

# Scaling Up Innovation - Exemplary Initiatives for Sustainable Development in European Smart Cities with a Focus on Smart Mobility

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## Abstract

The development of a sustainable economy is the goal of the whole society in the European Union. With over half of the global population residing in urban areas, the significance of building resilient cities cannot be overstated. Cities are at the forefront of driving adaptation and building resilience implementing ambitious strategies and activities to effectively cope, adapt, and transform, considering three pillars of sustainable development: economic growth, environmental management and social inclusion. This study explores the toolbox of best practices - activities and innovations that European cities are implementing to achieve sustainable development goals. In the article, the best practices and innovative approaches that cities are taking toward sustainability were identified. This article explores the key aspects of smart mobility and its potential to reshape urban transportation systems for a more sustainable future. The findings in the paper indicate that European cities are making significant efforts to adopt sustainable practices, including investments in renewable energy, green infrastructure, public transportation, waste management, and sustainable urban planning. The study highlights the importance of the need for inter-sectoral collaborations to achieve SD goals. The insights gained from this study can inform policy-making and assist cities in developing effective strategies for sustainable development.

*Keywords: smart city, innovation, sustainable development, urban development, smart mobility*

## 1. Introduction

Sustainable development aims to ensure sufficiently high ecological, economic, and socio-cultural standards for all people living today and in the future, within the limits of the earth's natural resilience, while considering the principles of intra- and intergenerational justice. Sustainable development advises that the needs of the future can be met depending on how well social, economic, and environmental objectives or needs are balanced (Hopwood B., Mellor M., O'Brien G., 2005). The socio-economic aspect plays a crucial role in achieving sustainable development, as it involves integrating actions to maintain the balance of nature and the sustainability of basic natural processes to guarantee the ability to meet the basic needs of individual communities or citizens, both present and future generations. Therefore, sustainable development constitutes a set of environmental, socio-demographic, economic and spatial aspects (Derlukiewicz et al., 2020).

The world has become increasingly urbanized. There are around 8 billion people in the world with more than half living in urban areas. More than that, of the 55% of the world's population that live in urban areas, 7% live in what are called mega-cities (Kuo, Yong-Hong & Leung, Janny M.Y. & Yan, Yimo, 2023). Rapid urbanization globally has

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aggravated air and water pollution, social inequity, and many other threats to human health and well-being (Lafortezza and Sanesi, 2019). In the last ten years, academia seems to take smart cities as sound solutions to these problems and promote urban sustainability via various applications of information and communication technologies (ICT) (e.g., artificial intelligence, blockchain, and big data) (Rani et al., 2021). Despite the increasing focus on intelligent governance in many cities, the lack of a widely-accepted definition and consistent technical standards continues to hinder the development of smart cities and sometimes even conflict with public benefits and values (Toli and Murtagh, 2020).

Sustainable development requires a knowledge-based approach and smart solutions for integrated environmental and social assessment (Szewrański, S., & Kazak, J. K., 2020). Managing cities effectively requires an understanding of the complex interdependencies and the ability to balance synergies and trade-offs to achieve more sustainable and livable urban environments (Bai, X., et al., 2016). Cities' actions and common solutions should be focused on building strategies for urban development aimed at constantly improving the state of the environment's resources including, among others, reducing greenhouse gas emissions into the atmosphere by the European Union's climate policy and the key provisions of the IPCC Sixth Assessment Report, as well as the provisions of the CITY 40 Agenda and the Annual Report (C40 Annual Report 2022). Three-quarters of C40 cities are now decreasing their per capita emissions at a faster rate than their own countries, while high-impact actions delivered by C40 cities – such as introducing low-emission zones, increasing green spaces and planting more trees to improve air quality, and reducing urban heat risk, and achieving universal waste collection – have tripled in the past decade, which is vital if global heating is to be kept under 1.5°C.

To achieve the package of actions for cities and regions, it is reasonable to develop and apply a low-emission action system (model) that aligns with the green city concept, improving the implementation of planned initiatives while considering both ecological effectiveness and economic efficiency. Innovations emerge as the pathway for the most advanced countries and cities to ensure sustainable long-term productivity growth. (Bloom et al., 2019). An increasing focus is placed on research addressing the specific inquiries on why, how, and where innovations are generated, then their effective implementation and development. (Archibugi et al., 1999). Cities are the place where most innovations are established and implemented (Derlukiewicz, N., Mempel-Sniezyk, A., & Mankowska, D., 2021). Cities have always been associated with transformative ideas and novel social initiatives. Some argue that innovative activities are the products of cities or regions and that cities and urban regions are not just mere containers for innovative activities but are actively involved in the generation of new ideas, new organizational forms, and new enterprises. Besides hosting technological progress, cities are also enabling various other types of innovation. This variety of innovations is associated with products, processes, marketing, and organizational contexts, all of which are significant in urban and metropolitan areas. Several tangible approaches through which urban areas promote innovation include:

- entrepreneurial innovation oriented to support small businesses in the creation of new jobs;
- social innovation highly focused on meeting social needs by enhancing social interactions and integrating ideas, knowledge and vision of civil society with urban development;

- innovation in work systems: including teleworking, high mobility of entrepreneurs, co-working spaces, open office areas and other alternative ways to generate income;
- culture-led innovation, typically stemming from the creative knowledge of the arts and cultural domains and inspiring many city-relevant sectors and areas, including cultural tourism, consumer electronics, and urban regeneration.
- green innovations, such as sustainable energy systems, green buildings, and eco-friendly transportation.

