

Entry

Social Aspects of Smart Urban Mobility

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Definition: There is a growing interest in sustainable urban transport solutions in cities around the world. These changes, known as “smart urban mobility”, aim to reduce the negative effects of transport on the natural environment and enhance the standard of living for urban dwellers. It should be noted that in addition to this transformation’s technological aspects, modifying the city’s structure and architecture also has a social dimension. The transformation of urban mobility has a significant impact on social relations. Introducing new modes of transport, such as city bikes and electric scooters, creates new ways of moving around the city and can impact social interactions. This can increase social integration and a community’s sense of belonging. At the same time, it is necessary to consider the differences between social groups to ensure equal access to the benefits of these changes in addition to deeper social elements, such as changing the habits and expectations of residents and adapting solutions to the specific needs of each city. This paper aims to look at the social aspects of smart urban mobility, including the impact of these changes on the lives and relationships of city residents.

Keywords: urban mobility; smart mobility; social transformation; innovative mobility; sustainable mobility



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1. Introduction

Society’s functions are changing as technology progresses and the world’s population increases. These changes are particularly visible in the character of dynamically developing cities.

It can be said that cities are becoming one of the primary elements in the functioning of countries, economies and societies. It is significant that with the increase in population and urbanization, meeting citizens’ expectations and ensuring a comfortable and dignified life has become more problematic and demanding.

Nowadays, the relationship between society and technology and the economy is becoming closer, and cities play a key role in this field, which is why the idea of what is commonly referred to as “smart cities” has become extremely popular over the last few years [1]. These challenges also apply to mobility.

Smart urban mobility is a key element of the transformation (including greening) of cities toward a more sustainable, effective and friendly space for residents. Thanks to the use of modern technologies, data and innovative solutions, cities have the opportunity to create a better and more future-proof transport system that will respond to the needs of modern travelers, reduce the negative impact on the environment, and contribute to improving the quality of life in the city [2,3].

Research on changes in the spatial and economic structure of cities increasingly points to new development factors, such as advanced technologies that save time and energy, as well as human capital and social capital, which play extremely important roles in the development of cities. A modern city is not only its physical structure but also a huge network of cyber connections that strive to optimize the use of city resources and prevent negative effects resulting from its functioning, in accordance with the principle of sustainable development [4]. At the same time, all changes should aim to introduce zero or

low-emission solutions and technologies to eliminate the negative effects of human activity on the natural environment.

At the same time, it should be noted that these changes (related to smart urban mobility) should be consistent with the idea of green transformation, which can be defined as a wide range of activities aimed at reducing greenhouse gas emissions (including achieving climate neutrality), improving energy efficiency, focusing on renewable energy sources, introducing the concept of closed loop, as well as conducting research and development activities in this area. These aspects are characterized in the following sections.

2. Urban Mobility in the Smart City Concept

In the face of globalization, we can observe processes of knowledge diffusion, interpenetration of city functioning patterns, creation of hybrid solutions and the growing importance of local (community) initiatives in shaping urban spaces. Cities are currently struggling with many changes stimulated by both external and internal mechanisms. Therefore, it can be pointed out that there are various parallel phenomena that may shape a smart city.

The concepts of smart city and urban mobility are closely related both historically and practically. Historically, the development of urban mobility was one of the main factors that created the idea of a smart city. In cities with an increasing number of people and vehicles, there is a need to manage traffic, ensure safety and improve residents' quality of life. As technology progressed, modern technologies, such as computer-controlled traffic lights, traffic monitoring systems and passenger information systems, began to be used to optimize urban mobility.

In practice, the smart city concept is implemented by integrating advanced technologies in urban mobility systems, such as the Internet of Things (IoT), artificial intelligence (AI), and data analysis. This makes it possible to intelligently manage traffic, optimize routes and timetables, and improve transport accessibility for residents. For example, mobile applications enable residents to easily plan trips, share information about road conditions, and use on-demand transportation services. Moreover, the development of innovative solutions, such as autonomous vehicles or sharing electric bicycles or cars, is becoming more and more visible in the context of urban mobility in smart cities. As a result, the smart city concept influences the transformation of urban mobility, striving to create more sustainable, efficient and resident-friendly urban environments. Integrating modern technologies with transport systems aims not only to improve traffic and reduce pollution but also to improve residents' quality of life by providing them with easier access to various transport options and more comfortable and safe travel conditions.

