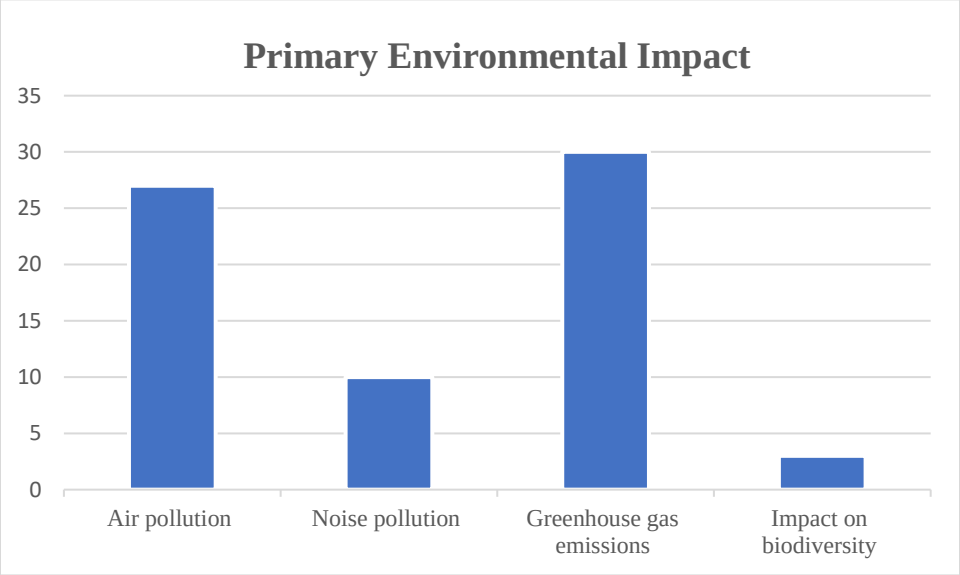

Figure 4.5. Primary Environmental Impact

4.3.2 Effectiveness of Strategies in Reducing Carbon Footprint

There are differences in the effectiveness of the above-mentioned current strategies, these being only some of the strategies with the emphasis on sustainable transportation in reducing the carbon footprint of the transportation system for the European regions. According to the survey, 24% (17

participants) of respondents consider the strategies in place to be highly effective. These regions likely have well-developed infrastructure for electric vehicles, robust public transportation systems, and strong policies supporting sustainable practices.

However, most respondents, 37% (26 participants), rated the strategies as moderately effective. This suggests that while progress is being made, there is still significant room for improvement in areas such as policy enforcement, public adoption, and technological advancements.

A notable 33% (23 participants) rated the strategies as slightly effective, indicating that, the current measures may not be sufficient to meet long-term sustainability goals in many regions. This might be due to inadequate infrastructure, lack of funding, or insufficient policy support.

The remaining 6% (4 participants) consider the strategies ineffective, signaling areas where sustainable mobility initiatives may be non-existent or significantly lagging the required pace for meaningful impact.

The following figure 4.7 represents the above hypothesis regarding the Effectiveness of Strategies in Reducing Carbon Footprint.

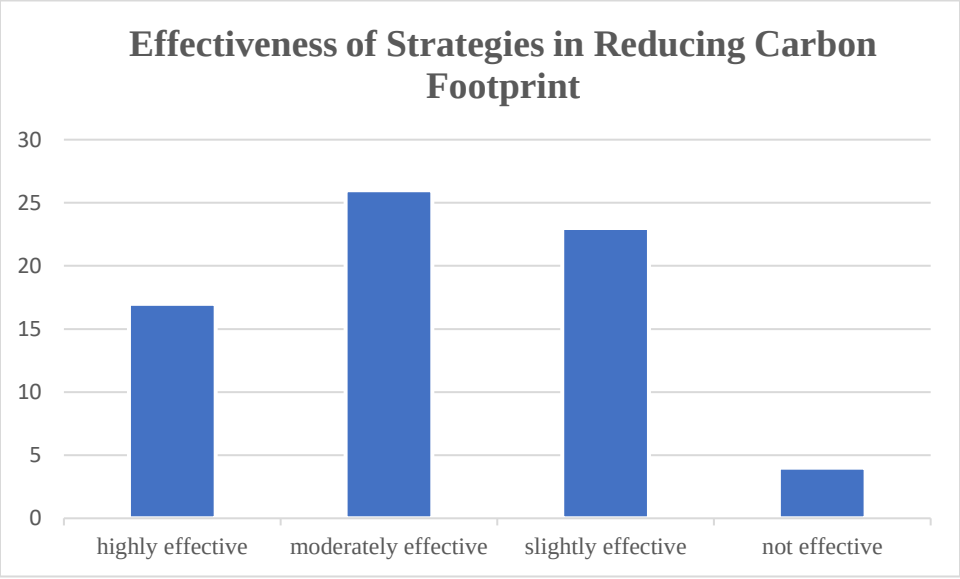

Figure 4.6. Effectiveness of Strategies in Reducing Carbon Footprint

4.4 Innovative Solutions and Policy

4.4.1 Innovative transportation solution

A significant portion of respondents view Electric Vehicles (EVs) as a highly promising solution. Thirty percent (21 participants) of the survey participants believe that EVs offer substantial potential for reducing emissions and transitioning away from fossil fuels.

27% (19 participants) consider Shared Mobility Services, which include options like car-sharing and bike-sharing, beneficial. These services can help reduce vehicle ownership rates, alleviate congestion, and provide more flexible travel options.

