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Towards inclusive mobility between innovation and social rights: the role of Smart Shared Mobility

*Verso una mobilità inclusiva tra innovazione e diritti sociali: il ruolo della Smart Shared Mobility**

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Abstract

The paper analyses transportation poverty as a barrier to social inclusion, examining its economic, availability, and accessibility dimensions. The study highlights the potential of smart and shared mobility—including autonomous vehicles—to mitigate inequalities, while also considering the risks associated with the digital divide and regulatory gaps. In this framework, social leasing is proposed as a tool to promote access to sustainable mobility, with the hope of a harmonized European regulatory framework that can combine technological innovation and social justice.

Il contributo analizza la povertà dei trasporti quale barriera all'inclusione sociale, esaminandone le dimensioni economica, di disponibilità e di accessibilità. Lo studio evidenzia le potenzialità della mobilità intelligente e condivisa — inclusi i veicoli autonomi — nel mitigare le disuguaglianze, pur considerando i rischi connessi al digital divide e alle lacune regolatorie. In questo contesto, il social leasing può divenire uno strumento per favorire l'accesso alla mobilità sostenibile, auspicando un quadro normativo europeo armonizzato che sappia coniugare innovazione tecnologica e giustizia sociale.

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Keywords: Transport poverty; Smart and shared mobility; Autonomous vehicles; Social inclusion.

Summary: 1. The need to define and address the concept of transport poverty. – 2. Strategies for sustainable and shared mobility. – 3. Opportunities and challenges arising from the development of autonomous vehicles and smart mobility. – 4. Economic inclusivity as a fundamental tool to remove barriers to access sustainable mobility. – 5. Towards an European shift in smart mobility field as a catalyst for social cohesion.

1. The need to define and address the concept of transport poverty.

Mobility is not merely a necessity, but a fundamental element of social inclusion[1]. According to the European Pillar of Social Rights, every individual has the right to access a range of essential services, including transportation[2].

While the ability to move freely represents both a necessary condition and a legal-logical prerequisite for accessing education, healthcare, and the labor market, the phenomenon of «transport poverty»[3] emerges with force, affecting vulnerable groups within the population, hindering their access to services, and reinforcing social exclusion.

The European Union has provided a formal description of transport poverty and, to address this phenomenon, established the Social Climate Fund under Regulation (EU) 2023/955[4], which allocates € 86.7 billion between 2026 and 2032 for vulnerable families and users.

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[1]*This paper is an in-depth analysis of the lecture titled "Autonomous vehicles and vulnerable people: How technology can improve mobility for all," delivered as part of the LLM Personality Rights program at the Department of Private Law and the Faculty of Law at the University of Pretoria on September 4, 2025. Mobility as a Right (MaaR), as a transformative approach to transport planning that recognises mobility as a fundamental enabler of economic and social participation. Built upon decades of work on passenger rights and social inclusion, MaaR offers transport practitioners a framework to create more equitable, sustainable, and inclusive mobility systems across Europe. https://e-library.iclei.org/uploads/ICLEI-ES-recommendations-on-MaaR-05-2025-pages.pdf

[2]See Principle 20 of the European Pillar of Social Rights, available at the following link (https://commission.europa.eu/system/files/2017-12/social-summit-european-pillar-social-rights-booklet_en.pdf), which states that every person has the right to access essential services, including transportation.

[3] The European Commission Recommendation (EU) 2025/1021 of 22 May 2025 on transport poverty (https://transport.ec.europa.eu/transport-themes/social-issues-equality-and-attractiveness-transport-sector/social-issues/accesstransport_all_en#:~:text=Access%20to%20transport%20for%20all%20is%20a%20political%20priority%20of,EUR%2086.7%20billion%20from%202026.) provides guidance to Member States to ensure fair and accessible mobility and calls on them to address transport poverty through accessible, sustainable, and affordable mobility solutions that support social and climate justice. Key measures include improving public transport in low-income areas, introducing social leasing programs for zero-emission vehicles, and enhancing accessibility for vulnerable groups. The document aims to promote social and climate justice by ensuring equitable access to mobility for all Europeans. To support these efforts, the Joint Research Centre has launched the Transport Poverty Hub, an online platform offering high-resolution maps that visually identify areas with well-developed and underdeveloped transport networks, providing policymakers with valuable insights on regional connectivity.

[4] See Regulation (EU) 2023/955 of the European Parliament and of the Council of 10 May 2023, which establishes a Social Climate Fund and amends Regulation (EU) 2021/1060 (OJ L 130, 16.5.2023, p. 1, ELI:

Article 2, paragraph 2, of this regulation introduces the first and only existing definition of the phenomenon, according to which «transport poverty» means *"the inability or difficulty of individuals and families to afford the costs of public or private transport, or the inability or difficulty to access the means of transport necessary to reach essential socio-economic services and activities, taking into account the national and geographical context"*.

From this textual formulation, three main dimensions can thus be identified: a) economic, that is, the ability of individuals and families to afford the costs of public or private transport; b) transport availability, that is, the existence and frequency of transport services; c) accessibility, that is, the ability of individuals and families to reach essential socio-economic services and activities within a reasonable time frame[5].

