



Centre of Excellence
for Decarbonising Roads

CATAPULT
Connected Places

ADEPT Live Labs 2

Material Innovation for a Low Carbon Future
External factors shaping the future of low
carbon roads in the UK

February 2025

Executive Summary

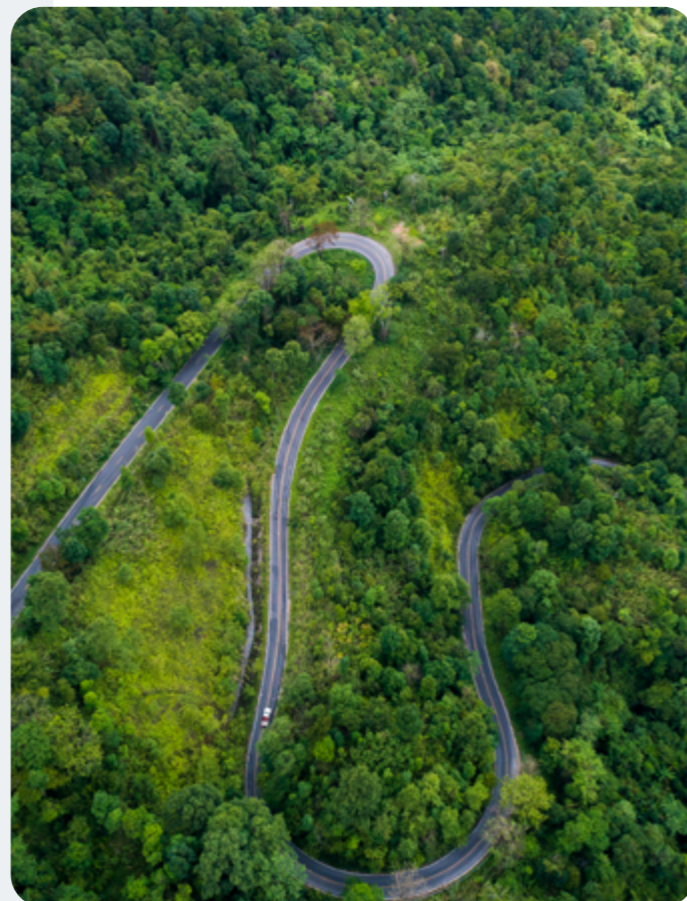
Key objectives

This report, a collaborative effort between Connected Places Catapult and a consortium led by Transport for West Midlands, North Lanarkshire Council, Amey, and Colas, aims to empower local authorities to plan and implement strategies for decarbonising road infrastructure by addressing the external drivers accelerating low carbon materials innovation. This involves identifying, trialling, and procuring novel materials to replace carbon-intensive ones. The contents of this report aims to de-risk decision-making, align stakeholders with a shared understanding of anticipated events, and provide a foundation for the development of shared strategies.

Purpose

Conducting foresight activities enhances understanding of **both barriers and opportunities** related to innovating road materials. The ability to work in harmony with external factors leads to performance improvements, cost savings, and more informed, **future-proofed**, decision-making about road infrastructure. Together this results in a more sustainable and resilient road network.

The Centre of Excellence for Decarbonising Roads (CEDR) is uniquely positioned to work across local authorities to produce and share the requisite knowledge to navigate the development of a low carbon material ecosystem. This report complements a growing library of content available on the CEDR website, including an International Scan of low carbon materials, as well as a forthcoming playbook design to help local authorities identify, assess, trial, monitor, and procure low carbon materials in the construction and maintenance of local roads across the UK.



Main findings

Drivers of change affecting the decarbonisation of road infrastructure span the entire PESTLE framework—**Political, Economic, Social, Technological, Legal, and Environmental factors**. Understanding these drivers is crucial to grasp their **impact, the direction of travel, and to** identify actionable strategies that accelerate the development of a low carbon material ecosystem.

The **Drivers of Change** surfaced through this research include:

1. Regional Collaboration
2. Grassroots Environmental Advocacy
3. Devolution of Government
4. Local Government Fiscal Pressures
5. Net Cost of Low Carbon Alternatives
6. Road Infrastructure Integrity
7. Confidence in Progress Towards Decarbonisation Targets
8. Embodied Carbon Awareness and Expertise
9. Road Usage Patterns
10. Responsible Material Innovation
11. Circular Supply Chain Readiness
12. Digital Transformation
13. Local Environmental Targets and Schemes
14. National Environmental Targets and Schemes
15. Ratification of Material Standards
16. Extreme Weather Events: Flood
17. Extreme Weather Events: Heat
18. Design Considerations for Users and the Environment

Opportunities and risks

Enhanced foresight associated with complex systems enables **proactive decision-making** around the construction and maintenance of sustainable, resilient, road networks. **Aligning stakeholders** around a shared understanding of anticipated events ensures **effective collaboration** and implementation of decarbonisation strategies. **Driving performance** improvements and **cost savings** optimises resources and demonstrates clear benefits.

Inaction results in reactive decision-making, stakeholder misalignment, and inefficiencies that jeopardise the success of road infrastructure decarbonisation efforts.

Recommendations

To successfully reduce carbon emissions across all scopes in road infrastructure, strong leadership and bold actions are needed. Those who adopt new, innovative materials early will play a key role in pushing progress. Leading the way with new approaches will inspire others and create momentum for broader change. Planning ahead is essential to navigate the future. Here are some practical steps to ensure low-carbon decisions are made for the long term:

- Create a group to share knowledge and best practices
- Collaborate with multiple stakeholders to create strategies
- Prioritise material testing based on important factors
- Share key trends and changes with a wide audience
- Keep engaging with experts regularly
- Use the insights gained to make decisions that are future-proof

Contents

ADEPT Live Labs 2

This report is the result of a collaboration between Connected Places Catapult and a consortium led by Transport for West Midlands, North Lanarkshire Council, Amey, and Colas. The partnership focuses on producing outputs that enhance decision-making and encourage the adoption of innovative materials and deployment processes in the construction of road and highway assets and the establishment of the Centre of Excellence for Decarbonising Roads (CEDR).

CEDR is one of the four themes included in Live Labs 2, a three-year, £30 million, UK-wide programme funded by the Department for Transport that will run until March 2026, with a five-year subsequent, extended monitoring and evaluation period.

Part of the ADEPT [Live Labs 2](#) : decarbonising local roads programme, a three year £30million UK-wide initiative funded by the Department for Transport that aims to decarbonise the local highway network.

Connected Places Catapult

Our work underpins Connected Places Catapult work to connect people, places and businesses to a future of inclusive sustainable growth and prosperity. This project was led by the Human Connected Design and Design Futures Teams for their expertise in Foresight and Speculative Design.

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Introduction

Decarbonising Roads

Transport accounts for 27% of carbon emissions (tailpipe emissions only), in the UK (Department for Transport, 2021). And road transport is the major contributor of these emissions. Extreme weather events have increased by 39% in the UK in the last few years compared to the last decade. To reduce the impact of climate change and move towards our net-zero goals, we have to significantly reduce the carbon footprint of our road infrastructure. This highlights the importance of decarbonising our road networks in achieving our net-zero targets and to urgently focus on making our road transport infrastructure and associated modes efficient, durable and sustainable.

Decarbonising roads with novel low carbon materials and processes presents significant challenges, including the uncertainty of long-term performance, higher upfront costs, and the need for industry-wide changes in standards and procurement practices. With such high stakes and uncertainty, adopting a long-term perspective is crucial to recognise how today's actions can have profound future impacts. The integration of these materials into existing infrastructure also requires overcoming resistance to change and ensuring alignment among various stakeholders.

Successfully adopting low carbon materials and processes in road construction demands strong foresight and a deep understanding of future user needs. By embracing a broader perspective, strategic points for intervention become clearer, facilitating the swift and effective achievement of decarbonisation targets. This, in turn, contributes to a more resilient and sustainable road infrastructure.

Foresight

A collaborative foresight approach has been implemented by convening experts from both academia and industry in a series of focused sessions. These sessions aim to identify the primary drivers of change across the PESTLE framework—Political, Economic, Social, Technological, Legal, and Environmental factors—that influence the development and adoption of low carbon road materials. By analysing these diverse elements, the sessions anticipate key events that could either accelerate or hinder innovation in this critical area.

The foresight process seeks to understand the broader consequences of successful decarbonisation of road infrastructure. Politically, this could reshape regulatory landscapes and public policies; economically, it could drive cost efficiencies and new market opportunities; socially, it may influence public perception and adoption; technologically, it could spur advancements and integration challenges; legally, it may necessitate new compliance standards; and environmentally, it could lead to significant reductions in carbon emissions. This comprehensive approach ensures informed decision-making for better strategic alignment with long-term sustainability goals.

Foresight, and later Strategic Foresight, emerged as formal practices in the mid-20th century, particularly during the Cold War, when governments and organisations sought structured methods to anticipate and navigate highly unpredictable futures. These practices evolved from military and defense planning into broader applications, offering tools to address complex, uncertain environments.

Today, foresight is integral to decision-making across industries, especially where uncertainty is extreme.

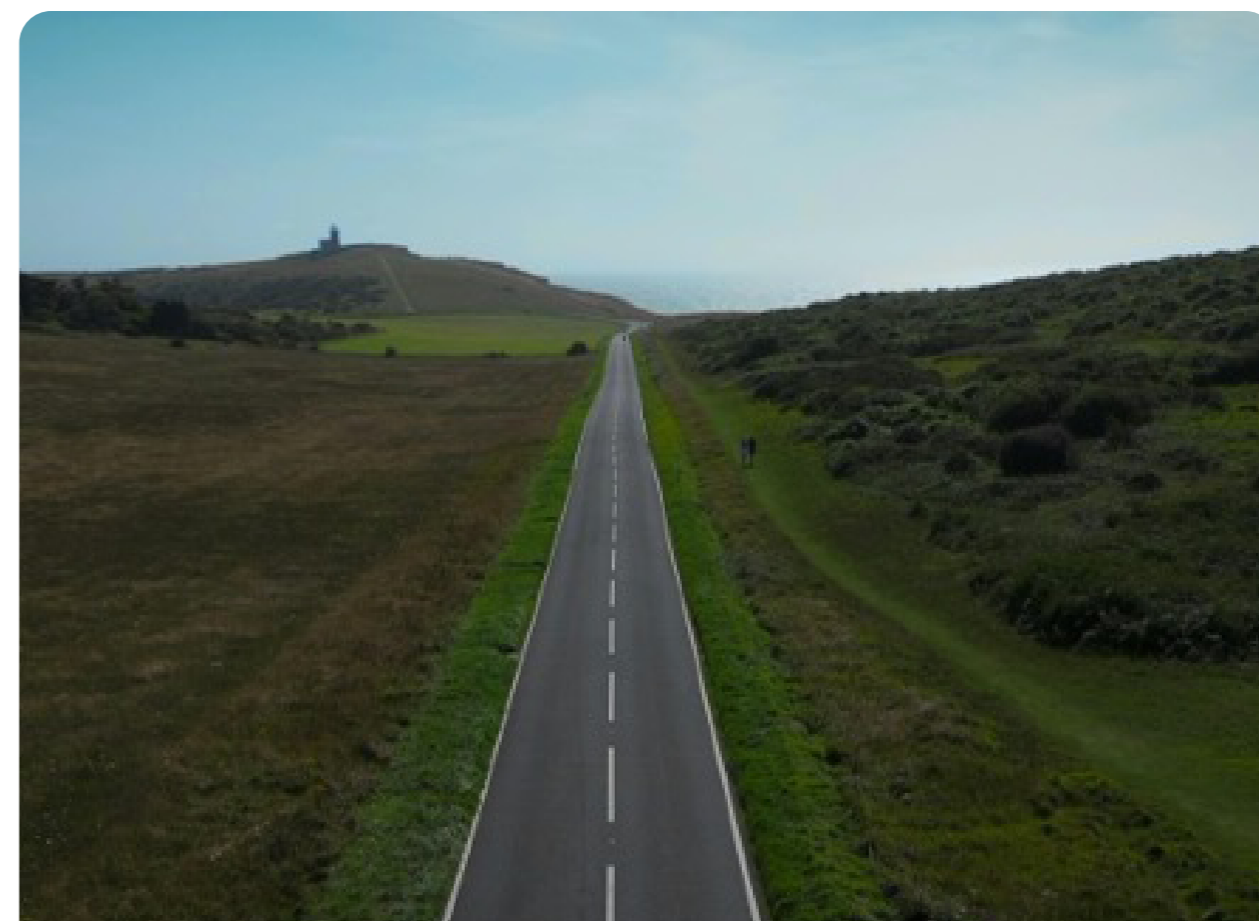
What is Strategic Foresight?

Strategic foresight is a systematic method for charting and analysing the future with an aim to direct and enable present-day decisions and strategies. It is formally defined as the process that aid decision-makers in mapping the firm's future course of action (Vecchiato, 2012).

Strategic forecasting carefully investigates alternative futures: the probable (what is highly likely), the possible (what can be), the plausible (what might be), the possible (what is theoretically feasible), the preposterous (that which seems infeasible or absurd), and the preferable (what ought to be). However, strategic foresight is more than just anticipating future circumstances: it is the deliberate approach to achieving (or avoiding) each of those scenarios (Sanzeni et al., 2019).

Foresight brings value to a business by enhancing its ability to sense, comprehend, and respond to change ahead of the competition, the capacity to influence other stakeholders, and the position to learn as an organisation (Iden et al., 2017 ; Rohrbeck et al., 2015). Strategic foresight is a worthwhile investment since it identifies change, initiates innovation activities, and challenges the evolution of innovation, thus overcoming prevalent mental models and enabling the appropriate organisational responses (Vigdor Gordon et al., 2020 ; Iden et al., 2017).

Simply put, Strategic Foresight is strategy in context.



The Future and nature of uncertainty



Normal Uncertainty

Imagine you're waiting for a train. You don't know exactly when it will arrive, but you can still plan around its schedule. You assume the train won't leave early, and though it might be a few minutes late, you anticipate it will be on time or close to it. This is normal uncertainty—bounded by rules and patterns from experience. We account for it in our everyday decisions, adjusting for expected delays based on factors like time of day, traffic, or weather. Our decisions are rational because we rely on averages, variances, and real-time clues to guide us. Normal uncertainty is manageable because we can observe it, measure it, and use that knowledge to adapt.

Extreme Uncertainty

Decisions based on crop yields, event attendance, and even construction timelines can all be made based on the principles of normal uncertainty. But what happens if the mean and standard deviation cannot be calculated, and we need to make decisions today?

Extreme uncertainty arises when patterns from the past provide little to no guidance for the future. In such situations, the future becomes highly unpredictable, and established rules and historical data may not be applicable. Leaders often face the challenge of making decisions without reliable data, leading to either overconfidence and rash decisions or paralysis and inaction. Extreme uncertainty is driven by factors such as long-time horizons, short-term volatility, complexity, asymmetry of information, and novelty, all of which amplify the unpredictability of future outcomes.

Long-time horizons: Uncertainty increases as the timeframe extends, making it difficult to predict how long-term trends, technological advancements, or social shifts will unfold and impact future outcomes.

Short-term volatility: Rapid and unpredictable changes over short periods, such as sudden market swings or political upheavals, create instability and make decision-making more challenging.

Complexity: Multiple interconnected factors, systems, and actors can interact in unforeseen ways, amplifying uncertainty and making it difficult to anticipate the outcomes of decisions.

Asymmetry of information: When key stakeholders have access to differing levels of information, decision-making becomes skewed, leading to uneven outcomes and increased uncertainty.

Novelty: The emergence of new technologies, markets, or social behaviours introduces unprecedented situations for which historical data or past experiences offer little guidance.

Decision-making under extreme uncertainty

Identification of Drivers of Change—the fundamental forces shaping the future sits at the core of contending with extreme uncertainty. This foundational step enables decision-makers to anchor their strategies in an understanding of the key factors influencing their sector, even when precise outcomes cannot be predicted. While there are numerous methods available, such as scenario planning, horizon scanning, and Delphi techniques, all begin with recognising the drivers behind potential changes.

Extreme uncertainty is particularly relevant to the decarbonisation of roads using novel materials. Identifying and understanding the drivers that influence this space—such as regulatory changes, advancements in materials science, and economic pressures—are crucial for creating resilient strategies that can adapt to rapid or unforeseen developments.

This approach, grounded in decades of foresight practice, ensures a structured yet flexible response to the challenges ahead.



Evidencing Drivers of Change

The process of evidencing drivers of change begins with convening industry and academics experts in foresight workshops. In these sessions, participants explore plausible changes affecting the decarbonisation of roads with novel materials. One essential activity is the futures wheel, a structured tool that visually maps potential consequences of change, allowing for the evaluation of direct and indirect impacts.