23% (16 participants) of respondents also see autonomous vehicles (AVs) as a promising technology. AVs can potentially improve traffic management, enhance safety, and increase overall transportation efficiency, although their widespread use is still developing.

Twenty percent (14 participants) regard mobility as a Service (MaaS) as a key solution. MaaS integrates multiple transportation modes into one accessible service, which can streamline travel planning and promote sustainable mobility practices.

The following figure 4.8 represents the above hypothesis regarding the Innovative Transportation Solution.

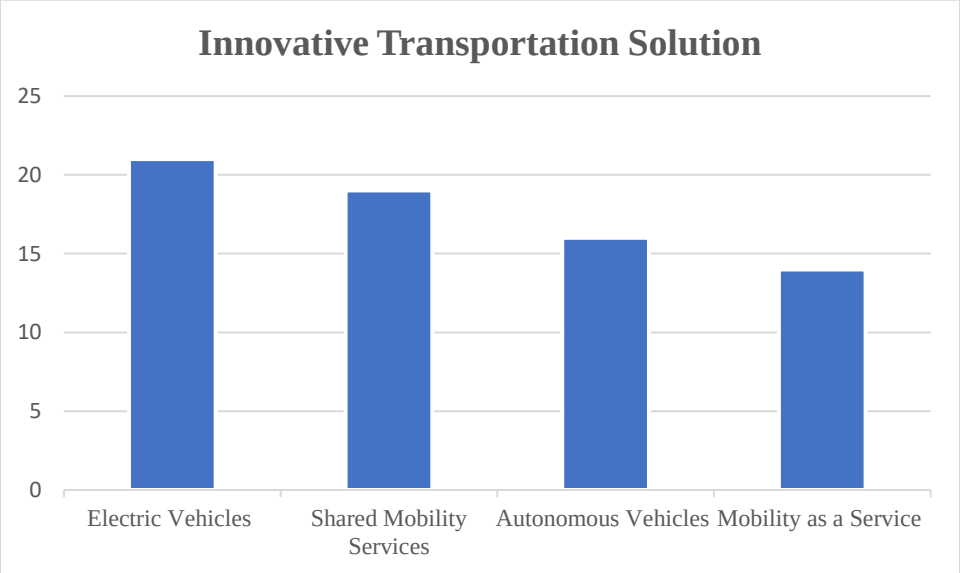

Figure 4.7. Innovative Transportation Solution

4.4.2 New transportation modes Integration

In some regions, the integration of traditional and new transportation modes varies. For 51 participants or 73% of respondents, the systems are reported as particularly integrated, indicating a high level of coordination between established modes like buses and trains and newer solutions such as bike-sharing and ride-hailing services.

A smaller group of 15 participants (21%) describes their systems as fully integrated, suggesting a seamless connection with minimal gaps.

Conversely, 4 participants, or 6%, report their systems as poorly integrated, highlighting challenges in merging new modes with existing infrastructure.

Notably, none of the respondents indicated that their transportation systems are not integrated, reflecting a general trend towards incorporating new mobility options into traditional networks.

The following figure 4.9 represents the above hypothesis regarding the New Transportation Modes Integration.

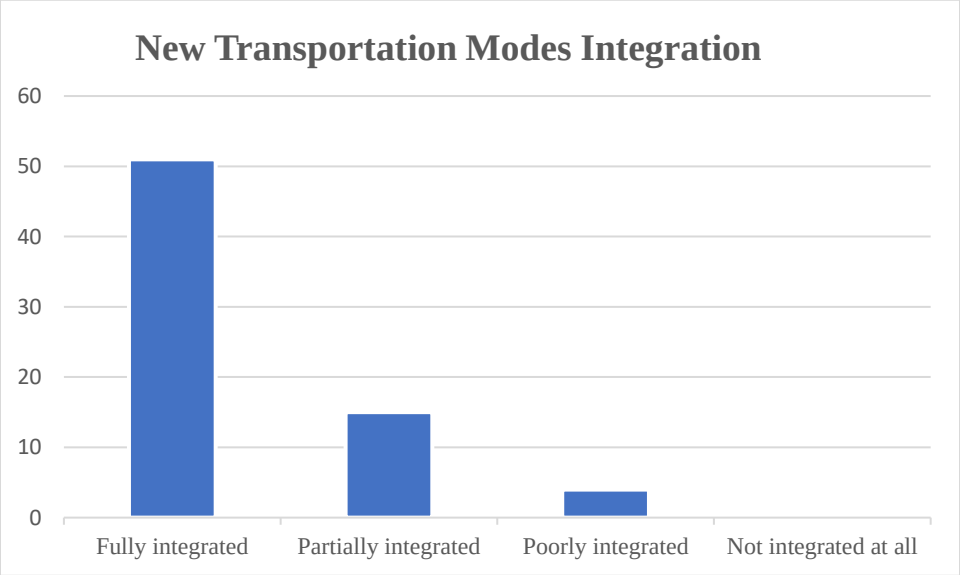

Figure 4.8. New Transportation Modes Integration

4.4.3 Accelerate the transition to sustainable transportation in European cities

Increased funding for green infrastructure is recommended by 30% (21 participants). This includes investments in public transit expansion, electric vehicle charging stations, and cycling infrastructure, essential for supporting and advancing sustainable transportation systems.

25% (17 participants) advocate for stronger emissions regulations. Implementing more stringent regulations can drive the adoption of cleaner technologies and reduce overall vehicle emissions, improving air quality and environmental sustainability.

Twenty percent (14 participants) suggest providing incentives for public transportation use. Financial benefits or other encouragements can promote greater use of public transit, decrease reliance on private vehicles, and enhance sustainability.