By adopting such innovations, cities can reduce their carbon footprint, improve air and water quality, and promote sustainable economic growth. The article aims to present cutting-edge innovations, activities, and good practices implemented by European cities to obtain sustainable development objectives. Moreover, it highlights the profound importance of smart mobility, considering its increasing relevance in response to the impacts of transportation systems in cities. (Maldonado Silveira Alonso Munhoz, Paulo Antonio, et al., 2020). The paper presents the European Union's sustainable development policy, as well as the environmental, social and economic challenges that cities face today. In the paper, we presented the issue of sustainable development as well the concept of a smart city. We also showcased the smartest cities in Europe as proposed models to exemplify and scale up to inspire widespread adoption and implementation. Furthermore, we explore the significance of smart mobility as a vital facilitator for the consistent functioning of urban areas. We hypothesize that European cities are at the forefront of sustainable development and have been implementing numerous innovative activities and solutions to support achieving sustainable development goals. Cities that are commonly referred to as 'smart cities' have acknowledged the pressing need to tackle environmental, social, and economic challenges, and have made considerable progress towards achieving a sustainable future. Through the implementation of sustainable innovations such as renewable energy, waste reduction, and green transportation, European cities are creating more livable and resilient communities that can adapt to a changing world. However, there may still be challenges that need to be addressed in order to ensure that these activities are effectively implemented and contribute to the overall goal of sustainability.

## 2. Methodology

To achieve the research objective of presenting activities and good practices adopted by European cities for sustainable development, desk research was conducted. This involved establishing the theoretical framework of sustainable development and expanding the knowledge related to smart cities. Our focus was on identifying the key objectives of sustainable development for the near future, identifying smart city entities, and analyzing the innovative practices and activities implemented by European cities to achieve sustainable development goals. In our research, we formulated the following research questions:

1. What actions are being taken in European cities to achieve the Sustainable Development Goals (SDGs)?
2. Which cities are recognized in reports and rankings as leading smart cities?
3. What innovative activities are cities taking to achieve the SDGs?
4. What are the biggest challenges for EU cities in achieving sustainable development?

5. What are the potential future directions and innovative solutions for sustainable development?
6. What trends in actions and innovations related to sustainable development can be observed in selected cities?

To answer particular questions, our research method included the following stages:

1. Literature review of academic articles, reports, and policy documents related to sustainable development and smart cities to establish the theoretical framework and key concepts.
2. Identification of the objectives of sustainable development for the forthcoming years, such as those outlined by the United Nations Sustainable Development Goals (SDGs).
3. Selection of European cities that have implemented sustainable development initiatives and practices, using sources such as case studies, reports, and best practices guides.
4. Analysis of the sustainable development initiatives and practices of selected European cities with a focus on smart mobility.

### **3. Sustainable development goals for cities**

Sustainable development goals (SDG) are a set of 17 interconnected objectives addressing economic, social, and environmental challenges and promoting sustainable development (Hák, T., Janoušková, S., & Moldan, B., 2016). The goals encompass the eradication of poverty, the reduction of socioeconomic disparities, the facilitation of equitable access to high-quality education and healthcare, the promotion of gender equality, and the implementation of prompt measures to mitigate the impacts of climate change to address socio-environmental vulnerability. Each SDG embodies a distinct area of focus. These include No Poverty, Zero Hunger, Good Health and Well-being, Quality Education, Gender Equality, Clean Water and Sanitation, Affordable and Clean Energy, Decent Work and Economic Growth, Industry, Innovation and Infrastructure, Reduced Inequalities, Sustainable Cities and Communities, Responsible Consumption and Production, Climate Action, Life Below Water, Life on Land, Peace, Justice and Strong Institutions, and Partnerships for the Goals (Halkos, G., & Gkampoura, E. C., 2021). These goals encompass a broad spectrum of social, economic, and environmental aspects and serve as a blueprint for collective action, guiding countries, organizations, and individuals to work together toward a more prosperous and sustainable world (Elder, M., & Olsen, S. H., 2019). The importance of the SDGs in current discussions about sustainability and policy related to development has been recognized by Scherer et al. (Scherer, L., Behrens, P., de Koning, A., Heijungs, R., Sprecher, B., & Tukker, A., 2018) and many other authors (Köhler, J., Geels, F. W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., ... & Wells, P. (2019). However, some critics, including Des Gasper (Gasper, D., 2019), argue that the SDGs lack certain important themes such as migration, terrorism, capital flight, and democracy. It is significant to recognize that, as noted by Biggeri et al. (Biggeri, M., Clark, D. A., Ferrannini, A., & Mauro, V., 2019). The SDGs collectively serve as a roadmap for a better future that inspires action and cooperation among diverse actors at different levels and with various purposes. While there may be limitations in their conceptual and technical dimensions, they offer flexibility for

adaptation to different contexts and goals inspiring actions and cooperation among diverse stakeholders (Fonseca, L. M., Domingues, J. P., & Dima, A. M., 2020)

