



TRANSPORT

This briefing summarises how transport has been assessed in the latest UK Climate Change Risk Assessment (CCRA) Technical Report, and what types of action to adapt to climate change risks would be beneficial in the next five years.

The full assessment looks at risks and opportunities for the UK under two climate change scenarios, corresponding to approximately a 2°C or a 4°C rise in global temperature by 2100. It answers three questions, for 61 different risks or opportunities using available published evidence and analysis:

- 1. What is the current and future level of risk or opportunity?**
- 2. Is the risk or opportunity being managed, taking account of government action and other adaptation?**
- 3. Are there benefits of further adaptation action in the next five years, over and above what is already planned?**

The main findings from the full assessment related to transport are summarised below, together with the adaptation actions that would be beneficial over the next five years. Each risk or opportunity has an identifier code linked to the full analysis, which is available in the CCRA3 Technical Report.

Readers are encouraged to use these briefings to locate the parts of the Technical Report of most relevance to them.

Key messages

- Transport is fundamental to day-to-day life, but regularly faces climate challenges from flooding, heat, erosion, subsidence and extreme weather. As the climate continues to change, the severity of these risks is projected to increase.
- In the absence of additional adaptation, the impacts of climate change on our weather systems will lead to costly disruption or loss of service, with significant implications for economic activity, societal equity, health and wellbeing.
- The interconnected nature of infrastructure systems means that impacts on transport networks can quickly disrupt other areas, for example by preventing the operation or repair of other critical infrastructure assets; and that impacts on other infrastructure sectors like information and communication technology (ICT) and energy can cascade into transport failures.
- Transport infrastructure has a long lifespan, so climate risks must be considered for existing, retrofitted, and new assets. The transformation in technology required to deliver Net Zero greenhouse gas (GHG) emissions in the UK is an opportunity to also build in resilience to climate change in new infrastructure schemes.
- More action or further investigation is needed on almost all these risks over the next five years.

Alternatively, if you would like a summary of the analysis by UK nation, please go to the national summary documents:

• England • Northern Ireland • Scotland • Wales

This briefing is aimed primarily at the UK Government, the governments of Scotland and Wales, the Northern Ireland Assembly and their respective departments and agencies responsible for transport. However, it should also be of interest to a wider audience.

Risks, opportunities, and benefits of further action



More action needed

Further investigation

Sustain current action

Maintain a watching brief

Average UK wide scores

I1. Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures

I2. Risks to infrastructure services from river, surface water and groundwater flooding

I3. Risks to infrastructure services from coastal flooding and erosion

I4. Risks to bridges and pipelines from flooding and erosion

I5. Risks to transport networks from slope and embankment failure

I7. Risks to subterranean and surface infrastructure from subsidence

I12. Risks to transport from high and low temperatures, high winds, lightning

1. Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures (I1)



Vulnerabilities on one infrastructure network can cause problems on others, and transport infrastructure represents a significant part of this system.

Recent research conducted to support the CCRA has indicated that the vulnerability of interconnected systems may be significantly underestimated. The risk of network failures is already high, potentially affecting hundreds of thousands or millions of people per year.

Examples of cascading failures for transport include flooding of electricity substations disrupting air travel, heatwave impacts on IT and communications services causing freight and travel delays, and (recently) impacts on one transport system e.g. canal breaches, damaging another e.g., flooding of railways.

Transport networks are critical during emergency management and recovery, providing access to hospitals and for repairs to other infrastructure assets.

Adaptation actions tend to tackle individual risks on individual networks, rather than addressing the interconnected nature of infrastructure systems.

The magnitude of this risk is high both now and in the future across all four countries.

Beneficial actions in the next five years include:

- Implement actions which support adaptation at a network level as well as for individual assets.
- Using common formalised standards of resilience, such as the new ISO 14091 standard, across different infrastructure sectors including the transport sector to help build systemic resilience across the whole infrastructure system.
- Improve arrangements for sharing data and information between transport and other sectors. Local and regional resilience forums and networking groups such as the Infrastructure Operators Adaptation Forum can promote collaboration and increase preparedness across geographical and organisational boundaries.

Further details on this risk: Infrastructure Technical Chapter, risk I1



2. Risks to infrastructure services from river, surface water and groundwater flooding (I2)



Extreme rainfall events cause flooding of transport infrastructure and hubs, resulting in travel and freight delays, accidents and impacts on emergency services.

Currently transport infrastructure faces greater exposure to surface water flooding than river flooding. For example, 596 railway stations and 3,544km of rail network are at risk from surface water flooding across the UK compared to 81 railway stations and 1,144km of rail network at risk from river flooding.

Many high-profile flood events have disrupted transport services, such as the impacts of storms Ciara and Dennis in 2020 on road, rail and air travel.

Between 2006 and 2016 flooding caused an average of approximately £15 million in annual compensation payments between Network Rail and Train Operating Companies (TOCs).

Transport infrastructure of all kinds continues to face an increased exposure to surface water flooding in future. Railways will also increasingly be exposed to river flooding.

The current and future magnitude of risk is high across all four nations.

