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ARTIFICIAL INTELLIGENCE IN THE ROAD SECTOR

A PIARC SPECIAL PROJECT

HIGH-IMPACT SUMMARY REPORT

PIARC

STATEMENTS

The World Road Association (PIARC) is a nonprofit organisation established in 1909 to improve international co-operation and to foster progress in the field of roads and road transport.

The study that is the subject of this report was defined in the PIARC Strategic Plan 2024-2027 and approved by the Council of the World Road Association, whose members are representatives of the member national governments. The members of the Technical Committee responsible for this report were appointed by the member national governments for their special competences.

Any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of their parent organisations or agencies.

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EXECUTIVE SUMMARY

2024SP03EN

ARTIFICIAL INTELLIGENCE IN THE ROAD SECTOR

A PIARC HIGH IMPACT SUMMARY

The use of Artificial Intelligence (AI) is quickly growing in terms of interest, products and services across multiple sectors, including the road, transportation and mobility sectors. As part of PIARC's Special Projects programme, this high-impact summary report provides a concise overview of the findings and key recommendations from a study which explores the growing role of AI in the road sector. This report, which is a shortened version of a more detailed full-length report, highlights the main outcomes of an in-depth analysis, considering the benefits, risks, and challenges of AI adoption across various stages of road infrastructure development, including planning, design, construction, inspection, operations, and maintenance. The full-length report offers comprehensive analysis, while this summary presents the key insights in an accessible format. The analysis considers a wide range of socio-economic contexts, addressing the specific needs of High-Income Countries (HICs), Upper-Middle-Income Countries (UMICs), Lower-Middle-Income Countries (LowerMICs), and Low-Income Countries (LICs) and providing separate recommendations for each to ensure a comprehensive and inclusive approach[1].

Using a multi-method approach - literature reviews, surveys, interviews, and case studies - the study assesses AI utilisation and maturity and also presents an expected 'To-Be' vision for AI adoption in the road sector by 2030. The study shows that AI adoption in the road sector varies, driven by technological infrastructure, workforce capabilities, and regulatory frameworks. HICs, especially in Europe, North America, and parts of Asia, are at the forefront, benefiting from advanced infrastructure and governance. In contrast, LMICs often face significant barriers, including limited resources, skills gaps, and regulatory challenges.

The most prominent uses of AI in the road sector were found to be in the areas of (i) road safety, (ii) infrastructure inspection and (iii) traffic operations / incident management and the most commonly reported benefits related to reductions in traffic accidents, improved driver safety and cost / time saving efficiencies. The most prominent challenges were either technical in nature or related to resistance to change amongst the workforce, highlighting the importance of education and upskilling to address concerns around trust in AI technologies and fears of job replacement among staff.

The full-length version of this report offers detailed recommendations for road administrations and PIARC, focusing on the effective integration of AI technologies. This version of the report provides a general overview of the key recommendations, as summarised below and in Section 0 along with roadmaps outlining the transition from 2024 to 2030. These roadmaps include key pillars which should be used to guide road administrations.

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[1] This report categorises countries into four income groups as recognised by the World Bank: HICs, UMICs, LowerMICs, and LICs. Additionally, the abbreviation LMICs is used throughout the report to collectively refer to all UMICs, LowerMICs, and LICs together.

Key recommendations for road administrations

- Learn from existing case studies / pilots to understand the range of problems which AI can help solve.
- Invest in pilots and trials with a view to enabling larger scale deployments.
- Establish foundational policies / procedures to ensure effective, ethical & sustainable AI deployment.
- Invest in enabling infrastructure to facilitate AI adoption.
- Invest in education and awareness to ensure that everyone is on the same journey.

Key recommendations for PIARC

- Promote international standards for AI.
- Support capacity-building initiatives and facilitate knowledge exchange.
- Facilitate international collaborations.
- Provide technical assistance to LMICs.
- Develop an AI working group / consider implications of AI on existing PIARC Technical Committees.

Overall, this study highlights AI's potential to significantly enhance safety, efficiency, and sustainability in the road sector. While LMICs face additional challenges due to regulatory, financial, and human capital constraints, the recommendations will support road administrations and PIARC members in overcoming these barriers and unlocking the full benefits of AI by 2030.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

PIARC established a Special Projects mechanism to address emerging issues beyond its regular Strategic Planning Cycle. In late 2023, member countries highlighted Artificial Intelligence (AI) in the road sector as a priority for international knowledge sharing. Following an open call in February 2024, ROD Consulting Engineers were selected to deliver the "AI in the Road Sector" project under PIARC's guidance.

1.2. DEFINITIONS

In line with the call for proposals produced by PIARC, the following definitions apply:

AI, including Generative AI as a subset, refers to the capability of digital computers, machines, or software to perform tasks typically associated with intelligent beings. This term often describes the development of systems equipped with human-like intellectual processes, such as reasoning, discovering meaning, generalising, and learning from past experiences.

AI applied to the road sector: When applying AI to the road sector, certain programmes can augment human decisions in performing specific tasks, thereby enhancing efficiency in various activities. A key benefit of AI lies in tasks where machines can enhance human capabilities, often involving repetitive tasks across large amounts of data, such as object detection in videos. Additionally, AI is creating new opportunities for services and management that were previously impossible, such as improved traffic monitoring and enhanced predictive maintenance.

Operational benefits to National Roads Authorities (NRAs) / Road Operators (ROs) refer to the advantages that directly enhance the operational efficiency, performance, and effectiveness of NRAs, ROs or their direct supply chain (i.e. their contractors, consultants and service/technology providers). These benefits are primarily concerned with improving internal processes, resource utilisation, quality, accuracy, cost-effectiveness, and decision-making capabilities within the organisation.

Societal benefits consist of the positive impacts that AI technologies have in an external context including impacts on road users, communities, and the wider public. These benefits often translate into enhanced safety, improved user experience, reduced travel times, and reduced environmental impacts.

Mixed benefits are those that deliver advantages to both the internal operations of NRAs / ROs and also provide external benefits. These benefits often arise from AI technologies that improve internal processes while also directly enhancing the experience and safety of road users.

1.3. OBJECTIVES

AI has the potential to transform the road sector by enhancing safety, optimising infrastructure operation, and improving design, construction, inspection, management, and maintenance processes. This study aimed to provide PIARC members, from HICs to LICs, with insights into the benefits, risks, and challenges of AI implementation in the road sector. While AI can improve safety, reduce costs, and enhance service delivery, its adoption also faces technological, organisational, and economic challenges. Understanding these dynamics is essential for effective integration of AI in road infrastructure management.

The objectives of this study were as follows:

- To review the current state of development of AI technologies and ongoing AI advancements relevant to the road sector. This included an analysis of cutting-edge AI applications and their maturity levels.
- To identify areas where AI technologies could provide substantial benefits to PIARC members by 2030. This involved examining the potential of AI to enhance road infrastructure planning, design, construction, inspection, operations, management, maintenance, and safety.
- To highlight risks and challenges associated with different potential applications of AI in the road sector. This included an evaluation of technological, ethical, regulatory, and organisational challenges that might impact AI adoption.
- To provide specific recommendations on the adoption of AI in the road sector. This included developing clear guidance for all PIARC members globally on how AI adoption could be approached in their organisations, tailored to the specific needs and capacities of HICs to LICs.
- To facilitate the transfer of knowledge and successful practices from around the world. These included lessons learned from various countries on deploying and operating AI technologies and addressing implementation challenges.

Data was collected by ROD through a literature review, surveys, and interviews with key stakeholders. An analysis of AI applications was conducted, informing recommendations for AI integration from HICs to LICs.

1.4. Scope

The project focused on three key areas when investigating AI in the road sector: (i) existing applications, (ii) potential near future applications (with a focus on the 2030 horizon), and (iii) the challenges and opportunities for implementing these AI solutions. An analysis of existing case studies was conducted to provide specific detailed examples of AI technologies which have been implemented / piloted in the road sector to help inform the recommendations to road administrators and PIARC members on how AI can best be integrated into countries with different levels of socio-economic development.

All stages in the life cycle of road infrastructure were considered, from planning and design through to operation and maintenance. The review included a horizontal scan across all road infrastructure assets and examined potential AI applications to the business processes of ROs and owners. The fields of expertise of the various PIARC Technical Committees were also considered. The focus was on the 2030 horizon, with recommendations targeting AI adoption within this timeframe.

Automated Vehicle (AV) applications were considered outside of the scope of this study. While some of the AI applications investigated might have secondary benefits for facilitating AVs, the study did not specifically focus on measures solely for this purpose. Moreover, the subject of this project was not to examine in detail the financial resources required for AI implementation. Instead, the study focused on providing more global recommendations for AI adoption that would prove useful to ROs and administrators around the world.

While the horizontal scan provided a general overview of the potential opportunities, risks, and challenges associated with the introduction of AI, it was recognised that high-level findings from such a wide-reaching review might not be particularly focused on areas already well developed and most likely to provide benefits by 2030. Therefore, particular attention was given to areas, as agreed by the POT, where AI had already demonstrated significant benefits or in technologies and processes showing the greatest promise for delivering new benefits in the next 6 years (e.g., video analytics using optical character recognition for Automated Number Plate Recognition (ANPR), which is widely used in tolling and other areas and has already provided significant benefits in the roads sector). It is noted that while the focus of this study was on AI technologies, the literature review also considered key technologies which may not explicitly use AI but are considered to be AI-enabling technologies. For example, Augmented Reality (AR) or Virtual Reality (VR) technologies may not always include AI capabilities, but given their increasing adoption and the potential for AI integration, some examples were considered in this study. The same applies to certain key data collection, processing, and visualisation technologies, which may not explicitly utilise AI but serve as enablers for AI-based algorithms. This inclusive perspective ensures a thorough understanding of the systems underpinning AI integration in the sector.

2. METHODOLOGY

2.1. OVERARCHING METHODOLOGY

The study aimed to investigate the adoption of AI technologies within the road sector, focusing on current applications, sector-specific challenges, and the potential for AI integration up to 2030. It examined regulatory frameworks, opportunities and barriers across countries of varying income levels, data governance, and ethical guidelines for private sector engagement. Additionally, the research assessed workforce preparedness and the implications of AI on gender inclusion and social equity. The overarching objective was to provide strategic recommendations for the effective development of AI in the road sector.

The methodology for this study was structured around five key themes, as shown in Figure 1, which guided the research from data collection to the delivery of findings. The themes centred on both the current state (“As-Is”) of AI in the road sector and a future vision for 2030 (“To-Be”). The research highlighted the variability of AI adoption across countries, emphasising that regional and national differences, including socio-economic contexts, infrastructure, and regulatory readiness, would shape the path towards AI integration. These differences necessitate tailored strategies for effective AI development.

The study employed case studies to provide real-world examples of AI applications in road infrastructure, covering various regions and income levels. These case studies offered insights into the challenges, benefits, and best practices in AI adoption, shaping the “As-Is” scenario and informing the “To-Be” vision. The research also incorporated stakeholder engagement through surveys and interviews to better understand the practical applications and limitations of AI technologies, providing a more comprehensive view of AI's role in the sector.

Key themes explored included the challenges, opportunities, and risks associated with AI in the road sector. While AI technologies offer significant potential benefits, such as improved traffic management and infrastructure optimisation, challenges such as data security, cyber-physical vulnerabilities, resistance to change, and the lack of skilled workforce must be addressed. Furthermore, the study examined implications for gender equality and social inclusion, ensuring that AI adoption contributes to inclusive and equitable outcomes.

The research identified the necessary changes National Road Authorities (NRAs) must implement to transition from the current state to the 2030 vision. This involved evolving business processes, upgrading workforce skills, and aligning with emerging regulatory frameworks. Governance was another critical area, focusing on the need for robust frameworks to manage AI technologies' risks, such as data security and algorithm transparency.

Finally, the “To-Be” vision outlined how AI could transform the road sector by 2030, with tailored recommendations for high- and low-income countries. These recommendations aimed to support the safe, ethical, and inclusive development of AI, ensuring its positive impact on road infrastructure globally.

Figure 1: Key themes underpinning the research methodology.

2.2. STRUCTURE OF RESEARCH METHODOLOGY

The research methodology for this study is structured in three phases: (i) information collection, (ii) data analysis & scenario development, and (iii) formulation of recommendations. The literature review involved a systematic examination of academic publications, industry reports, case studies, and government documents to provide a comprehensive overview of AI applications in the road sector. Key AI technologies across planning, construction, operations, and maintenance were evaluated, with a focus on regulatory frameworks, technological advancements, and socio-economic challenges in varying income levels. The findings identified best practices, technological maturity, and emerging trends in AI adoption.