Regarding European cities, numerous Sustainable Development Goals (SDGs) play a pivotal role in advancing sustainable development and enhancing the well-being of residents. Among these goals, SDG11 - Sustainable Cities and Communities and SDG13 - Climate Action stand out as particularly crucial (Assembly, G., 2015). SDG11 is a comprehensive and complex goal. It addresses the challenge of creating sustainable cities that can withstand the dual pressures of climate change and unprecedented population growth (Kellison, T., 2022). SDG11 aims to make cities and communities inclusive, safe, resilient, and sustainable (Duah, E. F., Ahenkan, A., & Larbi, D., 2020). The goal focuses on various aspects of urban development, including housing, transportation, environmental impact, and social inclusion (Sarachaga, J. M. D, 2021). To achieve SDG11, cities must adopt integrated and holistic approaches that consider environmental, social, and economic dimensions. This entails i.e. sustainable infrastructure, urban planning and design, inclusive communities, sustainable consumption and production (Habitat, U. N., 2018).

Achieving SDG13 in EU cities is essential to reducing the risks and impacts of climate change, preserving natural resources, and creating a more sustainable future (Mortimer, A., Ahmed, I., Johnson, T., Tang, L., & Alston, M., 2023). The adoption of SDG13 in EU cities necessitates a range of actions including promoting renewable energy, implementing adaptation measures, enhancing resource efficiency and pursuing sustainable urban development (Doni, F., Gasperini, A., & Soares, J. T., 2020).

Cities are at the forefront of sustainable urban development, driving positive change and implementing innovative solutions. However, it is important to recognize that they cannot accomplish this alone. Collaboration and cooperation among various stakeholders are crucial for achieving sustainable urban development goals. Governments, the private sector, civil society organizations, unions, communities, and residents all play vital roles in working hand in hand with cities to deliver sustainable outcomes. Taken as a whole, considering the profound influence of the SDGs on a sustainable future, it is essential to translate them into practical actions. In recent years cities are testing new models able to integrate as many voices as possible to deliver urban development most inclusively and creatively. These cooperation platforms represent different approaches, implementing good practices and activities, creating a new urban narrative for sustainable development (Keith, M., Birch, E., Buchoud, N. J., Cardama, M., Cobbett, W., Cohen, M., ... & van der Pütten, M., 2023). The concepts of front-runner cities, cities as platforms, triple-bottom line, participatory approach, based on interaction, cooperation, dialogue, and examples of achievement in the urban ecosystem, highlight the importance of multilevel governance and business model innovation in achieving sustainable urban development. Considering the diverse perspectives, cities have become a focus for action developing the overarching idea of a smart city.

#### **4. Urban Challenges and the Smart City Concept**

Considering fast-growing urban populations, cities are embracing opportunities as well as facing many challenges. The main challenges that cities face today are related to

intensive urbanization, congestion, climate insecurity and extreme vulnerability changes and, the deepening of socio-economic disparities. (Lee, J., Babcock, J., Pham, T. S., Bui, T. H., & Kang, M. 2023). Transportation plays a crucial role in facilitating the daily mobility of individuals, enabling their access to workplaces and educational institutions, while also supporting the transportation of goods necessary for commerce. However, the positive contributions of transportation are overshadowed by a range of severe negative impacts and challenges that significantly compromise the quality of life in urban settings. These challenges include the generation of environmental pollution, aggravated traffic conditions, street congestion, prolonged commute durations, and the consequent disruption of work-life balance. (Benevolo, C., Dameri, R. P., & D'auria, B., 2016). Nowadays cities are facing many technical, social, economic and environmental challenges. (Paiva, S., Ahad, M. A., Tripathi, G., Feroz, N., & Casalino, G., 2021). The examples of these challenges are presented in Table 1.

**Table 1.** Challenges and hurdles in contemporary cities

CHALLENGES IN CITIES		
TECHNICAL	SOCIO-ECONOMIC	ENVIRONMENTAL
<ul style="list-style-type: none"> <li>- security and cyber security</li> <li>- interoperability</li> <li>- infrastructure</li> <li>- the absence of universal standards</li> <li>- rapid urbanization</li> <li>- aging infrastructure</li> <li>- smart city implementation (IoT, data analytics, intelligent transportation systems, etc)</li> <li>- digital divide</li> </ul>	<ul style="list-style-type: none"> <li>- economic resilience</li> <li>- limited exposure to technology</li> <li>- implementation cost</li> <li>- unemployment and job displacement</li> <li>- inequality</li> <li>- social inclusiveness and quality of life and health</li> <li>- housing affordability and cost of living</li> <li>- influx of migrants</li> <li>- conventional mindset</li> </ul>	<ul style="list-style-type: none"> <li>- e-waste</li> <li>- ecological effects of technologies like 5G</li> <li>- climate change</li> <li>- pollution</li> <li>- natural disasters</li> <li>- global warming</li> <li>- greenhouse gas emissions</li> <li>- atmospheric issues</li> <li>- environmental friendliness of transport</li> <li>- reduce GHG emission</li> <li>- circular economy in terms of environmental goals</li> <li>- water reuse</li> </ul>

