CHALLENGES OF NEW TECHNOLOGIES IN THE FUNCTION OF MOBILITY AND SUSTAINABLE DEVELOPMENT / IZAZOVI NOVIH TEHNOLOGIJA U FUNKCIJI MOBILNOSTI I ODRŽIVOG RAZVOJA

Anja Maria Došlo[1]
[1]Internacional University Travnik in Travnik, Ul.Aleja Konzula-Meljanac bb, BiH
e-mail: anjamariadoslo@iu-travnik.com

Stručni članak
https://www.doi.org/10.58952/zr20261501262
UDK / UDC 62:656:502.131.1

Abstract
Emerging technologies are reshaping mobility toward greater sustainability by enabling electrification, automation, connectivity and shared services. While offering pathways to lower emissions, optimized resource use, and inclusive transport systems, their implementation faces significant hurdles. This paper provides a structured examination of these challenges, categorized into technological and operational barriers, economic and infrastructural constraints, socio-ethical and acceptance issues, regulatory and governance gaps, and unintended environmental rebound effects. Drawing on interdisciplinary literature from transportation engineering, sustainability studies, urban planning and information systems research it highlights interdependencies among barriers and discusses mitigation strategies. The analysis underscores the need for holistic, adaptive policy frameworks, public-private collaboration and context specific approaches, particularly in developing and transition regions to realize the full potential of technology driven sustainable mobility while avoiding exacerbation of inequalities or new vulnerabilities.

Keywords: *sustainable mobility, technological innovation, environmental sustainability*
JEL classification: R41, O33, Q56, R42

INTRODUCTION

Mobility is a fundamental component of modern societies and a key driver of economic development, social inclusion and territorial cohesion. In the context of accelerating urbanization, climate change and technological advancement, mobility systems are undergoing profound transformations driven by new technologies. Innovations such as electric vehicles, intelligent transport systems, autonomous mobility and digital platforms are increasingly promoted as essential tools for achieving sustainable development, particularly in relation to environmental protection, energy efficiency and reduced greenhouse gas emissions (Banister, 2008., Geels, 2012.).

The integration of new technologies into mobility systems is closely aligned with global sustainability frameworks, including the United Nations Sustainable Development Goals (SDGs), especially Goal 9 (Industry, Innovation and Infrastructure), Goal 11 (Sustainable Cities and Communities) and Goal 13 (Climate Action) (United Nations, 2015.). From a policy perspective, technological innovation in transport is often framed as a solution to congestion, pollution and inefficiencies in traditional mobility models (European Commission, 2020.). However, critical scholarship cautions that technological progress alone does not guarantee sustainability and may generate new forms of inequality, environmental pressure and governance challenges (Urry, 2007., Sheller & Urry, 2006.).

One of the central debates in contemporary mobility studies concerns the tension between technological optimism and socio-technical complexity. While smart mobility solutions promise cleaner and more efficient transport, their implementation depends on complex interactions between infrastructure, institutions, market actors and social behavior (Geels, 2012.). issues such as resource-intensive battery production, digital divides, data privacy and the uneven distribution of technological benefits raise important questions about the long-term sustainability of technology-driven mobility transitions (Newman & Kenworthy, 2015., Gossling, 2020.).

Furthermore, the rapid deployment of new mobility technologies challenges existing regulatory and governance frameworks. Many legal systems struggle to keep pace with innovations such as autonomous vehicles and platform-based mobility services, creating regulatory gaps related to safety, accountability, labor rights and environmental standards (Marsden & Reardon, 2017.). This paper examines the key challenges associated with the adoption of new technologies in the function of mobility and sustainable development. By critically analyzing environmental, economic, social and governance-related dimensions, the study aims to contribute to a more nuanced understanding of how technological innovation can support sustainability goals without undermining social equity and long-term resilience. Rather than viewing technology as an end in itself, the paper emphasizes the need for integrated, human-centered and policy-driven approaches to sustainable mobility transitions.