A smart city is commonly defined by the following characteristics [5,6]:

- Smart economy, which is characterized by highly efficient and technologically advanced practices facilitated by ICT technology, fostering innovation in products, services, and business models; promoting local and global connections and the exchange of goods, services, and knowledge;
- Smart mobility, which integrates transport and logistics systems primarily powered by clean energy;
- Smart environmental management, where natural resources are utilized sparingly, efforts are made to increase renewable energy usage, and infrastructure such as electricity and water networks, street lighting, and public services are optimized for environmental and financial efficiency; ongoing monitoring and control of pollution; building renovations aimed at reducing energy consumption;
- Smart communities, which are cultivated through social diversity, tolerance, creativity, and engagement;
- Smart living, which ensures safe and healthy lifestyles amidst a rich cultural and residential landscape, with widespread access to ICT infrastructure enabling customized lifestyle choices, behaviors, and consumption patterns;

- Smart governance, which emphasizes social participation in decision-making, including strategic choices, transparency in operations, and the quality and accessibility of public services; intelligent public management allows for the organization and integration of various aspects of a smart city.

C. Crowe [7] distinguishes the following directions and phenomena that will shape ventures and projects related to smart cities in the near future:

- Technology and innovative data analysis solutions will help bridge the digital gap;
- Cities will implement technologies and policies that alleviate the congestion and pollution challenges caused by increased commercial vehicle activity;
- Urban centers will lead in actions aimed at mitigating climate change;
- The concept of a circular economy in transport will be used on a large scale;
- Systems related to cybersecurity and protection against ransomware attacks will be expanded;
- Technological progress will stimulate the building of civic participation;
- Cities will modernize their infrastructure to become more resistant to unpredictable events with a significant destabilizing impact on their functioning;
- There will be the development of shared mobility using low-emission technologies;
- Expansion and creation of electric vehicle charging infrastructure;
- Wireless powering of infrastructure and buildings will reduce cabling and maintenance costs but will also enable consumers to power smart homes and personal gadgets;
- Public libraries should be a center for community rebuilding (and perhaps a return to civic/civic discourse), workforce development, entrepreneurship, and positive social change and advancement.

The implementation of the smart city concept has a significant impact on environmental issues by promoting sustainable development, optimizing the use of resources and reducing the negative impact on ecosystems. By using advanced information, communication and energy technologies, a smart city aims to reduce greenhouse gas emissions, reduce air pollution and protect biodiversity.

Issues relating to the functioning of broadly understood mobility in urban areas are among the fundamental development directions of the smart city concept. This is due to the fact that ensuring the effective, sustainable and friendly functioning of cities is directly related to the mobility of residents and other stakeholders.

The elements of urban mobility in relation to the “smart” concept include:

- Intelligent traffic management systems: Use advanced algorithms and data from various sources, such as road sensors, surveillance cameras, and GPS systems, to optimize vehicle flow, reduce traffic jams and minimize travel time.
- Public transport integration: Includes information services for passengers, electronic payment systems, and intelligent solutions for managing the fleet of public transport vehicles, which ensures better accessibility and efficiency of public transport.
- Electric and autonomous vehicles: The development of electric and autonomous (driverless) vehicles reduces greenhouse gas emissions and improves road safety. In addition, electric cars can be integrated with smart energy grids, which enables effective energy management.
- Vehicle sharing and on-demand transport services: Digital platforms enable easy vehicle sharing for both cars and e-bikes, reducing the number of vehicles on the road and optimizing the use of parking space.
- Mobile applications and information systems: Provide users with easy access to information about routes, timetables, road conditions and the availability of various transport options. They also enable travel planning, ticket purchases, and parking space monitoring.
- Infrastructure for pedestrians and cyclists: Investments in sidewalks, bicycle paths, and city bike stations help to increase the safety and attractiveness of pedestrians and cyclists as alternative means of transport.