Enhanced public-private partnerships are emphasized by 25% (18 participants). Collaborations between the public and private sectors can foster innovation, leverage resources, and facilitate the implementation of sustainable transportation initiatives.

The following figure 4.10 represents the above hypothesis regarding the Accelerate the Transition to Sustainable Transportation in European Cities.

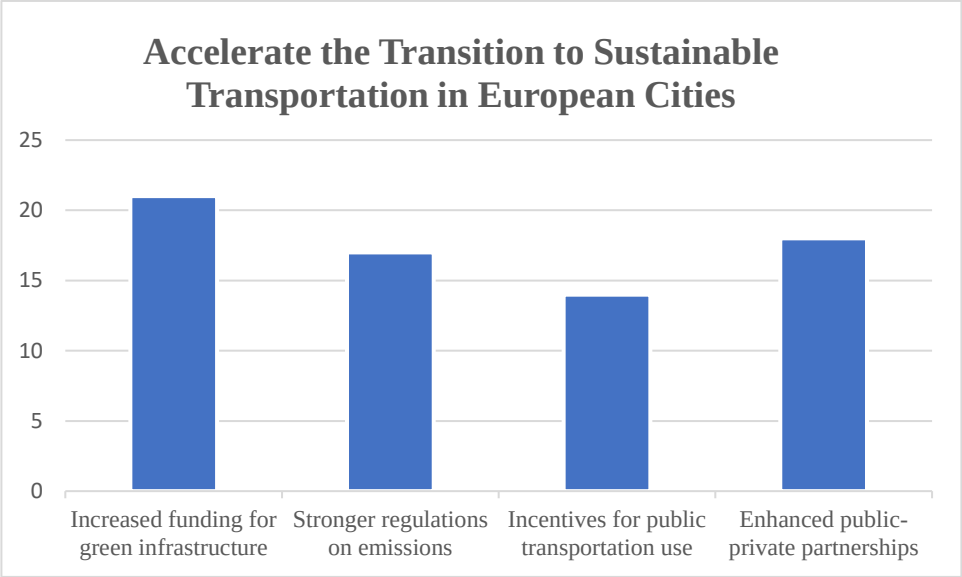

Figure 4.9. Accelerate the Transition to Sustainable Transportation in European Cities

4.5 Future Perspectives

4.5.1 Emerging trends for the future of sustainable mobility in Europe

The further integration of digital technologies is seen as a key trend by 34% (24 participants). This includes advancements such as smart traffic management, real-time data analytics, and interconnected transportation networks, which are expected to enhance efficiency and user experience.

The rise of multimodal transport systems is identified by 30% (21 participants) as a significant trend. Integrating various modes of transportation into cohesive systems can offer more seamless travel options and reduce reliance on private vehicles.

The expansion of low-emission zones is anticipated by 20% (14 participants). These zones can help reduce urban air pollution and promote cleaner transportation options, contributing to a more sustainable urban environment.

Increased adoption of active transport modes, such as cycling and walking, is also expected to be a trend of 16% (11 participants). Promoting these modes can improve public health and reduce the environmental impact of transportation by decreasing dependence on motorized vehicles.

The following figure 4.11 represents the above hypothesis regarding the Emerging Trends for the Future of Sustainable Mobility in Europe

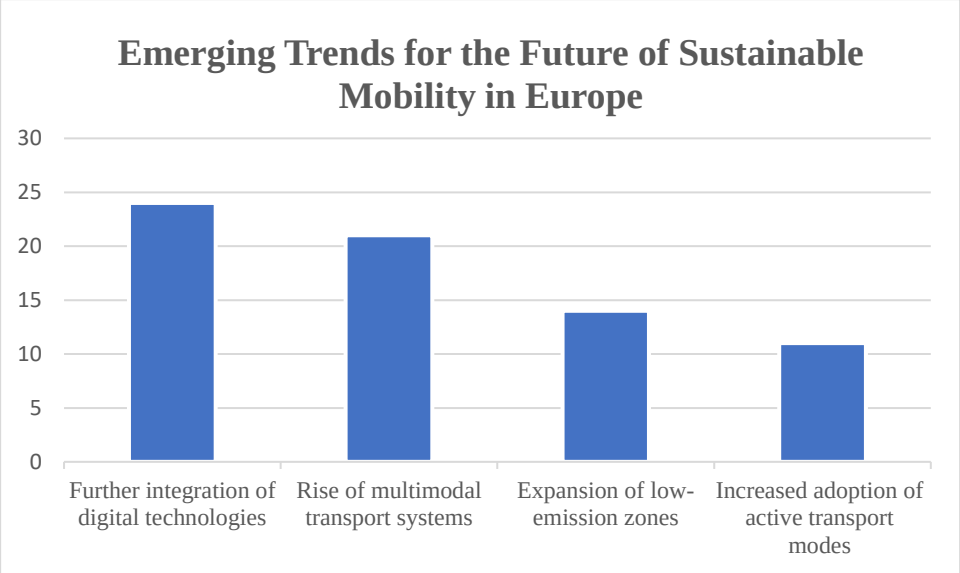

Figure 4.10. Emerging Trends for The Future of Sustainable Mobility in Europe

4.5.2 Critical factors for achieving long-term sustainability in European transportation systems

Thirty percent (21 participants) consider technological innovation the most critical factor. Advances in technology are essential for developing new solutions and improving existing systems, making them a key component of long-term sustainability.

Public engagement and education are highlighted by 24% (17 participants) as crucial. Ensuring that the public is informed and supportive of sustainable practices can drive broader adoption and effective implementation of transportation solutions.