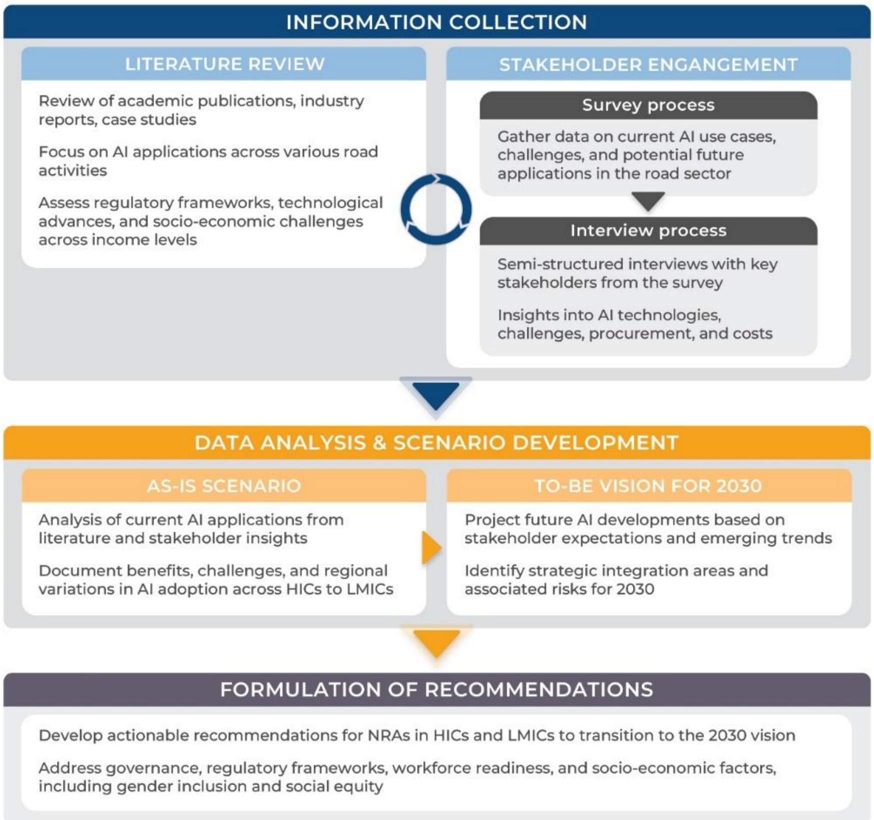

Figure 2: Structure of research methodology.

Stakeholder engagement was central to the research, involving surveys and interviews. An international survey conducted by ROD on behalf of PIARC captured information on challenges faced in the road sector, existing AI technologies, and future opportunities. Stakeholders, particularly NRAs, local road authorities, engineering firms, technology providers, and research institutions, provided valuable insights into AI's current role and future potential. The survey also highlighted disparities in technological infrastructure, particularly between urban and rural areas, and helped to select suitable interview participants. Interviews were conducted with professionals directly involved in AI implementation or strategic planning within the road sector. The semi-structured format allowed for flexibility while covering case studies, challenges in HICs, and opportunities in LMICs. Key topics included AI pilot programmes, procurement processes, risks, barriers to adoption, and policy changes necessary for AI integration. Concerns such as data privacy, cybersecurity, job displacement, and technical reliability were also addressed.

Data from the literature review and stakeholder engagement were synthesised to develop two scenarios: the “As-Is” scenario, documenting current AI applications and challenges, and the “To-Be” vision for 2030, projecting future AI developments. These insights formed the basis for targeted recommendations for NRAs, focusing on governance, regulatory frameworks, workforce development, and social equity in AI adoption.

3. LITERATURE REVIEW

3.1. INTRODUCTION

This Section summarises the literature review process, detailing the types of information examined and how 148 sources, including academic papers, industry reports, case studies, and government publications, were analysed to support the study of AI in the road sector.

3.2. AI TECHNOLOGY CATEGORISATION

A categorisation approach was developed to analyse AI technologies in the road sector, focusing on their impact across different infrastructure aspects. Technologies were assessed based on their application to different activities in the road sector such as asset management, road safety, and tolling, mapped to all life-cylce stages of road infrastructure from planning to maintenance. The analysis also examined targeted asset types (e.g., pavements, bridges) and associated data (e.g., traffic flow, maintenance alerts). Benefits, risks, and implementation challenges were also documented. Technologies were categorised by maturity, from prototypes to established systems, with effectiveness and financial implications assessed based on available data. In addition to the technical aspects, the review also incorporated legislation, regulations, and policies.

3.3. AI IN THE ROAD SECTOR: DEVELOPMENTS TO 2030

This Section presents AI technologies used in various activities in the road sector, based on the literature. Figure 3 indicates the proportion of reviewed AI examples which were attributed to the different activities. The percentages in Figure 3 are based on the reviewed literature, which of course, may not be fully representative of the areas in which AI is being used in practice.

As discussed in Section 3.2, AI applications were categorised by their supporting activity. This Section describes AI applications across the 15 main road related activity areas. Figure 3 highlights the distribution of literature, with 63% linked to infrastructure inspection, road safety, operations, asset management, and construction. These key areas are further explored in Section 5, which presents case studies from different parts of the world and offers recommendations for AI adoption across the road sector.

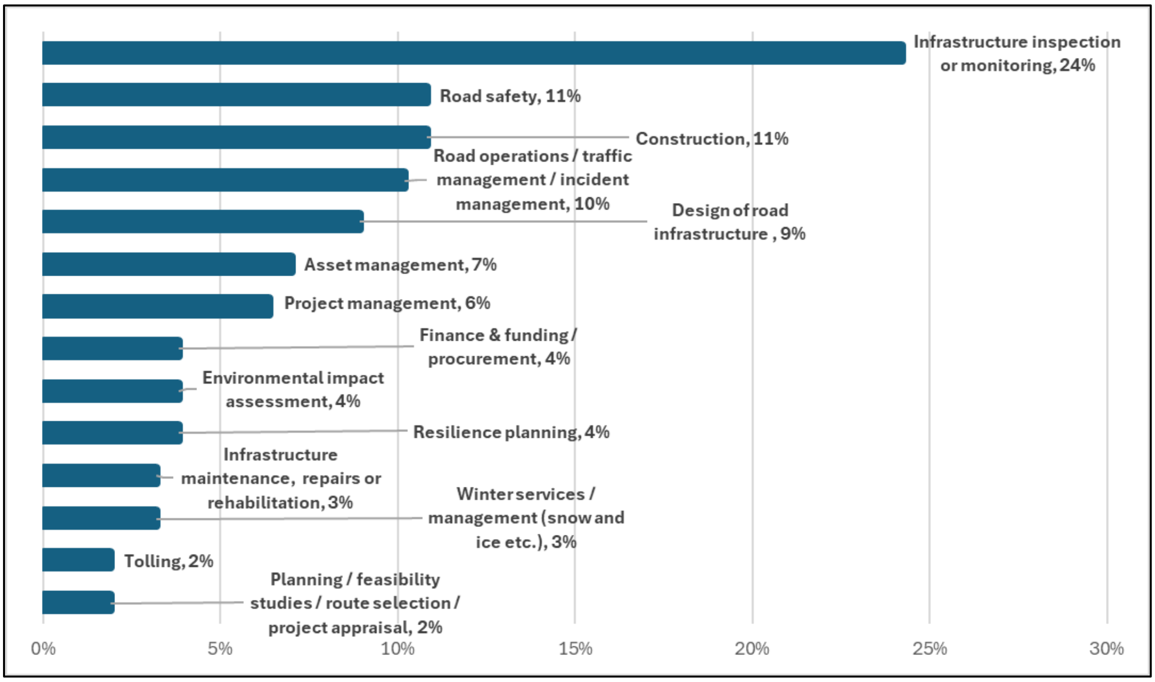

Figure 3: Areas of application of AI technologies in the road sector based on the literature.

Table 1: Key AI technologies for each road activity.

Road activity	Key AI technologies documented in the literature		
Planning, feasibility, route selection, appraisal	AI algorithms for data analysis and prediction	AI-driven image processing and 3D modelling	
Resilience planning	AI for climate forecasting	Remote sensing and imaging tech	
Environmental impact assessment	AI algorithms for environmental risk analysis	Digital screening tools for evaluation	Remote sensing for environmental monitoring
Road infrastructure design	AI algorithms for road layout optimisation	AR and MR for 3D visualisation	AI generative design algorithms
Construction	DT for real-time monitoring and decisions	AR with ML for site visualisation and precision	Predictive analytics for construction management
Project management	Predictive algorithms for project planning and scheduling	AI-driven resource allocation and optimisation	AI project management tools for decision-making and efficiency
Road operations, traffic, and incident management	Adaptive traffic signal systems	AI traffic management and incident detection systems	ML for traffic prediction
Tolling	AI-driven ANPR Systems	ML for toll revenue forecasting	
Winter services and management	Autonomous snowploughs with ML and sensors	ML for slippery road detection	AI predictive algorithms for resource management
Road safety	ADAS for vehicle safety	AI-powered monitoring for driver behaviour and violations	AI road attribute classification for risk assessment
Asset management	AI mobile sensing for real-time road condition monitoring	ML for predicting road conditions using satellite imagery	
Infrastructure inspection, monitoring, maintenance and repairs	UAVs for road assets Inspections	Computer vision and ML for pothole detection and mapping	AI-based air quality and emission monitoring systems
Policy development	Data-driven insights for tailored road safety policies	AI models for traffic analysis and accident prediction	
Finance, funding, and procurement	AI cost estimation tools for budgeting and forecasting		

Abbreviations
ADAS = Advanced Driver Assistance Systems, ANPR = Automated Number Plate Recognition, AR = Augmented Reality, DT = Digital Twin, ML = Machine Learning, MR = Mixed Reality, UAV = Unmanned Aerial Vehicle.

Current applications of AI in the road sector

AI integration in the road sector has advanced significantly in recent years, particularly in HICs, while LMICs are adopting solutions at a slower pace. AI technologies are used across various road infrastructure activities as shown in Figure 3. In HICs, AI is essential for managing traffic flows, optimising signal timings, and enhancing road safety. Adaptive traffic signal systems, powered by Machine Learning (ML) algorithms, adjust in real-time to traffic conditions, reducing congestion and improving traffic flow. AI-based traffic management systems dynamically allocate resources, such as adjusting lanes, to optimise efficiency. Additionally, AI-driven Advanced Driver Assistance Systems (ADAS) use computer vision and ML algorithms to monitor road conditions, detect obstacles, and warn drivers of potential hazards. These technologies, widely used in countries such as the US and several European nations, help prevent accidents and enable features such as autonomous braking and lane-keeping assistance.

AI also plays a key role in infrastructure inspection and maintenance in HICs. Predictive maintenance and automated inspections using computer vision and drone-based systems, such as Unmanned Aerial Vehicles (UAVs), monitor road assets e.g. bridges and pavements. These systems identify defects and wear, reducing reliance on manual inspections and allowing more frequent assessments. For instance, drones equipped with computer vision are used to identify structural issues such as cracks in bridges or potholes in the pavement surface. AI algorithms are also being used to analyse large datasets and forecast maintenance needs, enabling prioritisation of repairs and efficient resource allocation.

The literature also indicates that, in asset management, AI is being used to optimise road network management and maintenance schedules by processing data from sensors, satellite imagery, and traffic reports. AI models predict when assets will require maintenance or rehabilitation. In HICs, these systems enable proactive management, helping authorities focus on high-risk areas. AI scheduling ensures repairs occur during off-peak hours, minimising traffic disruptions. AI is also used for environmental sustainability. In HICs, AI models analyse data from satellite imagery and sensors to assess the environmental impact of road construction, optimise routes, and monitor air quality. AI is applied in climate forecasting and assessing the vulnerability of road networks to extreme weather events.

In LMICs, AI applications are still emerging. AI-powered traffic monitoring and incident detection systems are being trialled in countries such as India, Peru, and Kenya. AI is also used for asset management, utilising satellite imagery and drones to detect road damage and monitor infrastructure. However, financial and infrastructure limitations in LMICs can prevent the large-scale implementation of these technologies, with most applications confined to urban areas where digital infrastructure is more developed.

Challenges and barriers to AI implementation

In HICs, despite advanced technological infrastructure and financial resources, a major barrier to AI adoption is the quality and reliability of data. AI systems rely on accurate, consistent data, yet even in developed countries, road management systems often face data gaps, inconsistencies, and inaccuracies, undermining the effectiveness of AI in areas such as traffic management and predictive maintenance. For LMICs, challenges are more pronounced due to financial constraints and lack of technological infrastructure. The high initial costs of implementing AI technologies, including data collection, system integration, and staff training, can be prohibitive. Data availability is another issue, with many LMICs (and also some HICs) struggling with unreliable data, limiting the effectiveness of AI applications in predictive maintenance, traffic management, and infrastructure monitoring.

Predictions for 2030

By 2030, AI is expected to significantly impact the road sector, with advancements across various applications. While AI adoption will differ between HICs and LMICs, the trend towards automation, data-driven decision-making, and sustainability will shape global road infrastructure management. In HICs, AI will become integral to urban mobility systems, enhancing technologies such as adaptive traffic signals and intelligent transport networks. AI-driven traffic management will improve traffic flow, adjust signals, and manage congestion in real-time, using data from sensors and cameras to predict traffic patterns, improving safety and efficiency. In road safety, AI applications such as ADAS, including collision avoidance and lane-keeping, will become more widespread, reducing accidents caused by human error. AI will also improve incident detection, enabling quicker responses to hazards through real-time systems using video analytics and ML to detect dangerous behaviours.

