Smart Mobility, Just Cities and Road Safety: An AI-Enabled Road Safety Academy in Gauteng South Africa

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Abstract

Rapid urbanisation, fragmented transport systems, and persistently high road-traffic fatalities have placed mobility at the centre of Africa's development and justice agenda. While smart mobility initiatives are frequently framed as technological efficiency projects, African cities require approaches that simultaneously advance equity, safety, and behavioural change. This article repositions smart mobility as a foundational pillar of road safety and advances the case for institutionalising an AI-enabled Smart Road Safety Academy, using Gauteng Province, South Africa, as an analytic-conceptual case study. The study adopts a qualitative analytic-conceptual methodology grounded in policy analysis and thematic synthesis of secondary literature, supported by African case examples and normative legal and governance frameworks. The analysis demonstrates that mobility in African cities functions simultaneously as a socio-economic right and a behavioural risk environment, shaped by informality, weak enforcement, fragmented governance, and limited hazard-perception assessment mechanisms. The article argues that AI-enabled telematics, immersive simulation, and hazard-perception testing when embedded within just governance frameworks such as the National Transport Master Plan 2050 (NATMAP 2050) and the National Road Safety Strategy can meaningfully reduce risk while advancing inclusion, institutional capability, and climate resilience. It proposes an AI Smart Road Safety Academy as a scalable institutional mechanism linking smart mobility, behavioural rehabilitation, skills development, and the future of work in transport. Directions for further empirical research and pilot implementation across African urban contexts are identified.

Keywords: *smart mobility; just cities; road safety; hazard perception; AI governance; Gauteng*

1.Introduction

Across the African continent, mobility has emerged as a decisive determinant of access to economic opportunity, education, healthcare, and civic participation. Rapid urbanisation has intensified travel demand, yet public transport systems remain fragmented, underresourced, and often unsafe (UNECA, 2023; WHO, 2023). African cities are projected to absorb hundreds of millions of new residents in coming decades, placing increasing pressure on already strained transport networks. In this context, mobility failures translate directly into social exclusion, economic inefficiency, and preventable loss of life (Peak-Urban, 2019).

Informal transport modes, such as minibus taxis, motorcycle taxis, tuk-tuks, and non-motorized travel, dominate many urban corridors. These systems provide essential access where formal public transport is absent or unreliable, while exposing users to elevated safety risks due to weak regulation, inconsistent training standards, ageing vehicle fleets, and limited post-licensing oversight. Road-traffic injuries therefore remain a leading cause of death among economically active age groups, disproportionately affecting low-income households (Saksith Chalermpong et al., 2025; McKay et al., 2024).

Mobility thus extends beyond infrastructure and logistics. It constitutes a justice issue closely tied to dignity, inclusion, and citizenship. The *right to the city* frames mobility as a claim to urban life rather than mere movement. In African cities shaped by colonial spatial legacies and contemporary inequality, this claim remains unevenly realised. African urban scholars caution that technology-led planning approaches, when transferred without sensitivity to local realities, often reproduce spatial and social inequalities (Smith et al., 2024; Pieterse, 2020; Watson, 2014).

African cities are simultaneously entering an era characterised by artificial intelligence (AI), telematics, and the Internet of Things (IoT). Governments increasingly adopt "smart mobility" strategies aimed at efficiency, emissions reduction, and system integration. These technologies offer new tools for governing mobility systems, yet they do not automatically produce safer roads. Without a justice-orientated and safety-centered framework, smart mobility risks entrenching technocratic optimisation, while behavioural risk remains unresolved (Salih et al., 2025; Secchi & Gili, 2022).

Despite growing investment in smart mobility technologies, road-safety outcomes have not improved at a comparable pace. This disconnect exposes a critical gap between technological deployment and institutional capability. Current approaches prioritise infrastructure rollout and data generation while underestimating the behavioural, governance, and skills dimensions required to translate technology into safer road environments. Road safety interventions remain fragmented across enforcement agencies, licensing authorities, planners, and educational programs, particularly in contexts dominated by informality (SASSETA, 2025; Alam et al., 2024; Kussl & Wald, 2022).