26% (18 participants) emphasize robust policy frameworks. Effective policies and regulations are crucial for guiding and supporting sustainable transportation initiatives.

Economic incentives for sustainable practices are viewed as important by 20% (14 participants). Providing financial incentives can encourage both individuals and businesses to adopt more sustainable transportation options and practices.

The following figure 4.11 represents the above hypothesis regarding Critical Factor for Achieving long-term Sustainability in European Transportation Systems

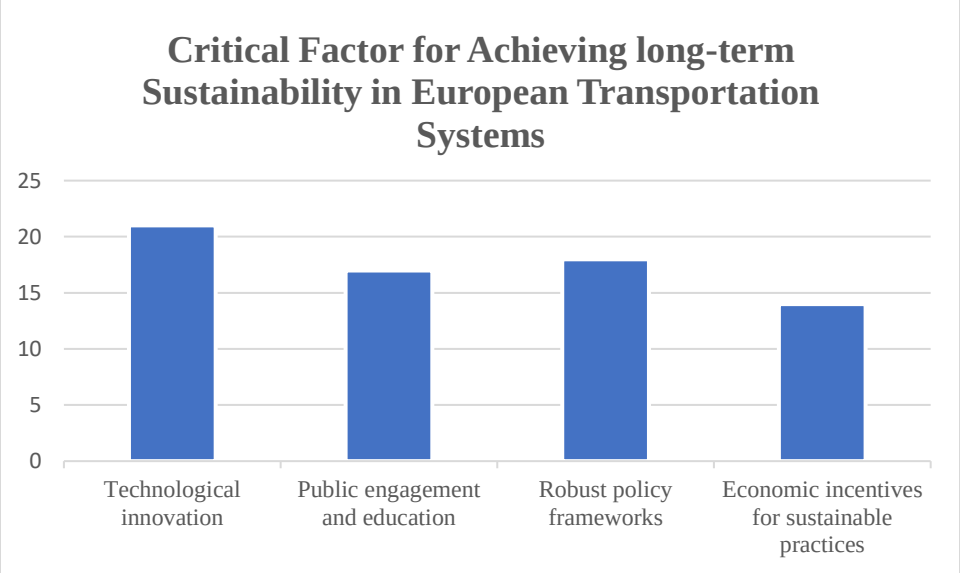

Figure 4.11. Critical Factor for Achieving Long-term Sustainability in European Transportation Systems

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5. Discussion and Conclusion

This chapter discusses and summarizes the study's main findings by and addressing the issue revealed in each of the four research questions that motivated this research. Consequently, this chapter comprehensively discusses the findings by detailing the history of sustainable transportation, its impacts, issues, and knowledge that can improve the practice of sustainability efforts around Europe.

Regarding the first Question,

RQ1. What are the key components of sustainable transportation in European cities and regions, and how have they evolved over time?

The key components of sustainable transport in Europe are promoting the uptake of electric vehicles, active transportation infrastructure and promoting active commuting, including walking or cycling. Over time, European cities have introduced an integrated transport system that incorporates the use of shared mobility services into existing multimodal public transport systems. Such systems seek to minimize dependence on private cars, reduce greenhouse gasses and promote a favorable urban climate (Asgarian et al., 2024).

The development is seen through a more significant commitment to policy change, with initiatives such as the European Green Deal aiming to reduce transportation emissions by 90% by 2050. Technological progress, especially in the formation of EV infrastructures and the use of a digital platform such as MaaS, has also changed the order of things and offers smarter and better ways of getting around (Dolge et al., 2023).

Addressing the second RQ2,

RQ2. How have European cities and regions implemented sustainable transportation solutions, and what measurable outcomes have these efforts achieved?

European cities have adopted several sustainable transportation programs, including the expansion of public transport systems, the construction of low-emission zones and the development of electric vehicle infrastructure. Cities such as Copenhagen and Amsterdam have made great strides in promoting cycling as an important mode of transport. The desired results include a quantifiable

reduction in CO2 emissions, better air quality due to increased use of public transport, etc. For example, in places where congestion charging has been introduced and the transport system supplemented, there has been less congestion from motor vehicles and better air quality. These programs have also improved public health by reducing chronic diseases through increased physical activity in walking and cycling (Galambos et al., 2024).

Considering the Results that point to a Hypothetical answer towards RQ3,

RQ3. What are the primary obstacles hindering the transition to sustainable transportation in Europe, and what strategies can be employed to address these challenges effectively?

The transitions to new modes of transportation have not been smooth. Several obstacles have emerged that make the transition to sustainable modes of transport more difficult: These include issues of capacity, affordability, technological inadequacy and public acceptance. For example, the lack of sufficient charging stations for electric vehicles, the high cost of building these systems or socio-cultural factors such as car use are also barriers. There are ways to address these issues: better planning multimodal transport networks, strengthening public-private cooperation to implement green measures and developing balanced low-emission technology projects. Overcoming attitudinal and behavioral resistance, strategies to change perceptions and promoting active lifestyles will be crucial in public health campaigns (Saraji & Streimikiene, 2023).

Finally, the last RQ,

RQ4. What insights and best practices can be derived from successful sustainable transportation initiatives in Europe that can inform global sustainability efforts and policies?

Lessons can be learned from implementing initiatives in European cities that can help in global sustainability efforts, especially in the transportation sector. Experience shows that cities, where public transport has been combined with cycling and shared mobility, have focused on cross-category schemes to reduce reliance on private vehicles. In addition, it is also important for developing countries to be aware of policies that promote the active use of public transport and restrict the use of the private cars, such as congestion charges and low-emission zones. Smart mobility involves the advanced use of urban traffic management using various digital technologies, focusing on events such as data analytics and intelligent transport systems whose operational

concept aims to reduce emissions, which serves as guidance for other regions to improve urban mobility (Tsavachidis & Petit, 2022).