AI will transform infrastructure management in both HICs and LMICs. In HICs, predictive maintenance and Digital Twins (DTs) will improve resource allocation and reduce downtime. AI systems will predict infrastructure wear and tear, enabling proactive repairs before significant damage occurs, improving safety and reducing costs. In LMICs, despite barriers, satellite imagery and drone inspections will grow rapidly, providing cost-effective solutions for monitoring road conditions, particularly in remote areas. Combined with AI-powered analytics, these tools will help governments prioritise repairs and enhance road safety.

AI will enhance sustainability by optimising traffic flow, reducing emissions, and improving fuel efficiency in HICs. It will contribute to climate resilience by assessing the impact of extreme weather on roads. In LMICs, AI will help build climate-resilient infrastructure by predicting risks, enabling pre-emptive action to minimise damage.

3.4. Legislation and governance

This Section highlights key regulatory developments and challenges in AI integration. These are outlined in Table 2. While HICs progress the development of AI regulations, many LMICs struggle to develop or enforce frameworks. The EU has taken a lead with the EU AI Act, the first comprehensive legal framework for AI. The Act categorises AI applications by risk level, with high-risk systems, such as those managing critical road infrastructure, subject to strict oversight. Set to take effect in 2026, the Act imposes penalties for non-compliance, setting a precedent for other regions and influencing global AI regulations. In North America, regulatory frameworks are still evolving. The US lacks comprehensive federal AI legislation, though states such as California and Colorado have introduced private-sector AI governance laws, which will likely impact AI systems in transport. Canada is preparing an AI and Data Act to regulate high-impact AI systems, ensuring ethical deployment and preventing biases, especially in road planning.

Many LMICs lack specific AI laws, with only general data protection laws governing AI deployment. Countries such as Mexico and Costa Rica are exploring AI but have yet to establish comprehensive frameworks. This regulatory uncertainty, along with a lack of clear AI guidelines for the road sector, presents compliance and risk challenges. These regions focus on developing digital infrastructure and capacity-building initiatives.

In conclusion, while progress is being made in AI legislation, particularly in HICs, a significant gap remains in regulatory preparedness, especially in LMICs. By 2030, most HICs are expected to have integrated AI regulations aligned with international standards, while LMICs will need to develop frameworks that support AI adoption and address concerns around data security, ethics, and accountability.

Table 2: Global AI regulation adoption by region.

Region	Matured	Developing	Nascent
Europe	Europe leads in AI regulation with the EU AI Act, classifying AI by risk and enforcing strict compliance for high-risk systems. Countries such as Germany, the UK, France, and other EU members have strong AI governance frameworks.	Some EU nations are implementing these frameworks, though the process may vary slightly between member states.	No notable regions here.
North America	The U.S. and Canada are advancing AI regulation with initiatives such as the NIST AI Risk Management Framework and Canada's AI and Data Act, guiding AI adoption in industries such as transportation.	Some U.S. states have AI laws, but they are not yet standardised nationwide.	Limited, though some areas, particularly smaller or less-regulated ones, are still in the early stages.
Asia	Japan and Singapore are leading AI initiatives in transport, smart cities, and infrastructure management.	China has ambitious AI plans, but its regulations are still developing, with inconsistent enforcement across regions.	Many developing Asian countries, especially in Southeast and South Asia, are still in the early stages of AI governance due to limited resources and infrastructure.
Africa	Limited examples exist, with ongoing projects such as AI guidelines from the African Union, but these are not yet binding regulations.	Some countries, such as South Africa, show interest in AI, but regulations are still in the conceptual stage.	Most African countries, especially in Sub-Saharan Africa, are in the early stages of developing AI legislation and governance.
Latin America	Brazil has made progress with digital governance frameworks, though not fully focused on AI-specific regulations.	Countries such as Argentina, Chile, and Colombia are developing AI policies, but regulatory frameworks are still forming.	Other countries in the region are exploring AI in the road sector, with limited regulatory frameworks.
Oceania	Australia is making significant progress in AI regulation with a national strategy and frameworks covering sectors like transportation.	New Zealand is developing AI policies but lags behind Australia.	No notable regions here.

4. RESULTS FROM STAKEHOLDER ENGAGEMENT

4.1. Introduction

The stakeholder engagement process was crucial for gathering insights from road sector actors and understanding the current and future roles of AI technologies. It involved an international survey and in-depth interviews. The survey offered a global view of AI challenges, applications, and opportunities, helping to identify stakeholders for interviews. These interviews explored case studies and examined challenges and opportunities in both HICs and LMICs. This approach shaped the study's recommendations in Section 0.

4.2. Surveys

Key survey findings are discussed below and presented in Figure 4 to Figure 8. These include current and planned AI applications in the road sector, as well as anticipated benefits of AI and barriers to its adoption.

The survey revealed notable regional differences in AI adoption. In HICs, AI applications were advanced, especially in traffic management and incident detection, as well as infrastructure inspection and monitoring, all supported by strong digital infrastructure in HICs. In contrast, AI adoption in LMICs was in its early stages, mainly limited to pilot projects or basic applications such as vehicle counting, with advanced uses such as predictive analytics being rare. Respondents reported varying AI benefits. In HICs, the main advantages were time savings, better infrastructure inspection, and improved road safety. In LMICs, benefits were more modest, particularly in asset management and savings. The survey indicated that AI's full potential, especially in asset management and network performance, remains underexplored in LMICs.

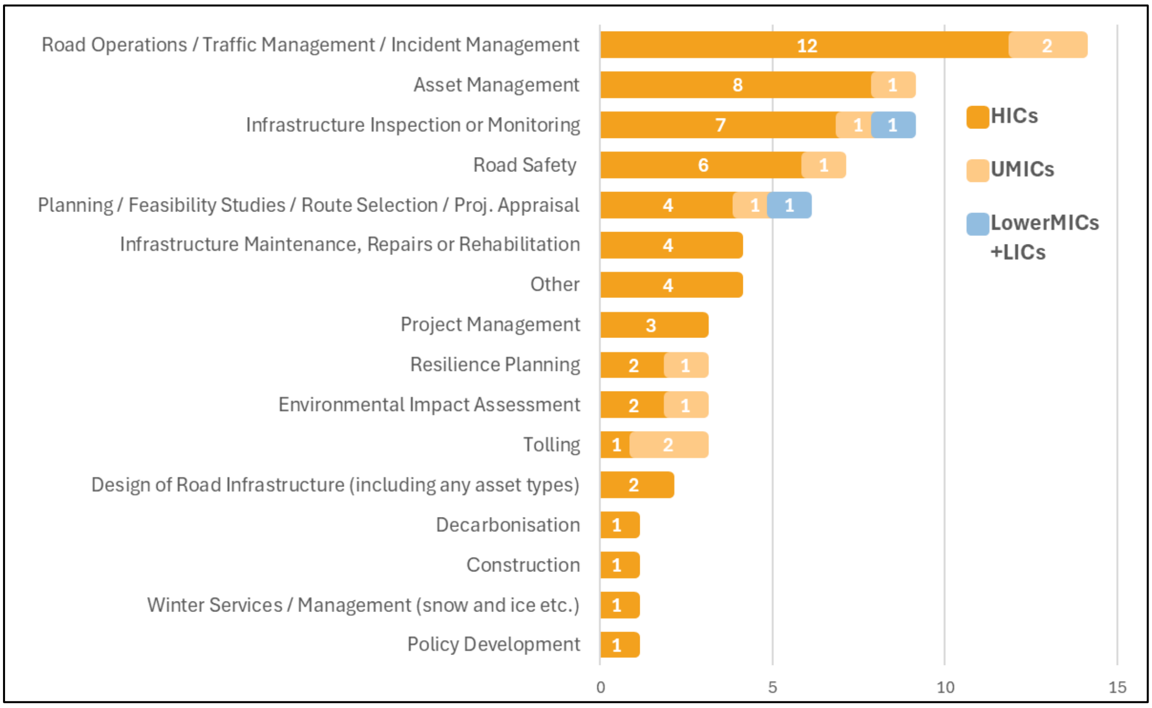

Figure 4: Current applications of AI in the road sector based on surveys and interviews.

Looking ahead to 2030, the survey predicted growing adoption of AI technologies across the road sector. However, respondents from HICs showed more definite plans to implement AI, with 80%

indicating a clear intention to adopt AI. In contrast, only 10% of respondents from UMICs and LICs expressed similar plans, though no respondent from any income group reported a lack of intention to adopt AI. This indicates recognition of AI's potential, though adoption will likely vary significantly depending on regional economic factors.

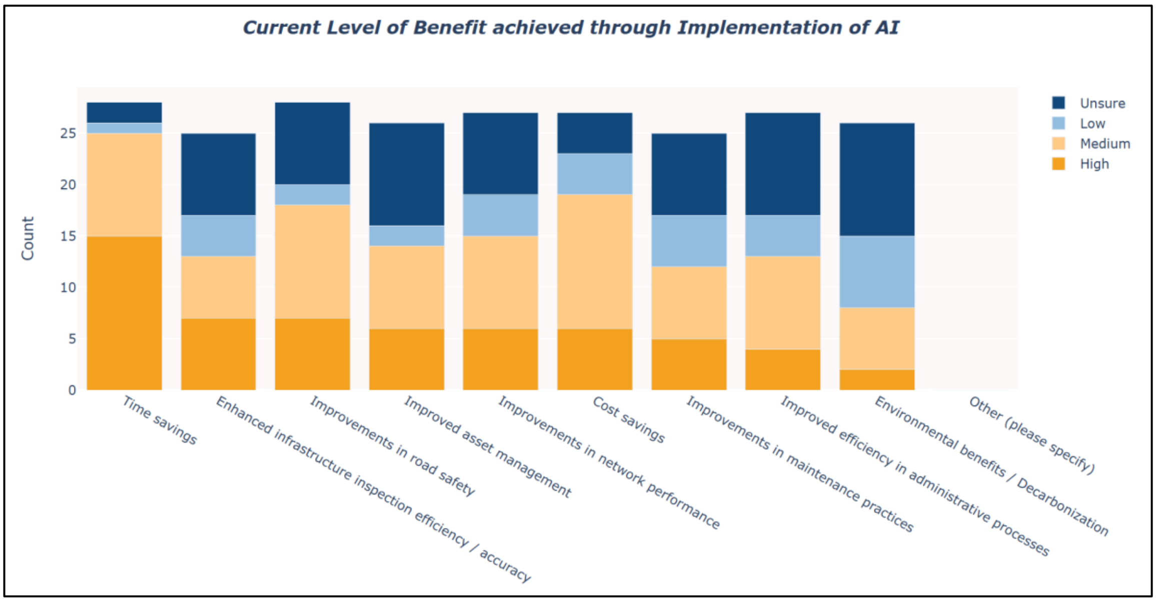

Figure 5: Current level of benefit achieved through AI Implementation.

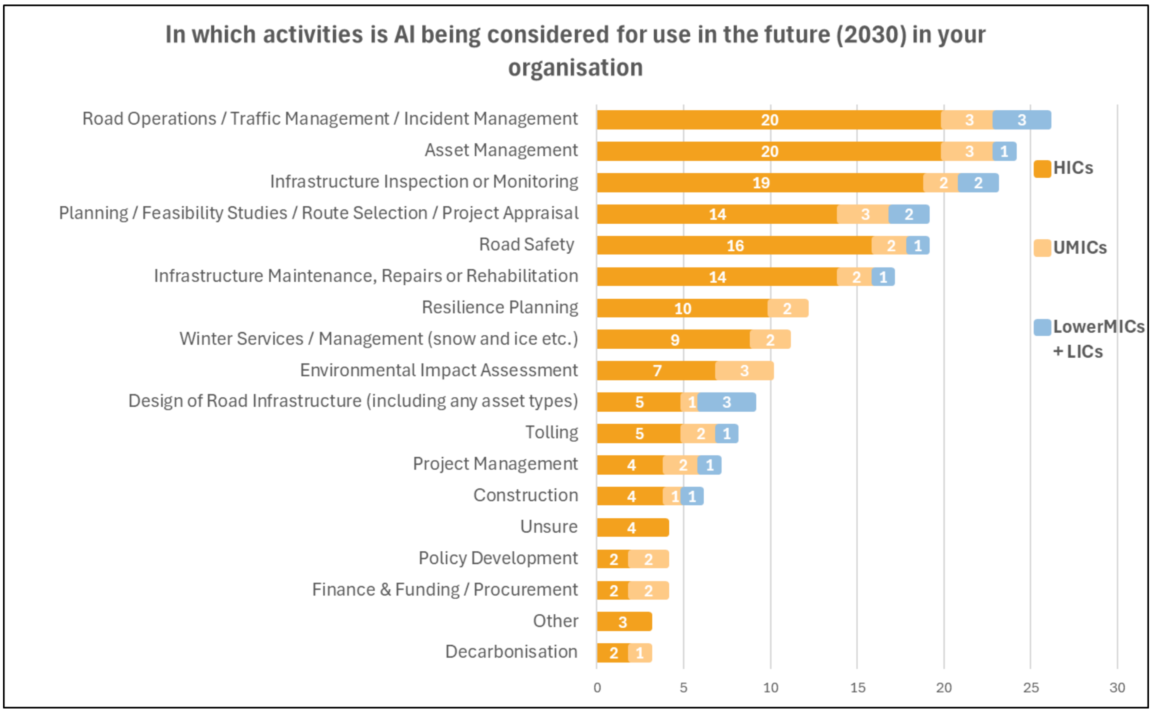

Figure 6: Predictions of AI applications in the road sector by 2030.