A PESTLE analysis is also applied to assess external factors. This framework examines Political, Economic, Social, Technological, Legal, and Environmental influences, providing a comprehensive view of how these dimensions impact decarbonisation efforts. It is particularly useful for identifying opportunities and threats.

Insights from these workshops are then mapped into affinity clusters and transformed into 18 distinct drivers of change. To further validate these drivers, a literature review is conducted, drawing from industry strategies and academic research. This review is designed to surface headwinds (factors that hinder progress) and tailwinds (factors that accelerate or support progress) underpinning each driver of change.

A trends and signals analysis is performed to add further evidence. Trends represent measurable, long-term changes that serve as proxies for the rate and direction of change from each driver, while signals are specific indicators—such as news headlines—that illustrate the presence and nature of change. Signals are collected at local, national, and international levels to provide a well-rounded view of each driver.

Finally, expert insights are gathered from participants in the workshops. These quotes provide additional evidence and perspectives, offering a deeper understanding of the drivers of change.

Assessment criteria

The assessment of drivers is based on a structured criteria that enables rapid understanding for decision-makers. Each driver is evaluated using a Rating Scale, which includes three key dimensions: Term, Certainty, and Impact.

Term refers to the immediacy with which events related to each driver are likely to influence the decarbonisation of roads through the adoption of low carbon materials. Drivers are classified as Short (immediate effects), Mid (emerging outcomes), or Long-term (distant impact), depending on how soon their effects are expected to materialise. This allows stakeholders to understand which drivers demand immediate attention and which may emerge over a longer period.

Certainty measures the likelihood of events associated with each driver occurring. The scale ranges from Projected, for events with a high degree of confidence, to Plausible or Possible, for those that are less certain. This criterion helps decision-makers gauge how reliable the evidence supporting each driver is.

Impact assesses the extent to which a driver will act as a catalyst for change. Drivers are rated as having Negligible, Substantial, or Transformative impacts. This enables stakeholders to prioritise those drivers that will most significantly affect decarbonisation efforts.

All ratings are based on evidence gathered from expert engagement, which includes interviews, workshops, and surveys. This ensures that the evaluation of each driver is rooted in direct insights from professionals and academics familiar with the sector.

Under **Monitoring, guidance** is provided to stakeholders on how to track and evidence changes related to each driver. Recommendations are made for continued monitoring, with **Frequency** indicating how often evidence should be revisited—ranging from Annually to Quarterly. Drivers that are driving rapid or highly impactful change are flagged for more frequent monitoring, ensuring stakeholders remain informed and responsive to evolving trends.



Summary of drivers of change

Drivers of change affecting the decarbonisation of road infrastructure span the entire PESTLE framework—**Political, Economic, Social, Technological, Legal, and Environmental factors**. Understanding these drivers is crucial to grasp the **impact and the direction of change** and to identify actionable strategies that can be employed in response.

Political

Regional
Collaboration

Grassroots
Environmental
Advocacy

Devolution
of Government

Economic

Local Government
Fiscal Pressures

Net Cost of Low
Carbon Alternatives

Road Infrastructure
Integrity

Social

Confidence in
Progress Towards
Decarbonisation
Targets

Embodied Carbon
Awareness and
Expertise

Road Usage
Patterns

Technological

Responsible
Material Innovation

Circular
Supply Chain
Readiness

Digital
Transformation

Legal

Local Environmental
Targets and
Schemes

National
Environmental
Targets and
Schemes

Ratification
of Material
Standards

Environmental

Extreme Weather
Events: Flood

Extreme Weather
Events: Heat

Design
Considerations
for Users and the
Environment

Political Drivers of Change

The Political category in the PESTLE framework refers to the ways in which government policies, regulations, and political structures influence societal transformations. Political factors play a pivotal role in shaping the regulatory landscape, determining funding priorities, and setting long-term strategic goals for sustainable infrastructure. When it comes to large-scale initiatives like decarbonising local roads in the UK, political factors play a pivotal role in shaping the direction, funding, and success of these efforts. As local authorities strive to reduce carbon emissions from road construction and maintenance, understanding the political context is essential for navigating challenges and seizing opportunities.

For decarbonising roads, political drivers reflect the increasing decentralisation of governance and the growing influence of public advocacy. Regional collaboration, the rise of grassroots environmental movements, and the devolution of powers from central to local governments are all critical to understanding how policy frameworks are evolving to meet climate targets. Local authorities are increasingly working together to overcome financial and logistical barriers, while public pressure is pushing governments to prioritise sustainable infrastructure investments. At the same time, the devolution of governance will allow more local administrations to take the lead on region-specific decarbonisation efforts, creating opportunities for tailored, community-focused solutions.

In the following sections, we will explore these political drivers in greater detail, examining how collaborative efforts, public sentiment, and shifts in governance are shaping the road to a low carbon future road network in the UK. We will look at real-world signals and trends that demonstrate how these drivers are playing out in practice, both locally and internationally.

Contributing Factors

Headwinds

Unequal funding

Regional funding disparities undermine cohesive nationwide decarbonisation efforts.

Differing priorities

Local councils' varied transport priorities complicate alignment with national decarbonisation goals and emissions reduction strategies.

Strategic Tunnel Vision

Government's focus on EVs overlooks coordinated efforts for broader low carbon transport and systemic planning changes.

Tailwinds

Shared knowledge and collaboration

Collaboration between authorities ensures consistent implementation of decarbonisation strategies and shared best practices nationwide.

Political agency

Local authorities' control over most UK roads gives them significant power to shape transport policy and design.

Engagement with local stakeholders

Engaging local stakeholders ensures public acceptance and integration of zero-carbon transport innovations in everyday life.

Check Appendix for details

Political Drivers of Change

Regional Collaboration

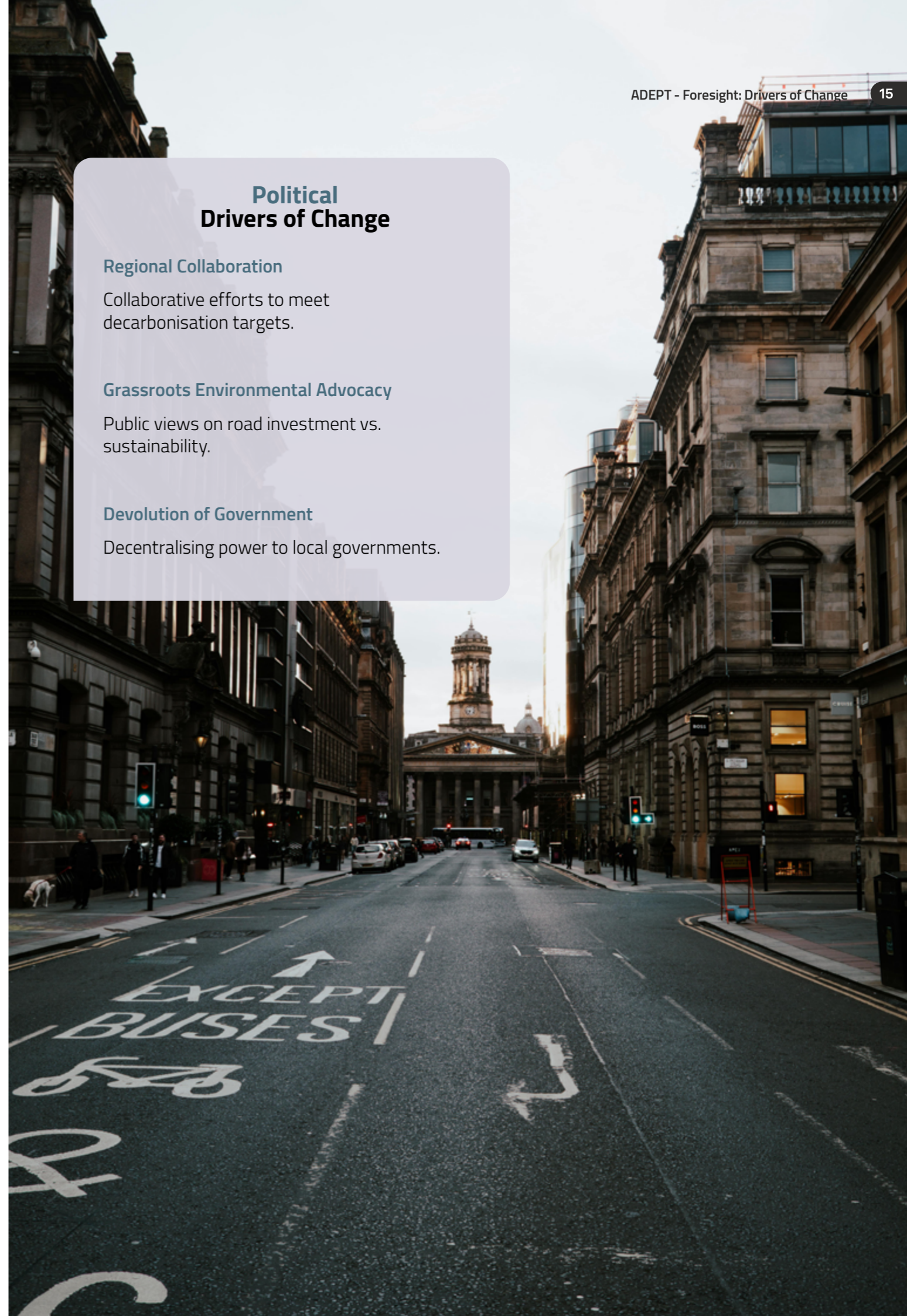
Collaborative efforts to meet decarbonisation targets.

Grassroots Environmental Advocacy

Public views on road investment vs. sustainability.

Devolution of Government

Decentralising power to local governments.



Regional Collaboratation


Drivers Definition

Regional collaboration refers to the power of collaborative efforts between different local authorities and within departments of the local authorities to achieve decarbonisation targets. This driver highlights isolated efforts for the same goal in different pockets leading to delays in achieving targets.

Trend


In response to a £375 million cut in funding for local road maintenance, from £1.5 billion to £1.125 billion between 2021 and 2022, local authorities are increasingly collaborating to address the deteriorating condition of roads. This collaboration is essential for efficient resource allocation and proactive maintenance. Source: [LocalGov Blog, 2024](#)

Signals


Local

A case study by the Local Government Association published in 2022 reveals that Lancashire County Council has effectively collaborated with supply chains and other authorities in 2021 to achieve a 15% reduction in carbon emissions in carriageway surfacing. They focused on innovative materials such as warm mix asphalt and in-situ carriageway recycling to enhance sustainability.

Source: [Local Government Association](#)


National

Four councils in Wales—Caerphilly, Bridgend, Blaenau Gwent, and Monmouthshire—have formed a collaborative group to address skills gaps in decarbonisation. This partnership focuses on sharing knowledge and training resources, enabling local authorities to better prepare staff and engage residents in achieving Net Zero targets. The initiative demonstrates the value of collective action in overcoming barriers to decarbonisation.

Source: [Local Government Association](#)


International


The ABC+De project is an ambitious initiative to construct a 786-mile motorway connecting Bulgaria, Romania, Greece, Hungary, Slovakia, and Turkey. This collaboration aims to enhance regional connectivity, boost trade, tourism, and cultural exchanges, and foster economic integration among participating countries, supported by their governments.

Source: [Daily Express](#)




Political Driver:
 Regional Collaboration

Rating Scale




Term

Short-term



Impact

Substantial



Certainty

Plausible

Monitoring

Frequency
 Semi-annually

Guidance

Stay updated with news feeds on regional initiatives and collaborations in transport and infrastructure projects. Engage with local authorities and regional stakeholders to explore new collaborative opportunities, policies, and the research supporting regional decarbonisation efforts. Initiate dialogue with neighbouring regions and peers to share best practices, attend conferences focused on regional collaboration, and contribute to joint knowledge platforms to ensure a continuous and aligned approach to regional cooperation.

Insight from experts

“ A 'guiding mind' mechanism is essential for ensuring the coherent joining-up of actions to achieve common purpose. Attention must be paid to how new decarbonised supply chains and associated markets and marketplaces will be built. ”

– Decarbonisation Expert

Grassroots Environmental Advocacy

Drivers Definition

Refers to the public’s perspective on the importance of local road investment and its impact on environmental issues. It highlights community sentiment toward balancing infrastructure development with environmental sustainability.

Trend

Grassroots environmental advocacy is on the rise, reflecting public concern over governmental actions. Confidence in political institutions, particularly parliament, has plummeted from a peak of 46% in 1990 to just 23% in 2022, indicating a growing disconnect between community needs and political responsiveness. Source: [The UK in the World Values Survey, KCL](#)



Signals

Local

The Hampshire County Council faces significant public opposition as it considers slashing its road works budget by £7.5 million. An overwhelming 88% of respondents opposed the cuts, indicating a strong grassroots sentiment prioritising infrastructure maintenance amidst local government budget challenges.

Source: [Daily Echo, 2024](#)

National

A recent Deloitte survey reveals that 70% of UK adults lack confidence in the government’s ability to meet the 2050 net zero target. While there is a growing demand for government action on sustainability, many believe that measures taken by authorities, particularly in energy and transport, will be more effective in reducing emissions than individual lifestyle changes. (Deloitte, 23 January 2024).

Source: [Deloitte Report, 2024](#)

International

A U.S. survey found that 82% of voters believe highway expansions are ineffective for reducing congestion, preferring investments in road repairs, public transit, and reducing driving. Over 70% agree that more transportation options enhance public health and safety, highlighting a disconnect between public sentiment and government spending priorities (Transportation for America, 29 June 2023).

Source: [Transport for America Blog, 2023](#)

Rating Scale

- Term** **Short-term**
- Impact** **Transformational**
- Certainty** **Probable**

Monitoring

Frequency
Routinely

Guidance

Stay current on local news feeds and grassroots channels on environmental advocacy efforts in your region. Engage with community groups and environmental activists to understand emerging movements and their impact on sustainable practices. Track national movements like Extinction Rebellion and Greta Thunberg’s initiatives as indicators of local momentum. Attend advocacy forums and community meetings and contribute insights from these movements to ensure ongoing alignment with grassroots environmental actions.

Insight from experts

“ Maybe the way to look at the road network is not as roads, but as service conduits... It's fundamental to how we are setting things up in this country. ”

– Decarbonisation Expert

Political Driver:
Grassroots Environmental Advocacy



Devolution of Government

Drivers Definition


Refers to the transfer of authority from central government to local administrations, allowing for greater autonomy and responsibility in areas such as education, innovation, environmental policy, and transport. This shift aims to enhance local accountability and responsiveness to community needs.

Trend

Since 2014, the trend towards devolution of powers to local governments in England has gained momentum, with the number of devolution deals rising from just one in 2014 to 22 by March 2024. This shift reflects a growing recognition of the importance of local governance in enhancing public service delivery and addressing regional challenges.

Source: [House of Commons Library, 2024](#)

Signals


Local


A £1.4 billion devolution deal for the Northeast was announced on 28 December 2022 signifying a commitment to local governance. With plans for an elected mayor and enhanced powers in skills, transport, and housing, it aims to foster economic growth and local decision-making.

Source: [Department for Levelling Up, Housing and Communities](#)


National

On 9 July 2024, all regional Mayors in England convened at 10 Downing Street to advance a significant devolution initiative, reinforcing the commitment to transfer power from Westminster to local authorities. This collaborative approach aims to stimulate economic growth and address regional disparities.

Source: [Ministry of Housing, Communities and Local Government](#)


International

On 14 March 2024, the Local Government Association published a report emphasising the need for collaboration between national and local governments for effective climate action, particularly in transportation emissions. It features case studies from Norway, the Netherlands, and South Korea, highlighting the role of national policies in supporting local initiatives.

Source: [Local Government Association](#)



Political Driver:
Devolution of Government

Rating Scale



Term

Long-term



Impact

Substantial



Certainty

Possible

Monitoring

Frequency
Semi-annually

Guidance

Review developments in devolved government policies focusing on changes in responsibilities, budgets, and powers that may impact regional projects, particularly in relation to the adoption of low carbon materials in infrastructure. Engage with local authorities and devolved administrations to understand how policy changes are being implemented, the availability of funding for sustainable materials, and their effects on local infrastructure and services.

Insight from experts

“ I think there's always this element of competition between local authorities and I don't know why. Because they're funded the same way and they're all trying to get to the same output. ”
– Independent Carbon Consultant

Economic Drivers of Change

The economic category in the PESTLE framework explores the financial forces and constraints that influence decision-making processes in various sectors. In the context of decarbonising local roads, economic drivers are particularly critical as they shape how resources are allocated, how investments are prioritised, and how costs are managed over time. These drivers include factors such as budgetary pressures on local governments, the costs associated with adopting low carbon technologies, and the need to maintain road infrastructure integrity. Together, these economic forces impact the ability of governments and industries to meet sustainability goals while ensuring road networks remain safe and functional.