Although this question is not one of the original research questions, it arises naturally from the context of the study and reflects the overarching theme expressed in the title of this thesis. Given the research into sustainable transportation practices across Europe, the Conclusion fall into this doubt:

What could be the Research Proposal on Sustainable Mobility to apply in Europe?

The conclusion refers to the question: What could the research proposal on sustainable mobility in Europe look like? The proposed research on sustainable urban mobility in Europe aims to design a comprehensive and policy-based transport strategy considering the development of systems, infrastructures and social components. One of the foundations in this area of research would be to promote public transport, cycling, electric vehicles and sedentary mobility in an overall package to create touch points that reduce the need for cars. The study would also explore IoT, AI and MaaS to improve the efficiency of urban transport and reduce emissions (Ho & Tirachini, 2024).

In addition, the proposal will examine the challenges related to infrastructure challenges, specifically including the expansion of electric vehicle (EV) charging stations and explore the potential for private sector involvement in these initiatives. An important theme in this type of research is to address the more social and behavioral aspects of the pursuit of sustainable mobility, with the prospect of influencing public opinion and public policies that would encourage the use of non-motorized modes such as bicycles and public transport. In addition, it will assess policies and regulations that inclusively support sustainable development by involving disadvantaged groups and regions in the promotion of sustainable transport policies across Europe (Pardo-Bosch et al., 2021).

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References

Acheampong, R. A., Cugurullo, F., Gueriau, M., & Dusparic, I. (2021). Can autonomous vehicles enable sustainable mobility in future cities? Insights and policy challenges from user preferences over different urban transport options. *Cities*, *112*, 103134. https://doi.org/10.1016/j.cities.2021.103134

Afifa, N., Arshad, K., Hussain, N., Ashraf, M. H., & Saleem, M. Z. (2024). Air pollution and climate change as grand challenges to sustainability. *The Science of the Total Environment*, *928*, 172370. https://doi.org/10.1016/j.scitotenv.2024.172370

Aminzadegan, S., Shahriari, M., Mehranfar, F., & Abramović, B. (2022). Factors affecting the emission of pollutants in different types of transportation: A literature review. *Energy Reports*, *8*, 2508–2529. https://doi.org/10.1016/j.egyr.2022.01.161

Arroyo, R., Ruiz, T., Mars, L., Rasouli, S., & Timmermans, H. (2020). Influence of values, attitudes towards transport modes and companions on travel behavior. *Transportation Research Part F Traffic Psychology and Behaviour*, *71*, 8–22. https://doi.org/10.1016/j.trf.2020.04.002

Asgarian, F., Hejazi, S. R., Khosroshahi, H., & Safarzadeh, S. (2024). Vehicle Pricing considering EVs Promotion and Public Transportation Investment under Governmental policies on sustainable Transportation Development: The case of Norway. *Transport Policy*, *153*, 204–221. https://doi.org/10.1016/j.tranpol.2024.05.017

Bakioglu, G. (2024). Selection of sustainable transportation strategies for campuses using hybrid decision-making approach under picture fuzzy sets. *Technological Forecasting and Social Change*, *206*, 123567. https://doi.org/10.1016/j.techfore.2024.123567

Barajas, J. M., & Braun, L. M. (2021). Are cycling and walking good for all? Tracking differences in associations among active travel, socioeconomics, gentrification, and self-reported health. *Journal of Transport & Health*, *23*, 101246. https://doi.org/10.1016/j.jth.2021.101246

Barceló, J. (2019). Future trends in sustainable transportation. In *Elsevier eBooks* (pp. 401–435). https://doi.org/10.1016/b978-0-12-814242-4.00016-8

Beaudoin, J., Farzin, Y. H., & Lawell, C. C. L. (2015). Public transit investment and sustainable transportation: A review of studies of transit's impact on traffic congestion and air quality. *Research in Transportation Economics*, *52*, 15–22. https://doi.org/10.1016/j.retrec.2015.10.004

Bolan, S., Padhye, L. P., Jasemizad, T., Govarthanan, M., Karmegam, N., Wijesekara, H., Amarasiri, D., Hou, D., Zhou, P., Biswal, B. K., Balasubramanian, R., Wang, H., Siddique, K. H., Rinklebe, J., Kirkham, M., & Bolan, N. (2024). Impacts of climate change on the fate of contaminants through extreme weather events. *The Science of the Total Environment*, *909*, 168388. https://doi.org/10.1016/j.scitotenv.2023.168388

Carvalho, J., De Sousa, J. P., & Macário, R. (2023). Sustainable urban mobility planning at the metropolitan scale: a review of current practices and narratives. *Transportation Research Procedia*, *72*, 4175–4182. https://doi.org/10.1016/j.trpro.2023.11.357

Cohen, T., Stilgoe, J., Stares, S., Akyelken, N., Cavoli, C., Day, J., Dickinson, J., Fors, V., Hopkins, D., Lyons, G., Marres, N., Newman, J., Reardon, L., Sipe, N., Tennant, C., Wadud, Z., & Wigley, E. (2020). A constructive role for social science in the development of automated vehicles. *Transportation Research Interdisciplinary Perspectives*, *6*, 100133. https://doi.org/10.1016/j.trip.2020.100133