Source: own elaboration on the basis: Appio, F. P., Lima, M., & Paroutis, S. (2019)

Cities that adopt digital technologies to solve urban problems are often called 'smart cities', but the development of smart cities goes beyond the technical aspects of their evolution. The concept of smart cities has evolved as a popular approach solving urban problems and an arena for reviving urban innovation. (Quan, X., & Solheim, M. C., 2023). Investment in smart cities is all about making it easier, safer, and better to live in these cities (Shvetsova, O., Bialevich, A., Kim, J., & Voronina, M., 2023). Thus, most

governments make efforts to become a ‘smart city’. In the literature, many definitions exist for the term ‘smart city’. Some definitions emphasize technology as the most important factor in making a city smart. Other definitions focus on the human, social, cultural, economic, and environmental aspects underlying a smart city, (van Twist, A., Ruijter, E., & Meijer, A., 2023) The smart city is often characterized as a city that uses information and communications technology (ICT) infrastructure and devices to provide a safe, secure, equitable, accessible, convenient and inclusive environment for its citizens (Leung, K. Y., & Lee, H. Y., 2023). It’s worth emphasizing that ‘smart’ technologies like cameras, kiosks, drones, and autonomous vehicles are already reshaping cities and their functioning. (Gordon, E., Harlow, J., Teng, M., & Christofereetti, E. (2023). The concept of a smart city extends beyond technological advancements and encompasses various domains, including smart mobility. This entails a comprehensive approach to address critical challenges such as pollution reduction, traffic congestion facilitation, enhanced safety measures, noise mitigation, improved transfer efficiency, and cost reduction. Moreover, analysed literature proves that smart cities are associated with almost every aspect of human life, such as communication, transportation, education, water, energy, and health (Park, J., & Yoo, S., 2023).

The main domains of a smart city include smart infrastructure, smart governance, smart policies, smart transportation, smart healthcare, smart agriculture, smart education, smart economy, smart environment, smart industry, smart energy and, smart feedback mechanisms that help to truly realize the concept of a smart city ecosystem (Balakrishna, 2012; Guelzim *et al.*, 2016; Nam & Pardo, 2011; Obaidat & Nicopolitidis, 2016). In Table 2 some of the major domains of the smart city ecosystem are presented.

**Table 2.** Domains of smart city

smart energy	smart security	smart policies	smart industries	sustainable development
smart living	smart economy	smart governance	smart energy	smart healthcare
smart mobility	smart maintenance	smart agriculture	smart wellbeing	smart feedbacks
smart environment	smart services	smart users	smart education	smart communication

*Source: Abad, M. A., Paiva, S., Tripathi, G., & Feroz, N. (2020). Enabling technologies and sustainable smart cities. Sustainable cities and society, 61, 102301.*

Smart city initiatives emerging as potential answers to today's urban challenges, constituting our collective planning and response capability. Thanks to information and communication technology to strengthen the relationship between society and the built environment, improvements in governance are possible both in terms of function and form. In line with the neo-evolutionary viewpoint of the Triple Helix framework, smart

city initiatives epitomize a concept of a distinctive platform for innovation, bringing together enterprises, governmental entities, and scholars (Leydesdorff and Deakin, 2011). Smart cities are mostly regarded as ‘Intelligent Communities’, collaborative ecosystems that facilitate innovation by establishing connections among residents, public authorities, businesses, and educational institutions. These progressive clusters foster the growth of high-value activities within the ‘knowledge economy’. To encompass these elements comprehensively, Bill Hutchison (Hutchison et al., 2011) devised a pyramid framework known as the ‘Intelligent Community Open Architecture - i-COA’, comprising five levels. (Appio, F. P., Lima, M., & Paroutis, S., 2019)

### 5. Smart City Rankings - identifying the City Leaders

Smart cities provide a wide range of services designed to enhance the quality of life for residents. These services act as valuable support systems for local governments, making it easier to improve residents' well-being while also reducing administrative costs. Smart city initiatives aim to create cities that are both seamless and sustainable. Through this approach, they seek to enhance the overall living experience and make urban life more efficient for everyone. (Siddiqui, S., Hameed, S., Shah, S. A., Khan, A. K., & Aneiba, A., 2023).

These efforts have resulted in notable outcomes, as evidenced by rankings that assess cities' sustainability performance.