As local governments grapple with limited budgets and rising costs, fiscal pressures are becoming a central concern. Economic constraints often force authorities to choose between immediate needs and long-term investments, which can delay essential projects like road maintenance or the adoption of low carbon alternatives. However, as the costs of sustainable technologies decrease, many governments are exploring cost-effective solutions, such as using low carbon asphalt, to reduce emissions while managing expenses.

In the following section, we will delve into these economic drivers of change in greater detail, examining the fiscal challenges local governments face, the evolving costs of low carbon alternatives, and the importance of maintaining road infrastructure. Through specific signals at local, national, and international levels, we will highlight how economic pressures are shaping the future of decarbonising local roads.

Contributing Factors

Headwinds

High upfront cost of innovation

High costs hinder investment in low carbon technologies due to uncertain market demand and supply chain risks.

Financial constraints

Decreased local authority funding limits their ability to invest in net-zero projects and essential services.

Lack of clear policies

Unclear policies and regulatory uncertainty delay infrastructure projects and complicate adoption of new technologies or materials.

Tailwinds

Financial support

Government policy ensures long-term financial support for adaptable, future-proof transport projects and improved public infrastructure.

Devolved budgets

Devolved transport budgets for local authorities ensure consistent maintenance and infrastructure upgrades.

Carbon pricing

Carbon pricing, which includes carbon cap and trade and carbon tax, incentivises low carbon technologies but risks overlapping with existing policies and raising complexity in transport operations.

Check Appendix for details

Economic Drivers of Change

Local Government Fiscal Pressures

Local government budgeting and funding challenges.

Net Cost of Low Carbon Alternatives

Net cost of low carbon alternatives evaluation.

Road Infrastructure Integrity

Road infrastructure durability and maintenance impact.

Local Government Fiscal Pressures

Drivers Definition

This refers to the budgeting and funding challenges faced by local authorities as they navigate competing priorities. This includes making difficult decisions on budget allocations amidst rising costs and demands for services. The driver highlights the necessity for effective financial management and prioritisation to ensure essential services while striving for long-term goals.

Trend

Local government core funding is projected to decline by 9% in real terms, with an 18% per-person decrease by 2024-25. Financial pressures continue to rise due to inflation and growing service demands.

Source: [Institute for Fiscal Studies report, 2024](#)



Signals

Local

Local authorities in England and Wales face significant fiscal pressures, with 45% reporting budget cuts or freezes in highway maintenance. Despite rising costs, maintenance remains underfunded, with a £7.2 million shortfall per authority, limiting proactive road upkeep and long-term infrastructure sustainability.

Source: [ALARM Survey, 2024](#)

National

The 2023/24 carriageway maintenance budget across England and Wales faced a £1.22 billion shortfall, with an average gap of £7.2 million per authority. Despite a modest 3% budget increase, inflationary pressures have intensified fiscal challenges, limiting local authorities' ability to maintain road networks effectively.

Source: [ALARM Survey, 2024](#)

International

Germany's 2025 budget allocates €5 billion for road infrastructure, including autobahns and bridges, but Autobahn GmbH estimates an additional €5.5 billion will be needed by 2028. This reflects growing fiscal pressures, as rising costs and debt constraints limit essential road maintenance and expansion projects.

Source: [DW Germany](#)

Rating Scale

- Term** **Short-term**
- Impact** **Transformational**
- Certainty** **Projected**

Monitoring

Frequency
Semi-annually

Guidance

Remain informed with mid-year budget reviews, examining fiscal forecasts and projections to identify emerging financial pressures on local government. Engage with officials to assess the impact of unexpected shocks, such as economic downturns or demographic shifts.

Semi-annual reviews of budgetary planning documents and council meeting records will offer insights into how local government fiscal strategies are adapting. Assess materials on a cost per functional year basis to acknowledge options that may have a higher volumetric cost, but a lower useable life-time cost.

Insight from experts

Decarbonisation is fundamentally about creating, improving and streamlining processes that lead to valuable outcomes. Process improvement leads to cost and value improvements, so shifting the mindset from decarbonisation as an added cost is crucial.

- ICE Policy Fellow

Economic Driver:
Local Government Fiscal Pressures



Net Cost of Low Carbon Alternatives

Drivers Definition

This refers to the net costs associated with low carbon options, including labour, transportation, and materials. This driver underscores the importance of evaluating initial investments alongside long-term expenses in the transition to low carbon solutions.

Trend

The cost of low carbon alternatives is decreasing, with the UK's Low Carbon and Renewable Energy Economy (LCREE) turnover increasing by 72.6% between 2015 and 2022, according to the Office for National Statistics. From 2021 to 2022, turnover rose by 28%, reaching its highest level since 2015, highlighting the growing affordability and adoption of low carbon technologies. Source: [Office for National Statistics UK, 2022](#)



Signals

Local

South Gloucestershire Council is pioneering a project as part of the UK-wide Live Labs 2 programme, receiving £4.7 million in funding to decarbonise local roads. The project focuses on using biomass from roadside grass cuttings as an additive for low carbon asphalt, contributing to both reduced road maintenance costs and carbon emissions.

Source: [South Gloucestershire Council, 2023](#)

National

Highways England is accelerating the use of warm mix asphalt (WMA) across the UK's strategic road network to cut carbon emissions. WMA can reduce CO₂ emissions by up to 15% compared to traditional hot mix asphalts, saving around 61,000 tonnes of CO₂ annually if widely adopted. This transition aligns with Highways England's goal of achieving net-zero carbon emissions by 2050.

Source: [Highways England, 2021](#)

International

In Austrian province Vorarlberg's "Green Asphalt" initiative incorporates biochar, a biomass byproduct, into asphalt to create climate-positive roads. Each kilogram of biochar sequesters 3 kg of CO₂, significantly reducing road construction's carbon footprint and long-term costs.

Source: [Biochar Industry, 2020](#)

Rating Scale

Term Mid-term

Impact Transformational

Certainty Probable

Monitoring

Frequency
Routinely

Guidance

Stay updated on factors impacting the net cost of low carbon road materials, such as fluctuations in fuel prices, supply chain disruptions, or breakthroughs in alternative technologies. Engage regularly with suppliers to understand material pricing trends and emerging innovations. Monitor industry reports and investment activities to anticipate cost changes. Attend relevant industry forums or discussions to stay informed ahead of purchasing decisions, ensuring that any shocks or developments can be accounted for in budgeting and procurement planning.

Insight from experts

“What happens if actually, it wasn't 25 years, it was 13 years before we needed to do something about it? ...what's in it for local authorities to take that risk on and ask their contractors to take those risks on?---- probably national government, might need to act as some kind of guarantor to these kinds of programmes, which have some risk but potentially high reward to them.”

– Professor, Transport Governance

Economic Driver:
Net Cost of Low Carbon Alternatives



Road Infrastructure Integrity

Drivers Definition

It encompasses the quality, durability, and longevity of road systems. It includes considerations of maintenance cycles, which can significantly influence infrastructure integrity—either enhancing it through regular upkeep or compromising it due to neglect or inadequate resources. This driver highlights the importance of investment in robust maintenance practices to ensure reliable and safe transportation networks.

Trend

The maintenance backlog for local roads in the UK has risen sharply, reaching £15.6 billion in 2023–24, up from £11.7 billion in 2019. Inflation, funding limitations, and shorter-term investment approaches are exacerbating the decline in road condition and increasing long-term maintenance costs.

Source: [Office for National Statistics UK, 2022](#)

Signals

Local

In 2023, Edinburgh City Council committed an additional £3 million to road and footpath repairs, including £500,000 for resurfacing and £800,000 for maintaining structures like bridges. This investment aims to improve the durability and safety of local infrastructure, addressing public concerns about road conditions.

Source: [The Edinburgh Reporter, 2023](#)

National

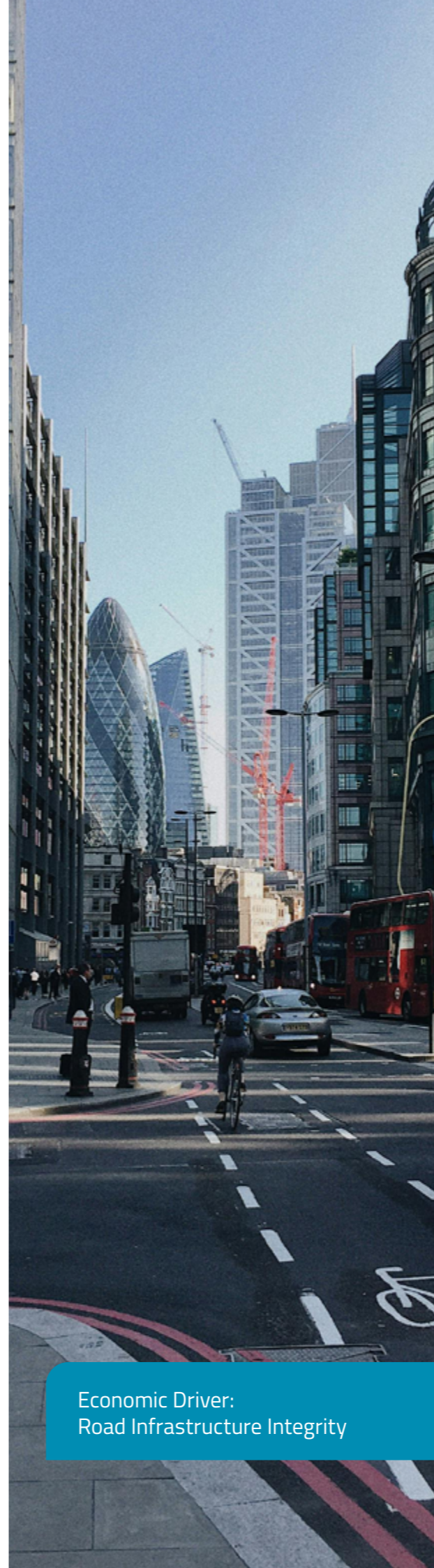
The Local Government Association (LGA) has called for a 10-year funding commitment to support local authority road repairs across the UK. This request comes amid significant budget reductions for road maintenance, with the LGA proposing that 2p from existing fuel duties be redirected to tackle growing issues such as potholes and ensure long-term road infrastructure integrity.

Source: [New Civil Engineer, 2023](#)

International

India's Ministry of Road Transport and Highways is undertaking a major infrastructure plan, with \$293 billion allocated to expand the national highway system by 30,600 km by 2032. This includes the construction of 18,000 km of expressways to improve road durability, reducing congestion and enhancing long-term infrastructure integrity.

Source: [World Highways, 2024](#)



Economic Driver:
Road Infrastructure Integrity

Rating Scale

- Term** **Short-term**
- Impact** **Transformational**
- Certainty** **Probable**

Monitoring

Frequency
Routinely

Guidance

Track road infrastructure conditions by regularly reviewing reports on extreme weather impacts and accident data that may cause acute damage. Extend monitoring to include a broader range of roads beyond the most and least maintained, increasing the fidelity of assessments. Engage with local authorities and road users to gather insights on emerging issues. Attend infrastructure-focused forums and leverage monitoring technologies to ensure timely identification of potential vulnerabilities across the entire road network, supporting proactive repair and maintenance planning.

Insight from experts

“If you have a road and you don't look after it, you end up with potholes and then you end up filling the potholes. So is it better long term to do some light touch maintenance to your roads?”
- Highways Consultant

Social Drivers of Change

The Social category in the PESTLE framework examines the societal values, behaviours, and public perceptions that influence decision-making and infrastructure development. In the context of decarbonising local roads, social drivers play a crucial role in shaping public attitudes towards sustainability initiatives, road usage patterns, and engagement with environmental targets. These drivers highlight how communities, individuals, and organisations respond to climate challenges and the actions they demand from governments and industries to address these issues. As local authorities work towards reducing carbon emissions, understanding the social context is essential for ensuring that decarbonisation efforts align with community values and needs.

Public perception and support are key social factors that influence the decarbonisation of local roads. As local authorities set ambitious goals for reaching net zero, the public's belief in the feasibility of these efforts can either propel or hinder progress. Engaging with local communities through transparent communication and education can help build trust and support for decarbonisation projects, ensuring that they are seen as beneficial to the public good. In addition, growing awareness of embodied carbon—the emissions produced during the construction and maintenance of road infrastructure—means that there is increasing pressure for more transparent, sustainable practices. Finally, road usage patterns reflect societal shifts towards more environmentally friendly transport modes, such as cycling and electric vehicles, which in turn influence the demands on road infrastructure.

In the following section, we will explore these social drivers in greater detail, focusing on how confidence in decarbonisation targets, embodied carbon awareness, and road usage patterns are shaping the decarbonisation of local roads. Through emerging trends and real-world signals, we will see how public attitudes and behaviours are driving changes in infrastructure and road design for a more sustainable future.

Contributing Factors

Headwinds

Equity Concerns

There may be concerns that low carbon road infrastructure could prioritise urban areas, leaving rural or disadvantaged regions behind in terms of access to upgraded infrastructure.

Skills gap

The mismatch between workers' current skills and employers' demands, often caused by technological advancements, outdated education systems, shifting industry needs, and insufficient training opportunities.

Misaligned Authority Roles and Expectations

Misalignment between local authorities' roles and public expectations hinders road safety and sustainability efforts.

Tailwinds

Long-term commitment

Long-term commitment to infrastructure development builds public trust and promotes social engagement in sustainable practices.

Integrated decision making

Integrated decision making implies the inclusion of multiple perspectives, inputs, and data sources in the decision process.

Demand for low carbon transport infrastructure

Public and government drive demand for low carbon transport infrastructure, such as freight to reduce emissions.

Check Appendix for details



Social Drivers of Change

Confidence in Progress Towards Decarbonisation Targets

Reliability of decarbonisation targets and local efforts shaping public belief.

Embodied Carbon Awareness and Expertise

Embodied carbon awareness and informed decisions.

Road Usage Patterns

Road usage patterns, vehicle types, and infrastructure demands.

Confidence in Progress Towards Decarbonisation Targets

Drivers Definition

This refers to the reliability and clarity of national decarbonisation targets as their deadlines approach, alongside the proactive measures taken by local authorities to achieve them. Public belief, or scepticism, towards these targets is shaped by the perceived effectiveness of these efforts.

Trend

According to Deloitte's State of the State 2024 survey, public confidence in the UK's ability to meet its 2050 net zero target has significantly declined, rising from 58% in January 2023 to 70% in January 2024.

Source: [Deloitte Report, 2024](#)



Signals



Local

A recent Local Government Association survey reveals a decline in confidence among councils regarding net zero targets, with 67% uncertain of success due to bureaucratic funding barriers and insufficient financing plans, undermining local climate action efforts.

Source: [LGA, 2024](#)



National

Local councils' struggles with bureaucratic hurdles and insufficient funding highlight a national issue, as 83% of the UK public believe the government should do more to tackle climate change, with 73% supporting related policies. Nearly two-thirds of councils lack confidence in meeting their net zero goals, emphasising the need for effective local support and streamlined funding.

Source: [Our World in Data, 2024](#)



International

Transport emissions in Europe are projected to constitute nearly half of the continent's greenhouse gas emissions by 2030, having decarbonised three times slower than other sectors since 2007. Urgent action is needed to address this pressing issue.

Source: [Transport & Environment, March 2024](#)

Rating Scale

- Term** **Long-term**
- Impact** **Substantial**
- Certainty** **Plausible**

Monitoring

Frequency
Annually

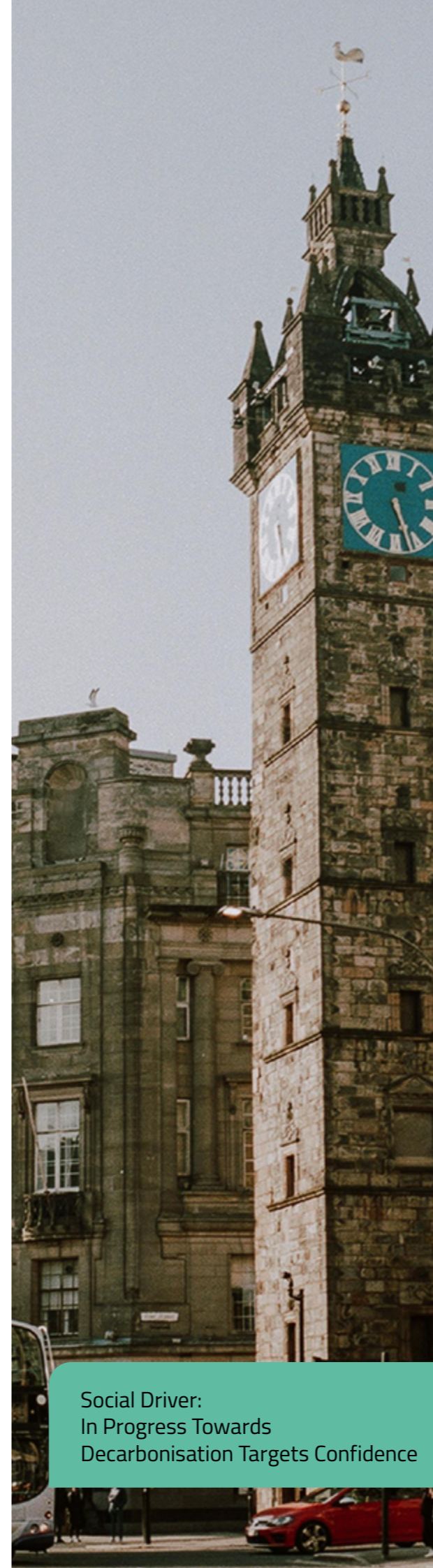
Guidance

Review national and regional reports annually to gauge not only actual progress but also public and stakeholder perceptions of success in meeting decarbonisation targets. Compare carbon emission reductions to set milestones, while also tracking sentiment through media coverage, surveys, and expert commentary. Pay attention to emerging narratives of optimism or scepticism around the targets and engage with both government and industry leaders to understand any perceived gaps or barriers.