Cook, S., Stevenson, L., Aldred, R., Kendall, M., & Cohen, T. (2022). More than walking and cycling: What is 'active travel'? *Transport Policy*, *126*, 151–161. https://doi.org/10.1016/j.tranpol.2022.07.015

D'Alberto, R., & Giudici, H. (2023). A sustainable smart mobility? Opportunities and challenges from a big data use perspective. *Sustainable Futures*, *6*, 100118. https://doi.org/10.1016/j.sftr.2023.100118

De Vos, J. (2024). Towards truly sustainable mobility. *Transportation Research Interdisciplinary Perspectives*, *24*, 101039. https://doi.org/10.1016/j.trip.2024.101039

Dolge, K., Barisa, A., Kirsanovs, V., & Blumberga, D. (2023). The status quo of the EU transport sector: Cross-country indicator-based comparison and policy evaluation. *Applied Energy*, *334*, 120700. https://doi.org/10.1016/j.apenergy.2023.120700

Dolla, T., & Laishram, B. (2020). Enhancing Sustainability in Public-Private Partnership Projects through Bid Selection Model. *Transportation Research Procedia*, *48*, 3896–3907. https://doi.org/10.1016/j.trpro.2020.08.031

Elassy, M., Al-Hattab, M., Takruri, M., & Badawi, S. (2024). Intelligent transportation systems for sustainable smart cities. *Transportation Engineering*, *16*, 100252. https://doi.org/10.1016/j.treng.2024.100252

Environmental noise in Europe — 2020. (2022). [Dataset]. In *Climate Change and Law Collection*. https://doi.org/10.1163/9789004322714_cclc_2020-0190-1083

Galambos, K. J., Palomino-Hernández, A. B., Hemmelmayr, V. C., & Turan, B. (2024). Sustainability initiatives in urban freight transportation in Europe. *Transportation Research Interdisciplinary Perspectives*, *23*, 101013. https://doi.org/10.1016/j.trip.2023.101013

González, L., Perdiguero, J., & Sanz, À. (2021). Impact of public transport strikes on traffic and pollution in the city of Barcelona. *Transportation Research Part D Transport and Environment*, *98*, 102952. https://doi.org/10.1016/j.trd.2021.102952

Gössling, S., Choi, A., Dekker, K., & Metzler, D. (2019). The social cost of automobility, cycling and walking in the European Union. *Ecological Economics*, *158*, 65–74. https://doi.org/10.1016/j.ecolecon.2018.12.016

Hafner, M., & Raimondi, P. P. (2020). Priorities and challenges of the EU energy transition: From the European Green Package to the new Green Deal. *Russian Journal of Economics*, *6*(4), 374–389. https://doi.org/10.32609/j.ruje.6.55375

Haghani, M., Sprei, F., Kazemzadeh, K., Shahhoseini, Z., & Aghaei, J. (2023). Trends in electric vehicles research. *Transportation Research Part D Transport and Environment*, *123*, 103881. https://doi.org/10.1016/j.trd.2023.103881

Hainsch, K., Löffler, K., Burandt, T., Auer, H., Del Granado, P. C., Pisciella, P., & Zwickl-Bernhard, S. (2022). Energy transition scenarios: What policies, societal attitudes, and technology developments will realize the EU Green Deal? *Energy*, *239*, 122067. https://doi.org/10.1016/j.energy.2021.122067

Heinen, E., Maat, K., & Van Wee, B. (2011). The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances. *Transportation Research Part D Transport and Environment*, *16*(2), 102–109. https://doi.org/10.1016/j.trd.2010.08.010

Ho, C. Q., & Tirachini, A. (2024). Mobility-as-a-Service and the role of multimodality in the sustainability of urban mobility in developing and developed countries. *Transport Policy*, *145*, 161–176. https://doi.org/10.1016/j.tranpol.2023.10.013

Ji, W., Huang, Z., Gao, G., & Zheng, P. (2024). Evaluation of integrated transport efficiency and equity at the county level——taking the counties in ningbo city as an example. *Transport Policy*. https://doi.org/10.1016/j.tranpol.2024.01.011

Jittrapirom, P., Caiati, V., Feneri, A., Ebrahimigharehbaghi, S., González, M. J. A., & Narayan, J. (2017). Mobility as a Service: A critical review of definitions, assessments of schemes, and key challenges. *Urban Planning*, *2*(2), 13–25. https://doi.org/10.17645/up.v2i2.931

Kheder, M. Q., & Mohammed, A. A. (2024). Real-time traffic monitoring system using IoT-aided robotics and deep learning techniques. *Kuwait Journal of Science*, *51*(1), 100153. https://doi.org/10.1016/j.kjs.2023.10.017

Khurshid, A., Khan, K., & Cifuentes-Faura, J. (2023). 2030 Agenda of sustainable transport: Can current progress lead towards carbon neutrality? *Transportation Research Part D Transport and Environment*, *122*, 103869. https://doi.org/10.1016/j.trd.2023.103869

Kim, H., Lazurko, A., Linney, G., Maskell, L., Díaz-General, E., Březovská, R. J., Keune, H., Laspidou, C., Malinen, H., Oinonen, S., Raymond, J., Rounsevell, M., Vaňo, S., Venâncio, M. D., Viesca-Ramirez, A., Wijesekera, A., Wilson, K., Ziliaskopoulos, K., & Harrison, P. A. (2024). Understanding the role of biodiversity in the climate, food, water, energy, transport and health nexus in Europe. *The Science of the Total Environment*, 171692. https://doi.org/10.1016/j.scitotenv.2024.171692

