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THE IMPACT OF THE PARIS CLIMATE AGREEMENT ON ROAD ASSET MANAGEMENT ACTIVITIES

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Abstract

The Paris Agreement has reshaped global climate policy, requiring countries and infrastructure managers to incorporate climate resilience and decarbonization into transport planning and operations. This paper will explore the expected impacts of the Paris Agreement on road asset management practices, with a focus on Serbia and the Western Balkans. It will examine how international climate commitments may influence national policies, investment strategies, and maintenance approaches in the road sector, particularly under the pressures of increasing extreme weather events and long-term emission reduction targets. A case study of selected institutions and projects in Serbia will be used to assess the extent to which climate adaptation measures - such as resilient pavement materials, improved drainage systems, and risk-informed maintenance planning - are planned or being considered. The paper will also identify key implementation challenges, including institutional capacity constraints, data gaps, and insufficient coordination between sectors. Based on the findings, the paper will propose recommendations to better align road management practices with climate goals, emphasizing the importance of integrating long-term climate risks into infrastructure decision-making.

Key words: *Paris Agreement, road asset management, climate-resilient infrastructure, adaptation strategies, transport policy.*

Introduction

The Paris Agreement [1], adopted in December 2015 under the United Nations Framework Convention on Climate Change (UNFCCC), marked a transformative moment in global climate governance. It established legally binding obligations for signatory countries to reduce greenhouse gas (GHG) emissions and enhance adaptive capacity. Unlike previous frameworks, the Paris Agreement emphasizes a balance

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between mitigation and adaptation, making infrastructure sectors, particularly transportation, central to achieving long-term climate objectives.

Road transport infrastructure is especially vulnerable to climate change impacts. Rising temperatures, increasing frequency of extreme rainfall, flooding, and landslides are already imposing significant costs on national and local road networks. For example, in Serbia, the 2014 floods caused damages estimated at EUR 166.5 million to transport infrastructure, while also triggering thousands of landslides that affected major road corridors [2]. These climate-related disruptions not only affect the safety and functionality of transport systems but also pose long-term economic risks by accelerating deterioration of assets and increasing maintenance needs.

In this context, the Paris Agreement acts as both a political and technical driver of change in road asset management practices. National governments, regional organizations, and infrastructure managers are being called upon to align with global climate commitments. This entails integrating climate resilience into infrastructure planning, design, operation, and maintenance. Specifically, road asset management must now encompass adaptation measures such as resilient pavement technologies, updated drainage standards, nature-based solutions for flood and landslide mitigation, and risk-informed maintenance planning.

The Western Balkans, and Serbia in particular, illustrate the urgency of these shifts. Serbia ratified the Paris Agreement in 2017, prompting legislative changes and national strategies to embed climate adaptation across key sectors. However, challenges remain in institutional capacity, financing, and data availability, which hinder systematic integration of climate risk into road asset management.

Risk-informed approaches have been advanced in international scholarship. For instance, Huibregtse et al. [3] proposed a risk-based methodology for infrastructure asset management, modeling how extreme rainfall can disrupt tunnel networks. Similarly, recent studies [4, 5] emphasize integrated frameworks that balance sustainability, resilience, and cost in transport planning. These approaches provide a conceptual foundation for operationalizing climate adaptation in road asset management.

Serbia's policy landscape demonstrates both progress and challenges in implementing the Paris Agreement. National frameworks have been aligned with European Union (EU) directives, but practical challenges persist at the municipal level [6, 7]. Projects such as CliRtheRoads [2] illustrate how hazard mapping, GIS tools, and cost estimation models are being employed to incorporate resilience into transport decision-making. At the regional level, nature-based solutions (NbS) are increasingly promoted as cost-effective and environmentally sound strategies for climate adaptation [8].

The Paris Agreement influences road asset management through three main pathways: policy alignment, technical adaptation, and analytical innovation. It provides a high-level framework that cascades into national infrastructure policies, encourages investment in resilient materials and systems, and fosters the adoption of new risk assessment tools. At the same time, implementation challenges highlight the need for improved governance, financing mechanisms, and cross-sector collaboration.