This article contends that smart mobility requires repositioning as a core pillar of road safety and just urban development, rather than a parallel or downstream policy agenda. It advances the concept of an AI-enabled Smart Road Safety Academy as an institutional mechanism capable of integrating behavioural science, digital infrastructure, and governance reform into a coherent, scalable road safety ecosystem, as illustrated through the Gauteng provincial context (Mitieka et al., 2025; Paiva et al., 2021; Toh et al., 2020).

1.1 Conceptual Contribution and Positioning within the Literature

This article advances the literature on smart mobility, road safety, and urban governance through four interrelated conceptual contributions.

First, it offers a justice-centred reconceptualization of smart mobility, positioning road safety as a normative outcome rather than a secondary technical benefit. Dominant smart mobility narratives emphasise efficiency, congestion reduction, and emissions management, frequently assuming safety improvements are automatic spillovers. This article challenges that assumption by demonstrating that safety outcomes depend on institutional design, behavioural capability, and governance coherence, particularly in unequal and informal urban contexts (Kussl & Wald, 2022).

Second, the article integrates behavioural road-safety research with digital governance and institutional theory. Behavioural studies highlight hazard perception and decision-making yet often treat these as individual attributes. This article extends that work, conceptualising behavioural risk as systemically produced and shaped through licensing regimes, training architectures, enforcement practices, incentive structures, and data feedback mechanisms embedded within mobility systems (Boua et al., 2022).

Third, the article introduces the AI-Enabled Smart Road Safety Academy as a novel institutional form within the smart mobility ecosystem. Unlike episodic, project-based, or enforcement-led interventions, the Academy operates as a permanent socio-technical institution integrating telematics, AI, immersive simulation, skills development, and governance feedback loops (SARF, 2025).

Finally, grounding the analysis in Gauteng Province contributes an African-centred analytical perspective that challenges the uncritical transfer of smart mobility models in the Global North. The analysis demonstrates that institutional innovation, rather than technological sophistication alone, determines whether smart mobility advances safety, justice, and sustainability in Global South cities (Musakwa & Trynos Gumbo, 2017).

2. Literature Review

2.1 Smart Mobility and Urban Justice

Smart mobility typically refers to digital technologies, data analytics, and integrated transport systems aimed at improving efficiency, sustainability, and reliability within urban mobility networks (Banister, 2008; Kitchin, 2014). Policy narratives frequently foreground congestion reduction, emissions mitigation, and modal integration. Critical scholarship, however, cautions that technological "smartness" pursued without justice-oriented frameworks often intensifies inequality (Pieterse, 2020).

In African cities, mobility constitutes a political and socio-economic phenomenon shaped through informality, inequality, and historical spatial exclusion. Informal transport systems provide the backbone of daily mobility while absorbing disproportionate safety risk. Smart mobility initiatives that privilege formal systems or data-rich users risk marginalising the majority of urban residents (Jennings et al., 2018).

Lefebvre et al. (1996) state that the *right to the city* situates mobility as an enabling condition for participation in urban life, while Watson (2014) cautions against planning paradigms detached from African urban realities. This article extends these debates, arguing that road safety remains one of the most under-theorised justice dimensions of smart mobility, particularly within African contexts.

2.2 Road Safety in Emerging Economies

Low- and middle-income countries account for over 90 percent of global road traffic fatalities, despite lower levels of motorisation (WHO, 2023). Structural conditions, including weak enforcement, ageing vehicle fleets, inadequate pedestrian infrastructure, and limited post-licensing development, compound this risk (World Bank, 2021).

Behavioural factors, particularly hazard perception, play a decisive role in crash involvement (OECD, 2020). While hazard-perception testing forms an integral component of licensing regimes in high-income countries, such assessment remains limited across much of Africa. Licensing systems frequently emphasise procedural compliance over behavioural capabilities, leaving drivers underprepared for complex urban environments (Habibzadeh Omran et al., 2023).

The literature signals the need for systematic behavioural capability development but offers limited guidance on institutionalising such approaches at scale. This gap provides the foundation for the institutional model advanced in this article.

2.3 Linking Road Safety to National and Global Priorities

Road safety aligns directly with SDGs 3.6, 11, and 13. In South Africa, NATMAP 2050 and the National Infrastructure Plan 2050 embed safety, digitalisation, and skills development within long-term transport planning (DoT, 2016; DPWI, 2022). Provincial policy discourse increasingly frames smart mobility and road safety as instruments of inclusion and institutional reform (Diale-Tlabela, 2024). Despite strong policy alignment, implementation gaps persist. The literature underscores the absence of institutional mechanisms capable of translating strategic intent into sustained behavioural and safety outcomes.