Kirchherr, J., Yang, N. N., Schulze-Spüntrup, F., Heerink, M. J., & Hartley, K. (2023). Conceptualizing the Circular Economy (Revisited): An analysis of 221 definitions. *Resources Conservation and Recycling*, *194*, 107001. https://doi.org/10.1016/j.resconrec.2023.107001

Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2024). Reducing transport sector CO2 emissions patterns: environmental technologies and renewable energy. *Journal of Open Innovation Technology Market and Complexity*, *10*(1), 100217. https://doi.org/10.1016/j.joitmc.2024.100217

Lucas, K., & Jones, P. (2012). Social impacts and equity issues in transport: an introduction. *Journal of Transport Geography*, *21*, 1–3. https://doi.org/10.1016/j.jtrangeo.2012.01.032

Lucas, K., Mattioli, G., Verlinghieri, E., & Guzman, A. (2016). Transport poverty and its adverse social consequences. *Proceedings of the Institution of Civil Engineers - Transport*, *169*(6), 353–365. https://doi.org/10.1680/jtran.15.00073

Mattioli, G., Roberts, C., Steinberger, J. K., & Brown, A. (2020). The political economy of car dependence: A systems of provision approach. *Energy Research & Social Science*, *66*, 101486. https://doi.org/10.1016/j.erss.2020.101486

Michelini, G., Dametto, D., & Michel, A. (2023). Who is doing what and how? Descriptive analysis of the sustainable mobility planning practice in Germany. *Transport Policy*, *134*, 231–241. https://doi.org/10.1016/j.tranpol.2023.02.022

Mizdrak, A., Tatah, L., Mueller, N., Shaw, C., & Woodcock, J. (2023). Assessing the health impacts of changes in active transport: An updated systematic review. *Journal of Transport & Health*, *33*, 101702. https://doi.org/10.1016/j.jth.2023.101702

Mladenovič, L., Plevnik, A., & Rye, T. (2022). Implementing national support programmes for sustainable urban mobility plans in a multilevel governance context. *Case Studies on Transport Policy*, *10*(3), 1686–1694. https://doi.org/10.1016/j.cstp.2022.06.007

Möller, H., Haigh, F., Hayek, R., & Veerman, L. (2020). What is the best practice method for quantifying the health and economic benefits of active transport? International Journal of Environmental Research and Public Health, 17(17), 6186. https://doi.org/10.3390/ijerph17176186

Mosca, O., Lauriola, M., Manunza, A., Mura, A. L., Piras, F., Sottile, E., Meloni, I., & Fornara, F. (2024). Promoting a sustainable behavioral shift in commuting choices: the role of previous intention and "personalized travel plan" feedback. *Transportation Research Part F Traffic Psychology and Behaviour*, *106*, 55–71. https://doi.org/10.1016/j.trf.2024.06.027

Mozos-Blanco, M. Á., Pozo-Menéndez, E., Arce-Ruiz, R., & Baucells-Aletà, N. (2018). The way to sustainable mobility. A comparative analysis of sustainable mobility plans in Spain. *Transport Policy*, *72*, 45–54. https://doi.org/10.1016/j.tranpol.2018.07.001

Mueller, N., Rojas-Rueda, D., Cole-Hunter, T., De Nazelle, A., Dons, E., Gerike, R., Götschi, T., Panis, L. I., Kahlmeier, S., & Nieuwenhuijsen, M. (2015). Health impact assessment of active transportation: A systematic review. *Preventive Medicine*, *76*, 103–114. https://doi.org/10.1016/j.ypmed.2015.04.010

Nieuwenhuijsen, M. J. (2020). Urban and transport planning pathways to carbon neutral, liveable and healthy cities; A review of the current evidence. *Environment International*, *140*, 105661. https://doi.org/10.1016/j.envint.2020.105661

Pangbourne, K., Stead, D., Mladenović, M., & Milakis, D. (2018). The Case of Mobility as a Service: A Critical reflection on Challenges for urban transport and mobility governance. In *Emerald Publishing Limited eBooks* (pp. 33–48). https://doi.org/10.1108/978-1-78754-317-120181003

Papadakis, D. M., Savvides, A., Michael, A., & Michopoulos, A. (2024). Advancing sustainable urban mobility: insights from best practices and case studies. *Fuel Communications*, *20*, 100125. https://doi.org/10.1016/j.jfueco.2024.100125

Pardo-Bosch, F., Pujadas, P., Morton, C., & Cervera, C. (2021). Sustainable deployment of an electric vehicle public charging infrastructure network from a city business model perspective. *Sustainable Cities and Society*, *71*, 102957. https://doi.org/10.1016/j.scs.2021.102957

Pereira, R. H. M., Schwanen, T., & Banister, D. (2016). Distributive justice and equity in transportation. *Transport Reviews*, *37*(2), 170–191. https://doi.org/10.1080/01441647.2016.1257660

Qadir, S. A., Ahmad, F., Al-Wahedi, A. M. a. B., Iqbal, A., & Ali, A. (2024). Navigating the complex realities of electric vehicle adoption: A comprehensive study of government strategies, policies, and incentives. *Energy Strategy Reviews*, *53*, 101379. https://doi.org/10.1016/j.esr.2024.101379

Quaglione, D., Cassetta, E., Crociata, A., Marra, A., & Sarra, A. (2019). An assessment of the role of cultural capital on sustainable mobility behaviours: Conceptual framework and empirical evidence. *Socio-Economic Planning Sciences*, *66*, 24–34. https://doi.org/10.1016/j.seps.2018.07.005