Barriers to AI implementation were also explored as part of the survey. In HICs and UMICs, data-related issues, such as privacy and cybersecurity concerns, were prominent. In LowerMICs+LICs, the main challenge was a shortage of skilled personnel, highlighting the need for targeted training.

Other barriers identified across all regions included financial constraints, regulatory uncertainty, and resistance to change within organisations, particularly in lower-income regions where fears of job displacement were more pronounced.

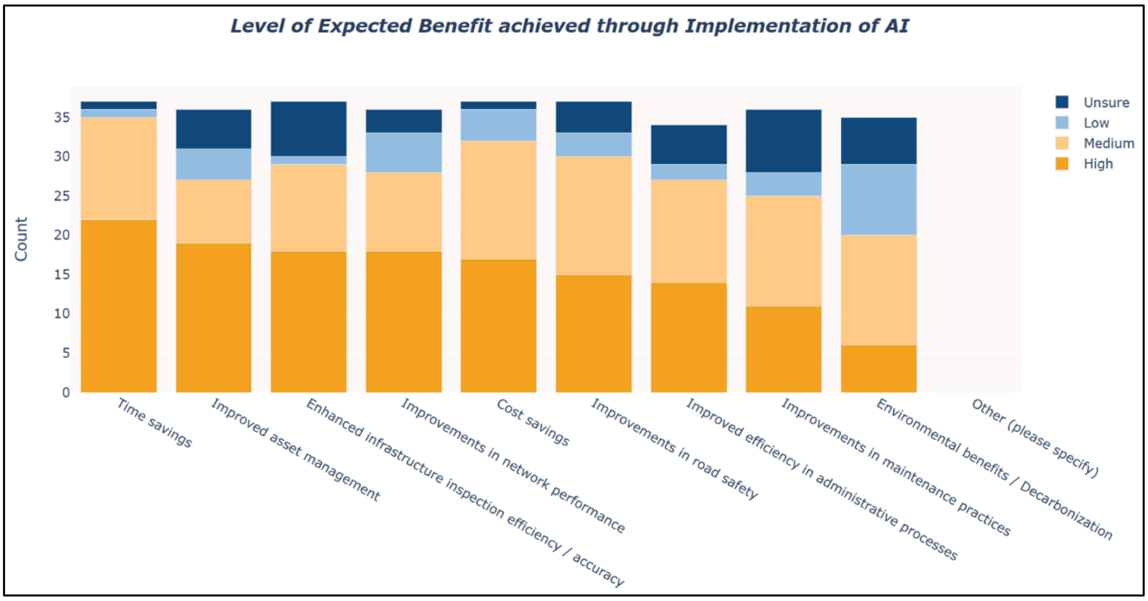

Figure 7: Level of Expected Benefit achieved through AI Implementation.

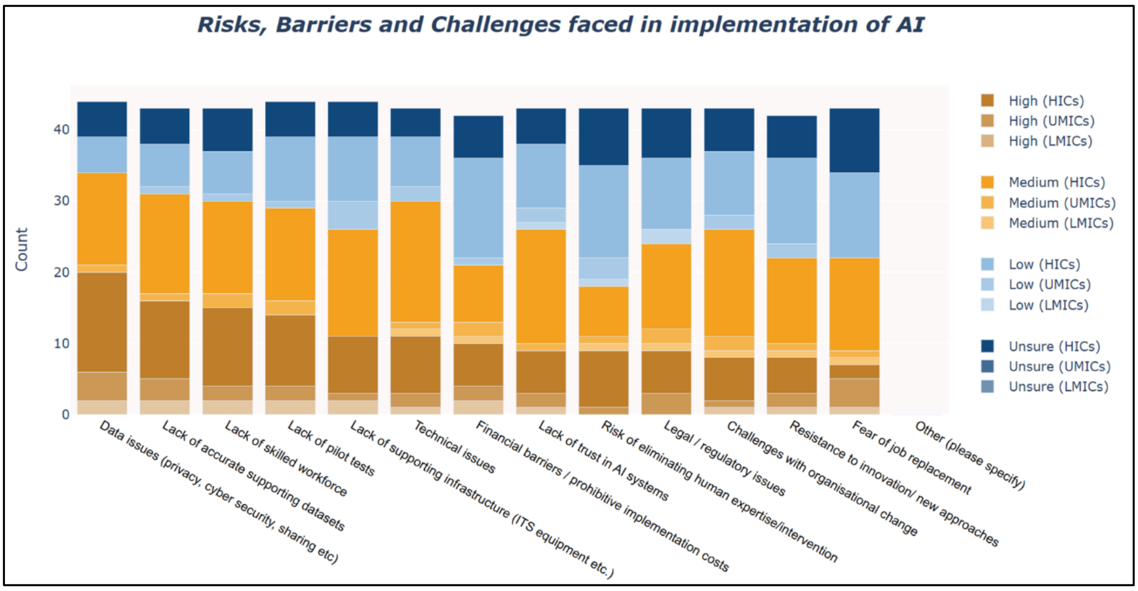

Figure 8: Risks, barriers and challenges faced in AI Implementation.

4.3. INTERVIEWS

The survey also allowed key stakeholders to be invited for interview. The interviewees were specifically chosen to gain in-depth insights on AI adoption by selecting individuals who had experience of implementing AI technologies in the road sector. These interviews allowed detailed case studies of specific AI use cases to be documented. Other interviews were also structured to gain insights into broader perspectives on AI in both HICs and LMICs. Overall, the interviews focused on (1) AI technology pilots, (2) challenges in HICs, and (3) opportunities and barriers in LMICs. ROD conducted 8 interviews with 11 stakeholders across 7 countries (3 from HICs, 1 from LICs, 1 from LowerMICs, and 3 from various incomes). The segmented questions enabled focused discussions, gathering actionable insights on regional AI applications. A semi-structured approach was used, with questions shared in advance to ensure that the interviewees had time to prepare.

Figure 9 illustrates that interviewees reported use of AI in asset management, infrastructure inspection, and road safety. Figure 10 highlights key benefits, with time savings and road safety being identified as the primary advantages. Figure 10 also outlines AI implementation challenges, including a shortage of skilled workforce, infrastructure issues, and data concerns.

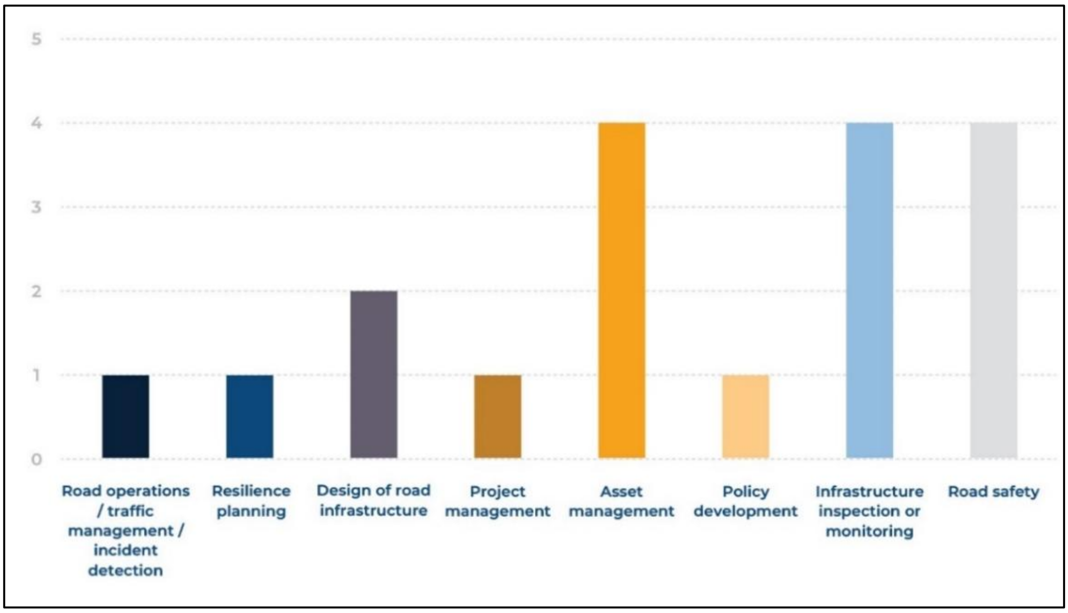

Figure 9: Different activities for which interviewees are involved or have implemented AI technologies.

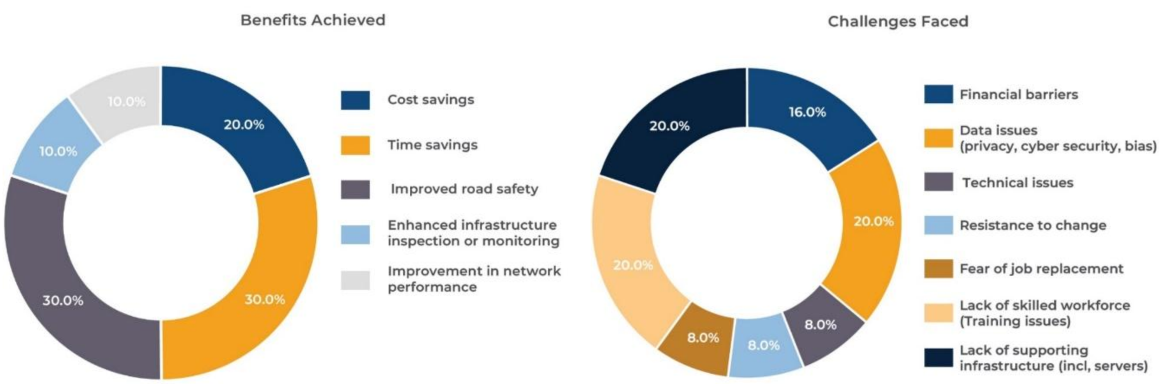

Figure 10: Key Benefits and Challenges Identified by Interviewees in AI implementation.

4.4. Comparison of Survey and Interview Findings

The survey and interview findings reveal similarities and differences in AI adoption within the road sector. Both highlight AI's potential in road operations, traffic management, and infrastructure inspection. The survey showed 30% of respondents reporting use of AI in road operations or road safety and 25% reporting the use of AI in asset management of infrastructure inspection. The interviews focused more specifically on the areas of asset management and road safety to gain further insights into AI applications and case studies in these areas. Both stages of stakeholder engagement noted AI maturity differences, with HICs being more advanced and LMICs limited to pilot projects. Interviews highlighted some of the key challenges experienced in LMICs, including skill shortages and infrastructure gaps. The survey was more optimistic, while interviews in LMICs emphasised financial and political barriers.

4.5. Conclusions, implications, and alignment with literature

The stakeholder engagement findings align with the literature, highlighting AI adoption challenges and opportunities in the road sector. There is a global consensus on AI's potential, though region-specific strategies are needed. The literature mentions AI applications in HICs, such as adaptive traffic signals and predictive maintenance, which agree with the results reported in the survey. HIC respondents report widespread AI use and optimism for 2030. In LMICs, barriers like poor infrastructure, data quality, financial constraints, and skill shortages are noted, highlighting the gap between HICs and LMICs. The findings suggest tailored approaches to address financial, data, and regulatory barriers in LMICs and promote international collaboration.

5. CASE STUDIES

This Section presents case studies which demonstrate real examples of AI being used in the road sector. The case studies focus on applications of AI to road safety and infrastructure inspection / asset management. A brief overview is provided for 7 case studies, and for readers who are interested in learning more about these case studies, the full-length version of this report includes full details. Examples include Oslo's EyeVi for road defect detection, the Faroe Islands' COWI for remote bridge inspections, and Lima's use of Lanternn for optimising traffic flow. Other projects cover AI-powered traffic law enforcement in New South Wales, road safety enhancement in India, and satellite monitoring of unpaved roads in Africa. These case studies highlight AI's potential and provide valuable lessons in relation to the integration of AI into important activities for NRAs and ROs.

Figure 11: EyeVi platform - digitalisation of defects on Oslo's urban road network

Figure 12: COWI virtual inspection platform - condition assessment of Faroe bridges.