Accessibility encompasses the availability of transport options, the spatial and temporal distribution of activities (considering the various modes of transport and their respective average speeds), and the characteristics of individuals, such as income, age, disability, health conditions, and other socioeconomic factors. These interrelated dimensions collectively shape an individual's, a household's, or a group's ability to access essential services.

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http://data.europa.eu/eli/reg/2023/955/oj). Among the objectives of this legislation is to support public and private entities in the development and provision of on-demand sustainable mobility, shared mobility services, and active mobility solutions. Previously, a definition was also provided in *Transport Poverty: Definitions, Indicators, Determinants, and Mitigation Strategies – Final Report*, Directorate-General for Employment, Social Affairs and Inclusion, November 2014: *"An individual or household is in transport poverty when they do not have (suitable) public or private transport (options) available to them and/or when the transport system limits access to (other) essential goods and services and/or when they have difficulty or are unable to meet the costs of transport."* On this topic see K Lucas, G Mattioli, E Verlinghieri, A Guzman 'Transport poverty and its adverse social consequences. Proceedings of the Institution of Civil Engineers (2016) Transport, 353-365; M del Carmen Pérez-Peña, Transport poverty: a systematic review of definitions, indicators and mitigation strategies (2021) Sustainability, 1451-1473.

[5] For studies on access poverty, see J Farrington, 'Rural accessibility, social inclusion and social justice: towards conceptualisation' (2005) Transport, 1-12; K Martens, 'An index to measure accessibility poverty risk' (2019) Measuring Transport Equi*ty*, 39-55. On the link between mobility and social participation, see J Preston, 'Accessibility, mobility and transport-related social exclusion' (2007) Transport, 151-160; G Currie et al, 'Investigating links between transport disadvantage, social exclusion and well-being in Melbourne — Preliminary results' (2009) Transport Policy, 97-105; K Lucas, 'Transport and social exclusion: Where are we now?' (2012) Transport Policy, 105-113; T Schwanen et al, 'Rethinking the links between social exclusion and transport disadvantage through the lens of social capital' (2015) Transportation Research Part A: Policy and Practice,123-135; K Martens, '*Transport Justice: Designing Fair Transportation Systems*'(London, Routledge 2016). On the concept of social equity, 'equity' and transport justice, see, P Jones, 'Social impacts and equity issues in transport: an introduction' (2012) Trasport, 1-3; M Sheller, 'Racialized Mobility Transitions in Philadelphia: Connecting Urban Sustainability and Transport Justice' (2015) 27 City and Society, 70-91.https://anthrosource.onlinelibrary.wiley.com/doi/10.1111/ciso.12049. On the comparison between energy poverty and transport poverty, see, N Simcock et al, '*Energy Poverty and Vulnerability: A Global Perspective* (Routledge, London 2017). On the relationship with 'transport wealth', see G Stokes, K Lucas, 'National Travel Survey Analysis' (2011) TSU Working Paper Series, 1053. Although these terms have different meanings, they show significant overlaps and sometimes imply similar approaches and assumptions; T Kuttler, M Moraglio, '*Re-thinking Mobility Poverty: Understanding Users' Geographies, Backgrounds and Aptitudes'* (London, Routladge 2022); ID, Mobility poverty (2025) Geography, Planning and Tourism 2025, 242-243. In this sense, other terms commonly used in transport studies include 'transport economic accessibility' [T Litman, Evaluating Transportation Equity (2021) Victoria Transport Policy Institute, , www.vtpi.org; K Lucas et al, 'Transport poverty and its adverse social consequences', (2016) Transport, 353-365]; 'forced car ownership' [A Curl et al, 'Household car adoption and financial distress in deprived urban communities: A case of forced car ownership?' (2018) Transport Policy, 61-71]; and 'car-related financial stress', G Mattioli, M Colleoni, 'Transport Disadvantage, Car Dependence and Urban Form' (2015) Understanding mobilities for designing contemporary cities. Cham: Springer International Publishing, 171-190.

Consequently, assessing accessibility requires diverse and complex datasets, which can be costly and difficult to obtain, despite the significant advances in digitalization that have helped overcome many past obstacles.

A fourth dimension, namely the "adequacy of the transport system," although not included in the official definition, proves useful for describing the system's usability.

Adequacy encompasses additional factors such as reliability, suitability for users engaged in professional or caregiving activities (including commuting and transporting children), system safety, availability beyond peak hours, absence of barriers, and the provision of useful information regarding travel options[6].

This broader perspective allows for a more comprehensive evaluation of how transport systems meet the practical needs of diverse populations.

2. Strategies for sustainable and shared mobility.

Thus, as underscored in the EU Recommendation on transport poverty[7], it is essential to guarantee mobility that is not only accessible and affordable but also equitable, recognizing it as a fundamental enabler of social inclusion.

Member States are encouraged to employ a range of policy instruments to finance a just energy transition, simultaneously promoting clean and sustainable mobility solutions[8].

These include on-demand sustainable transport services, shared mobility schemes, and active mobility initiatives such as cycling and walking infrastructure. Importantly, such programs should be designed primarily to benefit individuals and communities in vulnerable conditions[9], ensuring that

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[6] J Cludius, V Noka, N Unger, L Delfosse, et al, *Transport poverty: definitions, indicators, determinants, and mitigation strategies*, European Commission Directorate-General for Employment, Social Affairs and Inclusion, October (2024). It provides a comprehensive analysis of transport poverty in Europe, in fact the work outlines key definitions and concepts, identifies indicators useful for measuring the various dimensions of transport poverty, and examines the determinants influencing its prevalence. Furthermore, the report proposes mitigation strategies and best practices to reduce inequalities in access to mobility, drawing on evidence from national case studies. In this regard, the report represents an essential resource for policymakers, researchers, and practitioners aiming to promote equitable, inclusive, and sustainable mobility.

