European Smart Mobility–Aspects Connected with Bike Road System

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Smart mobility refers to the use of technology and data to enhance the efficiency, sustainability, and accessibility of transportation systems. It encompasses a wide range of transportation modes, including cars, bikes, buses, trains, and more.

Keywords: smart city ; smart mobility ; bike ; bikeway ; European Union ; quality of life

1. Introduction

Today, many cities are implementing smart mobility solutions into their important activities. Smart mobility refers to the use of technology and data to enhance the efficiency, sustainability, and accessibility of transportation systems. It encompasses a wide range of transportation modes, including cars, bikes, buses, trains, and more. The aim of smart mobility solutions is to optimize the use of existing transportation infrastructure, reduce congestion and emissions, improve safety and accessibility, and enhance the overall mobility experience for users [1][2][3][4]. These solutions often involve the use of sensors, data analytics, and advanced technologies such as Artificial Intelligence, the Internet of Things (IoT), and 5G networks. The ultimate goal of smart mobility is to create transportation systems that are more efficient, sustainable, and accessible, resulting in an improved quality of life for people in cities.

2. European Union Smart Mobility–Aspects Connected with Bike Road System's Extension and Dissemination

A smart city can be described as a modern and efficient city that is shaped by six key areas and is based on the active involvement of informed, independent, and decisive citizens [5][6][7]. This concept is distinct from earlier models of sustainable development, as it places a distinct emphasis on "mobility" as a crucial aspect that determines communication accessibility, ICT infrastructure, and innovative and safe transportation systems [8][9][10][11]. Smart cities are developing due to the intelligent utilization of digital information in various fields such as healthcare, mobility, energy consumption, education, knowledge transfer, and urban management [12][13].

A smart city can be defined as a well-functioning forward-looking city created by the above six areas and based on the active participation of informed, independent, and decisive citizens [5][6][14]. The essential element distinguishing this concept from previous models of sustainable development is the presence of "mobility" as a separate, important dimension defining communication accessibility, ICT infrastructure, and innovative and safe transportation systems [15]. Smart cities are emerging because of the intelligent use of digital information in areas such as health care, mobility, and energy consumption, based on papers [16][17] with meta-analyses on smart city concepts. It can be said that although there is no unanimous agreement on the dimensions of smart city concepts, there is a certain level of the accord, which can include concepts such as: "community", "governance", and "technologies". Additionally, it is worth mentioning that the continuous advancement in digital technologies has disrupted conventional business models in various sectors, allowing for the creation of new products and services. However, even though the reorganization of procedures and the development of new models aim to add value for customers, all signs indicate that the integration of product services in networked smart cities is not as effective as desired. This issue could even be utilized by policymakers to encourage public investment in creating strategies for building network structures. Regarding the sustainability of smart cities (third topic), the focus should not only be on economic growth and territorial expansion, but rather on a sustainable development approach that seeks to balance ecosystems and enhance the quality of life for citizens [17][18]. The literature on the smart city concept indicates a consensus on the primary characteristics of smart cities, which include: sustainability, advanced ICT technology, high-tech governance, citizen participation, an innovative and highly skilled society, and a knowledge-based economy. A smart city should cultivate a society that values innovation and has the skills needed to develop a knowledge-based economy while utilizing advanced ICT technologies to promote sustainability and participatory urban governance [17].

The main features of a smart city typically include [18][19][20][21][22]:

- The sustainable and efficient use of resources such as energy, water, and transportation;
- High-quality and accessible public services and infrastructure;
- A robust and integrated Information and Communication Technology (ICT) infrastructure;
- Active citizen engagement and participation;
- Innovative solutions for urban challenges and continuous improvement;
- A safe and secure living environment;
- Data-driven decision-making and management;
- The integration of various urban systems such as transportation, healthcare, education, and energy.