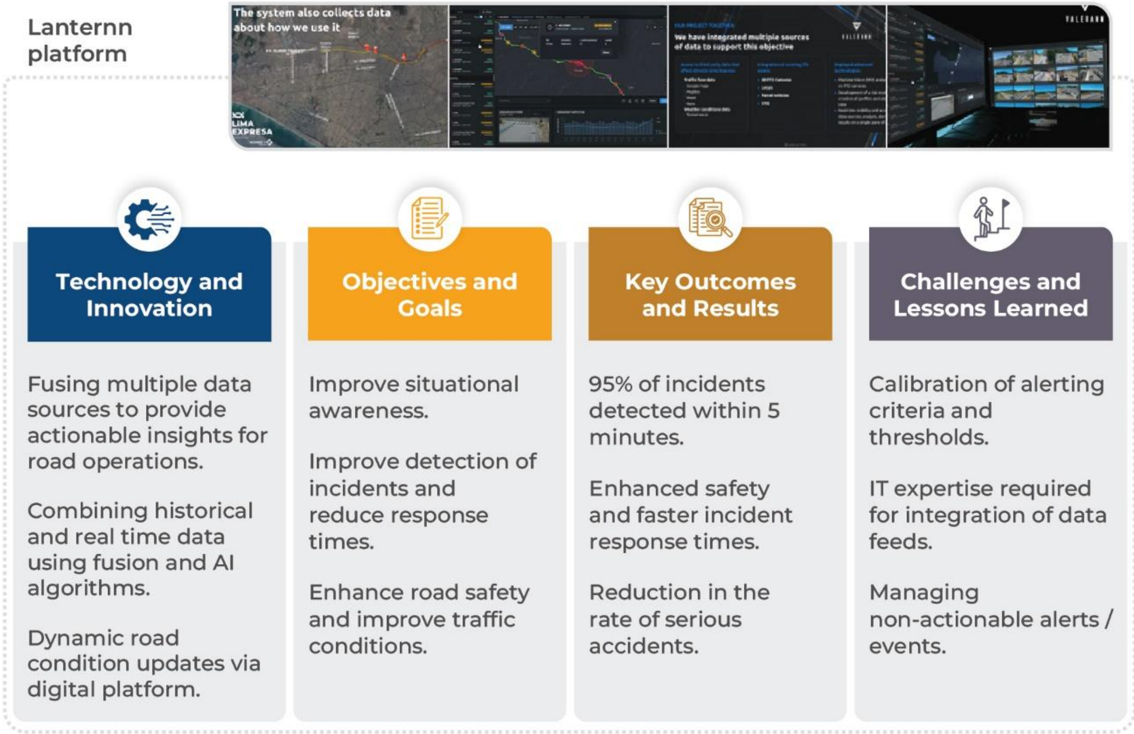

Figure 13: Lanternn by Valerann used for incident detection in Lima, Peru.

Figure 14: Acusensus used for detecting mobile phone & seatbelt offences in New South Wales, Australia.

Figure 15: iRASTE project focused on using AI for improving road safety, India.

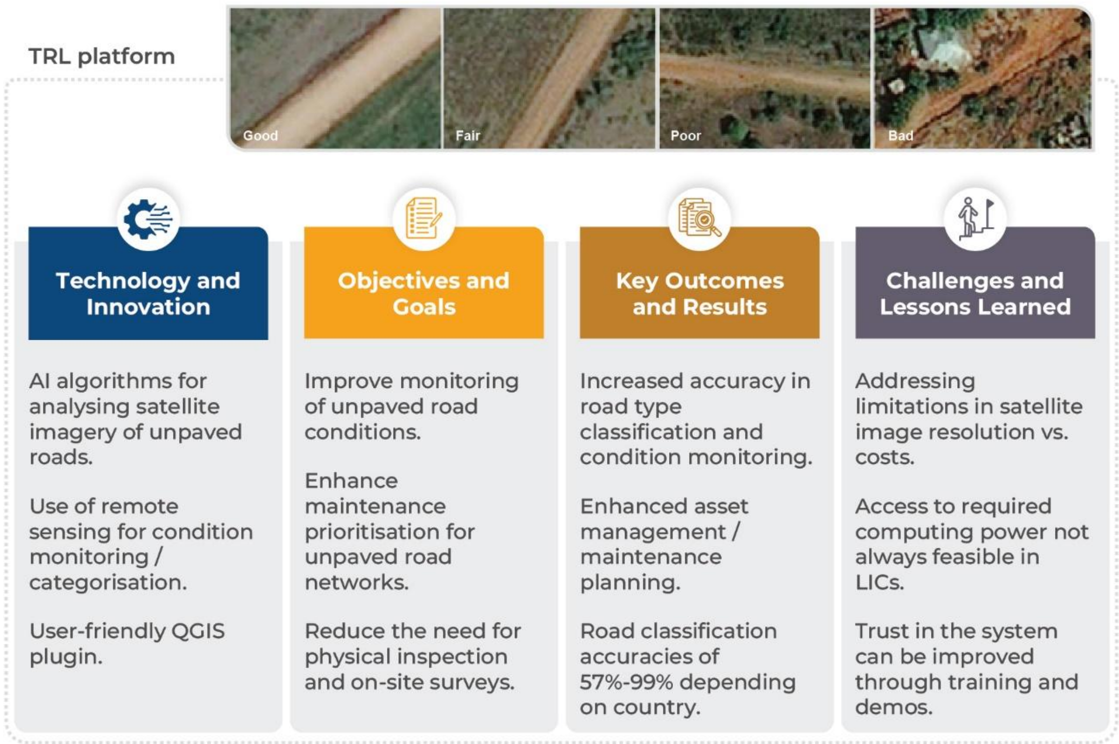

Figure 16: TRL - Monitoring of unpaved road conditions in Africa using satellite imagery and AI.

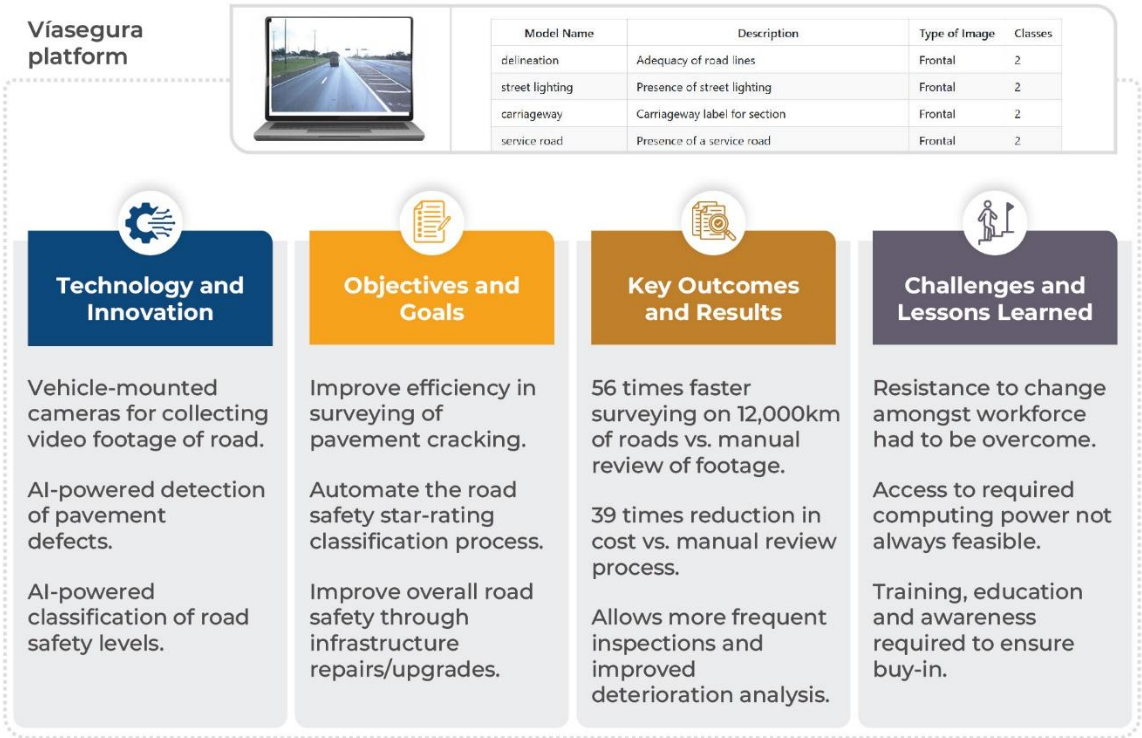

Figure 17: Víasegura - Automated classification of road safety and pavement condition in South America.

6. SUMMARY OF AI USE IN THE ROAD SECTOR

6.1. “AS-IS” SCENARIO FOR AI IMPLEMENTATION IN THE ROAD SECTOR

Based on the overall findings from the literature review and the stakeholder engagement, Figure 18 presents the current “As-Is” scenario for AI adoption in the road sector, highlighting the relevant AI technologies in use in HICs and LMICs. AI adoption is more advanced in HICs, particularly in areas such as infrastructure inspection, road safety, traffic management, and maintenance or rehabilitation. In contrast, LMICs are beginning to implement AI mainly for infrastructure inspection and road safety. The diagram also shows that HICs use AI extensively in road operations, traffic management, and incident management, while these applications are still developing in LMICs. HICs also use AI for infrastructure maintenance and repairs, areas where these applications in LMICs are not as well developed. In HICs, applications of AI in the construction phase are becoming quite common, whereas LMICs have not yet reached the stage where these technologies have been adopted as part of the construction phase. This diagram highlights the disparity in AI adoption between HICs and LMICs, reflecting differences in infrastructure, resources, and regulatory frameworks. While there is potential for growth in AI adoption in LMICs, it will require investment, technological infrastructure, and regulatory development.

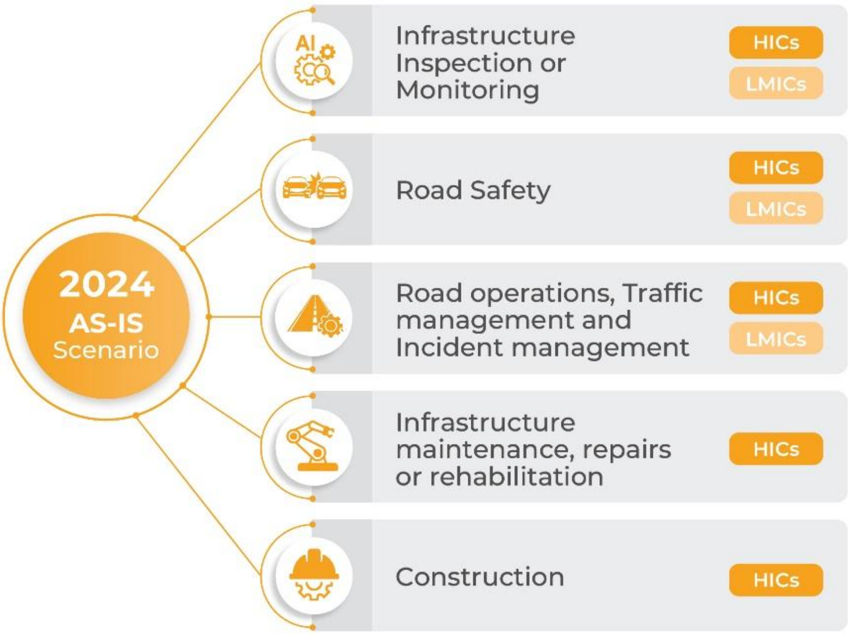

Figure 18: Current status of AI use in the road sector (As-Is scenario).

6.2. “TO-BE” VISION FOR AI IN THE ROAD SECTOR

Figure 19 illustrates the anticipated “To-Be” vision for AI adoption in the road sector by 2030. HICs are expected to lead in AI application, expanding its role to proactive asset management, predictive maintenance, planning, feasibility studies, and road infrastructure design. This marks a significant shift from operations to strategic planning and design. LMICs are expected to make progress, particularly in infrastructure maintenance, repairs, rehabilitation, and construction, but AI use in planning and design is expected to remain largely in HICs by 2030. The diagram highlights LMICs’ potential to integrate AI, requiring advancements in infrastructure, investment, and supporting regulatory frameworks. By 2030, AI is expected to play a central role in road safety, traffic management, and proactive asset management in both HICs and LMICs, with a clear trajectory towards broader AI adoption, improving efficiency, safety, and sustainability. The following Sections provide a high-level overview of the opportunities, challenges and risks associated with AI adoption in the road sector. Detailed discussion and relevant recommendations for each item can be found in the full-length version of this report.

Figure 19: To-Be vision for AI in the road sector in 2030.

6.3. OPPORTUNITIES ASSOCIATED WITH AI IMPLEMENTATION

Figure 20 outlines the opportunities and benefits of AI adoption in the road sector, categorised into operational benefits for NRAs / ROs and societal benefits. These categories reflect AI's dual impact, improving internal operations and offering broader societal gains. Operational benefits include enhanced road safety, better asset management, cost savings, and improved worker safety. AI optimises processes such as predictive maintenance, enabling efficient resource allocation, reducing disruptions, and lowering costs. AI also improves internal efficiency, providing time savings and better decision-making. Societal benefits focus on road users and the wider community, including improvements in road safety, service quality, and resilience planning, as well as the creation of new job opportunities. AI-driven traffic management systems reduce congestion, enhance safety, and improve travel experiences. Moreover, AI's potential to generate new roles and evolve existing jobs supports workforce development in the road sector, ensuring long-term sustainability and growth.

Opportunities and Benefits	Operational Benefits to NRAs / Road Operators	Societal Benefits
Enhanced Road Safety	●	●
Enhanced Efficiency / Time Savings	●	
Cost Savings	●	
Improved Asset Management & Maintenance	●	
Improved Worker Safety	●	●
Improved Quality of Service	●	●
Improved Resilience Planning	●	●
Reputational Benefits	●	
New Job Opportunities & Evolving Roles	●	●

Figure 20: Key opportunities and benefits of AI in the road sector.