1. THEORETICAL FRAMEWORK

The theoretical framework of this paper is grounded in the interdisciplinary relationship between technological innovation, mobility systems and the concept of sustainable development. Understanding this relationship requires an integration of theories from transport studies, environmental policy and socio-technical transitions. At the core of this framework is the concept of sustainable development, which refers to development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This concept is typically structured around three interconnected pillars, environmental protection, economic efficiency and social equity. In the context of mobility, sustainable development implies the creation of transport systems that are environmentally responsible, economically viable and socially inclusive (World Commission on Environment and Development, 1987.).

Closely related to this is the concept of sustainable mobility, which focuses on minimizing the negative environmental impacts of transportation while maintaining accessibility and efficiency. Sustainable mobility emphasizes the reduction of greenhouse gas emissions, the promotion of energy-efficient transport modes and the integration of alternative mobility solutions such as public transport, cycling and shared mobility services (European Commission, 2020.). Another important theoretical perspective is the socio-technical systems approach, which views mobility not only as a technological system but as a complex interaction between technology, society, institutions and infrastructure. According to this approach, technological innovations alone are insufficient to achieve sustainable mobility, instead, systemic changes are required, including behavioral shifts, policy reforms and institutional adaptation (Geels, 2002.).

In this context, the theory of socio-technical transitions provides a useful analytical framework for understanding how new mobility technologies emerge and become integrated into existing systems. It highlights the role of innovation niches, regulatory frameworks and market dynamics in shaping the transition from traditional transport systems to more sustainable alternatives. Furthermore, the concept of smart mobility has gained prominence in recent years, particularly in the development of smart cities. Smart mobility relies on digital technologies, data analytics and intelligent transport systems to improve the efficiency, safety and sustainability of mobility services. It is closely linked to the idea of mobility-as-a-service (MaaS), which integrates different modes of transport into a unified, user-centered system (OECD, 2021.). This framework also incorporates elements of governance theory, which emphasizes the role of public institutions, regulatory mechanisms and multi-level governance in managing technological change. Effective governance is essential for ensuring that new mobility technologies contribute to sustainability goals while addressing issues such as equity, data protection and environmental impact.

2. NEW MOBILITY SERVICES (NMS)

New Mobility Services (NMS) denote a set of digitally enabled, user centered transport solutions that move beyond traditional, ownership-based mobility models. NMS include services such as ride-hailing, car-sharing, bike and scooter-sharing. Mobility-as-a-Service (MaaS) platforms, and on demand public transport. These services rely heavily on digital technologies, including mobile applications, real-time data, artificial intelligence and platform-based coordination, to optimize travel behavior and improve accessibility. NMS are often promoted as instruments for reducing private car ownership, lowering greenhouse gas emissions and increasing the efficiency of transport systems. By encouraging shared use of vehicles and integrating multiple transport models into a single digital interface, NMS have the potential to support environmentally sustainable and socially inclusive mobility patterns. When properly governed, NMS can contribute to reduced congestion, improved land use efficiency and enhanced accessibility for urban populations (Banister, 2008.).

3. GOVERNANCE AND SOCIO-ENVIRONMENTAL CHALLENGES OF NEW MOBILITY TECHNOLOGIES

The rapid diffusion of new technologies in mobility systems has intensified scholarly debate regarding their actual contribution to sustainable development. While innovations such as electric vehicles, autonomous transport and data driven mobility platforms are often framed as inherently sustainable solutions, research increasingly emphasizes that their outcomes depend on broader governance structures, social contexts and environmental trade-offs (Banister, 2008., Geels, 2012.).

As a result, governance and socio-environmental challenges have emerged as the central analytical dimension for understanding the sustainability of technology driven mobility transitions.

From an environmental perspective, new mobility technologies present both opportunities and risks. Electric vehicles and intelligent transport systems have the potential to significantly reduce local air pollution and greenhouse gas emissions. However, their environmental benefits are closely linked to energy sources, battery production processes and life-cycle impacts (Gossling, 2020.). The extraction of critical raw materials such as lithium and cobalt raises concerns about resource depletion, ecological degradation and global environmental injustice (Newman & Kenworthy, 2015.). These dynamics challenge the assumption that technological substitution alone can achieve sustainability without addressing consumption patterns and systemic demand for mobility.