The Arcadis Sustainable Cities Index 2022 ranks 100 of the world’s cities revealing a strong European presence at the top, particularly with exceptional performances from three Scandinavian capitals: Oslo (1), Stockholm (2), and Copenhagen (4).

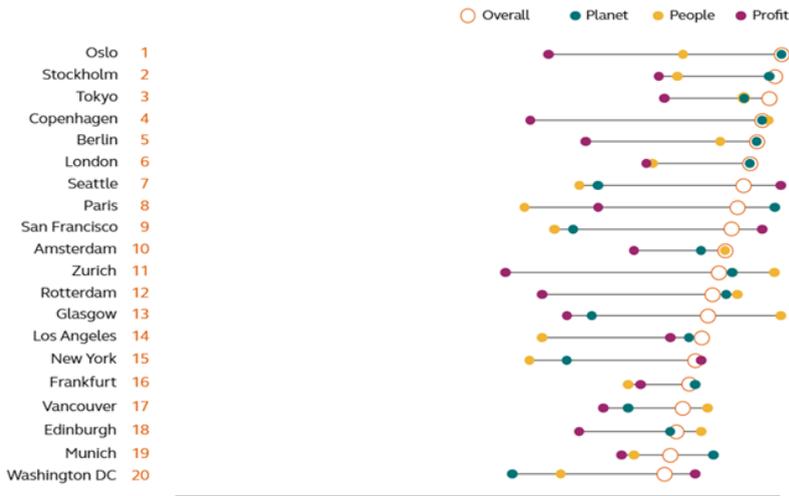


Figure 1. The Arcadis Sustainable Cities Index 2022 ranking  
 Source: The Arcadis Sustainable Cities Index 2022, Arcadis

The highest-scoring city on the 2022 Sustainable Cities Index ranking is Stockholm, followed by Oslo, Copenhagen, Lahti, and London. Seven of the top 10 cities are in the United Kingdom and Europe, attributable to sustainability leadership in countries in the European Union.

Produced by the Smart City Observatory The IMD-SUTD Smart City Index (SCI) assesses the perceptions of residents based on economic and technological criteria, including health and safety, mobility, governance, and environment. According to IMD Smart City Index 2023 Report, since 2019 Zurich, Oslo and Copenhagen are ahead of the pack.

**Table 3.** Ranking of smart cities

City	Rank 2023	Rank 2021	Rank 2020	Rank 2019
Zurich	1	1	1	1
Oslo	2	2	2	2
Canberra	3	–	–	–
Copenhagen	4	5	3	4
Lausanne	5	4	–	–
London	6	3	10	3
Singapore	7	7	7	10
Helsinki	8	9	5	6
Geneva	9	6	8	7
Stockholm	10	11	9	9
Hamburg	11	8	6	–
Beijing	12	17	22	30
Abu Dhabi	13	12	14	16
Prague	14	10	4	8
Amsterdam	15	13	11	11
Seoul	16	18	20	23
Dubai	17	14	19	13
Sydney	18	29	32	22
Hong Kong	19	33	34	38

Source: *smartcityindex-2023-v7.pdf (imd.org)*

The latest study unveils also the top 10 European cities that are at the forefront of successfully implementing smart technologies. The report named London as the smartest city in Europe. Amsterdam ranked in second place, followed by Berlin, Paris and Lisbon, as Europe's top 5 smart cities. London scored particularly highly on its technology infrastructure and green infrastructure. It has more EV charging stations and more green-certified buildings than any other European or American city featured in the study.

The IESE Business School University of Navarra reveals Cities in Motion Ranking. The 2022 CIMI (Cities in Motion Index) 2022 analyzed the cities across the following dimensions: economy, human capital, international profile, urban planning, environment, technology, governance, social cohesion, mobility and transportation. According to the CIMI ranking of the cities and their index value, the leading European cities are: London, Paris, Berlin, Amsterdam, Oslo, Copenhagen, and Munich. <sup>1</sup>

## 6. Results - activities and innovations in selected cities to support sustainable development

Cities are increasingly recognizing the importance of sustainable development and actively implementing various activities and innovations to achieve their sustainability goals. Sustainable cities engage residents in actions to protect the environment who participate in projects related to sustainable energy, mobility, and waste management.

<sup>1</sup> <https://media.iese.edu/research/pdfs/ST-0633-E.pdf>

Sustainable mobility in cities entails the integration of technology and innovative approaches to enhance transportation and mobility systems within urban areas. The concept of smart mobility seeks to tackle prevalent urban challenges including traffic congestion, pollution, limited parking space, and inefficient public transportation systems. By embracing smart mobility solutions, cities can pave the way for a greener, more connected, and more efficient future of urban transportation. (Benevolo, C., Dameri, R. P., & D'auria, B., 2016). Smart mobility in cities aims to create a more connected, accessible, and sustainable transportation ecosystem by leveraging technology, data, and innovative solutions. It offers the potential to enhance the quality of life for urban residents, improve economic productivity, and reduce the environmental impact of transportation systems. (Mangiaracina, R., Perego, A., Salvadori, G., & Tumino, A. (2017). The key benefits of smart mobility in cities are presented in Fig. 2.