Insight from experts

“ A lot of it (barriers to decarbonising) was also around how to communicate it to the public. That other decision has been taken into prioritising (decarbonising initiative) because of course the public might not see the full issue and might look at things like oh, we've got potholes we really need you to fix those potholes. ”

–Policy Expert



Social Driver:
In Progress Towards
Decarbonisation Targets Confidence

Embodied Carbon Awareness and Expertise

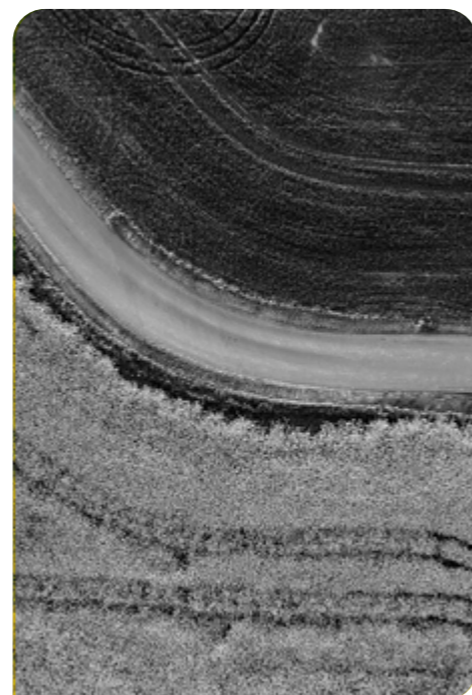
Drivers Definition

Embodied carbon awareness refers to the increasing understanding of carbon emissions linked to road infrastructure among users, authorities, and manufacturers. As sophistication in carbon data grows, so do the skills required to interpret it effectively, promoting informed decision-making and reducing the risk of greenwashing in sustainable practices.

Trend

Between 2015 and 2020, the UK saw a nearly 4% increase in full-time equivalent green jobs, rising from 507,100 to 526,400. This growth reflects the rising awareness and expertise regarding embodied carbon as industries adapt to the green economy, particularly in sectors like renewable energy and low carbon transport.

Source: [The UK in the World Values Survey, KCL](#)



Signals



Local

Westminster City Council, in partnership with FM Conway, has pioneered the UK's first road resurfacing project using 92% recycled materials, achieving a 78% reduction in carbon emissions. This initiative exemplifies the growing awareness and application of low carbon techniques in urban infrastructure, setting a precedent for future sustainable construction practices.

Source: [Westminster Council, 2024](#)



National

National Highways has become the first major roads organisation globally to achieve PAS 2080 accreditation, recognising its comprehensive carbon management strategies. This milestone highlights a growing commitment within the infrastructure sector to integrate carbon reduction practices in road design, construction, and operations, significantly enhancing awareness and expertise in embodied carbon management.

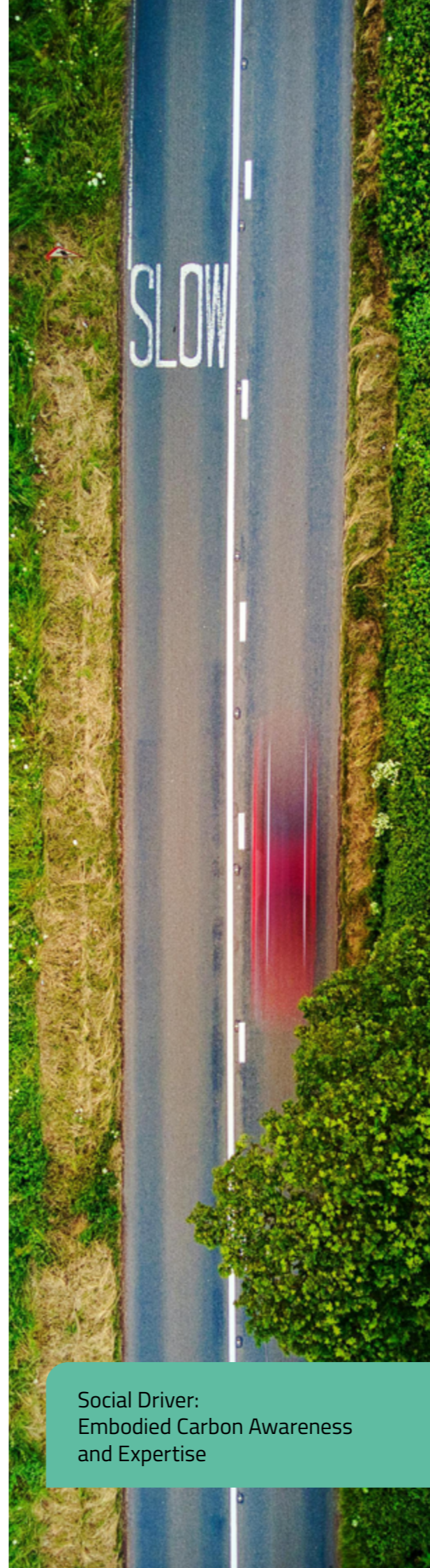
Source: [National Highways, 2022](#)



International

In an effort to formulate a carbon reduction strategy, researchers have proposed a binary statistical method to quantify CO₂ emissions in highway construction, estimating emissions from various activities based on an expressway case study in central China. The study highlights that material production contributes over 95% of total emissions, predominantly from steel and cement, underscoring the need for recycling and low carbon alternatives.

Source: [AzoBuild.com, 2024](#)



Social Driver:
Embodied Carbon Awareness
and Expertise

Rating Scale

Term	Mid-term
Impact	Transformational
Certainty	Probable

Monitoring

Frequency
Semi-annually

Guidance

Keep up to date with the latest practices in embodied carbon accounting and reporting standards within the construction sector. Engage with industry bodies and experts to enhance skills and knowledge around embodied carbon measurement and disclosure. Attend relevant conferences and workshops to stay updated on evolving carbon accounting methods. Ensure your workforce is trained in the latest carbon reporting practices to meet regulatory and sustainability requirements, supporting transparent and accurate environmental disclosures aligned with industry best practices.

Insight from experts

“ Awareness of embodied carbon throughout the client and supply chain organisations is vital – to enable people to make carbon-informed decisions, making the carbon impact of decisions visible. ”
– Independent Carbon Consultant

Road Usage Patterns


Drivers Definition

Road usage patterns refer to the changing volume, weight, and types of vehicles on roads, encompassing both personal transport and freight movement. These patterns reflect user behaviours, transport modes, and freight logistics, highlighting the growing demand on road infrastructure and the need for adaptive maintenance and future planning.

Trend

Between 1993 and 2023, road traffic in Great Britain increased by 29.1%, rising from 256.2 billion to 330.8 billion vehicle miles. Despite pandemic-related declines, the long-term trend shows a steady increase in road usage over the 30-year period. Notably, Bus and Coach miles have steadily decreased by roughly 30% (2.9 to 1.9 B vehicle miles) while Pedal Cycles and Light Commercial Vehicles have increased (2.5 to 3.6 and 25.8 to 57.8 billion vehicle miles, respectively). Source: [DfT Traffic Statistics, 2023](#)

Signals


Local

South Gloucestershire Council is investing in sustainable travel along the A432, aiming to reduce car dependency. Proposals include cycle lanes, pedestrian crossings, and improved bus stops, supporting climate goals and improving safety for walking, cycling, and mobility aid users.

Source: [South Gloucestershire Council, 2024](#)


National

Cycling traffic levels in England have increased by 8.2% between 2013 and 2024, reflecting a long-term rise in cycling activity, despite fluctuations during the pandemic (a short-term 50% spike). The National Cycle Network (NCN) connects to local roads and paths, integrating cycling infrastructure across towns and cities. The network's redesign in 2020, which focused on safety, impacts local roads by linking traffic-free paths with quieter, traffic-calmed streets to promote safer, sustainable travel options.

Source: [DfT Cycling Statistics, 2024](#)


International


The US State of Michigan Department of Transportation's annual spring weight restrictions protect local roads from damage during the thawing period. By enforcing reduced weight limits, the state mitigates pothole formation and roadbed deterioration caused by freeze-thaw cycles, safeguarding road infrastructure.

Source: [Michigan Department of Transportation, 2024](#)




Social Driver:
Road Usage Patterns

Rating Scale




Term

Mid-term



Impact

Substantial



Certainty

Probable

Monitoring

Frequency
Semi-annually

Guidance

Review reports on road usage patterns to identify how changing mobility behaviours, like increased cycling or walking, can support adoption of low carbon materials in all aspects of the road infrastructure, including bike lanes and pavement. Engage with authorities to explore low carbon materials like recycled plastic bollards or biogenic thermoplastics for bicycle lanes. Gather feedback at forums or consultations on public demand for sustainable transport options. Regularly monitor trends to ensure material choices align with evolving usage patterns and environmental goals.

Insight from experts

“ The increasing weight of vehicles, EV vehicles being case in point, will exacerbate the rate of deterioration. So as we move (away) from petroleum and (towards) electric power environment, (we) need to ensure that the road network can sustain the loadings to which it's being subjected to. ”

- Highways Consultant

Technological Drivers of Change

The Technological category in the PESTLE framework focuses on innovations and advancements that drive progress across industries. In the context of decarbonising local roads, technological drivers are essential for developing more sustainable materials, improving infrastructure management, and reducing overall carbon emissions. Technological factors are essential in determining the feasibility, efficiency, and scalability of adopting low-carbon solutions in road infrastructure. These drivers include the adoption of responsible material innovations, the integration of circular economy principles into road construction, and the digital transformation of road networks through advanced technologies. Together, these technologies influence how roads are built and maintained, ensuring that decarbonisation goals are met while enhancing road performance and safety.

As low-carbon technologies evolve, materials such as low-emission asphalt and circular supply chains are becoming more widely adopted, offering cost-effective, environmentally friendly alternatives to traditional construction methods. Additionally, the increasing use of digital technologies—such as IoT sensors, AI, and data-driven analytics—allows for better road management, predictive maintenance, and resource optimisation. These innovations reduce both the environmental footprint of road infrastructure and long-term costs for local authorities. However, the integration of these technologies requires careful consideration of their long-term performance, durability, and compatibility with existing infrastructure. Staying updated on the latest technological trends and breakthroughs is vital for local authorities to make informed decisions.

In the following section, we will explore these technological drivers in more detail. We will examine how innovations in material science, circular supply chains, and digital infrastructure are transforming the decarbonisation of local roads, and we will provide insights into how these technologies are influencing decision-making at local, national, and international levels.

Contributing Factors

Headwinds

Skills gap

The skills gap hampers the adoption and development of new technologies necessary for low carbon transport solutions.

Cost of early adoption

Early adoption involves higher initial costs due to research, testing, low economies of scale in production, and integration challenges.

Interfacial complexity

Interfacial properties affect the bonding between materials, contributing to road construction durability, longevity, and resistance to wear.

Tailwinds

Knowledge sharing

Knowledge sharing across local authorities and nations accelerates decarbonisation initiatives.

Grid decarbonisation

Grid decarbonisation supports the transition to green steel and other high intensity product production by providing low carbon electricity.

Demand for low carbon transport infrastructure

Public and government drive demand for low carbon transport infrastructure, such as freight to reduce emissions.

Check Appendix for details

Technological Drivers of Change

Responsible Material Innovation

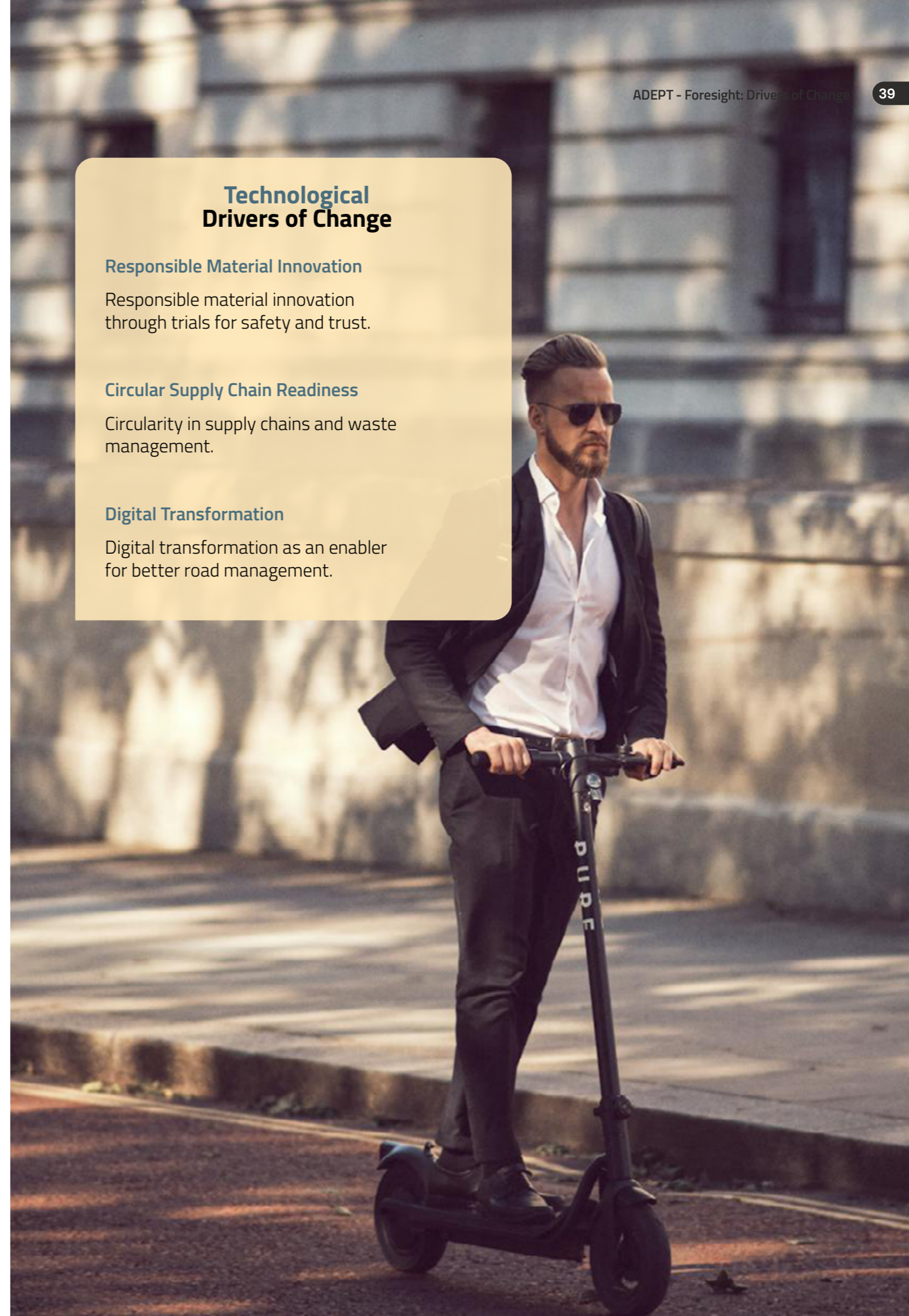
Responsible material innovation through trials for safety and trust.

Circular Supply Chain Readiness

Circularity in supply chains and waste management.

Digital Transformation

Digital transformation as an enabler for better road management.



Responsible Material Innovation

Drivers Definition

Responsible material innovation refers to developing new materials and the need for trials to ensure market readiness. For low carbon materials to gain acceptance, users must understand their performance, value, and safety through trials that build trust.