6.4. CHALLENGES AND BARRIERS FOR AI IMPLEMENTATION

Figure 21 highlights the challenges faced by different income groups (HICs, UMICs, Lower-MICs, and LICs) in adopting AI in the road sector. These challenges span technical, financial, infrastructural, and regulatory barriers, with varying impacts across each group. HICs face issues such as technical challenges, data ownership, resistance to change, and procurement, as well as financial barriers and complex legislation. UMICs share similar challenges but with greater emphasis on infrastructure and skilled workforce shortages. LowerMICs and LICs experience even more severe challenges, including financial barriers and the lack of infrastructure, skilled workers, and supportive legislation. A common issue across all groups is the incompatibility between AI outputs and existing processes, requiring alignment between AI technologies and traditional road sector operations. Overcoming these challenges will require tailored strategies, investments, and capacity building.

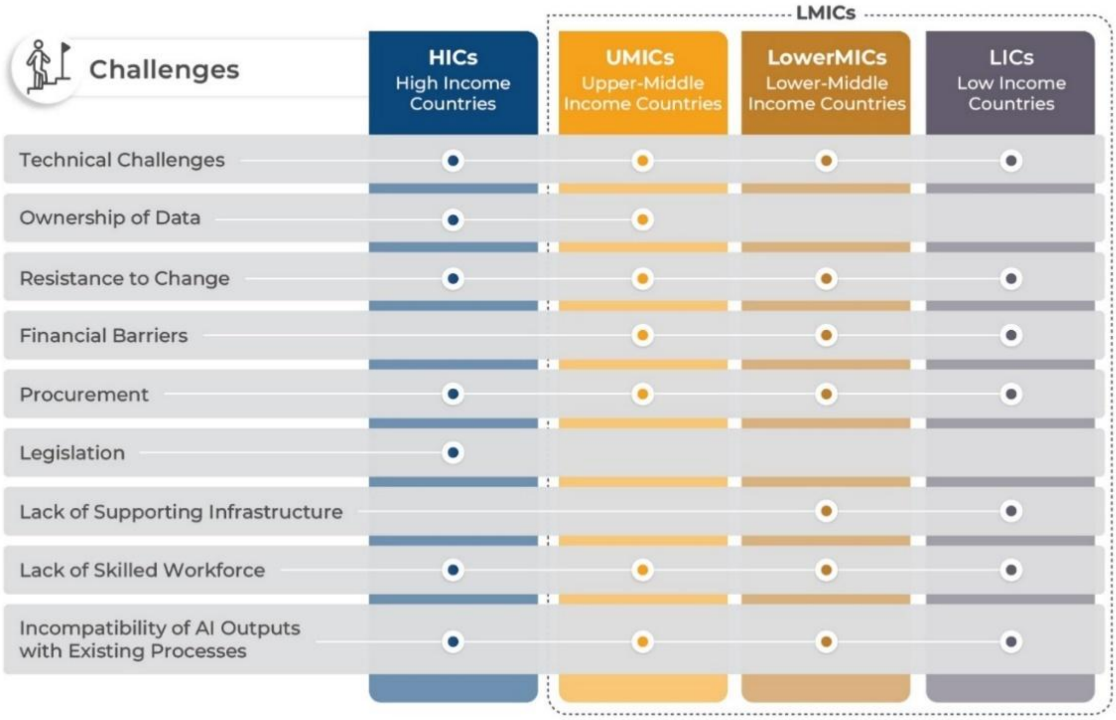

Figure 21: Key challenges and barriers for AI adoption in the road sector.

6.5. RISKS ASSOCIATED WITH AI IMPLEMENTATION

Figure 22 outlines the risks associated with AI adoption in the road sector across different income groups (HICs, UMICs, Lower-MICs, and LICs), as identified from the study. The risks are categorised into technical, financial, and ethical concerns, with varying impacts for each group. In HICs, risks include misinterpretation of AI outputs, cybersecurity issues, over-reliance on AI, data privacy, and funding continuity, as well as ethical concerns about inequality. In UMICs, these risks are similar, but financial and cybersecurity challenges are more significant. LowerMICs and LICs face greater vulnerability due to a lack of technical infrastructure and skilled personnel. The diagram highlights that while all groups share common AI risks, their ability to manage these risks depends on their economic and technical capabilities, requiring tailored risk management strategies.

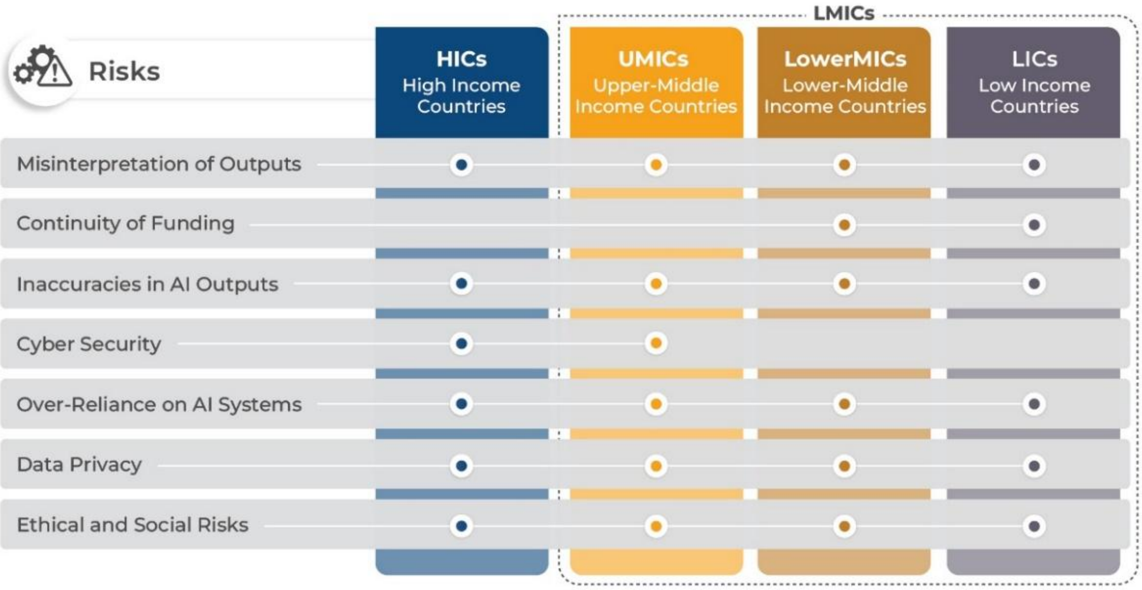

Figure 22: Key risks associated with AI adoption in the road sector.

7. RECOMMENDATIONS

7.1. UNIVERSAL PRINCIPLES FOR AI TRANSITION IN THE ROAD SECTOR

Before developing roadmaps for HICs and LMICs, it is essential to establish universal principles for AI integration in the road sector. These principles will provide a foundation for NRAs and ensure a structured approach to AI adoption by 2030. Key principles include:

1. The **Establishment of strong governance and regulatory frameworks**, with clear policies on ethics, cybersecurity, and oversight.
2. **Investment in capacity building and workforce development** is crucial, enabling staff to operate and maintain AI technologies.
3. **Enhancing data infrastructure** to ensure high-quality, interoperable data is vital.
4. **Collaborative innovation through international partnerships and private sector** engagement will support AI scalability, while
5. Ensuring **Inclusivity in AI deployment** will guarantee equitable benefits across regions, particularly rural areas.

7.2. ROADMAP: TRANSITION FROM "AS-IS" TO "TO-BE" VISION

HICs

Figure 23 outlines a roadmap for AI integration in the road sector in HICs, tracking progress from 2024 to wider-scale adoption by 2030. In 2024, was already shown to be providing benefits for infrastructure monitoring and transport operations, with 24% of reported usage focused on inspection, 14% on drone-based sensing, and 48% on road operations, traffic management, and incident detection, ultimately focused on improved road safety. Four strategic pillars support large-scale adoption: investment in pilot projects to establish business cases, workforce education to enhance AI skills, development of AI-enabling systems for data accuracy and scalability, and policy development for ethical deployment. By 2030, AI is expected to play a significant role in infrastructure inspection, predictive maintenance, autonomous transport, and construction site safety and efficiency, while also supporting early project planning and feasibility studies.

UMICs

The corresponding diagram for UMICs is shown in Figure 24. In 2024, AI is primarily being used in road operations, traffic management, and incident detection, highlighting its increasing role in improving transport efficiency and safety. Additionally, road safety is identified as a high-priority use case, reinforcing AI's potential to mitigate risks and improve traffic management systems. Four strategic pillars have been identified: investment in pilot projects, strengthening public-private partnerships for knowledge transfer, developing scalable AI solutions for deployment across road networks, and establishing a regulatory framework to ensure ethical AI development. By 2030, UMICs are anticipated to have adopted video analytics and sensor-based technologies for congestion management, AI-driven infrastructure inspection, deterioration modelling, and predictive maintenance systems.

Lower MICs

A similar diagram for LowerMICs is shown in Figure 25. In 2024, AI has already been trialled in asset management and infrastructure inspection, marking the initial phase of its adoption. Additionally, road safety is identified as a high-priority use case, reinforcing AI's potential to enhance safety measures and mitigate risks in transport networks. Four key pillars have been identified as shown in Figure 25: prioritising low-cost AI applications to address road safety and infrastructure issues, investing in digital infrastructure for data collection, securing funding for collaborative trials through international partnerships, and establishing a regulatory framework for ethical implementation. By 2030, LowerMICs are envisaged to have adopted low-cost traffic management systems, AI-driven infrastructure inspection, and road safety applications, including defect and 'blackspot' detection within road networks.

LICs

Figure 26 illustrates the progression of AI for LICs. In 2024, AI usage in LICs remains limited, while early-stage trials have been conducted for asset management and infrastructure inspection. These initial implementations are designed to assess AI's viability in improving infrastructure monitoring and management. Four strategic pillars have been identified: Developing AI readiness strategies involves assessing infrastructure gaps and action planning. Focusing on foundational AI applications prioritises low-investment, high-impact solutions, such as traffic monitoring. Capacity building and upskilling will raise AI awareness, fostering expertise. Finally, international collaboration will provide access to technical support and infrastructure, including cloud-based AI systems. By 2030, LICs should be expected to adopt reliable data collection systems, with some developments towards AI-driven road infrastructure identification, and traffic monitoring and maintenance planning.

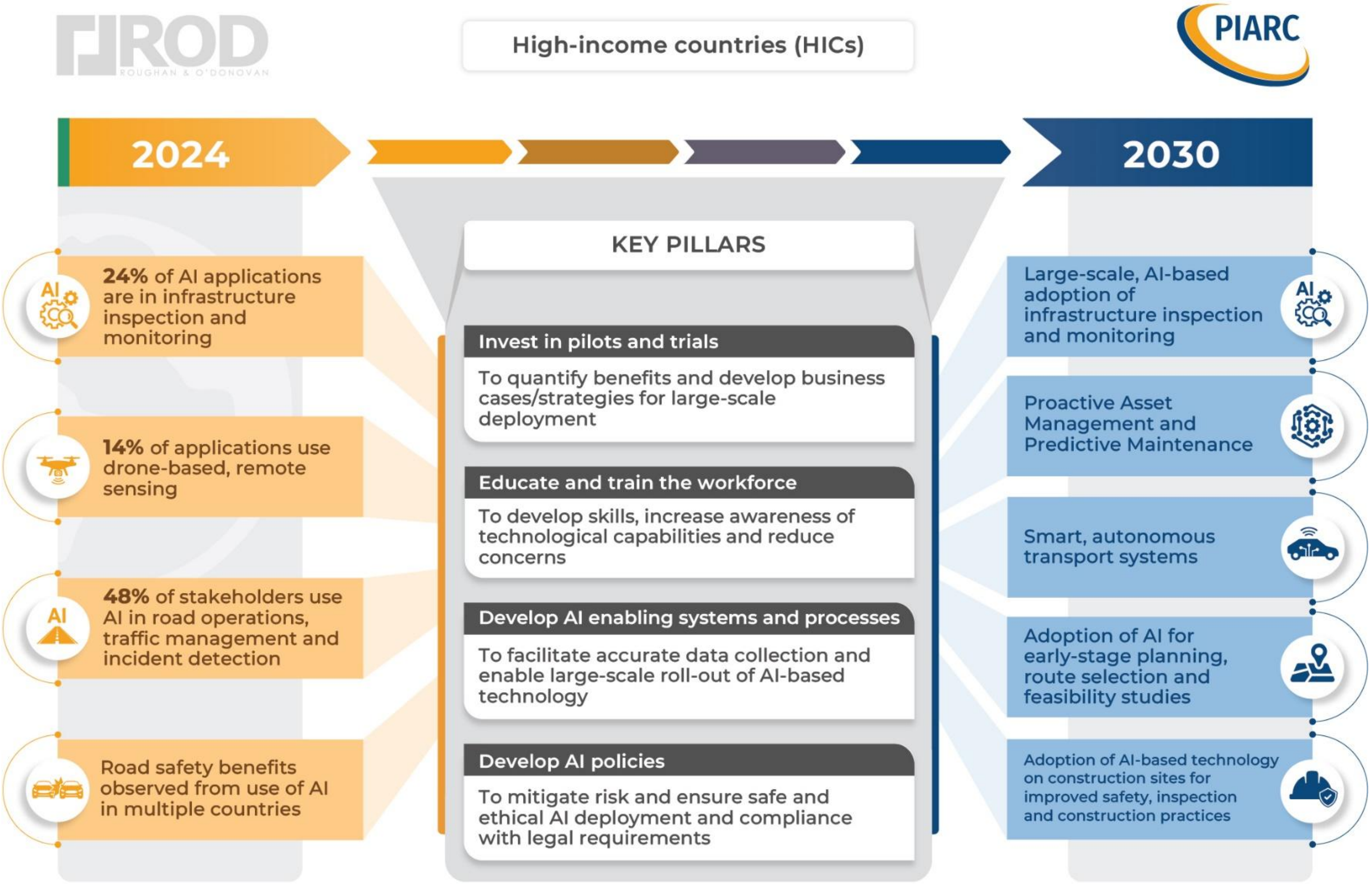

Figure 23: Roadmap for AI adoption in HICs.