[7] Commission Recommendation (EU) 2025/1021, cited. On this topic: T Schwanen, 'Rethinking the links between social exclusion and transport disadvantage through the lens of social capital' (2015) Transportation Research Part A, 123-135; D Banister, *Transport, Sustainability and Social Equity* (London Routledge 2019), 45-70.

[8] The introduction of the emissions trading system for the building and road transport sectors (ETS2), scheduled for 2027, represents a critical phase in the European Union's climate policy, posing both structural challenges and economic opportunities for Italy. Particular attention is given to the integration of ETS2 auction revenues with the Social Climate Fund (SCF) through the proposal of a *"proactive"* governance model aimed at mitigating regressive impacts on vulnerable groups and micro-enterprises, thereby turning decarbonization into a driver of social equity. See MASE data consultation (June 2025/2026); Social Climate Plans Tracker, Italy Report 2026. On this topic: A Biondi, 'Climate policy and social equity in the EU Emissions Trading System' (2021) Climate Policy, 320-338; M Grubb, 'Distributional impacts of emissions trading: theory and evidence from transport and energy sectors' (2022) Energy Economics, 215-231; S Carattini, 'Carbon pricing and inequality: evidence from Europe' (2020) Journal of Environmental Economics and Management, 234-253; F Castagneto Gissey, ETS reform and social justice: the case of transport emissions in the EU (2023) Environmental Politics, 182-199.

[9] The Transport Poverty Lab (TPLab) aims to propose solutions for addressing the issue of transport poverty in a systematic and structured manner, serving as a platform for analysis and participatory

those most affected by barriers to mobility are prioritized in policy and investment decisions.

The Regulation[10] goes beyond providing a definition of transport poverty by specifying the conditions under which it manifests and the factors that contribute to its persistence.

It further establishes a formal definition of vulnerable transport users, identifying them as *"individuals and households experiencing transport poverty, as well as individuals and families, including those with low or lower-middle incomes, who are significantly affected by price increases resulting from the inclusion of greenhouse gas emissions from road transport under Directive 2003/87/EC and who lack the means to acquire zero- or low-emission vehicles or to shift to sustainable alternative transport modes, including public transport".*

This comprehensive definition highlights the multifaceted nature of vulnerability, encompassing economic, environmental, and infrastructural dimensions.

By articulating these criteria, the Regulation emphasizes the need for targeted, inclusive interventions that combine environmental sustainability with social justice.

Policies addressing transport poverty must therefore not only alleviate immediate financial burdens but also facilitate access to low-emission and shared mobility options, reduce barriers to participation in essential socioeconomic activities, and enhance overall accessibility for those historically excluded from efficient transport networks.

In doing so, the EU framework seeks to align climate policy objectives with the promotion of social equity, recognizing that true sustainability requires attention to both ecological and social dimensions of mobility.

In line with this policy direction, the European Union's new guidelines for the development of the Trans-European Transport Network (TEN-T)[11] explicitly prioritize the prevention and reduction of transport poverty.

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planning that involves trade associations, local authorities, research institutes, transport sector companies, and stakeholders in sustainable mobility. The first document produced by the TPLab is titled "Green Paper on Transport Poverty." The Green Paper developed an initial transport poverty matrix as a key framework for interpreting the phenomenon, useful for analysis, measurement, and policy formulation so that everyone can participate in the ecological transition and the right to mobility is equitably distributed among different segments of the population. With regard to the degree of vulnerability, the matrix identifies four macro-categories: absolute vulnerability: low income and lack of adequate transportation options in the area; territorial vulnerability: adequate personal resources, but insufficient mobility options, often compensated by the use of private cars; personal vulnerability: well-served area, but personal capacity limited by economic, physical, or social barriers; accessibility status: adequate personal capacity and availability of efficient mobility options.

[10] Regulation (EU) 2023/955, cited. See, S Perdana, Regional inequality of the European ETS-2 Energy Policy (2026), 114891-114891 ; G Valdmanis, 'Transport Poverty: An Urgent Issue in the Future of the EU Climate and Energy Policy'(2025) Latvian Journal of Physics and Technical Sciences, 29-45 ; Y Cui, 'The economic burden of EU ETS2 carbon pricing on single and childless households' (2025) Frontiers in Environmental Science, https://doi.org/10.3389/fenvs.2025.1572246; J Nill, The Distributional Impact of EU Climate and Energy Policies on Households and Possible Mitigation Measures (2025) European Economy Discussion Papers, 1-52.

[11] The Trans-European Networks in the transport, energy, and telecommunications sectors (TENs), as established under the Treaty on the Functioning of the European Union (Art. 170), are designed to promote the interconnection and interoperability of national infrastructure networks. These networks aim not only to strengthen the cohesion of the internal market but also to ensure that peripheral, island, and landlocked regions are effectively linked to the Union's central regions. By enhancing connectivity across borders and sectors, TENs play a critical role in reducing regional disparities, facilitating the free

Indeed, TEN-T infrastructure is expected to ensure seamless mobility and accessibility for all users, with particular attention to those who are economically disadvantaged or otherwise vulnerable[12].