Trend

A growing trend in responsible material innovation is reflected in the rise of Green Channel patent applications, which increased by 12.2% in 2023 to 560, compared to 499 in 2022. Green Channel patents fast-track environmentally beneficial inventions, enabling faster market entry. This system accelerates innovation in green technologies, supporting sustainability by prioritising patents that offer clear environmental advantages, according to UK Government IPO administrative data.

Source: [IP Office, UK, 2024](#)

Signals

 **Local**

Oxfordshire County Council implemented an innovative road resurfacing technique called cold recycling, which reuses old road materials with a foamed bitumen binder. This process may reduce carbon emissions by 50% and saves thousands of tonnes of waste, enhancing both sustainability and cost efficiency.

Source: [Oxfordshire Council, 2023](#)

 **National**

A materials passport trial in London, involving Waterman Group and developers BauMont Real Estate and Yard Nine, could lead to a UK-wide materials database. While currently focused on buildings, infrastructure clients are showing interest, potentially expanding the initiative's reach into wider construction sectors.

Source: [New Civil Engineer, 2023](#)

 **International**

A global initiative is underway to decarbonise the cement and concrete industry, responsible for 8% of global CO₂ emissions. Companies like Brimstone, Holcim, and Heidelberg Materials are leading efforts, supported by U.S. Department of Energy funding, to develop low-emission production technologies for infrastructure applications.

Source: [Transport for America Blog, 2023](#)



Rating Scale

-  **Term** **Short-term**
-  **Impact** **Substantial**
-  **Certainty** **Probable**

Monitoring

Frequency
Routinely

Guidance

Keep up to date with news feeds related to scientific breakthroughs and product trials. Engage with road builders to learn about new low carbon materials and the research supporting them. Initiate discussions with experts and peers for knowledge exchange, attend relevant conferences, and contribute to shared knowledge banks to ensure continuous learning about material innovation.

Insight from experts

“ We haven't got a lot of time to meet our 2050 targets. Technology development cycle is around about 20 to 25 years typically... so we've got one technology cycle left. ”

—ICE Policy Fellow

Technological Driver:
Responsible Material Innovation

Circular Supply Chain Readiness

Drivers Definition

Circularity refers to both supply chain and waste stream readiness in making road infrastructure materials more sustainable. This involves developing processing infrastructure, coordinating across sectors, and implementing comprehensive tracking systems for materials and carbon data to ensure circular practices are integrated into manufacturing.

Trend

A clear trend towards improved resource recovery in the UK is demonstrated by Defra data, showing that non-hazardous construction and demolition waste recovery in England increased from 92.2% (49.4 million tonnes) in 2010 to 94.3% (59.4 million tonnes) in 2022. Notably, waste generation also rose substantially during this period, from 53.6 million tonnes to 63.0 million tonnes, reflecting increased construction activity alongside improved sustainability efforts.

Source: [Defra, UK, 2024](#)

Signals



Local

Shropshire Council's innovative road maintenance strategy, including a 'find and fix' model and local supply chain engagement, has optimised resource use, cutting repair costs and reducing pothole backlogs by 75% from 2020 to 2023. This approach has earned them a spot as a finalist for the 2024 LGC Innovation Award.

Source: [Shropshire Council, 2024](#)



National

National Highways' A303 road scheme, a £1.5 billion project, integrates circular economy principles from the outset. By focusing on resource efficiency, reuse, and sustainability, this initiative serves as a pathfinder for future UK infrastructure projects, reducing waste and carbon emissions while setting a new standard in sustainable road construction.

Source: [AECOM](#)



International

Tampere, Finland, is pioneering circular economy procurement in road construction. The city's Yliopistonkatu renovation project, launched in 2021, integrated resource reuse, recycling, and reduced emissions, setting a new benchmark for sustainable infrastructure projects in Europe.

Source: [EU Green Business](#)



Technological Driver:
Circular Supply Chain Readiness

Rating Scale

Term	Long-term
Impact	Transformational
Certainty	Plausible

Monitoring

Frequency
Routinely

Guidance

Stay informed with news feeds on developments in circular supply chains and sustainable material flows. Engage with suppliers and partners to understand how they are incorporating circular principles into their operations and explore the supporting research. Encourage knowledge-sharing discussions with peers and industry experts, attend conferences focused on circularity, and contribute to collaborative platforms to continuously enhance your understanding of circular supply chain readiness.

Insight from experts

“ Avoidance of material waste and over-specification is also vital. Currently, over-specification accounts for up to 40% additional embodied carbon in materials. ”
—Decarbonisation Expert

Digital Transformation

Drivers Definition

Digital transformation in local authorities enables road inventory creation and predictive maintenance through technologies like GIS, IoT sensors, AI-driven analytics, and BIM. It also facilitates cross-departmental, organisational, and regional collaboration, improving road infrastructure management.

Trend

Digital transformation in local authorities enables road inventory creation and predictive maintenance through technologies like GIS, IoT sensors, AI-driven analytics, and BIM. It also facilitates cross-departmental, organisational, and regional collaboration, improving road infrastructure management.

Source: [Grandview Research, 2022](#)



Signals

Local

Digital Local Roads initiative, backed by organisations such as Ringway, Jacobs, Vinci Highways, Ordnance Survey, TRL, DfT, Innovate UK, and ADEPT, highlights the growing need for digital solutions in local road networks. Consultation with Local Authorities underscores the potential of connected technologies to improve asset management and data sharing amidst budgetary pressures.

Source: [Digital Local Roads, 2022](#)

National

National Highways' Digital Roads initiative is transforming the UK's Strategic Road Network by integrating data, connectivity, and automation. This aims to improve road safety, asset management, and customer experience through advanced technologies.

Source: [National Highways, Digital Roads](#)

International

Huawei's Smart Airport Expressway Project in Hangzhou uses digital twins, AI, and mm Wave radars to manage traffic in real-time, reducing accidents by 20% and improving response times by 90% since its implementation.

Source: [Huawei, 2023](#)

Rating Scale

Term	Mid-term
Impact	Transformational
Certainty	Probable

Monitoring

Frequency
Routinely

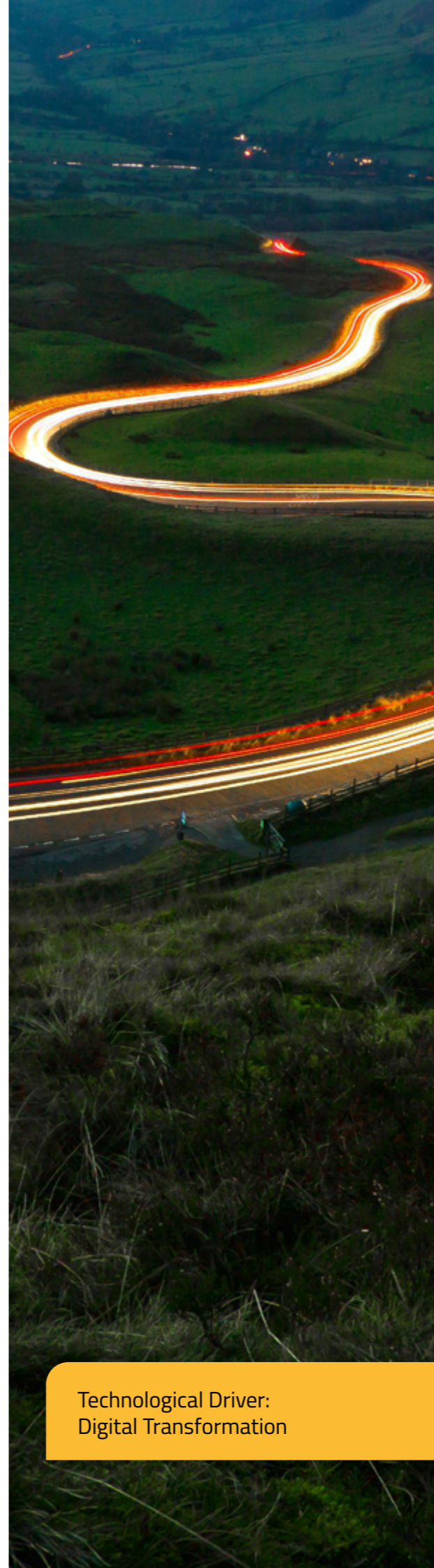
Guidance

Subscribe to news feeds on advancements in digital technologies and innovations in road infrastructure. Engage with road infrastructure suppliers offering asset monitoring and predictive maintenance tools to minimise repairs and emissions. Collaborate with supply chains that use digital platforms to optimise transport and track embodied carbon. Exchange insights on digital twins for testing and modelling low carbon materials at forums and stay informed via conferences and knowledge-sharing platforms.

Insight from experts

“ The key to that is there are signs of when a material is starting to fail, which can be picked up with detailed survey techniques like the ones that WDM have... If you measure it with accurate laser profiling sensors, which is what WDM does, you can understand the deterioration mechanism of a particular material. ”
- Highways Consultant

Technological Driver:
Digital Transformation



Legal Drivers of Change

The Legal category in the PESTLE framework focuses on the regulatory frameworks, standards, and policies that guide industries and sectors. In the context of decarbonising local roads, legal drivers are crucial for setting the rules and expectations that govern environmental targets, material standards, and road infrastructure maintenance. These drivers include the enforcement of local and national environmental targets, which compel authorities to implement decarbonisation strategies, and the ratification of material standards, which ensures the safe and efficient use of low carbon technologies in road construction. Legal frameworks are essential in providing local authorities with the guidance they need to meet both environmental and safety goals, while also addressing public and governmental expectations.

As local authorities work to meet national environmental goals and pursue strategies to reduce carbon emissions, understanding the legal landscape is essential for ensuring that these efforts comply with current regulations and anticipate future legal developments. Policies that guide the reduction of carbon emissions, such as material standards and environmental schemes, help local governments implement effective road infrastructure projects that align with national and international decarbonisation targets. Legal structures ensure that sustainable practices, like using low carbon materials, are embedded into road construction processes, while national frameworks provide the support required for local authorities to meet climate goals.

In the following section, we will explore these legal drivers of change in more detail. We will examine how local environmental targets, national frameworks, and the standardisation of low carbon materials are influencing the decarbonisation of local roads. By analysing signals from both the UK and internationally, we will provide insight into how legal frameworks are shaping the future of sustainable infrastructure.

Contributing Factors

Headwinds

Supply chain limitations

Lack of clear information on material supply chains hampers compliance with legal and environmental standards.

Bureaucratic challenges

Delays in obtaining development consents and compliance with evolving environmental laws hinder infrastructure project timelines.

Data gaps and lack of niche expertise

Limited expertise and data gaps hinder legal compliance and effective management of complex infrastructure projects.

Tailwinds

Climate policies align with legislation

Legal frameworks streamline decarbonisation efforts across local authorities, advancing sustainable transport infrastructure and carbon reduction goals for local roads.

Spillover effects of technology research

Legal mandates for technological advancements and research create a supportive environment for innovation in road infrastructure, resulting in spillover effects.

Legally mandated decarbonisation

Legal mandates ensure emissions cuts while delivering broader environmental and community benefits.

Check Appendix for details

Legal Drivers of Change

Local Environmental Targets and Schemes

Local targets enforce decarbonisation compliance.

National Environmental Targets and Schemes

National targets guide decarbonisation efforts.

Ratification of Material Standards

Material standards ensure low carbon safety and compliance.



Local Environmental Targets and Schemes

Drivers Definition

Local environmental targets refer to the frameworks, goals, schemes, and policies designed to assist government officials in achieving national decarbonisation targets. This empowers local authorities and stakeholders to adopt a proactive approach to decarbonisation, fostering community engagement and innovation.

Trend

Local environmental targets have gained strong support, with over 300 of 333 UK local authorities declaring climate emergencies between 2018–2020. However, only 62% of these authorities followed up with detailed climate action plans. Key barriers include limited funding, lack of coordination with national policies, and expertise gaps. This raises concerns about local authorities' capacity to meet net-zero targets, particularly without clear national support.

Source: [Place-Based Climate Action Network, 2021](#)

Signals



Local

The West Midlands Combined Authority (WMCA) received £4 million from the Department for Transport to develop a National Centre of Excellence for Materials Decarbonisation. This centre will trial low carbon road innovations, supporting the WMCA's #WM2041 net zero target. The project aims to share best practices across the UK, contributing to decarbonising roads nationwide.

Source: [West Midlands Combined Authority, 2024](#)



National

The UK Government's 2021 Net Zero Strategy emphasised the essential role local authorities play in reaching national climate targets. While no statutory targets are set for local governments, many councils have committed to net zero in line with the national 2050 goal. However, barriers like fragmented funding, capacity issues, and unclear roles hinder progress.

Source: [Commons Library, 2023](#)



International




The U.S. Environmental Protection Agency (EPA) has developed a framework for local governments to incorporate materials management and waste reduction into climate action plans. These strategies focus on reducing emissions through circular economy practices, including recycling, reuse, and reducing construction waste.

Source: [USA EPA, 2024](#)



Legal Driver:
Local Environmental Targets and Schemes

Rating Scale

- 
Short-term
- 
Substantial
- 
Probable

Monitoring

Frequency
Routinely

Guidance

Follow local council meetings and committee actions for updates on environmental targets and strategies. Watch for changes in political administrations, as they can influence the direction of local initiatives and progress. Keep track of budget allocations and local plans that impact sustainability goals, ensuring that any new or revised schemes are considered in decision-making processes.

Insight from experts

“That's why I'm convinced that they need to start thinking about employing people internally.... at the end of the day, this is getting to be a legal requirement as well.... to employ people internally and train them to achieve net-zero goals.”
–Independent Carbon Consultant

National Environmental Targets and Schemes

Drivers Definition

National environmental targets refer to the decarbonisation goals established for local authorities and businesses. These include frameworks, policies, or schemes designed to guide and support various stakeholders in proactively achieving these targets while enhancing their environmental performance and sustainability practices.

Trend

Data indicates that the UK has successfully met its Third Carbon Budget (2018–2022), with emissions now less than half of 1990 levels. However, achieving the 2030 target will require accelerated reductions across various sectors, as past progress has largely been driven by energy supply, with transport and buildings needing urgent action.

Source: [Climate Change Committee 2024](#)



Signals



Local

Local authorities are guided by the UK Roads Liaison Group's Code of Practice for Well Maintained Highways, which provides regularly updated recommendations for addressing climate change impacts on local roads. In response to these challenges, the Government has launched its most extensive road resurfacing programme to date, targeting pothole-damaged roads to enhance infrastructure resilience.

Source: [UK Climate Change Risk Assessment 2017](#)



National

National Infrastructure Commission's report highlights the need for coherent policy and long-term funding to enhance local transport infrastructure. The report notes that recent funding reallocations have the potential to improve local road maintenance, but greater specificity and commitment are necessary to avoid future capacity challenges.

Source: [National Infrastructure Commission, 2024](#)



International

The U.S. Department of Transportation's Federal Highway Administration (FHWA) has announced nearly \$830 million in grants aimed at enhancing transportation infrastructure resilience against climate change and extreme weather. This funding supports projects that will help meet national environmental targets by reducing transportation-related emissions and improving community sustainability through resilient infrastructure investments.

Source: [FHWA, 2024](#)

Rating Scale



Term

Mid-term



Impact

Substantial



Certainty

Probable

Monitoring

Frequency

Semi-annually

Guidance

Review national environmental policies with a focus on progress reports and compliance with emissions reductions. Engage with governmental departments to understand how new or revised schemes are being implemented and monitored. Attend relevant national environmental forums or policy review sessions to gain insights into policy shifts or potential new targets. Tracking national schemes and regulatory changes will help ensure alignment with emerging sustainability priorities and compliance frameworks.

Insight from experts

“ We(CIHT) do have a manifesto out in which we are calling for more funding from Central government... not just fixing the pothole anymore but considering decarbonisation and extreme weather events. ”

– Policy Expert

Legal Driver:
National Environmental
Targets and Schemes

Ratification of Material Standards

Drivers Definition

Ratification of material standards involves the standardisation of specifications for low carbon materials, focusing on safety, insurance, and compatibility. This driver also addresses the guidance on construction methods using these materials to ensure compliance and safety.

Trend

The uptake of the RICS Whole Life Carbon (WLC) assessment guidance has significantly increased since its publication in 2017. Organisations such as British Land, Landsec, Derwent, and Grosvenor have embedded WLC assessments into their practices, demonstrating a growing commitment to reducing carbon emissions in the built environment.

Source: [RICS Construction Journal, 2020](#)



Signals

Local

Devon County Council is pioneering a climate-focused approach to highway maintenance, developing a carbon calculator to assess the carbon impact of various materials and processes used in roadworks. This innovative strategy aims to reduce emissions by up to 10% and positions carbon reduction as a core component of maintenance decisions

Source: [Devon County Council, 2021](#)

National

The UK's Highways Sector Council has launched a toolkit to support public agencies and private companies in meeting PAS 2080 carbon emission standards. This initiative reflects a national commitment to decarbonisation, enabling infrastructure stakeholders to manage and reduce carbon emissions effectively throughout their supply chains.