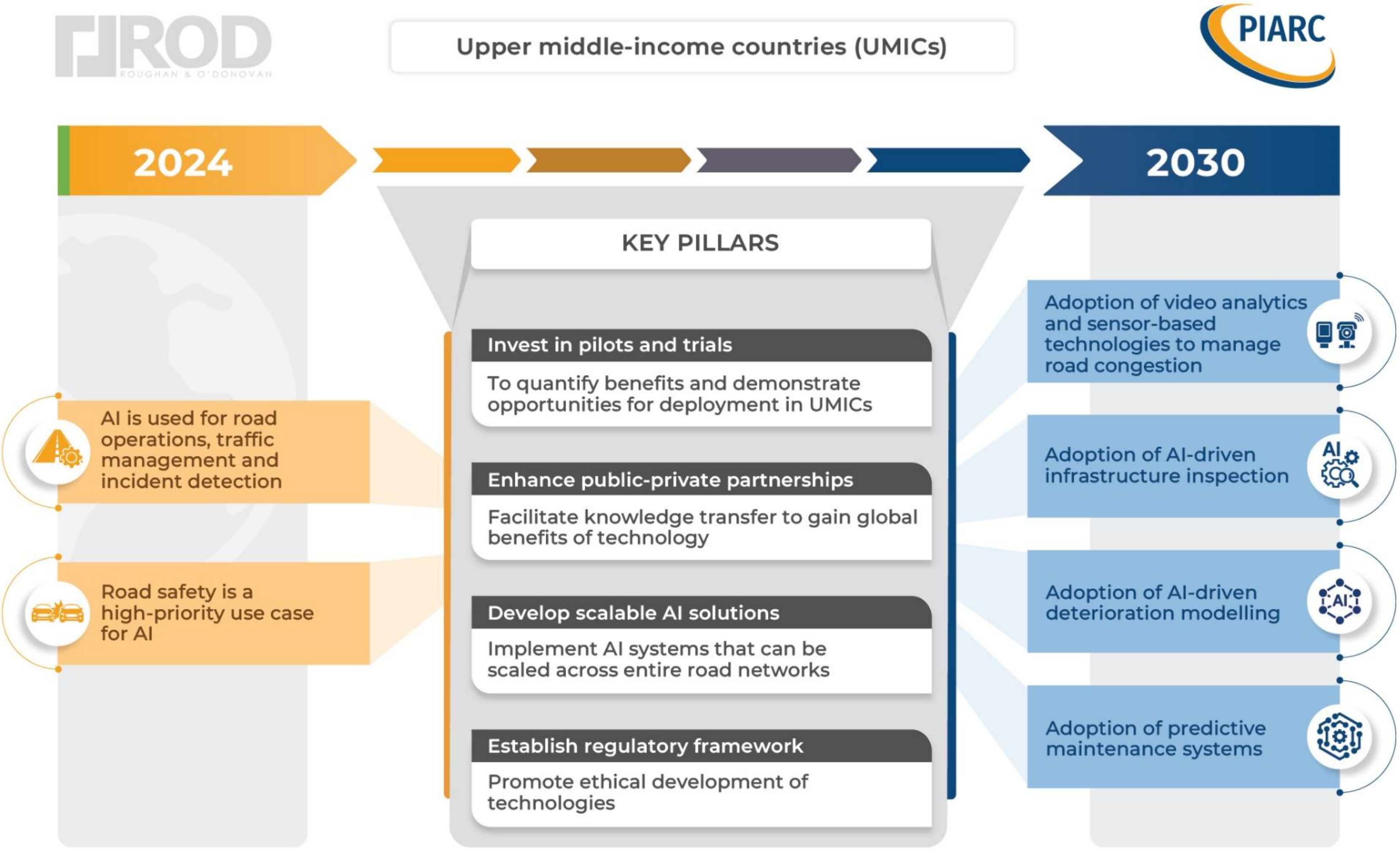

Figure 24: Roadmap for AI adoption in UMICs.

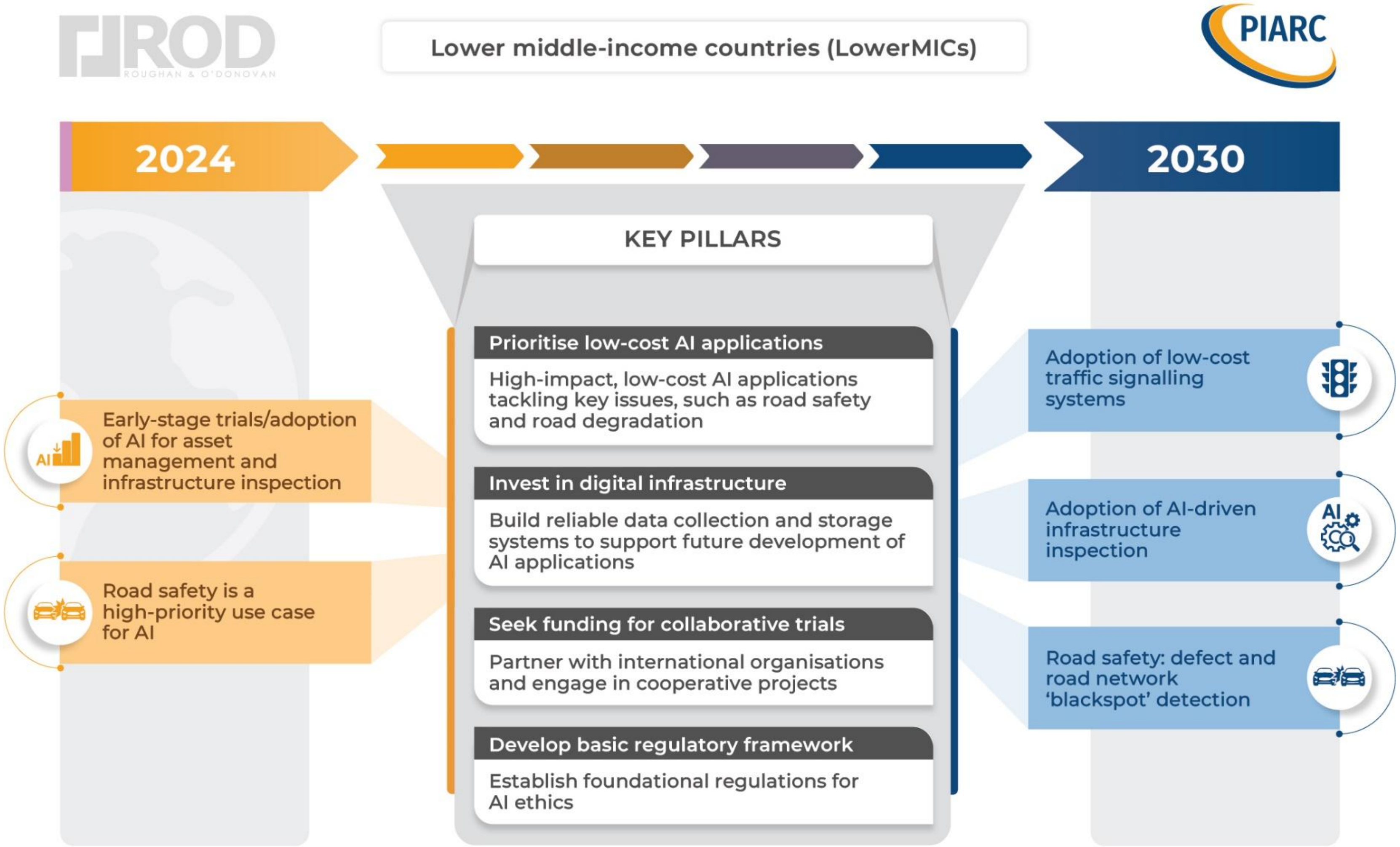

Figure 25: Roadmap for AI adoption in LowerMICs.

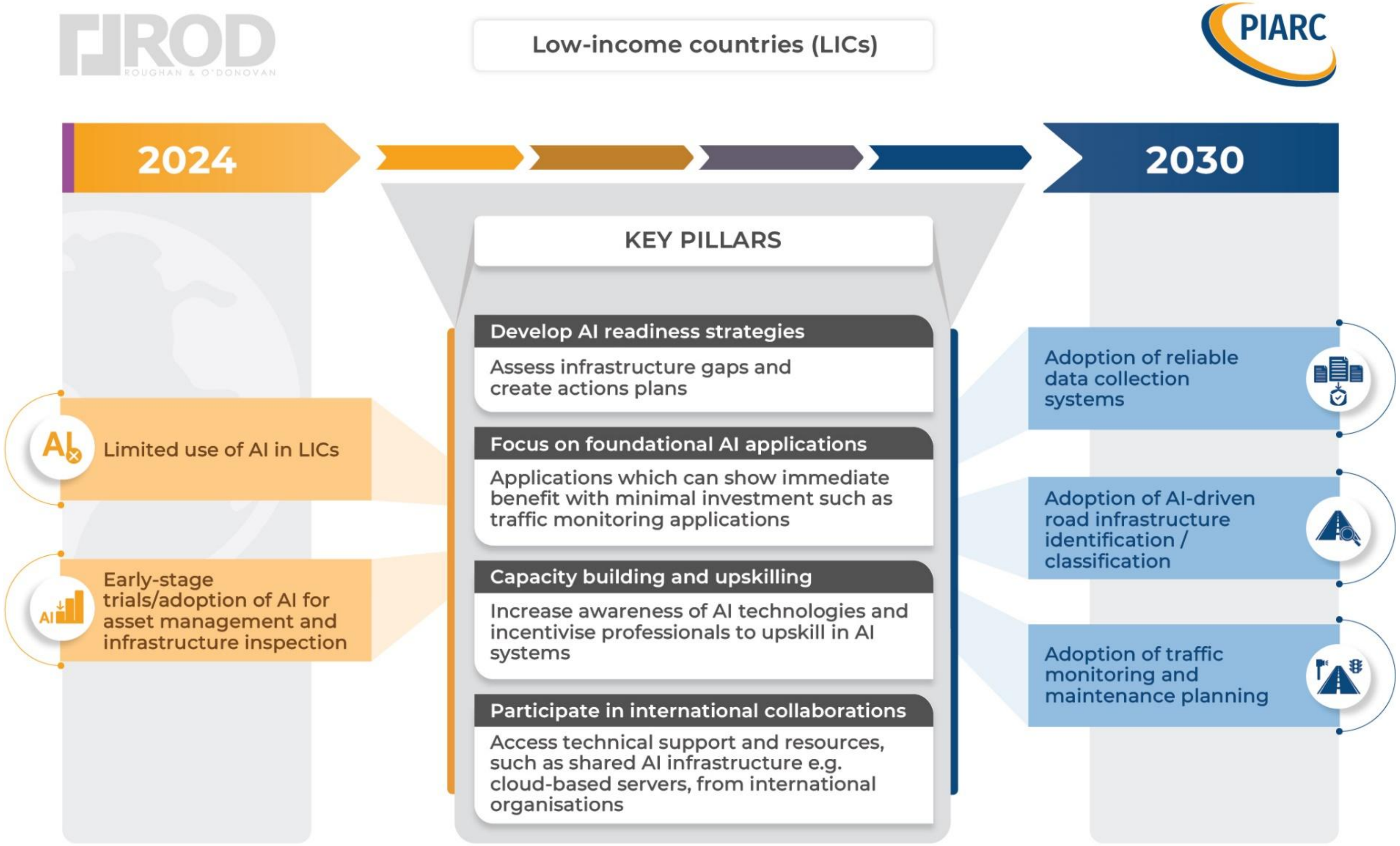

Figure 26: Roadmap for AI adoption in LICs.

7.3. RECOMMENDATIONS TO ROAD ADMINISTRATIONS

In Section 6 of the full-length version of this report, challenge-specific individual recommendations are provided for overcoming each of the different challenges and risks, along with recommendations for maximising the likelihood of achieving each of the potential benefits and opportunities. This section provides a high-level summary of these recommendations. Table 3 also provides a visual summary of these recommendations, highlighting the key aspects which organisations from countries of different socio-economic development should focus on, to initiate the transition to AI in the road sector. It should be noted that many of the recommendations are relevant to all countries, however, the recommendations presented in this section focus on the key priority areas which should be addressed initially by countries in different socio-economic categories, to realise the 2030 vision for AI in the road sector.