The use of modern methods of intelligent transportation can benefit city residents and contribute to an increase in their quality of life. The main beneficial methods of pro-ecological transportation in a smart city can be electric cars and bikes [23]. The future of transportation systems is a causing concern due to the scarcity, expensive cost, and environmental damage caused by fuel-based vehicles. The implementation of electric vehicles is seen as a possible solution to address these issues, and it could pave the way for significant advancements in connected and automated transportation systems [24].

In particular, the widespread use of the bicycle as a means of transportation can contribute to an increase in residents' quality of life [25][26][27]. Additionally, cycling is a form of exercise that can help improve cardiovascular health, reduce stress and anxiety, and increase overall physical fitness. Cycling is important for air quality. It does not emit pollutants, helping to improve air quality and reduce exposure to harmful substances, especially in cities. Cycling can help reduce noise pollution and promote a more active, livable, and sustainable urban environment. Cycling reduces the number of cars on the road, leading to less congestion and improved traffic flow. Widespread bicycle use can provide affordable transportation options for people who cannot afford cars or public transportation, improving accessibility and mobility for all [28][29][30].

It can be observed in the literature that biking is one of the factors which is connected with quality of life in a smart city [4][31]. The rising amount of bike usage is observed in many cities in European Union countries [32]. The smart city concept consists of six main areas—one of them is so-called smart mobility [33][34][35]. For example, Namiot, in his paper, points out that bicycles and their usage is an important element of smart mobility system's implementation in the city [36][37].

The integration of bike usage as a crucial aspect in smart city models demonstrates its significance in modern, smart cities. For instance, the authors of smart mobility indicators, Orłowski and Romanowska [38], include biking as one of the indicators used in their analysis. Similarly, the other authors of a smart mobility solutions analysis, view bike usage and bike-sharing systems as key components of the smart mobility concept [39]. A report from Deloitte highlights the importance of bike commuting in smart mobility and suggests that investing in bike infrastructure, improving smart biking systems, and promoting bike-sharing programs are essential for enhancing smart mobility in cities.

In another paper about smart mobility in smart cities [40], the authors also use traveling by bike as one of the factors of smart mobility. They also use bicycle routes as one of the sub-indicators in technical infrastructure indicators in their concept of smart mobility measurement.

A city without an extensive system of bike roads cannot be smart because it cannot use new concepts of bike sharing and other smart solutions. A bike-sharing system is a service in which bikes are available for individual users to share on a very short-term basis. In the newfangled bike-sharing solution, there is a special smartphone application to monitor the system. Those bike-sharing systems can be also very beneficial for cities [41]. The extensive bike road system is the first step to building bike-sharing facilities. After there are enough bike lanes in particular area, the local authorities can start to build a system of bike sharing [42].

In another study on smart mobility in smart cities, the authors also consider biking as a factor in their smart mobility analysis. They include bicycle routes as one of the sub-indicators in their technical infrastructure indicators [43][44][45]. A city lacking a robust bike road system cannot be considered a smart city, as it cannot implement new concepts such as bike sharing and other smart solutions. Bike-sharing systems, where bikes can be used for short-term sharing, can be monitored through smartphone applications. These systems can also bring benefits to cities [46][47]. The creation of a comprehensive bike road system is crucial for establishing bike-sharing facilities. Once there are enough bike lanes in a particular area, local authorities can implement bike-sharing systems [48][49].

Bicycles are important in smart cities because they offer numerous benefits such as [50][51][52]:

- Improved health and wellness: Biking is a great form of physical activity that can improve health and wellness.
- Reduced traffic congestion: Biking can reduce traffic congestion, leading to smoother and faster commutes.
- Lower carbon footprint: Biking produces no emissions, making it an environmentally friendly mode of transportation.
- Cost savings: Biking eliminates the need for fuel and maintenance costs, making it a cost-effective mode of transportation.
- Increased mobility: Biking provides a flexible and convenient mode of transportation, especially in densely populated areas.
- Improved air quality: Biking reduces air pollution, leading to cleaner air and better public health.