Source: [World Highways, 2024 Commission, 2024](#)

International

The U.S. Inflation Reduction Act aims to decrease the embodied carbon in construction materials through enhanced standardisation, measurement, and reporting. The EPA has been allocated \$250 million to support these initiatives, which include developing labels for materials with low embodied carbon and improving data accessibility for effective procurement.

Source: [USA EPA 2024](#)



Legal Driver:
Ratification of Material Standards

Rating Scale

Term	Mid-term
Impact	Substantial
Certainty	Probable

Monitoring

Frequency
Semi-annually

Guidance

Monitor developments in material standards and regulations within the construction and transport sectors, staying engaged with standard-setting bodies and material experts to track low-carbon material standards. Attend industry events and engage with stakeholders in compliance to remain aligned with evolving standards. Review research and industry updates to understand the ratification process and ensure your strategies are informed by the latest innovations and regulatory changes in materials.

Where possible, select materials that have reputable EPDs or suppliers that are actively pursuing more transparent carbon emissions factors.

Insight from experts

“ The problem we've got is how do you give them the carbon figures? Because there's no regulations around standards. ”
– Independent Carbon Consultant

Environmental Drivers of Change

The Environmental category in the PESTLE framework addresses the external ecological and climatic factors that influence decision-making processes. In the context of decarbonising local roads, environmental drivers are particularly crucial due to the increasing frequency of extreme weather events, as well as the need to balance road design with sustainability and user safety. These drivers include the impact of extreme weather conditions—such as floods and heatwaves—which damage infrastructure and require more resilient designs, and the integration of environmentally-conscious road designs that promote low carbon transport solutions like cycling and pedestrian paths. Local governments must therefore adopt adaptive design strategies to improve the resilience of roads and ensure that they can withstand these intensifying environmental conditions

As climate change intensifies, extreme weather events are becoming more frequent, causing significant disruptions to road networks. Floods can wash away sections of roads, while heatwaves can deform asphalt, accelerating deterioration and increasing maintenance costs. These challenges necessitate innovative, climate-resilient designs that can withstand such conditions. At the same time, road design is increasingly focused on sustainability and user safety, with the inclusion of low carbon transport modes, such as cycle lanes and pedestrian pathways, becoming standard practice in infrastructure projects. This not only supports environmental goals but also encourages active, eco-friendly modes of transportation.

In the following section, we will explore these environmental drivers in more depth. We will examine how extreme weather events and sustainable design considerations are reshaping the future of local road infrastructure. Through various local, national, and international examples, we will highlight how environmental factors are driving the need for resilient and sustainable road systems that meet both climate adaptation and decarbonisation targets.

Contributing Factors

Headwinds

Short-term fixes

Short-term fixes manage environmental risks but delay sustainable, long-term resilience strategies.

Policy and regulation gaps

Lack of clear policies on circular economy hinders large-scale adoption of sustainable environmental practices across sectors.

Material performance uncertainty

Uncertainty about material performance over time and in extreme weather, like flooding, threatens infrastructure resilience and environmental sustainability.

Tailwinds

Long-term cost benefits

Decarbonisation investments lower emissions and promote long-term environmental sustainability.

Policy support & advocacy

Policy-backed funding promotes innovative solutions for flood resilience and environmental sustainability.

Improved resiliency assessments

Mandatory resilience assessments improve infrastructure's ability to withstand environmental risks and climate impacts.

Check Appendix for details

Environmental Drivers of Change

Extreme Weather Events: Flood

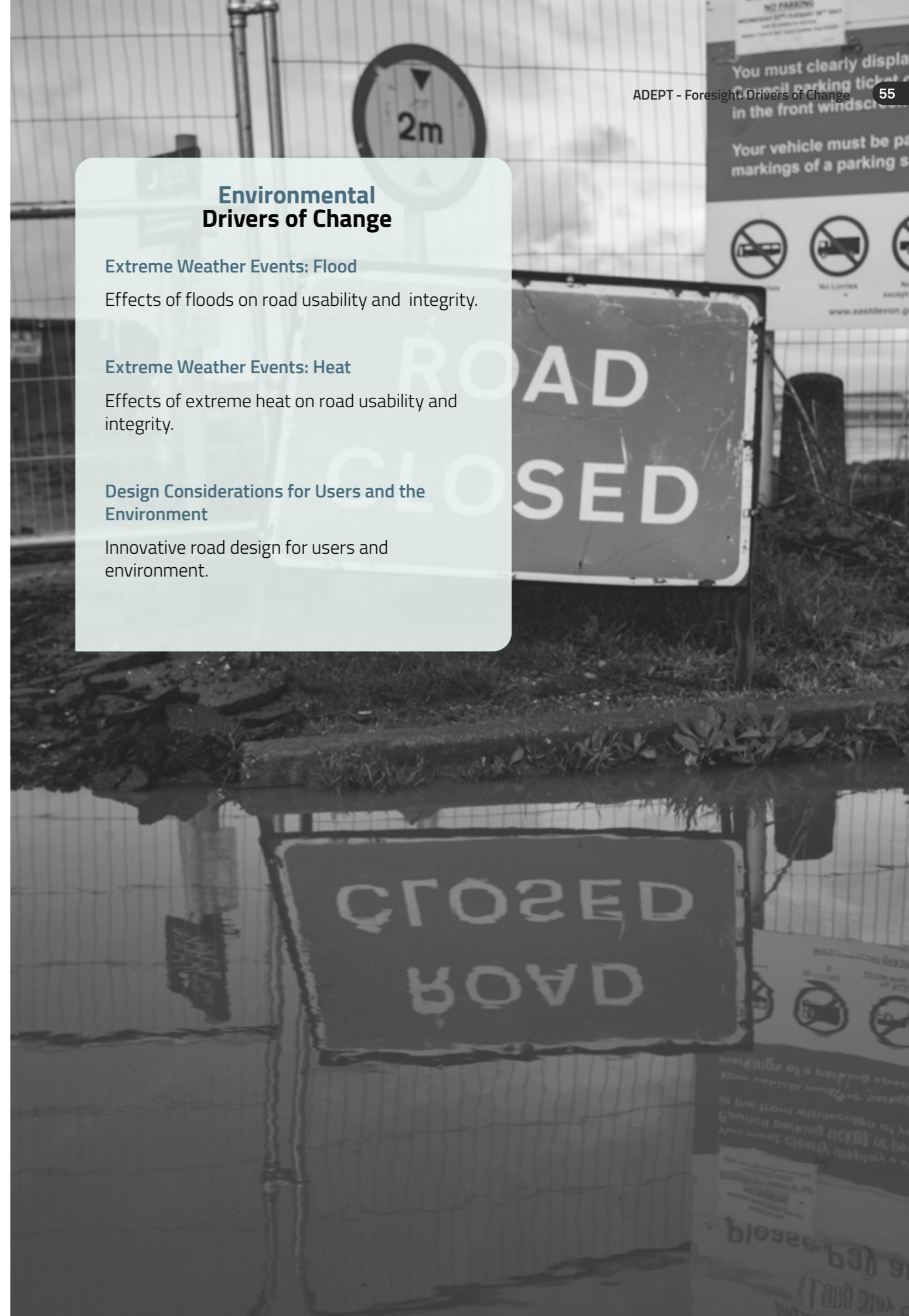
Effects of floods on road usability and integrity.

Extreme Weather Events: Heat

Effects of extreme heat on road usability and integrity.

Design Considerations for Users and the Environment

Innovative road design for users and environment.



Extreme Weather Events: Flood

Drivers Definition

This refers to severe and unusual conditions, such as floods, which can cause significant damage to road infrastructure, impacting usability and integrity. This also includes safety considerations around flash floods, which can lead to rapid water accumulation, washouts, and structural failure. Enhanced flood resilience measures are essential for effective road design and maintenance.

Trend

The UK has experienced a 9% increase in rainfall from 2011 to 2020 compared to 1961–1990, with rainfall events exceeding 50mm becoming more frequent. From 2011–2020, days surpassing 95% and 99% of average rainfall totals also rose, highlighting the increasing frequency and intensity of extreme weather events, impacting road infrastructure integrity. Source: [Climate Change Committee 2024](#)



Signals

Local

The Mansfield Sustainable Flood Resilience project, supported by £76 million from Severn Trent Water, uses nature-based solutions like SuDS to combat increasing flood risks due to climate change. These measures protect local road infrastructure by reducing surface water accumulation during extreme rainfall events.

Source: [AECOM, 2024](#)

National

The UK government's Road Investment Strategy 2 (2020–2025) allocated £300 million towards addressing flood resilience, carbon emissions, and landscape management. This initiative reflects a growing national focus on building road infrastructure that can withstand increasing extreme weather events, particularly floods, which are exacerbated by climate change according to DfT's Road Investment Strategy 2.

Source: [Road Investment Strategy 2: 2020–2025, 2020](#)

International

Dubai is launching an \$8 billion stormwater management project to enhance flood resilience. This initiative aims to upgrade the city's drainage capacity, including the construction of new culverts and ponds, to manage extreme rain events effectively. The plan is crucial for safeguarding road infrastructure and urban areas from flooding impacts.

Source: [Gulf News, 2024](#)



Legal Driver:
Extreme Weather Events: Flood

Rating Scale

Term	Mid-term
Impact	Substantial
Certainty	Projected

Monitoring

Frequency
Annually

Guidance

Review annual reports on flood frequency and severity, tracking long-term trends while considering seasonal variations. Be mindful of confounding factors, such as heat spikes, which may provide only near-term correlations. Engage with climate scientists and local authorities to assess the impact on infrastructure and risk mitigation strategies. Monitor updates on flood defence policies and participate in forums to stay informed about evolving resilience strategies. Consider material susceptibility to water ingress, ensuring readiness for future extreme weather events.

Insight from experts

“ One of the main issues that I've seen... is how much the aging infrastructure is aging and will keep aging and will also receive much more wear and tear from weather events that we've got. ”
–Policy Expert

Extreme Weather Events: Heat

Drivers Definition

It encompassed severe and unusual conditions, such as heatwaves, which can cause substantial damage to road infrastructure. These events affect the usability and integrity of roads, leading to issues like asphalt deformation, increased wear, and accelerated deterioration. Consequently, there is a pressing need for enhanced resilience and adaptation strategies in design and maintenance.

Trend

The UK has seen a significant rise in hot weather, with the average number of summer days (maximum temperature above 25°C) increasing by 28%, from 6.9 days (1991–2020) to 8.8 days (2013–2022). This escalation in heat extremes raises concerns about impacts on road infrastructure, including risks of asphalt deformation and accelerated deterioration.

Source: [Office for National Statistics, 2023](#)



Signals

Local

In response to recent heatwaves, Cambridgeshire County Council is addressing melted road surfaces in Wisbech, where temperatures above 30°C caused bitumen to soften. The council is collaborating with contractors to implement remedial actions, including using gritters to apply granite dust to stabilize affected roads.

Source: [Wisbech Standard, 2017](#)

National

As climate change raises road surface temperatures, UK highway authorities face challenges in maintaining road integrity. The Asphalt Industry Alliance has reported that while material improvements exist, high temperatures can soften bitumen, risking deformation. Ongoing research aims to enhance road resilience amid escalating costs.

Source: [LocalGov, 2022](#)

International

In India, the National Highways Authority of India is responding to rising temperatures causing road bitumen to melt, particularly on heavily trafficked routes. To enhance road safety, officials are spreading sand on affected areas to mitigate risks for motorcyclists, highlighting the need for improved materials in road construction.

Source: [Times of India, 2024](#)

Rating Scale

Term	Mid-term
Impact	Substantial
Certainty	Projected

Monitoring

Frequency
Annually

Guidance

Review annual data on heat events, tracking long-term trends in temperature spikes and their impacts on road infrastructure. Heat can accelerate wear on road surfaces and increase driving as favourable weather conditions encourage higher road usage. Engage with meteorologists and infrastructure experts to assess the correlation between extreme heat and road degradation. Stay informed on evolving heat-resistant materials and cooling technologies, ensuring readiness for more frequent or severe heat waves in the future.

Insight from experts

“...you just have to look at what the weather's doing in terms of the last few winters. And it will really show up with an impact on the roads, in terms of the number of potholes in the way it's, you know, even in the summer how it's melting and cracking.”
—Independent Carbon Expert

Legal Driver:
Extreme Weather Events: Heat



Grassroots Environmental Advocacy

Drivers Definition

Refers to the public’s perspective on the importance of local road investment and its impact on environmental issues. It highlights community sentiment toward balancing infrastructure development with environmental sustainability.

Trend

Grassroots environmental advocacy is on the rise, reflecting public concern over governmental actions. Confidence in political institutions, particularly parliament, has plummeted from a peak of 46% in 1990 to just 23% in 2022, indicating a growing disconnect between community needs and political responsiveness.

Source: [The UK in the World Values Survey, KCL](#)



Signals

Local

Brighton & Hove City Council in 2021 highlights the development of a Local Cycling and Walking Infrastructure Plan (LCWIP). The plan aims to strategically enhance the city's walking and cycling network to promote active travel and improve connectivity, supporting the city's carbon neutral target by 2030.

Source: [Brighton and Hove Council, 2021](#)

National

In 2024, Ordnance Survey (OS) released the OS Multi-modal Routing Network (OS MRN), a tool integrating road, rail, path, and ferry networks across Great Britain. This product supports sustainable transport planning, enabling local authorities to design low carbon routes for active travel, including cycling and walking.

Source: [Ordnance Survey, 2024](#)

International

According to a case study by ITDP titled Protected Bicycle Lanes Protect the Climate , in 2020, Bogotá, Colombia introduced 84 kilometres of temporary bike lanes to its existing Ciclovía network as part of its response to the COVID-19 pandemic. The new lanes were designed to encourage cycling and reduce car dependency, contributing to cleaner air and lower emissions during a period when public transport use was reduced for health reasons.

Source: [ITDP, 2022](#)

Rating Scale

Term **Short-term**

Impact **Substantial**

Certainty **Plausible**

Monitoring

Frequency
Semi-annually

Guidance

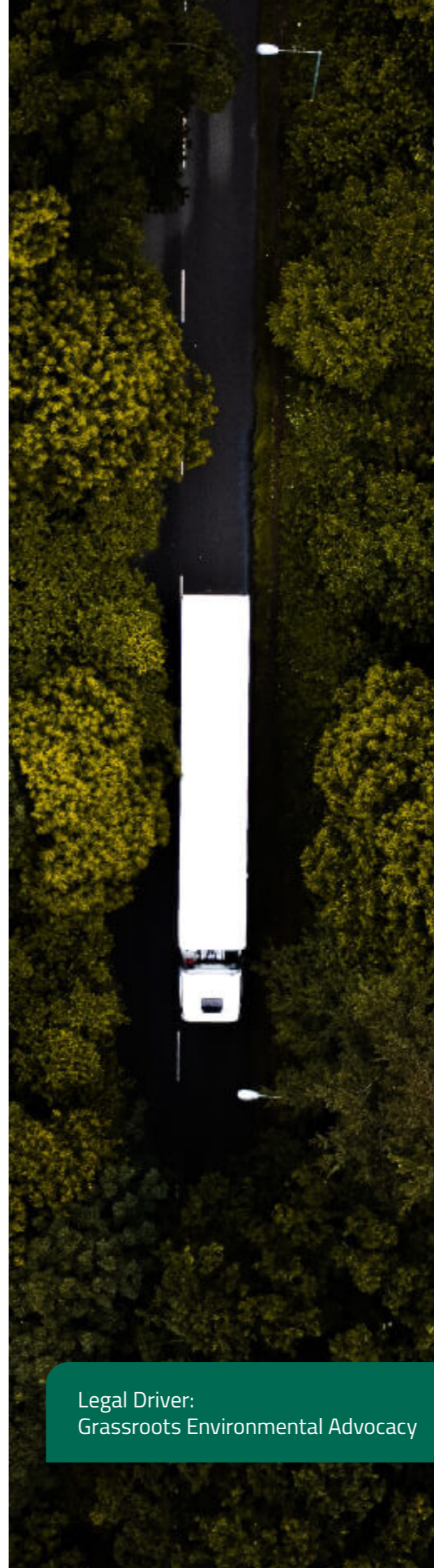
Review the general design plan semi-annually to ensure that both user needs and environmental objectives are being met effectively. Attend key conferences such as ADEPT and Highways UK to stay informed of emerging best practices and innovative design considerations. Engage with stakeholders and local authorities to gather feedback on design functionality and environmental impacts. Keeping updated on these factors will enable timely decision-making and ensure that infrastructure projects align with sustainability and user experience goals.