Despite progress, challenges persist. These include institutional capacity constraints, inadequate coordination between agencies, insufficient financing for climate-resilient projects, and data gaps in climate risk projections. Addressing these gaps will be critical for fully realizing the potential of the Paris Agreement to reshape road asset management practices.

The remainder of this paper builds on the contextual and theoretical foundations outlined above and explores the implications of global climate commitments for the management of road infrastructure. It begins by examining the Paris Agreement and its overarching objectives, highlighting how these international climate goals reshape the expectations for infrastructure planning and resilience. The discussion then turns to the practical consequences for road asset management, analyzing both emerging technical requirements and strategic considerations. Subsequently, the paper considers the role of international financing institutions (IFIs) in promoting climate-aligned investments and the ways in which their frameworks influence design, maintenance, and financing decisions. Finally, the focus shifts to regional experiences in Serbia and the Western Balkans, assessing how climate-aligned practices are being implemented, identifying remaining challenges, and proposing actionable recommendations to better integrate long-term climate objectives into road management strategies.

The Paris Agreement: overview and significance

The Paris Agreement, adopted on December 12, 2015, and entering into force on November 4, 2016, is a landmark global treaty under the UNFCCC that defined a new approach to international climate governance. Its pivotal long-term temperature goal aims to hold the global average temperature increase to well below 2°C above pre-industrial levels and to pursue efforts to limit the rise to 1.5°C [9]. Embedded within the agreement is an aspirational goal to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases, effectively pointing toward a global net-zero target [10].

Unlike earlier top-down frameworks such as the Kyoto Protocol, the Paris Agreement adopts a bottom-up structure. Parties submit Nationally Determined Contributions (NDCs) - their nationally set targets for mitigation and adaptation. These contributions are periodically reviewed and ratcheted up every five years through a "ratcheting mechanism" to progressively raise global ambition [11].

While the mitigation goals are widely highlighted, the Paris Agreement notably elevates adaptation as a core pillar (establishing, for the first time in a global climate treaty, a global adaptation goal under Article 7.1) thus elevating adaptation to the same level of importance as mitigation [12]. This normative shift underscores the urgent need for climate resilience alongside emissions reduction [13].

To support both mitigation and adaptation tracking, the Agreement sets up an enhanced transparency and reporting framework (Articles 13 and related), requiring parties to regularly report on their progress. Flexibility is provided to accommodate differing capacities among parties while maintaining transparency over time [14].

The Paris Agreement's architecture combines voluntary action with accountability - countries voluntarily craft their NDCs but are bound by the treaty's procedural requirements around reporting, review, and global stocktakes. This blend of

discretion and structure is reinforced by its legally binding character, even as the stringency of obligations varies by article [15].
From a legal and governance standpoint, the Agreement makes adaptation, mitigation, and even loss and damage explicit and integral to the treaty - not merely peripheral concerns - marking a significant shift in international climate law [16].
Despite its transformative design, scholars note that the collective ambition of individual NDCs still falls short of the 2°C and 1.5°C targets. For example, linking climate policies across regions and enhancing ambition remains a persistent challenge [9]. Further, the literature highlights challenges in defining and operationalizing the GHG balance, which affects national interpretations of net-zero goals and their implications for future temperature outcomes [10].

The Paris Agreement's influence on road asset management

The Paris Agreement has introduced a profound shift in the way infrastructure systems are planned, managed, and financed. While traditionally road asset management has focused on efficiency, safety, and cost optimization, the global climate framework now requires infrastructure managers to integrate both climate mitigation, through reductions in greenhouse gas emissions, and climate adaptation, by ensuring resilience to increasingly frequent and severe weather events. This dual requirement fundamentally expands the scope of road asset management, linking it not only to engineering and economic considerations but also to long-term sustainability, risk-informed decision-making, and alignment with international climate commitments.
In practice, this means that road asset management must increasingly address new dimensions such as climate-resilient design standards, risk-informed maintenance planning, lifecycle cost optimization, robust data and monitoring systems, strengthened institutional capacity, and policy alignment with international financing requirements. The following subsections will analyze these aspects in greater detail, highlighting how the Paris Agreement is reshaping both the technical and governance frameworks of road infrastructure management worldwide.