Member States are therefore encouraged to adopt a strategic approach to combat and prevent transport poverty. T

his begins with the identification of affected groups, based on available data and a thorough understanding of the underlying causes of transport deprivation in their respective territories, considering all relevant dimensions—economic, spatial, temporal, and social.

A crucial element of this strategy is the integration of services, which entails providing vulnerable users with access to zero-emission vehicles, whether new or second-hand, through mechanisms such as social leasing schemes[13].

Such initiatives should be accompanied by the development of adequate charging infrastructure and complementary services to ensure that access to sustainable mobility is both practical and reliable.

By combining targeted interventions with infrastructure planning, Member States can foster an inclusive transport system that mitigates social exclusion while supporting the broader objectives of environmental sustainability and the EU's low-carbon transition.

When designing such programs, several factors should be considered, including income levels, accessibility to existing public transport and shared mobility services, as well as travel distances and journey times.

It is therefore crucial to expand mass public transport coverage while integrating it with shared mobility solutions, such as car-sharing, e-bikes, e-scooters, autonomous shared vehicles, and carpooling, along with Mobility-as-a-Service (MaaS) and active mobility options.

Moreover, the potential introduction of autonomous shared vehicles, self-driving shuttles, and remotely operated transport should be assessed to provide affordable and efficient mobility in disadvantaged communities, addressing first and last mile challenges while ensuring appropriate legal frameworks are in place to facilitate such services.

It is equally important to embed gender equality, inclusivity, and accessibility —including economic accessibility — into the design and implementation of policies, ensuring that public transport and shared mobility services are accessible to passengers with disabilities or reduced mobility.

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movement of people, goods, energy, and information, and supporting the broader objectives of economic, social, and territorial cohesion within the European Union.

[12] Regulation (EU) 1315/2013 (and subsequent amendments) on the Union guidelines for the development of the Trans-European Transport Network (TEN-T) establishes a comprehensive framework to promote the construction, modernization, and interconnection of transport infrastructure across the European Union. The Regulation sets strategic priorities for the development of core and comprehensive network corridors, aiming to enhance cross-border connectivity, reduce bottlenecks, and ensure seamless mobility for people and goods. It emphasizes interoperability, sustainability, and multimodality, integrating road, rail, inland waterways, ports, and airports into a cohesive network. Subsequent updates have reinforced the TEN-T framework to align with climate objectives, support digitalization of transport systems, and address regional disparities, particularly by connecting peripheral, remote, and landlocked regions to the EU's central economic hubs. Overall, Regulation 1315/2013 provides the legal and strategic foundation for a modern, resilient, and inclusive European transport network capable of supporting economic growth, social cohesion, and environmental sustainability.

[13] This topic will be examined in greater detail below.

Complex mobility patterns, such as multi-modal journeys, and the diverse needs of social groups, particularly individuals who cannot afford private car ownership, must also be considered.

Support should be provided through investments in digital infrastructure that is widely available, especially in remote and rural areas, to enable the development and dissemination of digital transport services.

These services can offer a wider array of travel options, reduce waiting times, travel durations, and transport costs, while also introducing innovative solutions, where appropriate, such as mobility budgets through Mobility as a Service (MaaS) applications[14] or digital wallets, providing targeted support for vulnerable users.

In the end, digital solutions must be complemented with non-digital alternatives to ensure that information and services remain accessible to users with limited digital literacy or internet access. This approach, often referred to as inclusive digitalization[15], ensures that MaaS platforms are accompanied by offline options for individuals with low technological proficiency, thereby preventing digital exclusion and promoting equitable access to sustainable mobility[16].

3. Opportunities and challenges arising from the development of autonomous vehicles and smart mobility.

A promising frontier for promoting inclusion is represented by autonomous vehicles. These vehicles, capable of navigating without human intervention through advanced artificial intelligence and sensor systems, have the potential to profoundly transform the mobility experiences of vulnerable populations.

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[14] D A Hensher, Future bus transport contracts under a mobility as a service (MaaS) regime in the digital age: Are they likely to change?' (2017) Transportation Research Part A: Policy and Practice, 86-96, where the Author examines the evolution of public bus transport contracts within the context of Mobility as a Service (MaaS) in the digital age. The author highlights also how the integration of digital services and MaaS platforms can fundamentally transform traditional contractual arrangements, enabling greater flexibility in route management, resource allocation, and service personalization for users. He emphasizes the challenges related to regulation, the economic sustainability of contracts, and the need to ensure equitable access for vulnerable groups, noting that digitalization can represent both an opportunity to improve efficiency and inclusiveness in public transport and a risk of exacerbating inequalities if not accompanied by adequate governance strategies as well.

[15] See Report on "Inclusive Digitalization": studies by the European Union Agency for Fundamental Rights (FRA) on access to technologies for persons with disabilities. It The report explores how digital services, platforms, and applications, including e-government, mobility services, and digital learning, can either enable or restrict participation in social, economic, and civic life. It emphasizes the importance of designing technologies in accordance with the principles of universal design, accessibility standards, and assistive solutions, while highlighting the role of inclusive policy frameworks and targeted support measures in bridging the digital divide and ensuring equal access to technological innovations for all users.