  Enhanced public safety: Biking creates a safer environment by reducing the number of cars on the road and reducing the risk of accidents.
- Increased social interaction: Biking promotes social interaction and community engagement, as it encourages people to get out and interact with others.
- Improved access to services and amenities: Biking provides improved access to services and amenities, making it easier for people to get around and access what they need.
- Promotes sustainability: Biking promotes sustainability by reducing carbon emissions, conserving energy, and reducing the demand for non-renewable resources.

Overall, bicycles can play a crucial role in creating smart, sustainable, and livable cities.

Of course, biking in smart cities can also have many problems and disadvantages. Main important of them are [50][51][52]:

- A lack of infrastructure: in some cities, there may be a lack of proper bike lanes, bike parking, and other infrastructure that is necessary for safe and convenient bike usage.
- Weather conditions: depending on the location, weather conditions such as rain, snow, and extreme heat can make bike usage difficult and unpleasant for riders.
- Theft and security concerns: bikes are often easier to steal than cars, which can be a concern for riders who leave their bikes parked in public places.
- Physical exertion: cycling can be physically demanding and may not be suitable for everyone, especially those with health problems or disabilities.
- Cost: although bikes are generally less expensive than cars, they still require an initial investment, maintenance, and replacement costs.
- Limited carrying capacity: bikes are often limited in terms of the amount of cargo they can carry, which can be a problem for people who need to transport large items or heavy equipment.
- Safety concerns: riding a bike on busy roads and intersections can be dangerous, and the risk of accidents is higher for cyclists than for drivers.

- Inconvenience: cycling may be time-consuming and less convenient than driving, especially for longer trips and errands.

The transformation of cities into smart cities with increased bike usage is driven by environmental problems caused by overreliance on traditional modes of transportation [53][54]. Climate change and pollution are major global and European concerns, and making cities safe, resilient, and inclusive is one of the key goals of the Agenda for Sustainable Development, which includes mobility as a crucial aspect [55][56].

Smart mobility is an important component of modern smart cities and is necessary for Polish cities due to high levels of air pollution, long traffic congestion, and the high number of car accidents, which negatively affect the safety of residents [57]. A balanced approach that incorporates innovative technology and the needs of residents is essential for the successful implementation of smart mobility solutions. The goal is not to focus on innovation itself, but to integrate technology, systems, infrastructure, and capabilities to achieve maximum impact [58][59][60][61].

Cycling, scootering, and other alternative modes of transportation are crucial in advancing the concept of smart mobility. Commuting by bike or scooter offers the benefits of reducing traffic congestion and emissions and promoting physical fitness, as well as reducing greenhouse gases emitted by cars [62][63][64].

As cycling becomes more popular, cities will adopt technology and bike-sharing systems as part of their strategy to become smarter [65]. Many cities promote bike usage and bike-sharing among citizens, and incorporate bike-related eco-friendly solutions [66][67].

The pro-environmental impact of smart mobility is a crucial aspect of creating sustainable and livable cities. Smart mobility refers to the integration of digital technology and data analysis to optimize and improve transportation systems. It is designed to create more efficient, accessible, and sustainable forms of mobility that reduce traffic congestion, air pollution, and carbon emissions [68][69][70][71][72][73].

The environmental impact of traditional transportation systems, particularly cars and trucks, is well documented. Automobiles are major contributors to air pollution, including carbon dioxide, nitrogen oxides, and particulate matter. The emissions from cars and trucks are a significant source of greenhouse gases, which contribute to climate change. Additionally, cars are a major source of noise pollution, which can negatively impact public health and the quality of life in cities [74][75].

Smart mobility solutions aim to reduce the negative environmental impact of traditional transportation systems. For example, the increased use of public transportation, cycling, and walking can reduce the number of cars on the road, leading to less traffic congestion, reduced air pollution, and lower carbon emissions. The use of electric vehicles and clean fuels can also help reduce the carbon footprint of transportation systems [76][77].

Because of the very important pro-environmental impact of smart mobility and biking, the cities need to extend their bike road system to be better prepared for new smart mobility solutions.

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