Social equity constitutes another major challenge in the deployment of advanced mobility technologies. Access to smart and low-carbon transport solutions is often unevenly distributed, favoring urban populations and higher income groups while marginalizing rural communities and socially vulnerable populations (Sheller & Urry, 2006.). The digitalization of mobility services further exacerbates exclusion for individuals, lacking digital literacy or access to technological infrastructure. Governance and regulation play a decisive role in shaping the outcomes of technological mobility transitions. Existing legal frameworks frequently lag behind rapid technological developments, particularly in areas such as autonomous vehicles, algorithmic decision making and platform-based mobility services (Marsden & Reardon, 2017.).

Regulatory gaps raise critical questions concerning safety, accountability, data protection and labor rights, especially as private technology companies increasingly influence public transport systems. Effective governance therefore requires adaptive regulatory mechanisms capable of balancing innovation with public interest and democratic accountability.

The integration of new mobility technologies challenges traditional models of transport planning and policymaking. Sustainable development requires a shift from technology centered approaches toward human-centered and system-oriented strategies that integrate land use planning, environmental policy and social objectives (Geels, 2012.). Without such integration, technological solutions risk reinforcing car dependency, increasing energy demand and undermining climate goals (Urry, 2007.). New technologies should be understood not as neutral tools, but as socio-technical systems embedded within political, economic and cultural structures. Their contribution to sustainable development depends on inclusive governance, ethical regulation and public participation.

4. FUTURE PROSPECTS

The future of mobility in the context of sustainable development will largely depend on the successful integration of new technologies with environmental, economic and social objectives.

Technological innovation is expected to continue driving the transformation of transport systems, particularly through the expansion of electric mobility, automation and digital connectivity. These developments have the potential to significantly reduce greenhouse gas emissions, improve energy efficiency and enhance the overall sustainability of mobility systems (European Commision, 2020.).

One of the most important future trends in the widespread adoption of electric and low-emission vehicles. As battery technologies improve and charging infrastructure becomes more accessible, electric mobility is likely to become a dominant component of transport systems. This transition will contribute to reducing dependence on fossil fuels and mitigating the environmental impact of transportation.

Another key development is the advancement of intelligent transport systems and autonomous vehicles. These technologies can optimize traffic flow, reduce congestion and improve road safety. In combination with data analytics and artificial intelligence they enable more efficient use of existing infrastructure and support the development of smart cities.
Digitalization will also play a central role in shaping future mobility. The concept of mobility-as-a-service (MaaS) is expected to expand, integrating various modes of transport into unified digital platforms. This approach can enhance accessibility, reduce the need for private car ownership and promote more sustainable patterns of mobility (OECD, 2021.).
However, the realization of these future prospects depends on addressing existing challenges. Governments and policymakers will need to develop comprehensive regulatory frameworks that support innovation while ensuring safety, data protection and environmental sustainability. Public and private sector cooperation will be essential for financing infrastructure and promoting the adoption of new technologies.
In addition, future mobility systems must prioritize social inclusion and equity. Ensuring that all segments of society have access to new technologies and sustainable transport options is crucial for achieving balanced development. Investments in education, digital literacy and infrastructure in underserved areas will play a key role in this process.
The future of mobility offers significant opportunities for advancing sustainable development, but it also requires coordinated efforts across multiple sectors. By aligning technological innovation with sustainability goals, societies can create more efficient, inclusive and environmentally friendly mobility systems.

5. POLICY RECOMMENDATIONS

The successful integration of new technologies into mobility systems, in line with sustainable development goals, requires comprehensive and well-coordinated policy measures. Governments, international organizations and private stakeholders must collaborate to ensure that technological innovation contributes to environmental protection, economic efficiency and social inclusion.
One of the key policy priorities is the development of clear and adaptive regulatory frameworks. As new mobility technologies such as autonomous vehicles, artificial intelligence and digital mobility platforms evolve rapidly, legal systems must keep pace with these changes. Policymakers should establish regulations that address safety standards, liability issues and data protection, while also encouraging innovation and technological development (European Commission, 2020.).
Another crucial recommendation is investment in sustainable infrastructure. The transition to electric and smart mobility requires the expansion of charging networks, smart grids and digital communication systems. Public investment, combined with private sector participation is essential to ensure the availability and accessibility of such infrastructure, particularly in less developed and rural areas.
Environmental policies must also play a central role in guiding technological development. Governments should promote low-emission and energy-efficient transport solutions through incentives, subsidies and environmental standards. At the same time, it is important to adopt a life-cycle approach that considers the environmental impact of technologies from production to disposal.
In addition, policymakers should focus on social inclusion and accessibility. Sustainable mobility systems must be designed to serve all segments of society, including vulnerable and marginalized groups. This includes ensuring affordable access to mobility services, improving public transport systems and addressing the digital divide that may limit access to new technologies (OECD, 2021.).