Policy and planning: changing objectives and planning horizons

The Paris Agreement's twin emphases on mitigation and adaptation shift strategic objectives for road authorities from short-term operational efficiency to longer-term resilience and decarbonization goals. Asset plans therefore must incorporate climate targets (e.g., resilience to more frequent extreme precipitation and heat) and be aligned with national/sub-national NDCs and adaptation plans. This creates an obligation to move from "design from historical climate" to forward-looking planning based on climate scenarios and periodic updating (global stocktakes and NDC cycles) [17, 18].
Practical implication: Road asset management plans (AMPs) must include explicit climate objectives, incorporate scenario-based vulnerability assessments, and establish review cycles that align with the ratcheting mechanism of NDCs.

Design standards and technical specifications: raising the bar for resilience

The Agreement's adaptation emphasis motivates updates to design standards and specifications for materials, drainage, slopes, and bridges so assets withstand future climates (higher peak rainfall, freeze-thaw cycles, higher pavement temperatures). Peer-reviewed reviews document the need to revise design return periods, safety margins and material specifications because historic design bases will underestimate future hazard frequencies [19, 20].
Practical implication: Engineers must adopt climate-adjusted design rainfall and temperature inputs, specify resilient pavement mixtures, and require larger drainage capacities as well as slope and drainage protections as routine elements of upgrades and new works. While these measures increase up-front investment costs, they significantly reduce lifecycle risks and long-term maintenance burdens.

Asset inventories, vulnerability mapping and risk-based prioritization

A core operational change is systematic integration of climate exposure and vulnerability into the asset register. Instead of purely condition-based priorities, managers must add climate-risk attributes (exposure, sensitivity, consequence) so interventions are prioritized by risk reduction and socio-economic impact. Recent literature shows frameworks and toolkits (GIS + hazard layers + consequence scoring) that convert climate projections into prioritized intervention lists [18, 20].
Practical implication: Road authorities should develop or upscale geospatial asset inventories that are linked to hazard layers (such as floodplains, landslide susceptibility, and heat index) and loss-of-service consequences, enabling the computation of risk scores and the ranking of investment priorities.

From reactive maintenance to risk-informed and adaptive maintenance planning

Climate change increases both the frequency and severity of events. Road asset management must shift from reactive, calendar-based maintenance to risk-informed, adaptive maintenance that anticipates climate-driven deterioration (e.g., rutting under higher temperatures, pavement material loss under heavier rainfall). Comparative modelling studies show proactive (planned) adaptation substantially reduces total expected damage compared with reactive responses [20, 21].
Practical implication: Condition monitoring should be combined with predictive models that integrate climate projections to estimate accelerated deterioration rates and to schedule interventions earlier when cost-effective.

Lifecycle costing and economic appraisal (including adaptation finance)

The Paris framework increases the need to include climate risk and carbon implications in whole-life cost appraisals. Investment appraisal must account for:

(a) increased probability of climate damage and associated lifecycle repair/closure costs, and (b) embodied and operational GHGs (mitigation). Several studies model trade-offs between low-carbon construction choices and resilience outcomes. Integrating these yields better value-for-money and aligns investment with Paris mitigation/adaptation goals [19, 21].
Practical implication: Road sector investment planning should adopt whole lifecycle costing methods that explicitly discount future climate risks, apply scenario analysis when calculating benefit-cost ratios, and pursue innovative blended finance mechanisms (such as adaptation funds or resilience bonds) where national budgets are insufficient to cover higher upfront costs.

Operations, emergency management and service continuity

The Paris Agreement's focus on adaptation makes service continuity and disruption-management a core asset-management goal. Managers must prepare operational contingency plans, redundancy strategies, and rapid response procedures to minimize socio-economic disruption from increasingly common extreme events. Empirical analyses show that proactive infrastructure resilience planning lowers direct and indirect economic losses [21, 22].
Practical implication: Road asset management strategies should formalize emergency routing protocols, strengthen monitoring and early-warning system linkages, and invest in network redundancy, through alternative routes or temporary bridges, for critical transport corridors.