2.4 Behavioural Risk, Governance Capacity, and Institutional Design

Behavioural road-safety research often neglects institutional conditions required for sustained behavioural change. Fragmented training systems, weak post-licensing engagement, and inconsistent enforcement undermine long-term outcomes (World Bank, 2021). Smart mobility technologies generate behavioural data at scale, yet governance capacity to convert data into learning, regulation, and rehabilitation remains limited (Pieterse, 2020). This article conceptualises behavioural risk as an institutional design challenge, advancing the AI-Enabled Smart Road Safety Academy as a governance response to this gap.

3. Methodology

This study adopts a qualitative analytic-conceptual case study design, using Gauteng Province as the unit of analysis. The methodology draws on policy analysis and thematic synthesis of secondary scholarly literature and official policy instruments (Creswell & Poth, 2018; Yin, 2014).

The analytic-conceptual approach enables integration of normative theory, governance analysis, and contextual interpretation, particularly suited to Global South contexts where quantitative datasets remain fragmented. Contextual expertise derived from practitioner engagement informs analysis and undergoes triangulation with peer-reviewed literature and policy documents to enhance rigour (Denzin, 2017).

Thematic analysis focused on mobility justice, behavioural risk, governance capacity, digital infrastructure readiness, and institutional design (Haxhija et al., 2025). The study remains generative, offering conceptual clarity to inform future empirical research, pilot programmes, and comparative studies across African cities.

4. Findings and Discussion

The analysis reveals that mobility in African cities operates simultaneously as a socio-economic right and a behavioural risk environment. Access to mobility enables participation in work, education, healthcare, and social life, yet the same systems expose users to disproportionate levels of danger. This dual character reflects structural conditions rather than isolated individual choices. Fragmented governance, regulatory gaps, and high levels of informality interact with behavioural factors such as limited hazard perception, distraction, speeding, fatigue, and economic pressure, producing persistently elevated crash rates (Ugboma, 2020; Pirie, 2013; Sietchiping et al., 2012).

In many African urban contexts, informal transport systems function as essential public services while remaining weakly integrated into formal governance frameworks. Operators often face competing incentives that prioritise income generation over safety compliance, particularly in environments characterised through congestion, poor infrastructure quality, and limited enforcement consistency. These pressures shape everyday driving behaviour and contribute to normalised risk-taking across the mobility system (Elias, 2021).

Smart mobility technologies introduce new forms of visibility into this risk environment. Telematics, digital fare systems, AI-enabled monitoring, and sensor-based infrastructure generate detailed data on driving behaviour, vehicle performance, and traffic conditions. However, the findings indicate that data generation alone does not translate into improved safety outcomes. Without institutional mechanisms capable of interpreting behavioural data and linking it to training, rehabilitation, and regulatory adaptation, smart mobility systems risk functioning as passive observation tools rather than active safety interventions (Elassy et al., 2024).

The analysis therefore underscores a central insight: road safety failures persist not due to technological absence, but due to institutional incapacity to convert behavioural visibility into behavioural change.

This gap highlights the importance of governance arrangements that treat road safety as a continuous developmental process rather than an episodic enforcement function.

4.1 The AI Smart Road Safety Academy as a Governance Innovation

The AI Smart Road Safety Academy emerges from the analysis as a governance innovation that addresses this institutional gap. The Academy integrates behavioural assessment, hazard-perception testing, immersive simulation, and digital monitoring within smart mobility infrastructures, forming a permanent institutional capability rather than a project-based intervention (Publishers, 2025).

Unlike conventional road safety initiatives that rely on enforcement campaigns or once-off training, the Academy repositions safety governance around continuous capability development. Hazard-perception assessment functions as a diagnostic tool that identifies risk profiles across different categories of road users. Immersive simulation environments allow drivers and operators to experience complex and high-risk scenarios in controlled conditions, strengthening anticipatory decision-making and situational awareness (David et al., 2025).