Another important area is data governance and cybersecurity. As mobility systems become increasingly digitalized, large amounts of data are generated and processed. Governments must establish clear rules regarding data ownership, privacy protection and cybersecurity to build public trust and ensure the safe use of digital mobility solutions.
Furthermore, international cooperation is essential for addressing global challenges related to mobility and sustainability. The development of common standards, exchange of best practices and coordinated policy approaches can facilitate the global transition toward sustainable mobility systems. Finally, policymakers should invest in education and capacity building. Promoting digital literacy and raising awareness about sustainable mobility can support the adoption of new technologies and encourage more responsible behavior among users (United Nations, 2022.).

CONCLUSION

The integration of new technologies into mobility systems represents a profound transformation with significant implications for sustainable development. Innovations such as electric vehicles, intelligent transport systems, autonomous mobility and New Mobility Services (NMS) offer considerable potential to reduce environmental impacts, enhance efficiency and improve accessibility. However, technological innovation alone is insufficient to ensure sustainability. The effectiveness of these technologies depends fundamentally on governance structures, social contexts and environmental constraints.
The analysis has shown that while new mobility technologies can contribute to lower emissions and more efficient transport systems, they also introduce new challenges related to resource consumption, digital inequality, data governance and regulatory capacity. Environmental benefits are closely tied to energy sources and life-cycle impacts, while social outcomes depend on equitable access and inclusive design. Without appropriate regulatory frameworks, NMS and other platform-based mobility solutions risk reinforcing existing inequalities and increasing overall transport demand rather than promoting sustainable mobility patterns.
Governance emerges as the central determinant in aligning technological innovation with sustainable development goals. Adaptive and integrated policy frameworks are necessary to balance innovation with public interest, ensuring accountability, safety and social justice.
Effective governance must also promote the integration of new technologies with public transport systems, land-use planning and broader environmental policies. In this sense, sustainability in mobility is not merely a technological challenge, but a socio-technical and political process.
Ultimately, new technologies should be understood as means rather than ends in the pursuit of sustainable mobility. Their contribution to sustainable development depends on human-centered planning, democratic oversight and long term environmental responsibility. By adopting holistic and inclusive approaches, policymakers and stakeholders can harness technological innovation to support mobility systems that are not only efficient and smart, but also equitable, resilient and aligned with the principles of sustainable development.

REFERENCE

1. Banister, D. (2008.), The sustainable mobility paradigm, Transport Policy
2. Geels, F. W. (2012.), A socio-technical analysis of low-carbon transitions: Introducing the multi-level perspective into transport studies, Research Policy
3. Geels, F.W. (2002.), Technological Transitions as Evolutionary Reconfiguration Processes, Research Policy
4. Gosling, S. (2020.), Risks, resilience and pathways to sustainable mobility, Journal of Transport Geography
5. Marsden, G. & Reardon, L., (2017.), Questions of governance: Rethinking the study of transportation policy, Transport Policy
6. Newman, P. & Kenworthy, J., (2015.), The End of Automobile Dependence: How Cities Are Moving Beyond Car-Based Planning, Island Press
7. Sheller, M. & Urry, J., (2006.), The new mobilities paradigm, Environment and Planning A
8. Urry, J., (2007.), Mobilities, Polity Press

Articles

1. European Commission, (2020.)., Sustainable and Smart Mobility Strategy – Putting European Transport on Track for the Future, Brussels: European Commission
2. OECD, (2021.), ITF Transport Outlook, Paris
3. United Nations, (2022.), Sustainable Development Goals Report, New York
4. World Commission on Environment and Development, (1987.), Our Common Future, Oxford