- **Chargers for electric vehicles:** The development of charging infrastructure for electric vehicles in public and private places is crucial to promoting electromobility and providing users with convenient charging infrastructure.

Smart urban mobility is a key element of the transformation of cities towards a more sustainable, effective and friendly space for residents. Thanks to the use of modern technologies, data and innovative solutions, cities have the opportunity to create a better and more future-proof transport system that will respond to the needs of modern travelers, reduce the negative impact on the environment and contribute to improving the quality of life in the city.

3. Smart Urban Mobility as an Element of the Green Transformation

Smart urban mobility is an integral part of the green transformation of transport as it introduces technological innovations that significantly reduce pollutant emissions, increase energy efficiency and promote more sustainable forms of transport. Traditional means of transport, such as combustion cars, are the main sources of CO₂ emissions and other harmful substances in cities. Smart urban mobility promotes alternatives such as electric vehicles, bicycles, electric scooters and public transport that generate much less pollution, thus contributing to reducing a city's carbon footprint.

Therefore, the assumptions, as well as the direction of changes and implemented innovations, are consistent, while the green transformation is a broader socio-economic phenomenon, which is described below.

The term "green development of the economy" is understood to mean a new path of socio-economic development that implements sustainable development goals in a more effective way. The definition of the concept of "green growth" covers four priority areas: biodiversity and ecosystem services, climate change, sustainable management of natural resources with particular emphasis on water resources and forests, and more efficient use of raw materials. The so-called "greening of the economy" is considered on many levels and covers a number of narrower issues, such as the development of clean technologies, renewable energy sources, improving energy and material efficiency, changing the consumption and production model to a more sustainable one, integrated product policy, green public procurement, jobs or ecological fiscal reform [8–19].

In the context of ecology and "greening the economy", the European Union has made the greatest progress due to the political decisions and reforms outlined in the European Green Deal (EGD) [20–22], the strategic blueprint shaping future economic progress.

Thanks to the provisions contained in the EGD, Europe is to become the first climate-neutral continent with a modern and competitive economy. The initiative highlights the need for a holistic and cross-sectoral approach in which all policy areas contribute to the overarching goal of achieving climate neutrality.

The European Union strongly advocates for the green transition, viewing it as a gradual and ongoing shift towards decarbonizing the economy. This transition aims to foster well-being by embracing a new sustainable model of economic development while also addressing the socio-economic and ecological dimensions of sustainable growth [23]. It encompasses not only the energy sector but also all sectors of the economy that can adopt business models conducive to decarbonization and adherence to the principles of the circular economy. Consequently, the EU integrates systematic backing for green innovations, technologies, and investments into all its public policies [24] and sets similar expectations for all aspiring member countries.

The Green Deal Roadmap [25] stands as a far-reaching strategic plan [26] sanctioned by the European Commission in December 2019. Its overarching objective is to propel Europe toward becoming the initial climate-neutral continent by 2050, targeting a 55% reduction in emissions compared to 1990 levels. While each EU member pursues climate neutrality independently, five member states have enshrined climate neutrality goals into law, with Sweden aiming for 2045 and Denmark, France, Germany, and Hungary aiming for 2050.

At the forefront of the Green Deal lies the imperative to shift towards clean energy and the sustainable management of resources. This trajectory of progress is anticipated to spawn novel avenues for innovation, investment, and employment. The anticipated advantages of the Green Deal encompass improved air quality, pristine water sources, fertile soil, and biodiversity conservation. It also entails refurbishing energy-efficient structures, access to wholesome and affordable food, enhanced public transportation networks, advancing cleaner energy sources, and integrating cutting-edge clean technologies. Furthermore, it envisions the production of longer-lasting goods that can be repaired, recycled, and repurposed, as well as the cultivation of future-proof occupations and the provision of skills training for the transition. Ultimately, the Green Deal aims to cultivate a globally competitive and resilient industrial landscape [20,27].