Behavioural data generated through telematics and AI systems feeds into adaptive learning pathways, enabling targeted training and rehabilitation interventions. Regulatory authorities gain access to actionable insights that support proportional, evidence-informed responses rather than blanket punitive measures. In this arrangement, technology operates as an enabler of learning and institutional intelligence rather than as a substitute for governance capacity (Komolafe et al., 2025; Man et al., 2025).

The Academy also performs a coordinating role across fragmented institutional domains. It creates structured interfaces between transport authorities, licensing bodies, enforcement agencies, skills institutions, and labour-market actors. This integrative function positions the Academy as a central node within the smart mobility ecosystem, capable of aligning safety objectives with broader development goals such as employment creation, skills upgrading, and climate resilience.

4.2 Behavioural Risk as an Institutional Governance Challenge

The findings reposition behavioural risk as an institutional governance challenge rather than a matter of individual non-compliance. Risk-taking behaviour reflects the cumulative effects of regulatory design, training systems, incentive structures, and socio-economic conditions. Treating behaviour solely as a disciplinary issue obscures these systemic drivers and limits the effectiveness of enforcement-led approaches (Botha & Van, 2025).

The AI Smart Road Safety Academy institutionalises behavioural feedback loops that support anticipatory and developmental governance. Continuous assessment enables early identification of risk patterns, allowing interventions to occur before crashes take place. Rehabilitation pathways focus on capability restoration rather than punishment, reinforcing safety norms while preserving livelihoods, particularly within informal transport systems (Kredy, 2025).

This approach also facilitates the inclusion of informal operators within formal safety governance without imposing exclusionary compliance thresholds. Developmental integration recognises informality as a structural feature of African urban mobility rather than an anomaly to eliminate. The Academy provides a structured mechanism through which informal operators access training, certification, and skills recognition, strengthening safety outcomes while supporting economic inclusion (Azeez et al., 2025).

Through this institutional framing, behavioural governance shifts from reactive enforcement toward proactive risk management, embedding safety within everyday mobility practices and organisational routines.

5. Policy and Governance Implications (Aligned with SDGs, AU Agenda 2063, and National Frameworks)

The findings of this study carry direct implications for transport policy, urban governance, and institutional reform at global, continental, national, and subnational levels. Rather than positioning road safety as a technical or compliance-oriented concern, the analysis underscores its role as a developmental, governance, and justice priority that intersects with sustainable development, skills formation, and institutional capability.

5.1 Alignment with the Sustainable Development Goals (SDGs)

Road safety occupies a central position within the Sustainable Development Goals, particularly SDG 3.6, which calls for a substantial reduction in road-traffic deaths and injuries, SDG 11, which promotes inclusive, safe, resilient, and sustainable cities, and SDG 13, which addresses climate action and sustainable transport transitions (WHO, 2021; UN, 2015).

The AI-Enabled Smart Road Safety Academy directly advances these goals through institutional mechanisms that strengthen behavioural capability, reduce crash risk, and support safer modal integration. Continuous hazard-perception assessment and immersive simulation enhance preventive capacity, contributing to public health objectives under SDG 3.6. Integration of informal and vulnerable road users within safety governance frameworks advances the inclusivity mandate of SDG 11 (WHO, 2021).

The alignment of road safety institutions with digitalisation and future-of-work transitions further supports sustainable mobility pathways associated with SDG 13. Importantly, the Academy model reframes SDG implementation from target compliance toward institutional capability development, strengthening the durability and measurability of safety outcomes (WHO, 2021; Lim et al., 2018).

5.2 Alignment with African Union Agenda 2063

African Union Agenda 2063 envisions "The Africa We Want," characterised through inclusive growth, human security, and people-centred development. Mobility safety intersects directly with Aspiration 1 (a prosperous Africa based on inclusive growth), Aspiration 4 (a peaceful and secure Africa), and Aspiration 6 (people-driven development).

The findings support Agenda 2063's emphasis on strengthening institutions rather than relying solely on infrastructure expansion.

The AI Smart Road Safety Academy advances human security through reduction of preventable fatalities, while supporting inclusive economic participation within informal transport systems. Developmental integration of informal operators aligns with Agenda 2063's commitment to dignity, social cohesion, and shared prosperity (Nxumalo, 2025).