Raza, A., Zhong, M., Akuh, R., & Safdar, M. (2023). Public transport equity with the concept of time-dependent accessibility using Geostatistics methods, Lorenz curves, and Gini coefficients. *Case Studies on Transport Policy*, *11*, 100956. https://doi.org/10.1016/j.cstp.2023.100956

Remme, D., Sareen, S., & Haarstad, H. (2022). Who benefits from sustainable mobility transitions? Social inclusion, populist resistance and elite capture in Bergen, Norway. *Journal of Transport Geography*, *105*, 103475. https://doi.org/10.1016/j.jtrangeo.2022.103475

Road transport. (2024, August 28). European Environment Agency's Home Page. https://www.eea.europa.eu/en/topics/in-depth/road-transport?activeTab=07e50b68-8bf2-4641-ba6b-eda1afd544be&activeAccordion=2693b5c5-6626-4ec7-9a4f-6f96446d4347

Saraji, M. K., & Streimikiene, D. (2023). Challenges to the low carbon energy transition: A systematic literature review and research agenda. *Energy Strategy Reviews*, *49*, 101163. https://doi.org/10.1016/j.esr.2023.101163

Sovacool, B. K., & Griffiths, S. (2020). The cultural barriers to a low-carbon future: A review of six mobility and energy transitions across 28 countries. *Renewable and Sustainable Energy Reviews*, *119*, 109569. https://doi.org/10.1016/j.rser.2019.109569

Tammaru, T., Sevtsuk, A., & Witlox, F. (2023). Towards an equity-centred model of sustainable mobility: Integrating inequality and segregation challenges in the green mobility transition. *Journal of Transport Geography*, *112*, 103686. https://doi.org/10.1016/j.jtrangeo.2023.103686

Thomopoulos, N., & Givoni, M. (2015). The autonomous car—a blessing or a curse for the future of low carbon mobility? An exploration of likely vs. desirable outcomes. *European Journal of Futures Research*, *3*(1). https://doi.org/10.1007/s40309-015-0071-z

Tsavachidis, M., & Petit, Y. L. (2022). Re-shaping urban mobility – Key to Europe´s green transition. *Journal of Urban Mobility*, *2*, 100014. https://doi.org/10.1016/j.urbmob.2022.100014

Ushakov, D., Dudukalov, E., Mironenko, E., & Shatila, K. (2022). Big data analytics in smart cities' transportation infrastructure modernization. *Transportation Research Procedia*, *63*, 2385–2391. https://doi.org/10.1016/j.trpro.2022.06.274

Waqar, A., Alshehri, A. H., Alanazi, F., Alotaibi, S., & Almujibah, H. R. (2023). Evaluation of challenges to the adoption of intelligent transportation system for urban smart mobility. *Research in Transportation Business & Management*, *51*, 101060. https://doi.org/10.1016/j.rtbm.2023.101060

Wong, Y. Z., Hensher, D. A., & Mulley, C. (2020). Mobility as a service (MaaS): Charting a future context. *Transportation Research Part a Policy and Practice*, *131*, 5–19. https://doi.org/10.1016/j.tra.2019.09.030

Zeiske, N., Van Der Werff, E., & Steg, L. (2021). The effects of a financial incentive on motives and intentions to commute to work with public transport in the short and long term. *Journal of Environmental Psychology*, *78*, 101718. https://doi.org/10.1016/j.jenvp.2021.101718

Appendix

Appendix A

What is your Age?

- ◯ 18-29
- ◯ 30-39
- ◯ 40-49
- ◯ 50-65

In which European region do you live?

- ◯ Western Europe
- ◯ Eastern Europe
- ◯ Northern Europe
- ◯ Southern Europe

How would you rate the overall progress of sustainable mobility in your city/region?

- ○ Excellent
- ○ Good
- ○ Fair
- ○ Poor

What are the most significant barriers to implementing sustainable transportation solutions in your area?

- ○ Technological limitations
- ○ Policy and regulatory challenges
- ○ Public resistance to change
- ○ Financial constraints

To what extent do you believe digital technologies can enhance sustainable mobility in urban areas?

- ○ Very significantly
- ○ Significantly
- ○ Moderately
- ○ Not significantly

What is the primary environmental impact of transportation in your region?

- ○ Air pollution
- ○ Noise pollution
- ○ Greenhouse gas emissions
- ○ Impact on biodiversity

How effective are current strategies in reducing the carbon footprint of the transportation sector in your area?

- ○ Highly effective
- ○ Moderately effective
- ○ Slightly effective
- ○ Not effective

Which innovative transportation solution do you believe holds the most promise for sustainable mobility?

- ○ Electric Vehicles (EVs)
- ○ Shared Mobility Services
- ○ Autonomous Vehicles (AVs)
- ○ Mobility as a Service (MaaS)

How well integrated are traditional and new transportation modes in your city/region?

- ○ Fully integrated
- ○ Partially integrated
- ○ Poorly integrated
- ○ Not integrated at all

What policy recommendations would you propose to accelerate the transition to sustainable transportation in European cities?

- ○ Increased funding for green infrastructure
- ○ Stronger regulations on emissions
- ○ Incentives for public transportation use
- ○ Enhanced public-private partnerships

What emerging trends do you see shaping the future of sustainable mobility in Europe?

- ○ Further integration of digital technologies
- ○ Rise of multimodal transport systems
- ○ Expansion of low-emission zones
- ○ Increased adoption of active transport modes

What do you think is the most critical factor for achieving long-term sustainability in European transportation systems?

- ○ Technological innovation
- ○ Public engagement and education
- ○ Robust policy frameworks
- ○ Economic incentives for sustainable practices