In December 2019, the EU embraced the Green Deal, outlining its ambition to evolve into a climate-neutral continent by 2050. Subsequently, the EU enacted its inaugural Climate Law, enshrining the objective of climate neutrality into legislation. This comprehensive endeavor culminated with the introduction of a long-range financial strategy and a series of 55 regulations delineating the requisite measures for realizing the Green Deal's objectives.

The green transformation of urban mobility in the context of social aspects is a comprehensive process of adapting transport systems in cities, striving to minimize the negative impact on society and promoting sustainable development. It includes both technological and social measures aimed at reducing emissions of harmful substances, improving air quality and ensuring safe, accessible and fair access to various forms of transport for all social groups. As part of this transformation, the priority is to promote alternative means of transport, such as public transport, cycling and walking, while limiting the use of vehicles powered by fossil fuels. There are also efforts to increase the availability of transport for people with different needs, reduce road congestion and limit spatial segregation by creating urban environments conducive to social integration and improving the quality of life of residents.

It should be noted that green transformation (including the urban mobility dimension) is an extremely complex process that includes economic, technological, environmental, administrative and social aspects.

Economic aspects of the green transformation of urban mobility include analyzing costs and benefits related to introducing new technologies and transport solutions. The introduction of low-energy means of transport and the reduction of harmful emissions can generate savings in the long term by reducing dependence on fossil fuels and costs related to environmental pollution and public health. However, this requires initial investment in infrastructure and public education.

The technological aspects of the green transformation of urban mobility focus on developing and implementing modern solutions, such as electric and autonomous vehicles, intelligent traffic management systems, and digital platforms supporting vehicle sharing. The use of advanced technologies allows for the optimization of transport systems, improved safety and increased efficiency.

Environmental aspects related to the green transformation of urban mobility focus on reducing greenhouse gas emissions, air pollution and noise reduction in the city. Switching to electric vehicles, bicycles, or public transport powered by renewable energy can significantly reduce the negative impact of transport on the natural environment and the health of residents.

Administrative aspects of the green transformation of urban mobility include the development of appropriate policies and regulations to promote sustainable transport and support investments in transport infrastructure. The introduction of financial incentives, such as tax breaks or subsidies for the purchase of electric vehicles, and the development of urban plans favoring pedestrians, cyclists and public transport are crucial to the success of the transformation.

The selection of social factors for further analysis is justified due to the important role of society in the process of urban mobility transformation. The urban community

is the ultimate recipient of changes in the transport system, so understanding its needs, preferences and barriers is crucial for effectively planning and implementing the green transformation. Researching social aspects allows us to consider social diversity and the availability of transport for people with different needs and ensure that the urban mobility transformation benefits all city residents.

4. Social Aspects of the Development of Smart Urban Mobility

4.1. Characteristics of Smart Urban Mobility

Smart mobility encompasses the utilization of technology and intelligent solutions to enhance the efficiency of transportation systems. These enhancements can be broadly categorized into four key areas: mitigating pollution, alleviating traffic congestion, reducing travel time and costs, and enhancing the safety of transportation methods. Consequently, smart mobility solutions hold the promise of fostering improved connectivity and accessibility while minimizing environmental and economic burdens. The risks identified primarily revolve around the economic and social impacts, with occasional considerations for technological, environmental, ethical, and political/legal consequences associated with smart mobility applications [28].

Smart urban mobility solutions involve many different stakeholders [28]:

- National and local authorities;
- Road/rail management;
- Transport (public) companies;
- Vehicle manufacturers;
- Mobility platforms.

Smart mobility applications encompass various solutions dedicated to enhancing the provision of mobility services, such as on-demand mobility platforms and shared vehicle systems. In urban settings, initiatives like car-sharing and the more recent introduction of shared electric scooters are swiftly gaining traction. Additionally, these applications tackle issues of interoperability and efficiency in transportation modes by incorporating multimodal platforms, journey planners, and intelligent traffic management systems. Furthermore, they strive to mitigate environmental and quality-of-life impacts associated with traffic by implementing smart parking solutions, city tolls, and low-emission zones [28–31].