[16] European Commission (2020). *Strategy for Sustainable and Smart Mobility: the European Action Plan to Drive the Digital Transformation of the Sector*. On this topic: K Gkoumas, F L Marques dos Santos, M Stępniak, F Pekár, 'Research and innovation supporting the European Sustainable and Smart Mobility Strategy: A technology perspective from recent European Union projects' (2021) Applied Sciences, 11981-11981; C Sluiter, *The new EU Sustainable and Smart Mobility Strategy: A local and regional perspective*, (CIDOB Publications 2021), 1-27.

However, it is essential to carefully consider the specific contexts in which such technologies can serve as effective tools.

The notion of vulnerability is inherently complex and difficult to delineate, as it often encompasses social, economic, cognitive, and physical dimensions[17].

Primary attention is therefore directed toward individuals with physical or cognitive disabilities who require accessible mobility solutions.

Equally, elderly populations may benefit from autonomous systems, given their higher exposure to mobility-related risks and limitations.

Furthermore, individuals with limited digital or financial literacy may face additional barriers in interacting with advanced technological solutions, highlighting the need for inclusive design.

Vulnerable road users, such as pedestrians, cyclists, and other non-motorized participants, must also be considered, as they remain disproportionately exposed to accidents and road hazards.

In sum, while autonomous vehicles offer significant promise, realizing their potential as instruments of social inclusion requires nuanced, context-sensitive planning that addresses the multifaceted nature of vulnerability and ensures equitable access to technological innovations.

In this context, the introduction of autonomous shuttles and remotely operated vehicles could also play a pivotal role in addressing mobility challenges in disadvantaged communities, providing affordable and efficient transport services where conventional systems struggle to reach.

However, despite their potential to enhance autonomy, improve quality of life, and foster social participation, such forms of mobility carry inherent risks concerning the social sustainability of infrastructural digitalization processes[18].

A lack of careful consideration of ethical and value-based dimensions during technological implementation could exacerbate existing socio-economic disparities, in clear contradiction with the principle of substantive equality.

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[17] One may refer to S Viciani, *Le tutele civilistiche dei soggetti vulnerabili per disabilità psico-fisica* (Napoli, ESI 2024); L Azzena, 'Divieto di discriminazione e posizione dei soggetti deboli. Spunti per una Teoria della debolezza' (2005) Quaderni della Rivista di diritto costituzionale, 35 ff. ; M. Barnes, 'Disability, Rights and Law, (London,,Routledge 2012), 101-125; E Flynn, *Vulnerability and Legal Protection: Comparative Perspectives*, (Hart Publishing, 2018), 55-83; P Alston, *International Human Rights and the Protection of Vulnerable Groups* (Oxford University Press 2013), 210-235.

[18] JF Bonnefon, A Brette, I Sharkey, 'The social dilemma of autonomous vehicles' (2016) 352 (6293) Science, 1573-1576; European Economic and Social committee, *Opinion on the social implications of autonomous vehicles and connectivity*, (2018), 1-24; l Linde, 'Ethical and safety challenges in the deployment of autonomous mobility' (2021) 99 Transport Policy, 12-25; M Hevelke, 'Algorithmic decision-making and public accountability in self-driving vehicles' (2020) 35 *A*I & Society, 45-60. These works collectively highlight the ethical, social, and safety challenges posed by the deployment of autonomous vehicles. Bonnefon et al. emphasize the moral dilemmas faced by algorithms in scenarios where harm cannot be entirely avoided, showing how public perception and trust are critical for acceptance. The European Economic and Social Committee stresses the social impacts of connectivity and autonomy, including the risk of digital exclusion and the importance of ensuring equitable access for vulnerable populations. Linde explores the practical and regulatory challenges in implementing autonomous mobility, focusing on safety standards, liability issues, and the integration of inclusive design principles. Hevelke further analyzes the need for transparency and accountability in algorithmic decision-making, warning that reliance on automated systems may introduce new forms of vulnerability if ethical and social considerations are not embedded in the design process. Collectively, these studies argue that the technological transition toward autonomous vehicles must be guided by principles of social justice, accessibility, and public trust to ensure that the benefits are widely shared, and risks minimized.

In accordance with principles of distributive justice and social cohesion, it is therefore essential to ensure an equitable distribution of the benefits arising from technological innovation, preventing the entrenchment or expansion of existing gaps.

From a regulatory perspective, autonomous mobility systems must be designed in compliance with the principle of universal accessibility, with particular attention to vulnerable groups, including older adults and persons with disabilities, in line with both national and European artificial intelligence legislation.

Correspondingly, algorithms used for infrastructure planning must not be guided solely by economic efficiency or profit maximization; instead, they should embed the fundamental right to mobility as a precondition for full civic participation.

The realization of this right necessitates the implementation of specific interventions, such as the mitigation of algorithmic bias through model adjustments that account for disadvantaged communities, and the imposition of binding regulatory requirements to guarantee minimum service standards.

These standards may include comprehensive public transport coverage and accessibility, independent of the commercial profitability of routes or services. Such measures ensure that technological advancement does not compromise social equity, but rather actively contributes to inclusive, just, and sustainable mobility.