General recommendations

1. **Establish robust regulatory frameworks:** To address ethical concerns and standardise AI implementation, regulatory frameworks must be established. HICs should focus on international harmonisation of AI standards, while LMICs should prioritise developing AI governance structures, supported by international bodies, to ensure contextually relevant and enforceable regulations. Key priorities include data privacy, bias reduction, and cybersecurity for ethical and secure AI deployment.

   Road authorities should establish guidelines and regulations for the private sector to develop AI responsibly in the road sector, prioritising public interests, ethical standards, and public policy goals. These should address data privacy, fairness in decision-making, and bias mitigation, while fostering transparency and accountability. Collaboration with academia, industry, and civil society is essential to create inclusive and enforceable regulations.

2. **Enhance data infrastructure and cybersecurity measures:** A comprehensive data management strategy is crucial to mitigating operational risks, as data quality directly impacts AI effectiveness. Converting non-digital data into AI-compatible formats is a key challenge, especially in road-related fields. Road asset data should be acquired and organised for long-term, multi-purpose use. Investment in data infrastructure ensures AI models are trained on high-quality, representative data. In LowerMICs and LICs, collaboration between NRAs and private companies can pool data, reduce costs, and promote standardisation. Accurate location data, privacy protection, and strengthened cybersecurity protocols are essential to safeguard AI systems and maintain public trust.

3. **Promote inclusive and equitable AI deployment:** To mitigate social risks, AI deployment must be equitable, addressing urban and rural needs. Policymakers and developers should prioritise diverse data to ensure AI systems reflect populations' needs. In LowerMICs and LICs, focusing on basic AI applications in rural areas can enable broader integration while addressing infrastructure gaps.

4. **Strengthen capacity-building initiatives:** Capacity-building programs are crucial to bridging the skills gap, especially in LowerMICs and LICs. International organisations, e.g. the World Bank and United Nations, should fund and organise training to equip professionals with AI

skills. Collaboration between HICs and LICs can foster knowledge transfer, strengthening global AI readiness.

5. **Training and upskilling of workforce:** To optimise AI systems, the workforce must be trained to understand the functionalities and capabilities of these systems. Once workers recognise the benefits and added-value which can complement their own skills, reluctance to adopt new processes will decrease. Continuous training and upskilling as systems evolve is essential to maintain effectiveness.

6. **Technical collaboration:** Collaboration between AI/software providers and end users' operational expertise is key to success, whether technical or domain-specific, such as infrastructure or traffic conditions. Early-stage collaboration is vital for successful implementation.

7. **Revision of processes and procedures**: Given AI's focus on new data and decision-making, local or international guidelines may need updating to enable effective use. For example, inspection and asset management processes in many countries may require changes to accommodate new technologies and incorporate broader quantitative data for asset condition assessments.

8. **Consider a holistic approach**: The benefits of an AI system can extend beyond its direct purpose. For example, driver assist systems reduce collisions through improved behaviour, while collected data can aid in redesigning dangerous roads and addressing high-risk blackspots. AI systems should not be viewed in isolation, as they often need to be paired with public awareness or educational campaigns for maximum effectiveness.

HICs

HICs, with advanced infrastructure, financial capacity, and regulatory preparedness, are leading AI adoption in the road sector. AI usage is growing, hence, key recommendations focus on safe, ethical deployment, balancing safety and trust with efficiency. These steps will ensure continued leadership and AI integration:

1. **Accelerate the deployment of AI enabling systems and processes:** Road administrations in HICs should prioritise the integration of AI into smart, autonomous transport systems. Investments in AI-based traffic management and safety, predictive diagnostics, and maintenance tools, such as AI-driven deterioration detection and drone-assisted inspections, will be crucial for managing aging systems.

2. **Invest in pilots/trials:** HICs are encouraged to invest in AI trials to introduce efficiencies into business processes. Pilots/trials should be designed to demonstrate added value and to allow potential challenges of wider scale deployments to be identified and understood. It is also recommended to include measurable/quantifiable targets to support business cases for further deployments. The results, including case studies in this report, will help develop strategies for larger-scale deployments.

3. **Invest in education & awareness:** Deployment strategies should include upskilling and training of existing staff, recruitment of specialists when needed, and general education and awareness among staff and the public. This will help avoid or mitigate people-related barriers and challenges.

4. **Consider climate change and resilience planning:** HICs should consider how integration of AI-based technologies can be incorporated into the planning, route selection, and feasibility phases of new road projects, or ongoing operation and maintenance, with a view to reducing environmental impacts. Furthermore, resilience planning should include maintaining network continuity during and after extreme events, ensuring that road infrastructure remains operational under adverse conditions such as floods, wildfires, or other climate-induced disruptions.
5. **Demonstrate added value:** The International Transport Forum (ITF) prepared a detailed report on 'AI in Proactive Road Infrastructure Safety Management.' This purpose of this paper was to highlight the road safety benefits of proactive rather than reactive road infrastructure safety management. The paper discusses various measures to increase acceptance and AI adoption technologies for road authorities. One of these key measures was to predict the economic benefit associated with the implementation of the technology as this will act as an incentive for road authorities to adopt new technologies (ITF OECD, 2021).
6. **Understand the risks:** Develop risk assessment methodologies to evaluate AI deployment risks and mitigation strategies. Assess factors such as biases, errors, or incomplete datasets, and the consequences of inaccurate AI outputs.
7. **Develop AI policies:** Given advanced AI development in HICs, road administrations should create policies addressing challenges such as data privacy, AI ethics, bias, and cybersecurity, aligned with regulatory frameworks. They should also consider international standardisation, particularly with the EU AI Act and ISO regulations, to reduce uncertainty as global AI regulation evolves.
8. **Foster international collaboration:** HICs should lead global collaborations, partnering with LMICs to share expertise and best practices. This will help establish AI standards and ensure that developing countries are not left behind in AI adoption.
9. **Invest in AI research and innovation:** HICs should allocate resources to AI research in transport, focusing on technologies e.g. AI-powered predictive maintenance and smart traffic systems to improve mobility. Collaboration with academic institutions and tech developers will accelerate innovation.
10. **Gender Inclusion and Diversity:** HICs are encouraged to utilise AI systems that are free from inherent bias. Bias within datasets must be minimised or at least understood to prevent discriminatory outcomes. Organisations involved in AI research, development, deployment, and monitoring should actively promote gender-balanced and inclusive teams. Mandating diversity within AI teams can enhance representativeness, reduce algorithmic bias, and improve fairness in AI systems. Policymakers should consider guidelines or requirements to ensure equitable participation in AI-related decision-making, fostering a more inclusive and socially responsible AI ecosystem.

UMICs

UMICs, despite financial and infrastructural limitations, show interest in AI adoption. To progress, UMICs should focus on cost-effective AI solutions and regulatory development.

1. **Focus on pilots and trials:** To understand the benefits, costs, and challenges, UMICs should invest in AI trials. The results will identify risks and inform decisions on large-scale deployments.

2. **Develop scalable AI solutions:** UMIC road administrations should focus on scalable, low-cost AI applications with high impact. Prioritising AI-driven traffic management, predictive maintenance, and sensor-based infrastructure monitoring can extend infrastructure lifespan and optimise repair budgets.
3. **Invest in education & awareness:** Deployment strategies should include upskilling and training of staff, recruitment of specialists where needed, and education and awareness for staff and the public. This will help avoid or mitigate people-related barriers and challenges.
4. **Establish comprehensive regulatory frameworks:** UMICs must prioritise AI governance frameworks for road infrastructure, addressing data privacy, bias, and societal impacts, while aligning with international best practices.
5. **Capacity building:** UMICs must invest in capacity-building initiatives to train professionals in AI management, ensuring local expertise to maintain AI systems effectively.

Lower MICs

Lower MICs face adoption challenges due to infrastructure and financial constraints, but with targeted interventions, they can progress in AI integration and benefit from lessons learned elsewhere.

1. **Focus on low-cost AI applications:** LowerMICs should prioritise cost-effective AI solutions, such as AI-powered traffic monitoring, vehicle counting, speed detection, smart traffic lights, and road safety technologies. These can improve safety and traffic management while being financially accessible.
2. **Develop basic regulatory frameworks:** Road administrations should develop foundational AI regulations addressing ethical, legal, and societal considerations. These frameworks should align with international standards and be tailored to the needs and capabilities of LowerMICs.
3. **Utilise international technical assistance:** LowerMICs should engage with international organisations such as the World Bank, the United Nations, and PIARC to access technical assistance and financial support for AI infrastructure development.
4. **Identify opportunities for funding collaborative trials:** LowerMICs should also engage with international organisations to identify organisations or potential avenues for funding trials of AI-based technologies which may provide benefits at low cost.
5. **Invest in digital infrastructure:** Road administrations should prioritise investments in digital infrastructure, focusing on establishing reliable data collection systems, cloud-based AI systems, and sensor technology to support AI-driven road management.

LICs

LICs face challenges such as limited infrastructure, finances, and skilled personnel. To prepare for future AI adoption, the following steps are recommended.

1. **Develop AI-readiness strategies:** LICs should prioritise the development of AI-readiness strategies, focusing on building basic infrastructure, such as communications infrastructure, reliable data collection systems and affordable IT resources.

2. **Capacity building and upskilling:** LICs must invest heavily in capacity-building initiatives to upskill professionals in AI systems management. Collaborations with international institutions will be key to providing training and technical expertise.
3. **Participate in international collaborations:** Road administrations should engage in international collaborations to pool resources, such as shared AI infrastructure (e.g., cloud-based servers), and access technical support from global AI experts.
4. **Focus on foundational AI applications:** LICs should start with simple AI applications, such as traffic monitoring, road safety solutions, and basic predictive maintenance tools, which can offer immediate benefits with minimal investment.
5. **Improve technological awareness:** By focusing on key pilot projects and detailing their benefits it can influence leaders to have a change in culture in respect to AI. This will promote further AI adoption technologies.

7.4. RECOMMENDATIONS TO PIARC

PIARC, as a global body for road infrastructure, has a key role in facilitating AI adoption across countries of varying income levels. The following recommendations will help PIARC support global AI integration:

1. **Promote international standards for AI:** PIARC should lead efforts to harmonise AI regulations and standards across countries, facilitating global collaboration and ensuring consistent AI implementation practices. Encouraging the adoption of international AI standards, such as ISO certifications, will ensure interoperability and safety across borders.
2. **Support capacity-building initiatives:** PIARC should facilitate training programmes and workshops that target professionals in LMICs, helping these countries build the necessary skills to manage and maintain AI systems. PIARC can also foster knowledge-sharing platforms where countries can exchange best practices and experiences in AI adoption.
3. **Facilitate international collaborations:** PIARC should play a key role in fostering collaborations between HICs and LMICs to transfer expertise, knowledge, and technologies. These partnerships will help address the technical and financial barriers faced by LMICs in AI adoption.
4. **Provide technical assistance:** PIARC should offer technical assistance to countries that lack the expertise to develop and implement AI strategies. By collaborating with global technology experts and road authorities, PIARC can help LMICs develop tailored AI-readiness plans.
5. **Develop an AI working group:** Given the focus on AI in the road sector, its potential benefits, and the uncertainty around evolving legal frameworks, PIARC could consider two approaches. One option is to form a dedicated Technical Committee for AI integration in the road sector. Another is to incorporate AI into existing committees, embedding expertise within areas such as infrastructure maintenance, road safety, and traffic management. A hybrid approach, combining both options, may also be considered. PIARC should evaluate the best method based on its goals and resources.

Table 3: Summary of key recommendations and primary focus areas for transition to AI in the road sector.

		LMICs		
Recommendations	HICs	UMICs	LowerMICs	LICs
Accelerate the deployment of AI enabling systems and processes	●			
Invest in pilots/trials	●	●		
Invest in education & awareness	●			
Consider climate change and resilience planning	●			
Demonstrate added value	●			
Understand the risks	●			
Develop AI policies	●	●	●	●
Foster international collaboration	●			
Invest in AI research and innovation	●			
Gender Inclusion and Diversity	●			
Develop scalable AI solutions		●	●	
Capacity building		●	●	●
Establish comprehensive regulatory frameworks		●	●	
Focus on low-cost AI applications			●	●
Utilise international technical assistance			●	●
Identify opportunities for funding collaborative trials			●	●
Invest in digital infrastructure			●	●
Develop AI-readiness strategies				●
Participate in international collaborations				●
Focus on foundational AI applications				●
Improve technological awareness				●

8. GLOSSARY

Term	Definition
ADAS	Advanced Driver Assistance Systems
AI	Artificial Intelligence
ANPR	Automated Number Plate Recognition
AR	Augmented Reality
AV	Automated Vehicle
CVI	COWI Virtual Inspection
DT	Digital Twin
HICs	High-Income Countries
IAPP	International Association of Privacy Professionals
IFI	Independent Fiscal Institution
IoT	Internet of Things
LICs	Low-Income Countries
LMICs	Low & Middle Income Countries
LowerMICs	Lower-Middle-Income Countries
ML	Machine Learning
NRAs	National Roads Authorities
PIARC	World Road Association
POT	Project Oversight Team
ROD	Roughan & O'Donovan
ROs	Road Operators
TRL	Transport Research Laboratory
UAV	Unmanned Air Vehicle
UMICs	Upper-Middle-Income Countries
VR	Virtual Reality

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World Road Association (PIARC)

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