Furthermore, the Academy's focus on skills development, digital literacy, and behavioural capability aligns with continental priorities related to youth employment, innovation, and human capital development. In this sense, road safety governance becomes an enabler of broader socio-economic transformation rather than an isolated sectoral concern (Mwansa et al., 2025).

5.3 Alignment with South African National Policy Frameworks

At the national level, the proposed institutional model aligns closely with South Africa's National Transport Master Plan 2050 (NATMAP 2050), which emphasises safety, integration, and long-term system resilience. The Academy supports NATMAP's strategic intent through institutionalisation of behavioural governance within smart mobility systems, addressing implementation gaps identified within existing road safety strategies (Department of Transport, 2025).

The model also aligns with the National Road Safety Strategy and the Green Transport Strategy (2018–2050), particularly in relation to behavioural change, digitalisation, and sustainable transport transitions. The Academy's integration of simulation technologies and data-driven learning supports national commitments to innovation and skills development within the transport sector (Vărzaru & Bocean, 2024.

From a public infrastructure perspective, the Academy complements the National Infrastructure Plan 2050, which prioritises institutional capability alongside physical investment. This alignment reinforces the argument that safety outcomes depend as much on governance design as on infrastructure provision.

5.4 Provincial and Subnational Governance Implications

At the provincial level, particularly within Gauteng, political and policy discourse increasingly frames smart mobility and road safety as instruments of inclusion, economic participation, and institutional reform. The Academy model provides an operational mechanism capable of translating this policy intent into sustained governance practice (Koh et al., 2023).

Provincial and metropolitan governments play a critical role in embedding Road Safety Academies within existing transport, skills, and economic development structures. Such embedding supports intergovernmental coordination, reduces institutional fragmentation, and strengthens accountability across the road safety value chain (Carnis, 2022).

5.5 Toward Integrated, Developmental, and Anticipatory Governance

Across all policy levels, the findings point toward the necessity of integrated and anticipatory governance approaches. AI-enabled behavioural data enables early identification of risk patterns and supports preventive intervention rather than reactive enforcement. Ethical data governance, transparency, and rights protection remain essential to ensure legitimacy and public trust (Hughes et al., 2025).

When aligned with global, continental, and national policy frameworks, the AI-Enabled Smart Road Safety Academy functions as a practical governance innovation capable of advancing development, justice, and safety objectives simultaneously (Zaidan & Ibrahim, 2024).

5.6 Policy Alignment Summary

Taken together, these alignments demonstrate that the proposed institutional model does not introduce a parallel policy agenda. Instead, it offers a governance mechanism that operationalises existing commitments under the SDGs, AU Agenda 2063, and South African transport and infrastructure frameworks. Smart mobility achieves its highest public value when embedded within institutions that prioritise learning, inclusion, and behavioural capability as foundational elements of sustainable urban development (Stats SA, 2023; Mthembu & Nhamo, 2022).

6. Contribution to the Body of Knowledge

This article makes a substantive contribution to the evolving scholarship on smart mobility, road safety, and urban governance through a set of interlinked conceptual, theoretical, and contextual interventions that extend beyond existing policy-oriented and technology-centric accounts.

1. Justice-oriented reconceptualization of smart mobility

The article advances for a justice-oriented reconceptualisation of smart mobility. Rather than treating smart mobility as a neutral assemblage of technologies aimed at efficiency and optimisation, the analysis positions mobility as a socio-political system deeply entangled with questions of dignity, inclusion, and risk. In this framing, road safety emerges as a core justice outcome rather than a secondary technical benefit. This perspective extends critical urban theory and challenges the implicit assumption within much of the literature that safety improvements naturally follow technological advancement (Mitieka et al., 2025; Sourbati & Behrendt, 2020)

2. A Systematic Understanding of Behavioural Road Saftey

Second, the article develops a systemic understanding of behavioural road safety that moves beyond individualistic explanations of driver behaviour. Behavioural risk is theorised as an outcome of institutional arrangements, regulatory design, and governance capacity. This shift contributes to behavioural road safety scholarship through integration with institutional and governance theory, offering a more comprehensive explanation for persistent safety failures in contexts characterised by informality, uneven enforcement, and limited post-licensing engagement (Nur Fadzilah Pahazri et al., 2024; Mooren & Shuey, 2024)

3. AI-Enabled Smart Road Safety Academy

Third, the article introduces the AI-Enabled Smart Road Safety Academy as a novel institutional model within the smart mobility ecosystem. The Academy is conceptualised not as a programme, pilot, or training facility, but as a permanent socio-technical institution integrating digital infrastructure, behavioural science, skills development, and governance feedback loops. This contributes to institutional innovation literature through illustration of how AI and smart technologies can be embedded within durable public-interest institutions, rather than remaining confined to fragmented projects or short-term interventions (Sahu et al., 2025).