Insight from experts

“ Infrastructure essentially delivers services or enables people to achieve life outcomes... We need to really understand what people are trying to do in their lives... make sure that the infrastructure that we create, which at the end of the day shapes and limits the options they've got to behave.

–ICE Policy Fellow

Legal Driver:
Grassroots Environmental Advocacy



Conclusion

This foresight project serves as a vital tool for empowering local authorities to make strategic, evidence-based decisions for decarbonising local roads. By identifying and addressing drivers of change across political, economic, social, technological, legal and environmental landscape, this report offers a comprehensive analysis of the diverse forces shaping the future of low carbon materials and effective decarbonising practises. From political shifts to technological innovations, the insights gathered through workshops, literature reviews, and expert interviews underscore the complexity of road infrastructure decarbonisation. These findings provide local authorities with a foundation for proactive decision-making, helping to de-risk strategies, foster collaboration, and ensure alignment across stakeholders.

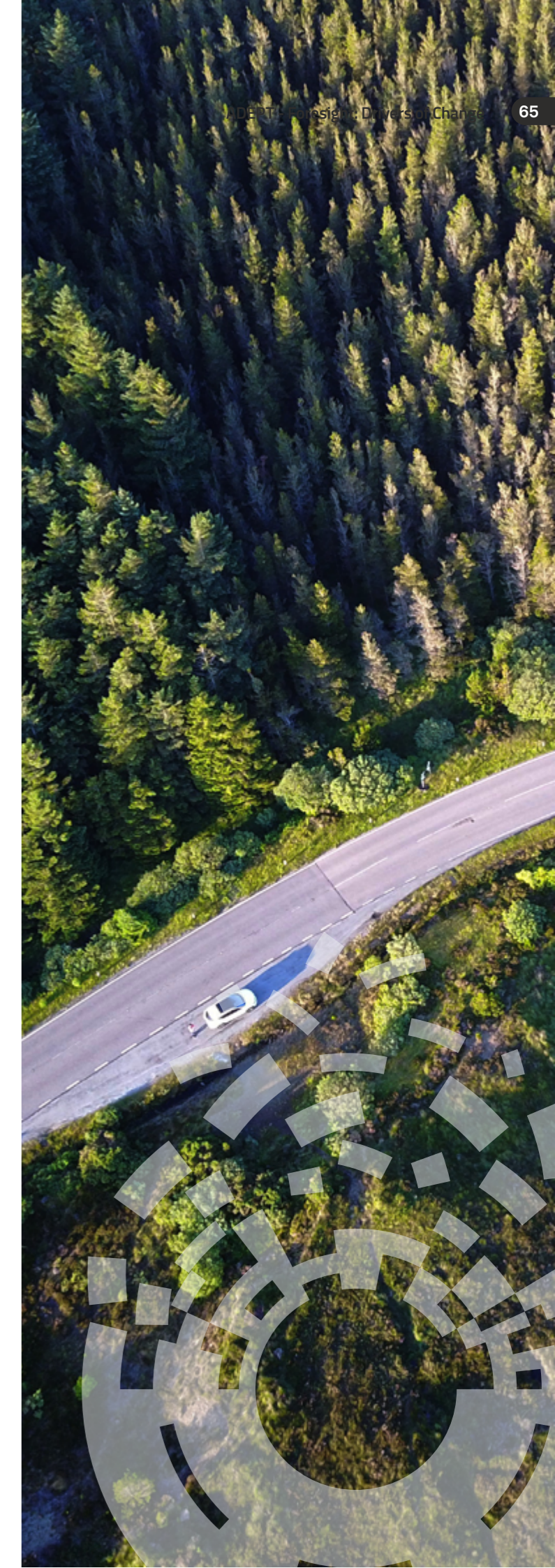
As external circumstances evolve, sustained foresight activities will be critical for adapting to new challenges and opportunities. By monitoring trends and signals, local authorities can remain responsive to key drivers, such as funding availability, environmental targets, and community engagement. Adopting a forward-looking approach to road decarbonisation promises to reduce emissions while enhancing resilience, stimulating economic growth, and supporting broader climate objectives. The findings of this report, help local authorities better content with the weight of the past, the push of the present, and the pull of the future. This knowledge and practice build resilience against the uncertainties of the future.

Recommendations

Ambition in decarbonising road infrastructure must be matched by bold leadership and pioneering efforts. Early adopters of innovative materials will play a critical role in pushing the boundaries of what's possible. Championing vanguard approaches inspires others and creates momentum for widespread transformation. Skillful navigation of the futures first requires foresight. For this reason, we recommend the following:

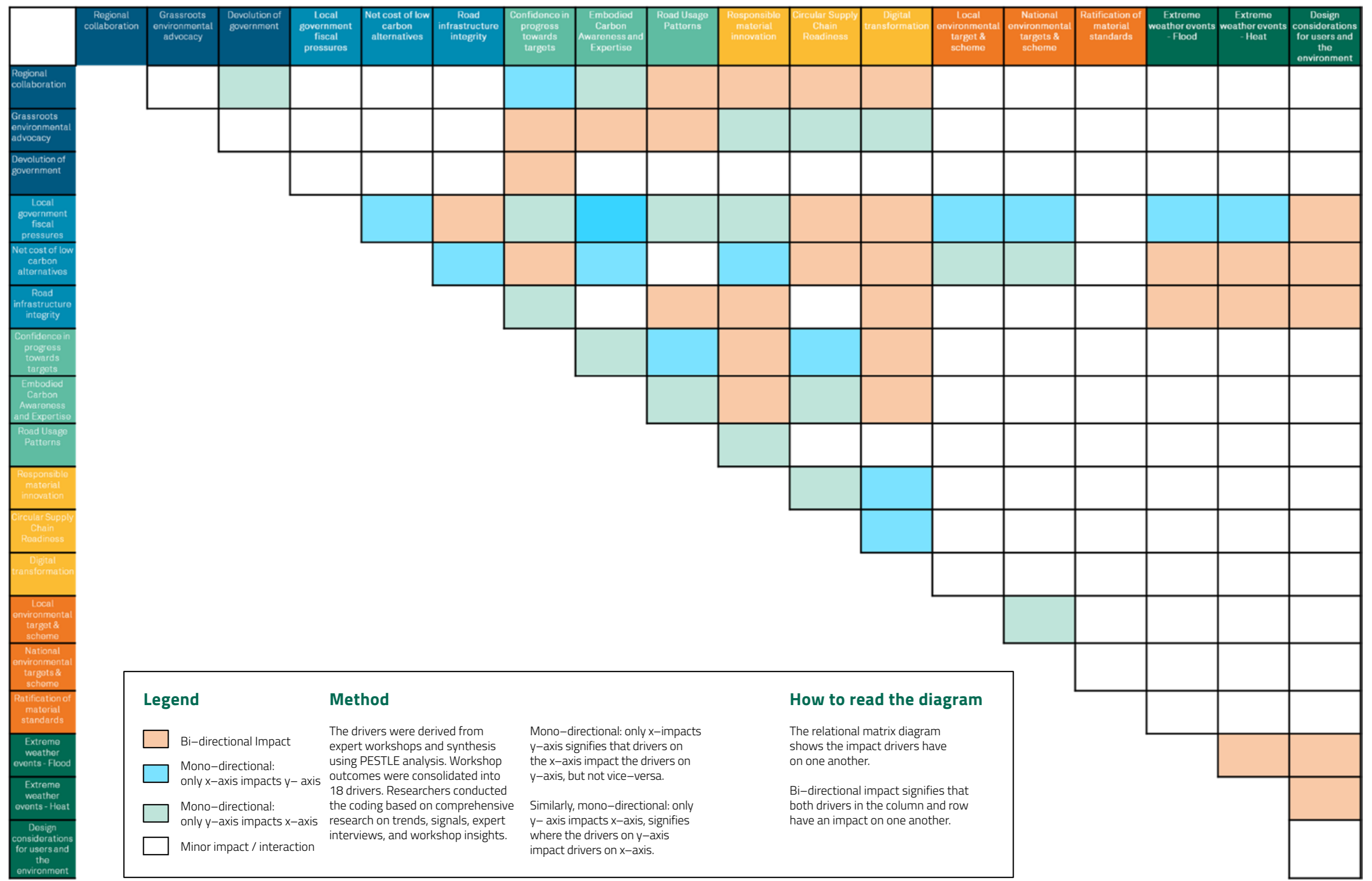
- 1. Develop a Foresight Community of Practice**
Foresight is an ongoing practice that should be embedded into regular decision-making, not treated as a one-off project. Establishing a community of practice including The Centre of Excellence, DfT, road infrastructure suppliers, individual LAs, and local road users ensures that knowledge and expertise on future trends remain central and evolve with changing contexts.
- 1. Co-design multi-stakeholder strategies**
Engage with diverse stakeholders such as The Centre of Excellence for Decarbonising Roads, DfT, road infrastructure suppliers and LAs to create collaborative strategies that are flexible and responsive. Agile pathways allow for adaptation to unexpected challenges, helping accelerate the adoption of novel road materials in a rapidly evolving landscape.

- 1. Use drivers to prioritise material trials**
Refine the criteria used to assess new materials based on insights from this foresight research. Prioritise trials for materials that show the most promise in decarbonisation, ensuring focus is placed on solutions that align with long-term sustainability goals.
- 1. Disseminate Drivers of Change broadly**
Ensure the key drivers of change identified in this research are shared widely with relevant stakeholders. Dissemination fosters greater awareness, encourages alignment across organisations, and helps drive coordinated action towards decarbonising road infrastructure.
- 1. Commit to ongoing expert engagement**
Establish a regular benchmarking survey to track progress in the adoption of novel road materials. Engage with experts continuously to ensure that this ongoing feedback loop refines strategies and responds to emerging trends, keeping the foresight process relevant and actionable.



Appendix





Legend

- Bi-directional Impact
- Mono-directional: only x-axis impacts y-axis
- Mono-directional: only y-axis impacts x-axis
- Minor impact / interaction

Method

The drivers were derived from expert workshops and synthesis using PESTLE analysis. Workshop outcomes were consolidated into 18 drivers. Researchers conducted the coding based on comprehensive research on trends, signals, expert interviews, and workshop insights.

How to read the diagram

Mono-directional: only x-axis impacts y-axis signifies that drivers on the x-axis impact the drivers on y-axis, but not vice-versa.

Similarly, mono-directional: only y-axis impacts x-axis, signifies where the drivers on y-axis impact drivers on x-axis.

The relational matrix diagram shows the impact drivers have on one another.

Bi-directional impact signifies that both drivers in the column and row have an impact on one another.

Appendix B(1) Political: Headwinds and Tailwinds

Category	Label: HW/TW	Title	Short Description	Summary	Source	Date
Political	Headwind	Unequal funding	Regional funding disparities undermine cohesive nationwide decarbonisation efforts.	According to recent analysis by the Institute for Fiscal Studies (IFS), local government funding is poorly aligned with regional needs. For example, Wokingham received 45% more funding than its estimated needs in 2022–23, while Hounslow received 31% less. This inconsistency in funding undermines efforts to create cohesive, nationwide decarbonisation strategies. More affluent regions often receive more funding than needed, leaving areas with greater transport needs underfunded. This inequality creates barriers to implementing low carbon transport infrastructure across all regions, especially in areas with higher transport-related carbon emissions.	How much public spending does each area receive? Local authority level estimates of health, police, school and local government spending Report by IFS	2023
	Headwind	Differing priorities	Local councils' varied transport priorities complicate alignment with national decarbonisation goals and emissions reduction strategies.	The report 'Decarbonising transport: Getting carbon ambition right' indicates that the absence of sector-specific budgets creates challenges. It's argued that prioritising sector-specific budgets, like those for transport, could risk uneven costs and effectiveness, as the decarbonisation expenses in one sector may differ substantially from others. This reveals that the transport sector needs to align its emissions trajectory with the national net-zero pathway, but differences in local councils' priorities and capacity can complicate this alignment. Furthermore, the report points out that only a small percentage of councils have set specific transport emissions targets, and fewer have clear interim budgets. This inconsistency among councils indicates differing local priorities and approaches, reflecting challenges in aligning their short-term goals with national decarbonisation strategies.	Decarbonising transport: Getting carbon ambition right Report	2020
	Headwind	Strategic tunnel vision	Government's focus on EVs overlooks coordinated efforts for broader low carbon transport and systemic planning changes.	The report points out that the UK government's policy focus remains narrowly centred on electric vehicles (EVs) and renewable energy without addressing broader systemic issues such as demand management and behaviour change. Despite the Climate Change Committee's (CCC) recommendation to reduce overall travel by cars, vans, and heavy goods vehicles (HGVs), there are insufficient incentives or coordinated guidelines to transform land use and transport planning in a way that consistently supports low carbon alternatives.	Bridging the Gap People and place: the key to bridging the transport decarbonisation gap	2023
	Tailwind	Shared knowledge and collaboration	Collaboration between authorities ensures consistent implementation of decarbonisation strategies and shared best practices nationwide.	The Decarbonising Transport Strategy by DfT highlights how the government supports local authorities by facilitating collaboration through Local Transport Plans (LTPs). These plans now include quantifiable carbon reductions, aligning regional strategies with national net-zero goals. The Sub-National Transport Bodies (STBs) play a critical role by joining up local plans across regions, ensuring coherence and sharing best practices. England's Economic Heartland (EEH), which coordinates this collaboration, exemplifies how cross-regional work and knowledge sharing are key to achieving sustainable transport connectivity and decarbonisation across the UK. These collaborative frameworks help to turn national priorities into actionable plans, ensuring consistency and shared learning across local authorities.	Decarbonising Transport A Better, Greener Britain	2021
	Tailwind	Political agency	Local authorities' control over most UK roads gives them significant power to shape transport policy and design.	Local authorities are responsible for building and maintaining roads to service the needs of their constituents. In fact, local authority-managed roads make up 98% of road length in the UK, showing the extent of influence local authorities have on what goes on in the local areas and the ability to change that.	Potholes and local road maintenance funding Report	2024
	Tailwind	Engagement with local stakeholders	Engaging local stakeholders ensures public acceptance and integration of zero-carbon transport innovations in everyday life.	The Bridging the Gap report highlights the development of the Societal Readiness Assessment (SoRA) to evaluate the societal alignment of zero-carbon transport innovations. While many technologies may be ready from a market or technical perspective, they often lack social readiness, meaning they are not easily integrated into everyday life or accepted by the public. SoRA provides a framework for engaging stakeholders in a reflexive, co-design process that invites diverse perspectives, including dissent. The framework encourages collaboration and creative dialogue, helping to build societal capacity and willingness to embrace new mobility systems. By addressing societal readiness, the SoRA process fosters greater public engagement and accelerates the transition toward net-zero transport	Bridging the Gap People and place: the key to bridging the transport decarbonisation gap	2023

Appendix B(2) Economic: Headwinds and Tailwinds

Category	Label: HW/TW	Title	Short Description	Summary	Source	Date
Economic	Headwind	High upfront cost of innovation	High costs hinder investment in low carbon technologies due to uncertain market demand and supply chain risks.	The most complicated of the cross-cutting challenges, the supply-demand catch-22, refers to a situation whereby an upstream company does not have a large enough market demand to upscale the production of low carbon materials or the technologies to produce them, and downstream companies cannot risk investing in alternative technologies before they have a stable supply of upstream low carbon materials or products.	The role of demand-led innovation in supporting decarbonisation in foundation industries: Challenges, opportunities and policy implications.	2023
	Headwind	Financial constraints	Decreased local authority funding limits their ability to invest in net-zero projects and essential services.	Funding is a critical issue for local authority work on net zero. Local authority finances have been under pressure after a period of funding reductions and growth in demand for services, and the impact of the COVID-19 pandemic.	Local government and net zero in England, 2021	2021
	Headwind	Lack of clear policies	Unclear policies and regulatory uncertainty delay infrastructure projects and complicate adoption of new technologies or materials.	The "Cost drivers of major infrastructure projects in the UK Report" analysis identifies that a lack of clear strategic direction and inconsistent regulatory frameworks are causing systemic cost issues in major infrastructure projects. Uncertainty in regulations can delay project implementation, making it harder for contractors and innovators to anticipate the requirements for new technologies or materials. The delay in updating key policies, like the National Policy Statements, adds to this uncertainty.	Cost drivers of major infrastructure projects in the UK Report by NIC	2024
	Tailwind	Financial support	Government policy ensures long-term financial support for adaptable, future-proof transport projects and improved public infrastructure.	The Second National Infrastructure Assessment report highlights that the government plans to allocate £22 billion for transport projects between 2028 and 2045, ensuring adaptability to future changes in travel demand. Improving existing public transport infrastructure, such as through integrated ticketing and real-time information systems, is a priority across all scenarios. This policy backing ensures that cities develop flexible transport systems to meet future needs while securing long-term government support.	The Second National Infrastructure Assessment	2023
	Tailwind	Devolved budgets	Devolved transport budgets for local authorities ensure consistent maintenance and infrastructure upgrades.	£8 billion a year should be available for devolved transport budgets for local authorities outside London, consisting of a combination of central government grants and locally raised funds. All county councils and unitary authorities that remain responsible for strategic transport planning should be provided with devolved five year transport budgets by the end of 2025, sufficient to cover maintenance, renewals and small to medium enhancements.	Infrastructure Progress Review 2024	2024
	Tailwind	Carbon pricing	Carbon pricing, which includes carbon cap and trade and carbon tax, incentivises low carbon technologies but risks overlapping with existing policies and raising complexity in transport operations.	According to research by LSE scholars, expanding the UK Emissions Trading Scheme (ETS) to cover road transport aims to incentivise a switch to low carbon technologies like electric vehicles. However, road transport is already subject to high implicit carbon taxes such as fuel duty, leading to potential double pricing and increased complexity. While the UK ETS could drive decarbonisation, existing measures like EV mandates and clean air zones may be more effective. There is stronger support for including road freight in the UK ETS, given its structured operational framework.	The future of UK carbon policy: how could the UK Emissions Trading Scheme evolve to help achieve net-zero? Policy insight	2022