Monitoring, data, and modelling needs

Paris-aligned asset management requires higher-resolution climate projections, asset performance models under non-stationary climates, and monitored performance data to validate models. Recent global analyses demonstrate that many asset networks are more exposed to changing precipitation regimes than previously understood - which makes high-quality data essential for accurate risk quantification [17, 19].
Practical implication: Investments should prioritize meteorological and hydrological monitoring systems, pavement and structural sensors, and integrated data platforms that enable scenario simulations and versioned "what-if" assessments. Addressing data gaps is often the critical step in transforming climate information into actionable interventions for road assets.

Institutional capacity, governance, and interdisciplinary coordination

Effectively translating Paris commitments into road-level measures demands institutional change: cross-sector coordination (water, land-use, emergency services), staff training in climate risk methods, new procurement clauses for resilience, and governance for multi-year funded adaptation programs. Reviews indicate that

institutional barriers (capacity, siloing, lack of standards) are among the largest obstacles to mainstreaming adaptation into transport asset management [23, 22].
Practical implication: Formal institutional mandates should be established to require climate screening in all major road investments. In parallel, asset managers and procurement teams should receive targeted training, and interagency working groups should be created to ensure alignment across transport corridors, drainage basins, and land-use planning.

Metrics, targets, and reporting (transparency)

Under the Paris transparency regime, transport agencies increasingly face expectations to report on both mitigation (e.g., embodied and operational emissions) and adaptation progress. Asset management key performance indicators (KPIs) should thus expand beyond condition and availability to include resilience metrics (vulnerability reduction, expected downtime, adaptation investments), and GHG metrics to demonstrate contribution to NDCs [22, 24].
Practical implication: Road asset management should adopt an expanded set of KPIs, including risk-weighted asset condition, expected annual downtime, and estimated avoided damages, while aligning reporting templates with national transparency and accountability requirements.

Trade-offs and synergies between mitigation and adaptation

The Paris agenda makes explicit the need to manage trade-offs (e.g., some resilient materials may have higher embodied carbon) while seeking synergies (e.g., nature-based solutions can both reduce flood risk and sequester carbon). Recent studies highlight decision frameworks that integrate Sustainability-Resilience-Cost (SRC) to identify options that jointly advance mitigation and adaptation [17, 18, 19].
Practical implication: When selecting interventions, road asset management should employ multicriteria decision analysis that incorporates GHG footprint, resilience scores, lifecycle costs, and co-benefits such as ecosystem services and social outcomes.

Impact of IFI Paris-Alignment approaches on road asset management

IFIs play a critical role in shaping infrastructure investment and management practices by embedding the goals of the Paris Agreement into their financing and project appraisal processes. Their Paris-alignment requirements influence not only the selection and design of road projects but also ongoing asset management, maintenance planning, and operational strategies. For road asset managers, this translates into integrating climate mitigation and adaptation considerations into routine practices, adopting risk-informed and lifecycle-based approaches, and ensuring that investments are resilient to both current and projected climate hazards. The following discussion explores the practical implications of IFI Paris-alignment frameworks on road asset management, highlighting how these requirements are reshaping engineering standards, maintenance strategies, data systems, financing approaches, and institutional capacities.

Climate-resilient design and construction

IFI requirements push road agencies to account for long-term climate risks at all stages of project preparation. This involves using climate-adjusted design standards for pavements, drainage systems, and slope stability to accommodate extreme weather events, as well as selecting materials and construction methods that both reduce emissions and enhance resilience. The practical impact is that roads financed or co-financed by IFIs increasingly need to meet higher resilience standards, which may differ from traditional national specifications. This, in turn, incentivizes national agencies to adopt forward-looking design codes and systematically integrate adaptation measures into their asset management plans [25, 26].

Risk-informed maintenance planning

IFI alignment frameworks require that climate risk assessment and adaptation planning be embedded into the lifecycle management of road projects. For road networks, this involves conducting hazard mapping and vulnerability assessments for existing assets and integrating predictive maintenance strategies that prioritize sections at high risk from flooding, landslides, or extreme heat. The practical impact of these requirements is a shift in road asset management practices from reactive, condition-based maintenance toward risk-informed, forward-looking maintenance schedules that account for both climate exposure and transition risks [27].