From this perspective, the concept of Public Service Obligations (PSOs), a cornerstone of transport law, represents a guiding paradigm for the regulation of artificial intelligence in the mobility sector.

Just as PSOs serve to ensure equitable, continuous, and universal access to scheduled transport services, the integration of AI systems must likewise be subordinated to the pursuit of the public interest. Technology, therefore, should not operate as an independent variable but rather as an instrument serving the broader objectives of social utility enshrined in the legal framework.

The advent of autonomous driving systems and so-called «smart mobility» signifies not merely a technical evolution but a fundamental shift in the legal paradigm.

The transition from human drivers to algorithmic control requires a reevaluation of traditional civil liability categories and raises unprecedented issues of advocacy and social justice within the transport sector.

Central ethical challenges include promoting inclusion, mitigating dependency, and addressing digital fragility. One key concern is digital exclusion: the right to mobility, constitutionally recognized, cannot be contingent upon advanced technological skills or access to costly devices.

At the same time, structural reliance on technology introduces new forms of vulnerability, arising from system malfunctions, cyberattacks, or data breaches. In this context, safety transcends mechanical concerns to encompass data and software security.

It becomes imperative that interfaces and AI-driven mobility systems be designed according to Universal Design principles[19], ensuring that individuals in vulnerable or fragile conditions can benefit from automation without encountering technological barriers.

This approach highlights the need for a socially attuned regulatory framework in which AI in mobility is harnessed not only for efficiency but also for equity, inclusiveness, and the protection of fundamental rights, ensuring that technological advancement does not reinforce existing inequalities but rather promotes genuinely accessible and just transport systems.

The shift from human to automated control also necessitates a thorough reconsideration of civil liability frameworks, moving from traditional notions of fault to product liability for defective systems. Consequently, responsibility tends to shift from the driver to the manufacturer of the vehicle and its software.

From a risk protection perspective, insurance policies will need to evolve to cover not only physical damage but also cybersecurity risks and software malfunctions, ensuring prompt compensation for victims regardless of the technical complexity involved in determining the cause of a failure[20].

Equally important is the establishment of clear standards for algorithmic transparency, enabling users to exercise their right to understand the rationale behind automated decisions.

Users must be fully informed in a comprehensible manner, not only regarding physical safety risks but also regarding the collection, processing, and use of their personal data in training and operating machine learning models.

Such measures are essential to uphold trust, fairness, and accountability in automated mobility systems, and to ensure that the deployment of artificial intelligence aligns with fundamental rights and principles of social equity.

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[19] Universal Design AI integrates artificial intelligence to create products, environments, and learning experiences that are accessible to the widest possible range of users, regardless of their abilities. By leveraging AI for personalization, automatic content adaptation, and accessibility testing, it enhances inclusivity, allowing tailored engagement, faster information processing, and a reduction of interaction barriers. In the context of transport and mobility, these principles can ensure that digital services—such as mobility-as-a-service (MaaS) platforms, autonomous vehicle interfaces, and shared mobility applications—are designed to serve users with diverse needs, including people with physical, cognitive, or sensory disabilities, older adults, and those with limited digital literacy. Furthermore, Universal Design AI supports continuous monitoring and adjustment of digital interfaces to accommodate changing user requirements, promoting equity in access and participation. See *European Commission*, *White Paper on Artificial Intelligence - A European approach to excellence and trust*, COM(2020) 65 final, Brussels, 2020; Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 *laying down harmonized rules on artificial intelligence (AI Act)*, Brussels, 2024.

[20] KAPC Brookhuis, 'Product liability and ADAS; legal and cognitive psychological perspectives' (2005) Research 5.4, European Journal of Transport and Infrastructure, 357 ff; A Albanese, 'La responsabilità civile per i danni da circolazione di veicoli ad elevata automazione' (2019) 4 Europa e diritto privato, 995; RA Fayjie, *Driverless car: Autonomous driving using deep reinforcement learning in urban environment*, in *15th International Conference on Ubiquitous Robots (UR)* (IEEE, 2018); N Gallardo, *Autonomous decision making for a driver-less car*, in *12th System of Systems Engineering Conference (SoSE) (IEEE*, 2017); J Lu, *Autonomous vision of driverless car in machine learning*, in *7th International Conference on Social Sciences and Economic Development, ICSSED 2022, Atlantis Press*, (2022); M D'Onofrio, *Volontà e responsabilità dell'intelligenza artificiale: nuovi problemi e categorie tradizionali*, in *La Volontà macchinica* (Pacini Editore, 2024), 22; G Calabresi, E Almureden, *Driverless cars, Intelligenza artificiale e futuro della mobilità* (Il Mulino, 2024), 57 ff..

4. Economic inclusivity as a fundamental tool to remove barriers to access sustainable mobility.

In this context, social leasing emerges as an intervention model designed to mitigate financial barriers that hinder access to individual mobility for low-income populations.

This scheme can be understood as an atypical contractual arrangement, situated at the intersection of the right to mobility and the principles of economic and social solidarity, aiming to ensure financial inclusion for individuals with limited creditworthiness or low credit scores.

A defining feature of the model is the use of objective indicators of economic vulnerability to determine eligibility, such as the Equivalent Economic Situation Indicator (*Indicatore della Situazione Economica Equivalente - ISEE*).