Figure 2. Key benefits of using smart mobility in a smart city

Source: Paiva, S., Abad, M. A., Tripathi, G., Feroz, N., & Casalino, G. (2021). Enabling technologies for urban smart mobility: Recent trends, opportunities and challenges. *Sensors*, 21(6), 2143, p. 14.

There are a few examples of best practices in smart mobility implemented in European cities. Each city has its unique approach and set of initiatives, showcasing the diverse range of innovations in smart mobility across Europe, for example:

1. Amsterdam is perceived as a frontrunner in the realm of smart mobility. The city has successfully established an expansive network of cycling infrastructure, fostering a culture of cycling as a preferred mode of transportation. Furthermore, Amsterdam has implemented efficient public transportation systems that seamlessly integrate various modes of travel. Embracing sustainable practices, the city promotes electric mobility and actively explores pioneering solutions such as autonomous boats to facilitate transportation within its intricate canal network. Through these initiatives, Amsterdam exemplifies the transformative power of smart mobility, setting an inspiring example for other urban centers to follow.

2. Berlin has also emerged as a leading hub for smart mobility initiatives in Europe. Its innovative approach to transportation and urban development has resulted in cutting-edge solutions ranging from bike-sharing programs and electric vehicle infrastructure to intelligent traffic management systems. The most popular ones are car-sharing, public

transit apps, electric mobility, Mobility as a Service (MaaS), where multiple transportation options are integrated into a single platform.

3. The city of Gothenburg has been actively involved in conducting thorough real-world testing of self-driving cars, with a strong focus on safety, efficiency, and environmental advantages. Additionally, Gothenburg has implemented electric and autonomous buses in select areas to further enhance sustainable transportation options.

4. Helsinki has implemented a Mobility as a Service (MaaS) platform called Whim, which integrates various modes of transportation, including public transit, taxis, bikes, and car-sharing, into a single app. Users can plan and pay for their journeys seamlessly, making it easier to navigate the city using multiple transport options.

5. Paris has undertaken various initiatives to enhance smart mobility within the city. They have implemented a bike-sharing program named 'Vélib', introduced electric scooter-sharing services, and established an integrated ticketing system called Navigo. This system enables users to conveniently access multiple transportation modes using a single card, promoting efficient mobility experiences.

6. London has introduced the Oyster card as a key component of their transportation system. This innovative card enables commuters to effortlessly travel across various modes of transport, such as buses, trams or the London Underground. Additionally, London has implemented congestion charging as a measure to alleviate traffic congestion and promote the widespread utilization of public transportation.

7. Copenhagen has taken significant steps to enhance cyclist safety and ensure efficient mobility for its residents and visitors by prioritizing and investing in smart traffic management systems. Renowned for its cyclist-friendly infrastructure as the sustainable model of transportation, the city boasts an extensive network of dedicated cycling lanes, well-equipped bicycle parking facilities, and even traffic signals specifically designed to cater to the needs of cyclists.

8. Barcelona has made great advancements in smart mobility. The city has introduced a program for sharing bicycles, set up charging stations for electric vehicles, and implemented a smart parking system that helps drivers find available parking spots using sensors. Barcelona has also developed a user-friendly app that combines different transportation options and provides real-time information to travelers. These efforts have greatly improved the efficiency, convenience, and eco-friendliness of transportation in the city.

In the literature and online platforms, one can find many other examples of activities undertaken for smart city development, sharing cutting-edge ideas and showcasing impactful case studies that tackle urban challenges worldwide. The prime examples of smart cities that have embraced advanced technologies and innovative strategies to enhance urban living are Barcelona, Dubai, and Abu Dhabi. The city of Amsterdam has implemented various innovative solutions to enhance urban living. The tool dedicated to shaping a smart, green, and healthy future for the Amsterdam Metropolitan Area is the Amsterdam Smart City open innovation platform. Focusing on sustainability, technology, and citizen well-being, the Amsterdam Smart City platform plays a vital role in driving the development of forward-thinking. The Amsterdam Smart City (ASC) Programme was established in 2007 to facilitate the sustainable use of resources and boost the creative economy by testing innovative urban solutions (Noori *et al.*, 2020). The ASC expanded

partnerships, fields of programs and pilot projects from energy sectors to smart mobility, smart living, digital city, and other initiatives. The City of Amsterdam implemented also the Clean Air Action Plan striving to achieve compliance with the air quality guidelines set by the World Health Organization by the year 2030.