Lifecycle costing and low-emission optimization

Projects aligned with the Paris Agreement are expected to minimize greenhouse gas emissions across the full lifecycle of assets, from procurement and construction to operation and eventual decommissioning. This entails prioritizing low-carbon materials and construction techniques and evaluating the costs of climate adaptation and mitigation alongside conventional capital and operating costs. As a result, road agencies must integrate comprehensive lifecycle costing into asset management decision-making, balancing emission-reduction trade-offs with operational efficiency [25, 26].

Data, monitoring, and reporting requirements

To ensure alignment with the Paris Agreement, IFI projects require robust monitoring and reporting systems. This includes continuous tracking of emissions from road construction and operations, as well as monitoring the climate resilience performance of assets over time. Consequently, road asset management increasingly relies on digital data platforms, GIS tools, and sensor networks, which enhance the evidence base for decision-making and improve transparency in climate-risk reporting [27].

Institutional capacity and governance

IFI standards often necessitate training and institutional strengthening to support climate-aligned investments. Road agencies are expected to enhance their technical capacity for conducting climate assessments and to develop guidelines and standard operating procedures for climate-resilient road asset management. Embedding climate expertise within national road authorities fosters more coordinated, technically robust, and adaptive management practices across the sector.

Indirect incentives for policy and standard updates

Through financing conditionalities, IFIs exert influence on broader national policy frameworks. This may involve updating technical standards and design codes to align with Paris goals and promoting the adoption of best-practice guidance for climate adaptation and mitigation in road networks. As a result, even projects not directly financed by IFIs may adopt improved standards, generating positive spillover effects on national road management practices [26, 27].

Incorporation of Paris-Aligned goals into road asset management - Serbia & Western Balkans

In Serbia and the broader Western Balkans, the integration of Paris Agreement goals into road asset management is at an early but evolving stage. National and regional authorities are beginning to consider climate mitigation and adaptation measures in planning, design, and maintenance practices, often guided by donor-supported pilot projects and international best practices. Despite these efforts, the adoption of climate-aligned standards remains uneven, with significant gaps in institutional capacity, data availability, inter-sectoral coordination, and sustainable financing. This section examines how Paris-aligned objectives are currently reflected in road asset management initiatives, highlights implementation successes, and identifies remaining challenges across the region.

What has been implemented?

A notable initiative is the CliRtheRoads [2] programme in Serbia, which developed practical tools (GIS databases, landslide data models, mobile/web applications) to assess climate-related hazards, vulnerability, and estimated costs of engineering and non-engineering responses along road corridors. The project aimed to mainstream climate-proofing into routine road agency activities by automating hazard screening and cost estimation for interventions [2].
The World Bank and other international partners have supported efforts to increase resilience of local road networks in Serbia, producing methodologies and digital tools (e.g., MaPLoRDs [28]) for municipalities to screen local roads for hazards and prioritize low-cost resilience measures. These initiatives illustrate how donor projects

translate Paris-driven adaptation priorities into practical asset management tools and pilot interventions [28].

The Transport Community's regional analysis [29] assessed climate exposure of TEN-T/indicative extension routes across the Western Balkans and produced ranked lists of critical road sections with estimated adaptation costs. This represents regionally coordinated strategic planning aligned with Paris-era priorities for resilience and continuity of international connectivity.

Governments and international organizations have built capacity for adaptation planning and promoted NbS. Scoping and pilot projects for flood and landslide mitigation have been undertaken across the region, framing interventions as measures that reduce hazard impacts and deliver co-benefits for mitigation and biodiversity [8, 30].

Recent regional studies and synthesis reports have quantified exposure, profiled vulnerabilities, and made the economic case for urgent adaptation investment across the Western Balkans, providing the analytical basis needed for Paris-aligned investment planning [31].

How implementation was done?