This criterion serves as the basis for providing vehicles under fixed, subsidized monthly installments, effectively eliminating the burden of an upfront payment (zero down payment).

By doing so, social leasing allows citizens to access a vehicle with predictable, affordable monthly payments, while also accommodating individuals with restricted financial capacity.

The model promotes transparent financial planning, reduces the risk of over-indebtedness, and facilitates equitable access to mobility.

Furthermore, social leasing can be integrated with sustainable mobility initiatives, including electric vehicles or shared mobility solutions, thus supporting broader policy objectives related to environmental sustainability, social equity, and inclusive urban transport systems[21].

From the perspective of banking and financial transparency, this scheme ensures simplified household financial planning, protecting the weaker contracting party from the risk of over-indebtedness through predictable and stabilized operational costs.

In this way, the strategy does not merely promote financial inclusion by stabilizing expenses and facilitating domestic budgeting, but also acts as a catalyst for the ecological transition by encouraging the adoption of low-emission vehicles.

Its primary objective is to accelerate the uptake of electric and hybrid cars, thereby contributing significantly to the reduction of CO_2 emissions.

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[21] S Maur, 'Social leasing and access to sustainable mobility' (2023) Transport Policy, 112-130; A Guillén, 'Financial inclusion and mobility transitions in Europe' (2022) Journal of European Social Poli, 245-262; M Wolsink, 'Equity in sustainable transport policy: addressing affordability and access' (2021) Sustainability, 78-95. These contributions highlight how eligibility criteria based on objective economic indicators—such as income thresholds or composite measures of household financial capacity—play a crucial role in targeting mobility support schemes toward vulnerable populations. Social leasing models are designed to remove entry barriers by eliminating upfront costs and offering predictable, subsidized instalments, thereby enhancing affordability and financial planning. The literature further emphasizes that such mechanisms not only reduce the risk of over-indebtedness but also contribute to a more equitable distribution of mobility opportunities. When combined with sustainable transport policies, including the promotion of electric or shared vehicles, these instruments can simultaneously advance environmental goals and social inclusion, reinforcing the role of mobility as a key enabler of participation in economic and social life. See also Öko-Institut, *Social Leasing of Electric Cars: A solution for 3 million European families,* (2025).

This approach not only supports the transition toward green mobility but also plays a crucial role in fostering a cultural shift toward more sustainable transport choices.

More specifically, social leasing does not exhaust its function in economic support; rather, it operates as a catalyst for the ecological transition, understood as a social function of the contract. From this perspective, the right of ownership over the vehicle is separated from the right of use, promoting more sustainable consumption patterns and contributing to a broader "cultural awareness" of environmentally responsible mobility choices.

The contractual framework is teleologically oriented toward the promotion of low-impact vehicles (electric or hybrid), in line with the objectives of the European Green Deal and EU legislation on the reduction of carbon emissions.

Moreover, while traditional leasing (long-term rental) continues to represent an instrument of fiscal optimization for businesses, through the deductibility of lease payments and VAT offsets, the European "social" model introduces a distinct philosophy grounded in inclusion.

Within the EU context, this mechanism is often complemented by public subsidies that ensure the economic sustainability of the instalments for private operators, thereby giving rise to a form of public–private partnership aimed at addressing contemporary mobility challenges.

These include economic accessibility, through protected social tariffs; environmental sustainability, through the renewal of vehicle fleets; and social innovation, by overcoming both the digital divide and the mobility divide[22].

Ultimately, social leasing represents a concrete response to the challenges of modernity, combining the need to protect vulnerable individuals with the imperative of environmental sustainability.

The key challenge for future legislators will be to further formalize and structure these contractual models, ensuring an appropriate balance between safeguards for lessors and the protection of citizens' fundamental rights.

5. Towards an European shift in smart mobility field as a catalyst for social cohesion.

At the present historical juncture, the path between innovation and social cohesion has become increasingly complex.

The challenge that modern society must undertake to address transport poverty is not merely technological, but above all regulatory, ethical, and social. To successfully meet this challenge, Europe must ultimately establish a

[22] See DDRI, *Social leasing pilot scheme: Lessons learned* (2024), that refers to evaluative reports or policy analyses examining the outcomes of experimental social leasing programs implemented in several European countries, particularly in France and Belgium. These pilot schemes are designed to test the effectiveness of subsidized leasing models, often focused on electric vehicles, in improving access to mobility for low-income households. The "lessons learned" component typically encompasses an assessment of the social impact of the measure, its environmental benefits in terms of emissions reduction, its financial sustainability for public authorities, and the practical challenges encountered during implementation, such as targeting eligible beneficiaries or managing demand. As such, the expression does not denote a specific legislative act, but rather a category of empirical and policy-oriented documents that aim to inform the scaling-up and refinement of social leasing initiatives within a broader European framework of inclusive and sustainable mobility.

coherent and comprehensive common regulatory framework, while also adapting the domestic legislation of individual Member States.

This includes revising and updating national road traffic codes and relevant legal provisions, as well as addressing the associated financial dimensions, including the provision of subsidies and other forms of public support and incentives.

The transition toward intelligent mobility entails significant risks, as it requires the identification of the technological standards that physical infrastructures, such as roads, highways, and related signage, must meet[23].