Appendix B(3) Social: Headwinds and Tailwinds

Category	Label: HW/TW	Title	Short Description	Summary	Source	Date
Social	Headwind	Equity Concerns	There may be concerns that low carbon road infrastructure could prioritise urban areas, leaving rural or disadvantaged regions behind in terms of access to upgraded infrastructure.	The paper, A "spatially just" transition? by Alice Garvey et al., examines the concept of spatial justice within low carbon transitions (LCTs). Spatial justice refers to the fair geographic distribution of both benefits and burdens associated with decarbonisation efforts. It highlights the inequities between urban and rural regions, and between national and subnational areas. Rural regions, for example, are often more vulnerable and receive fewer benefits, while regional disparities in policy powers further complicate equitable outcomes. The study suggests spatially targeted policies and devolved powers could improve justice in decarbonisation pathways.	A "spatially just" transition? A critical review of regional equity in decarbonisation pathways	2022
	Headwind	Skills gap	The mismatch between workers' current skills and employers' demands, often caused by technological advancements, outdated education systems, shifting industry needs, and insufficient training opportunities.	The 2023–2024 CLC Industry Skills Plan for the UK Construction Sector presents a comprehensive strategy aimed at addressing long-term skills shortages. Key focuses include improving workforce competence, enhancing access to training, and diversifying industry appeal. The plan highlights successes like increased apprenticeship starts and efforts towards a more inclusive industry culture. It also introduces new initiatives like a competence framework for safety and a pilot project to engage schoolchildren in construction careers, illustrating an ambitious approach to evolving construction industry standards and workforce capabilities.	CLC Industry Skills Plan	2022
	Headwind	Misaligned Authority Roles and Expectations	Misalignment between local authorities' roles and public expectations hinders road safety and sustainability efforts.	The UK National Audit Office (NAO) has pointed out key challenges regarding the roles and responsibilities of local authorities (LAs) in its various reports. A central issue is the misalignment between the responsibilities given to LAs and the expectations placed on them. This misalignment often creates gaps in execution and monitoring, which directly impacts road safety and environmental sustainability measures.	Local authority governance Report	2019
	Tailwind	Long-term commitment	Long-term commitment to infrastructure development builds public trust and promotes social engagement in sustainable practices.	The National Infrastructure Commission (NIC), in its National Infrastructure Strategy, emphasises the need for sustained efforts to achieve climate resilience and regional equity, highlighting the importance of long-term planning, particularly in transport connectivity and urban development. Progress has been made, such as in expanding renewable energy and broadband coverage, but gaps in policy implementation threaten these long-term goals.	National Infrastructure Strategy	2020
	Tailwind	Integrated decision making	Integrated decision making implies the inclusion of multiple perspectives, inputs, and data sources in the decision process.	The Decarbonising Transport: Setting the Challenge report underscores the importance of informed decision-making through consultations with stakeholders, including local authorities, industry experts, and the public. It stresses the role of evidence-based approaches in shaping UK transport policy, ensuring that social considerations and public input guide the transition to low carbon transport. This collaboration highlights how data-driven policies, aligned with stakeholder feedback, help achieve sustainable road transport solutions in the UK.	Decarbonising Transport Setting the Challenge, 2020	2020
	Tailwind	Demand for low carbon transport infrastructure	Public and government drive demand for low carbon transport infrastructure, such as freight to reduce emissions.	One of the main drivers behind this shift in demand is the recognition that freight transport accounts for about 7% of the UK's total CO ₂ emissions, with road freight being a major contributor. The DUKFT studies have shown government investment in this sector is beginning to scale up. For example, the government has committed £200 million for the zero-emission road freight demonstrator programme, which aims to expand the use of electric and hydrogen-powered HGVs. This aligns with the long-term goals set in the Transport Decarbonisation Plan, targeting net-zero by 2050.	DUKFT Project Accelerating Investment for Decarbonising UK Freight Transport	2022

Appendix B(4) Technological: Headwinds and Tailwinds

Category	Label: HW/TW	Title	Short Description	Summary	Source	Date
Technological	Headwind	Skills gap	The skills gap hampers the adoption and development of new technologies necessary for low carbon transport solutions.	<p>The report highlights the need for a skilled workforce to develop and implement mobility solutions that support the UK's net-zero goals. The Green Jobs Taskforce, launched in 2020, is working with businesses, skills providers, and unions to address the challenge of providing the necessary skills for the green transition, including those required in transport infrastructure. The taskforce aims to develop a long-term plan to deliver a skilled workforce by 2030, focusing on good-quality green jobs and supporting workers in high-carbon sectors as they transition to low carbon industries.</p> <p>Additionally, the government is investing in several initiatives like Apprenticeships, Skills Bootcamps, and the National Skills Fund, to help people retrain and upskill. These programmes, including the £2.5 billion National Skills Fund, are directed at growing talent pipelines for green industries, which are essential for overcoming the skills gap in the road decarbonisation process. This text reflects the recognition of this skills gap and outlines steps to address it.</p>	Decarbonising Transport A Better, Greener Britain	2021
	Headwind	Cost of early adoption	Early adoption involves higher initial costs due to research, testing, low economies of scale in production, and integration challenges.	The research on solar photovoltaic (PV) adoption reveals that early adopters are primarily driven by environmental concerns and a fascination with technology (technophilia), while later adopters are motivated more by economic gains. Using Green Party voting as a proxy for environmental concern, the study shows this relationship weakens over time in Sweden, suggesting motivations shift as markets mature. These findings may also apply to the adoption of other decarbonisation innovations, where early adopters prioritise environmental impact, and later adopters focus more on financial benefits.	Early adopters and their motives: Differences between earlier and later adopters of residential solar photovoltaics	2020
	Headwind	Interfacial complexity	Interfacial properties affect the bonding between materials, contributing to road construction durability, longevity, and resistance to wear.	This research investigates the interfacial adhesion between recycled aggregate (RA) and asphalt mastic filled with recycled concrete powder (RCP) using methods like boiling tests, binder bond strength tests, and surface free energy analysis. Results show increased surface roughness enhances bond strength, while higher filler-to-asphalt and RCP replacement ratios reduce it. Moisture damage stems from both cohesive and adhesive failure. These findings are relevant for understanding the interfacial complexity of novel low carbon materials used in road construction, especially in terms of material compatibility and durability under moisture conditions.	Interfacial adhesion between recycled aggregate and asphalt mastic filled with recycled concrete powder	2024
	Tailwind	Knowledge sharing	Knowledge sharing across local authorities and nations accelerates decarbonisation initiatives.	This research paper examines international approaches to achieving net-zero buildings, focusing on Norway, the UK, the USA, and Singapore. It identifies varying definitions and strategies for net-zero buildings, which hinder consistent global adoption. The paper advocates for increased international collaboration and knowledge-sharing to address these challenges, highlighting the importance of learning from each country's frameworks. Promising design strategies include passive and active measures to reduce both embodied and operational GHG emissions. The research calls for harmonised global standards for life cycle assessments and recommends embedding these within national policies to accelerate decarbonisation efforts.		2022
	Tailwind	Grid decarbonisation	Grid decarbonisation supports the transition to green steel and other high intensity product production by providing low carbon electricity.	The paper explores pathways to producing 'green steel' in the UK, focusing on reducing greenhouse gas (GHG) emissions. It highlights the critical role of decarbonising the electricity grid for achieving net-zero targets in the steel industry. Electrification, especially through Electric Arc Furnaces (EAFs), requires a low carbon power supply from renewable sources or nuclear energy. The research assumes the grid will decarbonise by 85% by 2050, which is essential for reducing emissions intensity in steel production. Technologies like hydrogen-based production and electrification rely heavily on grid decarbonisation to succeed.	The prospects for 'green steel' making in a net-zero economy: A UK perspective	2021
	Tailwind	Digital innovation	Leveraging digital technology, data, and automated processes to enhance road construction, maintenance, and operations, ultimately reducing carbon emissions and supporting the UK's net zero targets.	The Digital Roads report by National Highways highlights how digital innovation, such as data-driven asset management, modular construction, and connected infrastructure, supports decarbonisation by enhancing road design, maintenance, and operations. These advancements reduce carbon emissions, improve efficiency, and contribute to the UK's net zero goals, while also improving safety and customer experience on the Strategic Road Network (SRN).	National Highways Digital Roads Reports	2021

Appendix B(5) Legal: Headwinds and Tailwinds

Category	Label: HW/TW	Title	Short Description	Summary	Source	Date
Legal	Headwind	Supply chain limitations	Lack of clear information on material supply chains hampers compliance with legal and environmental standards.	The report highlights significant supply chain limitations and a lack of clear information, which hampers effective compliance with legal and environmental standards. It identifies inconsistent data on biodiversity impacts, limited transparency on material sourcing, and unclear enforcement of regulations, all of which complicate material specification and decision-making in the construction industry, particularly regarding biodiversity.	The Embodied Biodiversity Impacts of Construction Materials	2023
	Headwind	Bureaucratic challenges	Delays in obtaining development consents and compliance with evolving environmental laws hinder infrastructure project timelines.	The National Audit Office (NAO) report highlights how bureaucratic challenges faced by National Highways, particularly with development consent orders and budget cuts, create delays and cost increases. These challenges often cascade down to local authorities, affecting the local road networks they manage, as they must adjust plans and resources to align with shifting national infrastructure projects and priorities.	Road enhancements: Progress with the Second Road Investment Strategy (2020 to 2025) Department for Transport and National Highways REPORT, 2022	2022
	Headwind	Data gaps and lack of niche expertise	Limited expertise and data gaps hinder legal compliance and effective management of complex infrastructure projects.	The National Audit Office report highlights two significant challenges to road construction: lack of niche expertise and data gaps. National Highways struggled to meet evolving environmental and technical standards, leading to delays and legal challenges. Insufficient expertise in environmental compliance, coupled with gaps in data on cumulative impacts like carbon emissions, hinder project approvals and timelines.	Road enhancements: Progress with the Second Road Investment Strategy (2020 to 2025) Department for Transport and National Highways REPORT, 2022	2022
	Tailwind	Climate policies align with legislation	Legal frameworks streamline decarbonisation efforts across local authorities, advancing sustainable transport infrastructure and carbon reduction goals for local roads.	Local councils are pivotal in addressing climate change, with over 300 declaring climate emergencies. The National Audit Office found that nearly two-thirds of councils aim to be carbon neutral by 2030, far ahead of the national 2050 target. This leadership is essential for delivering low carbon infrastructure and creating economic, social, and environmental value at the local level.	Local Government Association	2021
	Tailwind	Spillover effects of technology research	Legal mandates for technological advancements and research create a supportive environment for innovation in road infrastructure, resulting in spillover effects.	The Innovation and Research Strategy by National Highways aligns with the government's Road Investment Strategy 2 (RIS2), which sets clear expectations for technological advancement and research. RIS2 legally mandates investments in new technologies, with a focus on digital infrastructure, connected and autonomous vehicles, and innovative construction practices. This legal framework provides a stable and supportive environment for pursuing research-led initiatives within road infrastructure projects.	National Highways Innovation and research Strategy	2021
	Tailwind	Legally mandated decarbonisation	Legal mandates ensure emissions cuts while delivering broader environmental and community benefits.	The UK's Net Zero Strategy and legally binding Carbon Budgets enforce stringent targets for reducing transport emissions by 76–86% by 2050. This legal framework not only mandates reductions in carbon dioxide emissions but also considers the broader environmental benefits such as better air quality, public health improvements, and noise reduction. It acknowledges the need for cross-sector collaboration, focusing on integrated solutions involving energy systems, transport infrastructure, and land use, which yield additional benefits to the environment and communities.	UK Net Zero Research and Innovation Framework	2023

Appendix B(6) Environmental: Headwinds and Tailwinds

Category	Label: HW/TW	Title	Short Description	Summary	Source	Date
Environmental	Headwind	Short-term fixes	Short-term fixes manage environmental risks but delay sustainable, long-term resilience strategies.	This paper highlights short-term fixes for environmental resilience, emphasising the role of emerging digital technologies in enhancing climate resilience for infrastructure. The authors argue that digital tools like IoT, digital twins, and AI enable rapid, real-time assessments and decision-making, improving infrastructure's ability to withstand and recover from hazards like floods or extreme weather. However, these approaches are primarily reactive and often focus on short-term resilience, addressing immediate risks rather than providing long-term sustainability solutions. Additionally, they face challenges such as data privacy, cybersecurity risks, and reliance on power supplies, which limit their broader application and the development of more holistic, long-term resilience strategies. The paper suggests that while digital technologies offer short-term solutions, there is a need for integrated legislation and collaboration to fully utilise their potential.	Digital technologies can enhance climate resilience of critical infrastructure	2022
	Headwind	Policy and regulation gaps	Lack of clear policies on circular economy hinders large-scale adoption of sustainable environmental practices across sectors.	The West Midlands Circular Economy Routemap identifies gaps in regulatory frameworks and calls for clear policies to accelerate circularity across sectors. Key enabling levers include policy reform, governance, and capacity-building to support the transition. The roadmap advocates for a stronger regulatory environment to drive circular business models and achieve broader environmental and socio-economic benefits.	West Midlands' circular Economy Route map Report	2021
	Headwind	Material performance uncertainty	Uncertainty about material performance over time and in extreme weather, like flooding, threatens infrastructure resilience and environmental sustainability.	The study evaluates magnesium phosphate cement (MPC), revealing uncertainties in both structural performance and carbon emissions. Structural factors, such as hydration, volume stability, and compressive strength, fluctuate based on mix ratios and additives. These variations influence the long-term reliability of MPC in construction applications, complicating its classification as a sustainable alternative to traditional cement.	A probabilistic life-cycle assessment of carbon emission from magnesium phosphate cementitious material with uncertainty analysis	2023
	Tailwind	Long-term cost benefits	Decarbonisation investments lower emissions and promote long-term environmental sustainability.	The UK's Road Investment Strategy 2 (2020-2025) outlines a £27.4 billion investment in the strategic road network, focused on long-term benefits such as safety, reliability, and decarbonisation. The strategy prioritises infrastructure that balances environmental sustainability and economic growth. Key goals include upgrading roads, integrating new technologies, and supporting carbon reduction to meet future transport demands.	Road Investment Strategy 2: 2020-2025	2020
	Tailwind	Policy support & advocacy	Policy-backed funding promotes innovative solutions for flood resilience and environmental sustainability.	The National Infrastructure Commission's Infrastructure Progress Review 2024 stresses the need for sustained long-term government policy and funding to meet decarbonisation targets. The government has committed £20 billion to carbon capture and storage and raised infrastructure investment from £20 billion to £30 billion between 2022 and 2025. Further private investment is necessary to meet the scale of challenges.	National Infrastructure Commission Infrastructure Progress Review 2024. (Armitt et al., 2024)	2024
	Tailwind	Improved resiliency assessments	Mandatory resilience assessments improve infrastructure's ability to withstand environmental risks and climate impacts.	The ICE report emphasises the need to make the Adaptation Reporting Power mandatory under the UK Climate Change Act. This policy mandates that infrastructure owners and operators must evaluate and report their resilience strategies. Mandating quantitative assessment, including financial quantification of expected damages/losses or impacts in a 'do nothing' scenario, would focus resilience efforts on the most material risks and ensure a systems-thinking approach to infrastructure is embedded in policy development and infrastructure planning.	ICE policy position statement: how can the UK's infrastructure system be made more climate resilient?	2019

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