The incorporation of Paris-aligned goals into road asset management in Serbia and the Western Balkans has largely followed a project-driven, stepwise approach, often supported by international donors, IFIs, and technical assistance programs. Implementation efforts have focused on piloting climate-resilient design standards, integrating hazard assessments into planning, and enhancing institutional capacity for risk-informed decision-making. While each initiative varies in scope and methodology, they share common objectives: improving the climate resilience of critical road infrastructure, strengthening data-driven management practices, and establishing frameworks for monitoring and reporting. The key elements of these implementation efforts are summarized below:

- Donor-led, pilot-to-scale approach - Initiatives often began as donor-funded pilots that developed methodologies, digital tools, and local capacity for mainstreaming adaptation [28, 30];
- GIS-based hazard + asset integration - Projects combine geospatial hazard layers (flood, landslide susceptibility) with asset inventories to calculate risk scores and prioritize interventions [2];
- Top-down strategic screening - Regional authorities produced corridor-level exposure assessments to prioritize adaptation investments for cross-border continuity [29];
- Promotion of NbS and hybrid engineering solutions - Nature-based and ecosystem approaches are trialed alongside conventional engineering to reduce flood/landslide risk while providing co-benefits [8].

What is missing?
Principal gaps and barriers

Despite initial progress in incorporating Paris-aligned goals into road asset management in Serbia and the Western Balkans, significant gaps and barriers remain. These challenges limit the systematic application of climate-resilient practices across the road network and hinder the full realization of mitigation and adaptation objectives. Key issues include insufficient institutional capacity, fragmented governance and coordination between sectors, data and monitoring deficiencies, limited financial resources for upfront investments, and gaps in regulatory and technical standards. The principal gaps and barriers identified through recent initiatives and pilot projects are presented below:

- Systemic scaling and institutionalization beyond pilots - While many promising pilot tools and methods exist (CliRtheRoads [2], MaPLoRDs [28]), scaling these into routine national/local asset-management practice remains incomplete. Several projects report limited uptake beyond pilot districts due to lack of formal adoption channels within road agencies [2, 28];
- Sustained funding and predictable financing for adaptation - Most adaptation measures (larger drainage works, slope stabilization, NbS) increase upfront costs. There is a shortage of predictable, long-term budget lines for adaptation within national road agencies; donor financing has been important but is not a sustainable substitute for domestic budget commitment. Regional investment prioritization reports highlight the large financing gap for implementing recommended adaptation measures at scale [29, 31];
- Data gaps and limited monitoring systems - Effective mainstreaming requires continuous meteorological, hydrological and asset-performance monitoring. Many municipalities and agencies still lack high-resolution hazard projections, systematic asset condition data linked to hazard exposure, and sensor networks - limiting risk quantification and adaptive maintenance planning [2, 31];
- Fragmented governance and weak cross-sector coordination - Adaptation for roads cuts across sectors (water management, land-use planning, emergency services). Reviews and policy evaluations show siloed institutional arrangements, unclear mandates for climate screening in transport investments, and coordination deficits that slow integrated adaptation responses [6, 30];
- Regulatory/standards gaps - design codes not yet fully climate-aware - Although guidance and case studies exist, national design standards and procurement specifications often still reference historical climate baselines (rainfall intensities, design storms, frost indices). Widespread updating of national technical standards to incorporate climate projections is uneven across the region [6, 29];
- Limited human capacity and technical expertise at municipal level - Local governments - responsible for a large share of the network where people and assets are most exposed - often lack trained staff, decision-support tools, and institutional mandates to implement climate-proofing measures without

external assistance. Projects that supplied tools, but not long-term training have seen lower institutional uptake [2, 29];
- Insufficient mainstreaming of NbS into formal asset management budgets - Although NbS pilots are growing, ecosystem-based measures are still not routinely included in standard road investment packages or lifecycle appraisals, partly because valuation of co-benefits and longer time horizons are not incorporated into procurement/economic appraisal practices [30, 8].

Short recommendations

Based on the analysis of current practices, implementation successes, and existing gaps in incorporating Paris-aligned goals into road asset management in Serbia and the Western Balkans, a set of concise recommendations can guide policymakers, infrastructure managers, and donors. These recommendations focus on strengthening institutional capacity, improving climate-informed planning and maintenance practices, enhancing data collection and monitoring, ensuring financial sustainability, and promoting inter-sectoral coordination. The key recommended actions are as follows:
- Formal adoption pathways, such as technical circulars and procurement clauses, are needed to institutionalize pilot tools like CliRtheRoads and MaPLoRDs, ensuring they become part of standard road asset management practice;
- Create dedicated, predictable adaptation budget lines within road agencies and explore blended finance (donor + domestic + resilience bonds) for large corridor upgrades;
- Upgrade standards and procurement to use climate-adjusted design inputs and to allow NbS and low-carbon resilient options in tenders;
- Invest in data and monitoring (sensors, hydrometeorological networks) and in staff training at municipal levels to convert pilot success into durable capacity;
- Strengthen cross-sector governance by creating interagency working groups (transport, water, emergency services, environment) to plan resilience measures at catchment/corridor scale.