This, in turn, demands a clear and forward-looking understanding of the current state of technology and its future developments, ensuring that infrastructure planning remains both resilient and adaptable in the face of rapid innovation.

This is particularly relevant about, on the one hand, determining the level of vehicle connectivity and their integration with road infrastructure[24], and, on the other hand, enhancing vehicle safety and the reliability of automated driving systems, with the overarching objective of improving road safety and reducing accidents[25].

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[23] As instance, with a harmonized infrastructure at the European level (Digital Twin), it would be possible to create a dynamic digital map of traffic, while simultaneously reducing energy consumption. See J Schot, W Steinmueller, 'Three frames for innovation policy: R&D, systems of innovation and transformative change' (2018) Research Policy, 335-346; M Porter, J Heppelmann, 'How Smart, Connected Products Are Transforming Competition' (2015) Harvard Business Review, 64-88; L van Zoonen, 'Digitalization and the Welfare State: The Risk of Exclusion' (2020) Government Information Quarterly, 101484; J Larsen, Equity and Justice in Sustainability Transitions, (2019) Sustainability Science, 123-140; D Jones, Characterizing the Digital Twin: a Systematic Literature Review in (2020) CIRP Journal of Manufacturing Science and Technology, 36-50; A Tzachor, S Sabri, CE Richards et al., 'Potential and Limitations of Digital Twins to Achieve the Sustainable Development Goals' (2022) Nature Sustainability, 822-835.

[24] The need to identify technological requirements for physical infrastructure translates into the concept of V2I (Vehicle-to-Infrastructure); The concept of V2I (Vehicle-to-Infrastructure) refers to a key component of intelligent transport systems, enabling direct communication between vehicles and road infrastructure. It is part of the broader ecosystem of connected mobility, often framed within V2X (Vehicle-to-Everything) technologies. In practical terms, V2I allows vehicles to exchange real-time data with infrastructure elements such as traffic lights, road signs, toll systems, parking facilities, and even smart road sensors. Through wireless communication technologies (e.g., 5G, DSRC, or cellular networks), infrastructure can transmit information about traffic conditions, road hazards, weather, speed limits, or signal timing, while vehicles can send back data regarding their position, speed, and operational status. This interaction serves multiple purposes. First, it enhances road safety, by alerting drivers, or autonomous systems, to potential risks such as accidents, congestion, or dangerous road conditions ahead. Second, it improves traffic efficiency, as vehicles can adapt their speed to traffic light cycles (so-called "green light optimal speed advisory") or reroute dynamically to avoid congestion. Third, it contributes to environmental sustainability, by reducing unnecessary braking, idling, and fuel consumption, thereby lowering emissions. From a regulatory and infrastructural perspective, the deployment of V2I requires significant investments in "smart infrastructure," including sensor-equipped roads, connected traffic management systems, and interoperable digital platforms. It also raises important legal and ethical issues, particularly concerning data governance, cybersecurity, liability, and standardization across jurisdictions. Ultimately, V2I represents a foundational element of smart mobility, bridging the gap between physical infrastructure and digital intelligence, and enabling a more integrated, safe, and efficient transport ecosystem.

[25] For example, by equipping vehicles with sensors and onboard units capable of communicating in real time with roadside infrastructure (RSUs – Road Side Units). More specifically, roadside units are fixed communication devices installed along the road network, such as at intersections, traffic lights, or highways, which interact with vehicles through wireless technologies. When combined with onboard sensors (e.g., cameras, radar, LiDAR) and in-vehicle communication systems, they enable a continuous exchange of data between vehicles and infrastructure. This interaction allows RSUs to transmit critical information, such as traffic signal timing, road conditions, accidents, or speed regulations, while

Another crucial aspect concerns the identification of privacy-related issues arising from the collection, use, and protection of personal data, as well as the ethical implications connected thereto, in accordance with the principles of privacy by design and algorithmic ethics.

Indeed, the large-scale collection of data, such as location, driving behaviour, and biometric information, entails the risk that intelligent mobility systems may evolve into instruments of surveillance if not subject to strict regulatory oversight.

Within this framework, one of the most complex doctrinal issues relates to the allocation of liability among natural persons in relation to autonomous systems, requiring a reassessment of traditional paradigms of fault and professional risk, alongside the development of new forms of mandatory insurance coverage.

Accordingly, a coherent and uniform approach must be adopted.

This entails the establishment of a common regulatory framework, the deployment of digitalized road infrastructures ("smart roads"), and sustained public support through incentives and subsidies.

Ultimately, the creation of a harmonized legal framework, such as that introduced by the European AI Act, represents the only viable path to ensure that "intelligent mobility" does not remain an unregulated domain. Legal rules must function as a bridge between innovation and the protection of fundamental rights, ensuring that technological progress does not leave behind the most vulnerable segments of society.

Only through inclusive design and the removal of both digital and physical barriers can mobility truly become a right guaranteed for all.

simultaneously receiving data from vehicles regarding their position, speed, and trajectory. As a result, the system supports real-time traffic management, enhances situational awareness for both human drivers and autonomous systems, and contributes to safer and more efficient mobility. From an infrastructural standpoint, the deployment of RSUs represents a key step toward the realization of smart roads, where physical infrastructure is integrated with digital technologies to enable predictive, adaptive, and interconnected transport systems.