Green spaces are integral to building smarter cities and several city representatives at the Cities Climate Action Summit highlighted the importance of greening their cities. Among the underlined top concerns were the impact of the climate crisis on urban migration and the need for more investment in city-led solutions. Improvement of the environmental condition through the implementation of good practices in selected cities in recent years indicates that these measures have rational outcomes in terms of improving residents' quality of life, living standards, and health parameters, for the cities covered in the publication, namely: London, Amsterdam, Berlin, Copenhagen, and Warsaw. Just to give a few examples: The City of Berlin has taken various measures to improve its air quality over the last few years. In their air pollution control plan, the focus is mainly on measures regarding the transport sector, which is a major source of emissions. The initial measures involve a significant transition within the Berlin Transport Authority (BVG) towards greater adoption of electric vehicles, accompanied by an increase in financial incentives to promote their usage. Natural gas vehicles are also on the horizon in terms of countrywide environmental promotion. London aims to achieve the highest air quality among major global cities by 2050, surpassing legal obligations to safeguard human health and reduce disparities. London has implemented the 'Our Vision for Cleaner Air' initiative to support this goal. The action plan for the Sustainable Development Goals (SDGs) in Copenhagen involves a comprehensive mapping of the city's current contribution to achieving the UN's world goals. Additionally, it includes a strategic plan for implementing these goals into the city's management practices moving forward.

One of the initiatives is the 'Copenhagen Solutions Lab' - a project that aims to develop and implement innovative solutions for sustainable urban development in Copenhagen. The lab brings together a diverse group of stakeholders, including local government, private sector companies, academic institutions, and citizens, to collaborate on developing and testing new ideas and technologies that can help the city achieve its sustainability goals. The lab focuses on areas such as green mobility, energy efficiency, waste management, and social inclusion, and aims to create scalable solutions that can be replicated in other cities around the world. By fostering collaboration and innovation, the Copenhagen Solutions Lab is helping to create a more sustainable and resilient future for the city and its inhabitants. In Barcelona, Spain, the 'Superblocks' project was created, which turns parts of the city into pedestrian and bicycle-only zones, allowing residents to use urban spaces safely and without restrictions and changing the city's mobility.

Urban departments face enormous pressure to ensure the safety of all road users, including pedestrians and vehicles, particularly when it comes to critical infrastructure like intersections and road systems. One prominent initiative addressing this concern is the Vision Zero project adopted by the Swedish parliament in 1997 as Sweden's Traffic Safety Policy (Johansson R., 2009; Kristianssen, A. C., Andersson, R., Belin, M. Å., & Nilsen, P., 2018), which aims to eliminate all traffic-related fatalities and severe injuries while promoting safe, healthy, and equitable mobility for all. This project has gained significant traction in cities worldwide (Shvetsova, O., Bialevich, A., Kim, J., & Voronina, M., 2023).

Inclusive cities prioritize equal opportunities and equitable access to services and opportunities for every resident, fostering a sense of belonging and participation for all members of the community. Social innovations enable residents with different needs and abilities to use these services. The forefront example and a part of the C40 Cities network is 'Cycling Without Age' - a global initiative that was started in Copenhagen, Denmark, in 2012. The project aims to improve the quality of life of elderly people and people with disabilities by offering them free bike rides in specially designed trishaws. The rides are provided by volunteers who cycle the passengers around parks, streets, and other scenic areas.

In summary, it can be concluded that the selected cities, as indicated by the authors of the publication, have demonstrated significant effort in implementing environmentally-friendly solutions in line with the concept of sustainable development. This highlights a strong commitment to environmental action and innovative practices, with a particular emphasis on economic, sociological, social, technological, and spatial parameters. The objective of these initiatives includes improving the environmental condition and air quality not only in European cities but also beyond. Therefore, innovations become challenges in terms of transformation and future actions aimed at enhancing the residents' quality of life.

## 7. Conclusion

With the growth of the population in cities and the development of the concept of smart cities, monitoring and managing the environmental impacts of urbanization, as well as improving the daily lives of citizens become more and more important (Siddiqui, S., Hameed, S., Shah, S. A., Khan, A. K., & Aneiba, A., 2023).

The future of humanity is urban (Yigitcanlar, T., & Kamruzzaman, M., 2015). Activities for sustainable urban development are increasingly crucial in the face of the challenges of rapid population growth, urbanization, climate change, and environmental degradation. Nature-based solutions present a pivotal opportunity to convert risks into resilience by implementing integrated actions across urban landscapes. In the pursuit of achieving greater sustainability and efficiency in urban transportation, the concept of smart mobility has emerged as a transformative solution. Through the utilization of cutting-edge technologies and groundbreaking approaches, smart mobility has the potential to revolutionize intra-city movement by emphasizing sustainability, accessibility, and convenience. Numerous initiatives and measures have been deployed across EU member states to nurture the development of smart mobility. As an integral component of the broader smart city concept, smart mobility encompasses a diverse range of solutions, some of which have already been implemented in our cities (such as e-ticketing, e-parking, live-tracking, etc.), while others are currently in the experimental phase, such as autonomous vehicles. Undoubtedly, smart mobility stands as one of the most promising domains, as it holds immense potential to significantly improve the quality of life for all stakeholders involved in urban environments. (Benevolo, C., Dameri, R. P., & D'auria, B. (2016).