The goals of smart mobility encompass a range of objectives, including promoting mixed-modal access, prioritizing clean and non-motorized options, and integrating Information and Communication Technology (ICT) [32]. Additionally, these objectives aim to reduce traffic congestion, transfer costs, and air and noise pollution while enhancing transfer speed and overall safety [32]. In a broader context, smart transportation is perceived as a contributor to an improved quality of life for citizens in smart cities [28], aligning in part with traditional sustainable urban mobility objectives. Smart mobility covers aspects related to mobility within smart cities, the sustainability of transport networks, integrated platforms, sustainable, intelligent, and cooperative vehicle technologies, as well as fostering a sustainable and safe environment, incorporating elements of behavioral economics, e-participation, and crowdsourcing.

4.2. Social Aspects of the Development of Smart Urban Mobility

Smart urban mobility is a complex area, but four main dimensions can be identified: vehicle technology, intelligent transport systems, data and travel information and new mobility services. Each of these dimensions can affect social spheres, which can be divided into seven issues [28]:

- Affordability of mobility;
- Accessibility of key services;
- Social equity;
- Health conditions;
- Safety and security;
- Social cohesion;

- Working conditions.

4.2.1. The Impact of Vehicle Technology on the Social Sphere

Vehicle technology within the realm of smart mobility plays a crucial role in enhancing fuel efficiency and improving overall safety in automobiles, thereby positively impacting health and safety outcomes. The predominant focus of this technology on information technology (IT) introduces a potential security challenge, as vehicles essentially transform into 'iPads on wheels' that are susceptible to hacking. Notably, much of the innovation in vehicle technology is concentrated on high-end segments, given the initial high costs associated with emerging technologies. This economic divide raises concerns about accessibility, with less affluent households facing barriers to adopting the latest technologies, potentially creating a temporary split between smart and non-smart cars along income lines. Consequently, less affluent households may experience delays in accessing the most advanced automotive technologies [33,34].

4.2.2. The Impact of Intelligent Transport Systems on the Social Sphere

Progress in Intelligent Transportation Systems (ITS) introduces new challenges. The integration of connected cars and truck platoons has the potential to create a more cohesive and coordinated traffic environment, departing from the current 'free for all' scenario. The envisioned safety benefits of connected cars are apparent, although security concerns outweigh those in the Vehicle Technology dimension. Initial grievances related to the working conditions of truck drivers in platoons have surfaced, citing reduced alertness and a shift in tasks. Affordability and social equity issues persist, mirroring the current scenario with driving assistance systems. Technologies like adaptive cruise control and cooperative cruise control are predominantly available in the highest car segments, with a gradual and slow 'trickling down' effect [28].

4.2.3. The Impact of Data and Travel Information on the Social Sphere

The data dimension in smart mobility encompasses real-time information on passengers and travelers, personalized travel assistance, logistics planning, IT systems aligning supply and demand for mobility, big data solutions often linked to smart city developments, and security architectures for generated traffic data. A key consideration for social sustainability is whether this data-centric work will remain focused on cars or extend to other modes of mobility. If it stays car-centric, car drivers gain advantages in accessing key services and possessing knowledge of travel options and available capacities. Real-time information and personalized travel assistance have the potential to benefit all individuals needing mobility to access services [28].

Currently, research primarily concentrates on car-related information, aiming to optimize road capacities, potentially leading to higher car densities and increased traffic, particularly in urban areas, raising health and safety concerns. Nevertheless, real-time information could also enhance the efficient use of existing car and truck capacities, promoting social cohesion. The affordability and social equity of information services are pivotal considerations, as accessibility to these services by individuals with lower incomes is crucial. Difficulty in affordability may result in personalized travel information becoming an additional advantage for the wealthier segment of the car-driving population [28,35–37].