4. African-centred Analytical Framework

Fourth, the article contributes an explicitly African-centred analytical framework. Situating the analysis within Gauteng's mobility landscape marked by informality, inequality, and complex governance dynamics responds to longstanding critiques of Global North model transfer in urban and transport scholarship. The analysis demonstrates that institutional design, rather than technological sophistication alone, determines whether smart mobility initiatives advance safety and justice in Global South cities (Azeez et al., 2025).

5. Advance Generative Research Agenda

Finally, the article establishes a generative research agenda for future empirical inquiry. The article identifies opportunities for longitudinal studies examining behavioural change over time,

comparative institutional analysis across African and Global South cities, and mixed-methods research exploring the socio-technical impacts of AI-enabled road safety institutions. In this sense, the proposed Academy functions not only as a policy instrument, but also as a platform for sustained scholarly investigation (Hughes et al., 2025; Nxumalo, 2025).

Taken together, these contributions position the article as both a theoretical intervention and a bridge between scholarship and practice, advancing understanding of how smart mobility can be governed in ways that are ethically grounded, institutionally coherent, and socially transformative.

7. Conclusion

This article set out to interrogate the persistent disjuncture between the rapid adoption of smart mobility technologies and the enduring crisis of road safety in African cities. Through an analytic-conceptual examination of Gauteng Province, the study demonstrates that technological innovation alone remains insufficient to deliver safer roads. The central challenge lies not in the absence of data, sensors, or analytics, but in the absence of institutional architectures capable of translating technological capability into sustained behavioural and safety outcomes.

The article highlights institutional design as the crucial connection between smart mobility technologies and road safety outcomes, demonstrating how governance arrangements influence the effectiveness of technological interventions. Road safety emerges not merely as a function of compliance or enforcement, but as an outcome of continuous learning, capability development, and coordinated institutional action. In this regard, the AI-Enabled Smart Road Safety Academy offers a strategic response that aligns digital innovation with behavioural science, skills development, and justice-orientated governance. Beyond Gauteng, the implications of this analysis extend to African and Global South cities grappling with similar conditions of rapid urbanisation, informality, and limited governance capacity.

The Academy model offers a scalable and adaptable pathway through which smart mobility can be reoriented toward life-preserving outcomes, without replicating exclusionary or technocratic models transferred from different urban contexts. Ultimately, the article argues that the future of smart mobility in Africa depends less on the sophistication of technologies deployed and more on the institutional imagination guiding their governance.

When embedded within coherent, justice-orientated institutions, smart mobility holds the potential not only to move people more efficiently but also to protect lives, expand inclusion, and reassert mobility as a foundational right within the African city.

8. Recommendations

The article offers the following recommendations for the considerations of researchers, policy developers, executive and road safety industry partners:

1. Institutionalise AI-enabled Road Safety Academies with smart mobility governance frameworks

Governments should establish Road Safety Academies as permanent public-interest institutions embedded within transport governance structures, ensuring continuity, accountability, and learning capacity.

2. Reframe driver licensing as a continuous regulatory relationship.

Licensing systems should evolve from once-off certification models toward ongoing capability assessment that incorporates hazard perception, behavioural feedback, and periodic skills renewal.

3. Deploy behavioural data to support developmental rather than punitive governance.

Telematics and AI-generated data should inform proportional interventions focused on learning, rehabilitation, and risk reduction rather than solely on sanctioning.

4. Align road safety institutions with skills development and future-of-work transitions.

Road safety governance should integrate with skills development frameworks, recognising the role of digital literacy, simulation training, and AI competency in emerging transport occupations.

5. Prioritise vulnerable road users and informal transport systems.

Policy frameworks should explicitly address the safety needs of pedestrians, cyclists, public transport users, and informal operators, embedding inclusion as a core safety principle.

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