The analysis conducted in the article reveals that European cities are driving sustainable development in environmental, social, and economic aspects. This indicates that by implementing various ideas and practices, European cities have the potential to assume a

leading role in shaping a green and sustainable future. However, cities should cooperate internally and scale up good practices, serving as models for achieving the Sustainable Development Goals (SDGs) by demonstrating innovative approaches to sustainable urban development, becoming liveable, equitable, and resilient places that contribute to the well-being of both people and the planet. Well-planned, well-coordinated, and well-managed urbanization can be a powerful sustainable development tool.

When it comes to planning for future transportation, it's important for policymakers at all levels to consider the challenges that will arise from expected trends. They should also make use of IoT technologies to meet the changing needs of travelers and promote sustainable initiatives.. By doing so, policymakers can ensure that future transportation plans are in line with sustainability goals. (Porru, S., Misso, F. E., Pani, F. E., & Repetto, C. (2020)

Based on our findings, we recommend the following solutions to promote sustainable development in all European cities: (Ahad, M. A., Paiva, S., Tripathi, G., & Feroz, N., 2020)

1. Encourage the use of renewable energy sources to reduce carbon emissions and mitigate the impacts of climate change.
2. Foster the creation and adoption of smart mobility solutions to establish a transportation ecosystem that is interconnected, easily accessible, and environmentally sustainable.
3. Develop and implement smart transportation systems to reduce traffic congestion, air pollution, and greenhouse gas emissions.
4. Promote the use of sustainable building materials and green infrastructure to enhance the environmental sustainability of urban areas and promote carbon-neutral living spaces.
5. Foster community engagement and participation in sustainable development initiatives to create a shared sense of ownership and responsibility for the environment.
6. Implement solutions in intelligent water management, intelligent street lighting, and smart waste management services.
7. Implement healthcare services such as connected, smart devices that will improve healthcare management in a smart city (i.e. access to patient's health information at any time and from any location).
8. Include climate change and environmental science at every level of education
9. Imposing sustainability fees for visitors.
10. Prioritizing locally-led initiatives, which hold immense potential for scalability

Smart mobility stands as a crucial element that characterizes smart cities. In developing countries, where urbanization is happening rapidly and the demand for intelligent and cleaner transportation options is rising, the significance of smart mobility cannot be overstated. It is vital to recognize that the successful implementation of smart mobility solutions necessitates the cooperation and coordination of multiple stakeholders, such as government entities, transportation authorities, private enterprises, and the general public. Benevolo, C., Dameri, R. P., & D'auria, B. (2016) Moreover, it is essential to address concerns regarding data privacy, cybersecurity, and equal access to transportation in order

to ensure that the advantages of smart mobility are inclusive and sustainable. Mangiaracina, R., Perego, A., Salvadori, G., & Tumino, A. (2017).

The implementation of smart mobility in urban areas holds the promise of transforming transportation, enhancing the quality of life, and establishing cities that are more livable, efficient, and environmentally conscious. With technology constantly evolving and expected to progress exponentially in the future, the transition from smart mobility to a Mobility-as-a-Service (MaaS) model is anticipated. This transition will introduce a new dimension to transportation, encompassing vehicle sharing, carsharing, and carpooling, thereby reshaping the way people move within cities. (Paiva, S., Ahad, M. A., Tripathi, G., Feroz, N., & Casalino, G., 2021). Through the adoption of smart mobility practices aimed at achieving sustainable development, cities can effectively address the environmental repercussions of transportation. By doing so, they have the potential to improve air quality, decrease greenhouse gas emissions, enhance the overall quality of life, and stimulate economic growth (Šurdonja, S., Giuffrè, T., & Deluka-Tibljaš, A., 2020). Achieving a greener, more efficient, and equitable transportation system requires collaboration among stakeholders introducing effective policy frameworks and ongoing innovation. This is the fundamental aspect in driving the transformation towards a sustainable transportation system that benefits both the environment and society as a whole (Porru, S., Misso, F. E., Pani, F. E., & Repetto, C. (2020).

It is necessary to address those challenges and adapt integrated approaches to sustainable development ensuring the balance between economic growth, environmental protection, and improved quality of life for residents. Implementing such measures requires the cooperation of various actors - government, local authorities, the private sector, civil society, and researchers (Graute U., 2016). Participation of the representatives of diverse sectors will bring added value in order to achieve the goals of sustainable urban development, such as environmental sustainability, social inclusion, economic growth, resilience and community participation. These initiatives are likely to enhance the quality of life and the environment, in addition to generating sustained investment returns over the long run. According to the latest article released by SmartCitiesWorld, over 300 local authorities have officially declared a climate emergency, with three-quarters of them having implemented a climate action plan or strategy. A groundbreaking approach for local authorities to go beyond static guidelines is the implementation of the Anthesis Impact Tracker. This tool facilitates the tracking of progress on action plans, allowing users to collaborate, monitor, and transparently report to stakeholders.

The outcomes achieved by leveraging such instruments as well as the undertaken activities: further analysis of trend reports and current assessments, tracking of opinions, and participation in thematic discussions and working groups serve as a starting point for addressing further research questions toward a sustainable future.

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