4.2.4. The Impact of New Mobility Services on the Social Sphere

The emergence of new mobility services, such as ridesharing, car sharing, innovative biking systems, integrated mobility modes, smartphone-enabled demand and ticketing solutions, and on-demand ride services, has the potential to disrupt established arrangements in the taxi industry, as well as impact rental and lease companies. This disruption has sparked debates on potential declines in working conditions within these organizations. However, there is also an optimistic perspective, foreseeing reduced individual car traffic, enhanced utilization of existing car capacities, and a positive impact on social cohesion.

While concerns about working conditions and debates persist, there is potential for increased accessibility to key services for non-car drivers, contingent on the success of ridesharing and on-demand ride services. This success, in turn, relies on the willingness of car drivers to share their vehicles. The anticipated reduction in car traffic and more efficient use of cars could contribute to improved health and safety outcomes.

4.2.5. The Impact of Smart Urban Mobility on Selected Social Spheres

It should be noted that smart urban mobility concepts, solutions and technologies affect various spheres of society:

- **Affordability of mobility:** By promoting alternative modes of transport, such as public transport, city bikes or on-demand transport services, smart urban mobility tools can reduce travel costs for residents. Electric vehicles and vehicle sharing can also reduce operating costs in the long run.
- **Accessibility of key services:** Improving the accessibility of public transport and integrating various transport options make it easier for residents to access key services such as health care, education, work, and shopping.
- **Social equity:** Smart urban mobility tools can reduce disparities in access to transport and services, especially for people with lower incomes, seniors, people with disabilities, and residents of areas with low transport accessibility. By promoting public transport, bike sharing and on-demand transport services, these solutions can increase social justice.
- **Health conditions:** Reducing exhaust emissions through the use of electric vehicles and promoting non-emission means of transport contributes to improving air quality, which has a beneficial effect on the health of residents, reducing the risk of respiratory and cardiovascular diseases.
- **Safety and security:** Intelligent traffic management systems, road monitoring, and user information services can improve road safety by reducing the number of road accidents and increasing awareness among road users.
- **Social cohesion:** The availability of various modes of transport and the integration of public transport promote social cohesion, enabling residents to move around the city more easily, participate in social life, and have access to a variety of places and events.
- **Working conditions:** Improving the availability of public transport and reducing traffic congestion can improve working conditions by reducing commuting time and travel stress, which translates into greater productivity and employee satisfaction. Additionally, developing the public transport and electromobility sectors may create new jobs.

5. Conclusions

In the evolving landscape of urbanization and technological advancements, cities are experiencing significant transformations, becoming hubs of innovation and key players in integrating smart solutions. The concept of “smart cities” has gained prominence, with a focus on improving urban mobility for sustainability and efficiency. Smart urban mobility, characterized by the use of modern technologies, data, and innovative solutions, aims to create a more future-proof transport system that meets the needs of modern travelers while minimizing environmental impact.

The social aspects of smart urban mobility encompass various dimensions, including vehicle technology, intelligent transport systems, data and travel information, and new mobility services. Vehicle technology plays a crucial role in enhancing fuel efficiency and safety but raises concerns about accessibility, particularly for less affluent households. Intelligent transport systems introduce challenges and potential benefits, such as cohesive traffic and safety improvements, but also issues related to working conditions and affordability. Data and travel information offer real-time insights that can enhance mobility for all, but affordability remains a key consideration. New mobility services, such as ridesharing and

car sharing, have the potential to disrupt traditional arrangements, sparking debates about working conditions.

However, there is optimism about reducing individual car traffic and improving utilization of existing capacities, contributing to social cohesion. Overall, the development of smart urban mobility presents opportunities for positive social impacts, including increased safety, reduced pollution, and improved accessibility to key services, but also raises challenges related to equity, affordability, and the potential divide between smart and non-smart car users. It underscores the importance of aligning technological advancements with sustainability and social equity principles in the pursuit of creating smarter and more inclusive cities.

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