Conclusion and recommendations: aligning road asset management with long-term climate goals

The Paris Agreement has set a global framework that compels road infrastructure managers to integrate both climate mitigation and adaptation into all stages of asset management. In Serbia and the Western Balkans, recent initiatives demonstrate early adoption of these principles through pilot projects, GIS-based risk assessments, corridor-level prioritization, and capacity-building programmes.
However, these efforts remain fragmented and largely donor-driven, with limited systemic uptake across national and local road agencies. Key challenges include:

- Promising pilot tools, such as CliRtheRoads and MaPLoRDs, are not yet fully embedded in routine road asset management workflows, reflecting insufficient institutionalization;
- High-resolution climate projections, hydrometeorological monitoring, and hazard-linked asset condition data remain limited, creating significant data and monitoring gaps;
- Adaptation planning often lacks integration across transport, water, land-use planning, and emergency management sectors, indicating weak cross-sectoral coordination;
- Adaptation measures increase upfront costs, and predictable budget allocations for climate-proofing interventions are frequently lacking, highlighting financial limitations;
- National design standards and procurement specifications still predominantly rely on historical climate baselines, limiting long-term resilience and revealing regulatory and technical gaps.

Based on the analysis of global frameworks, IFI alignment approaches, and regional practices in Serbia and the Western Balkans, a set of targeted recommendations is proposed to support the integration of Paris-aligned objectives into road asset management. These recommendations are structured across three key areas - policymakers, infrastructure managers, and donors - and focus on enhancing institutional capacity, embedding climate-resilient practices into planning and operations, strengthening monitoring and data systems, ensuring sustainable financing, and fostering inter-sectoral coordination. The following recommendations provide actionable guidance to align road management practices with long-term climate mitigation and adaptation goals:

1. For policymakers
    - GIS-based hazard assessments, risk-scoring tools, and pilot project methods should be formally integrated into national road agency procedures to institutionalize climate-proofing tools and methodologies
    - Regulatory frameworks and design standards should be updated to ensure that new road designs, reconstruction projects, and maintenance activities follow climate-adjusted criteria, including extreme weather projections and resilient materials
    - Interagency working groups across transport, water, environment, and emergency services should be established to promote cross-sector governance and harmonize planning and resource allocation for climate-resilient infrastructure;
2. For infrastructure managers
    - Probabilistic hazard models, predictive maintenance approaches, and lifecycle cost analyses that account for both climate impacts and greenhouse gas considerations should be adopted to support risk-informed decision-making
    - Monitoring and data collection should be expanded by deploying sensors, improving condition reporting, and linking asset registries to climate and hazard databases to enable proactive maintenance

- Where appropriate, conventional engineering measures should be combined with nature-based solutions and hybrid interventions to enhance resilience while delivering co-benefits for mitigation and biodiversity;

3. For donors and international partners
   - Successful pilot projects should be scaled up into systemic, institutionalized solutions that include standardized training and maintenance protocols
   - Blended finance mechanisms should be facilitated by combining domestic budgets, donor contributions, and innovative instruments such as resilience bonds to sustainably fund adaptation measures
   - Regional collaboration and knowledge-sharing should be enabled by strengthening networks across the Western Balkans to share best practices, harmonize standards, and support cross-border resilience projects.

Overall, achieving Paris-aligned road asset management in the Western Balkans requires a holistic approach: one that integrates risk-informed planning, inter-sectoral coordination, data-driven decision-making, and sustainable financing. Early pilots demonstrate the potential, but broad, systemic adoption is essential to ensure resilient, low-carbon, and safe transport networks capable of withstanding the impacts of climate change.

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