Beneficial actions in the next five years include:

- **Develop consistent indicators of flood risk resilience for transport networks to create the right institutional conditions for adaptation, allow improvements across the board to be better measured over time, building on improvement in local hazard information, such as the Cabinet Office's Resilience Direct platform which provides street-level surface water flood forecasts to authorities and category 1 and 2 responders.**
- **Enhance or develop adaptation strategies to identify areas of the road network most vulnerable to flooding, as well as parts of the network crucial for emergency services such as access to hospitals.**
- **Integrate green infrastructure solutions into transport developments, alongside implementing green Sustainable Drainage Systems (SuDS) to help reduce surface water flood risk.**

Further details on this risk: Infrastructure Technical Chapter, risk I2



3. Risks to infrastructure services from coastal flooding and erosion (I3)



Sea levels are currently rising and the rate of rise is accelerating, including around the UK. Coastal flooding and erosion risk to infrastructure services, including those associated with the transport sector, will therefore grow.

The consequences of coastal flooding have been tempered over time due to improvements in flood defences, together with advances in flood forecasting, warning and emergency response and spatial planning. Despite this, notable coastal flooding incidents have still occurred that have significantly impacted infrastructure, and assets remain located in low lying coastal areas which will be threatened in the event of a defence failure. In particular, the railway network is vulnerable at key locations across the four UK nations.

The magnitude of risk is medium both now and in future for all four nations. Analysis shows coastal adaptation is an extremely cost-effective response, reducing residual damage costs down to very low levels. This is especially important as the risk of coastal flooding will increase as sea level continues to rise. Current projections show the likely change to be between 0.27 and 1.12 metres by the end of the century.

Beneficial actions in the next five years include:

- The use of adaptation pathways for the long-term planning of flood risk management, first used in developing the Thames Estuary 2100 flood risk management strategy, has been shown to be a promising technique that can be applied more widely in the UK.
- Given the uncertainties around sea level rise, 'what if' planning for high coastal risk scenarios can help with understanding what could be done in the event of very high rates of change.

Further details on this risk: Infrastructure Technical Chapter, risk I3



4. Risks to bridges and pipelines from flooding and erosion (I4)



Bridges are critical transport assets. Flooding and erosion or scour (the eroding of soil around bridge foundations) due to increased rainfall can lead to travel disruption, significant repair costs and the potential isolation of remote communities.

Bridges also have significant potential for lock-in of climate risks due to their long service lives (often exceeding 100 years), and high cost of retrofitting, making them priority assets for adaptation.

There are significant uncertainties about the structural integrity of road and rail bridges, many of which were built without consideration of future climate change. Greater winter precipitation and river flows will increase scour, potentially increasing the rate of failure of bridges in the UK.

Both bridges and pipelines are also affected by road transport, such as flooding impacting the ability of engineers to access and repair assets.

Currently, there are no quantitative assessments of climate change impacts on pipelines. The magnitude of risk is classified as medium now and in future for all four countries, but confidence in the assessment is low.

Beneficial actions in the next five years include:

- Further research is needed to produce future estimates of the risks to bridges and pipelines from flooding, erosion and high temperatures.
- Modifications can be made to bridges to reduce their vulnerability to damage from flooding, including any other infrastructure they carry such as cables and pipelines.
- For pipelines, improving drainage in areas that regularly flood, monitoring of river and coastal erosion and the development of flood, coastal and updated contingency defence measures are potential adaptation strategies.
- Ongoing monitoring and maintenance of both types of assets will remain crucial to spot problems in enough time to act.

Further details on this risk: Infrastructure Technical Chapter, risk I4



5. Risks to transport networks from slope and embankment failure (I5)



There are around 20,000 km of slopes and embankments supporting the UK's transport infrastructure. Deterioration and failure of these assets have significant negative impacts on transport networks through damage, travel delays and accidents.

A tragic recent example from 2020 was near Stonehaven, where a passenger train hit a landslip following heavy rain and derailed, resulting in loss of life.

It is known that older, less well compacted assets such as those supporting the rail network are deteriorating at a faster rate than newer assets built to more modern standards. Between 2003 and 2014 there were, on average, 67 earthwork failures a year across the rail network in Scotland, England and Wales. Increases in high rainfall and soil moisture fluctuations combined with periods of dry weather and subsequent cracking are expected to lead to an increase in failures across transport assets. There are implications for more rural areas of the UK, where transport infrastructure systems are less resilient, and often follow natural features such as steep-sided river valleys prone to landslides.

The current magnitude of risk is medium now and in future for all four nations. The cost of adaptation measures across rail and road networks is usually offset by reduced repair costs and travel delays.

Beneficial actions in the next five years include:

- Factor in updated projected increases in heavy rainfall events into long-term renewal programmes for all transport networks, with particular focus on the rail network.
- Improve numerical tools, instrumentation and monitoring systems to increase understanding of slope failure processes in relation to weather and climate, as well as using more detailed characterisation of assets to better understand the spatial distribution of risk.
- Continue to use slope inspection programs and employ greater use of soft engineering techniques, such as vegetation management, to reinforce vulnerable slopes.
- Enhance maintenance of drainage systems for roads and railways and increased drainage capacity in new road infrastructure.

Further details on this risk: Infrastructure Technical Chapter, risk I5



6. Risks to subterranean and surface infrastructure from subsidence (I7)



Ground subsidence is often due to shrinkage and swelling of clay soils, with damage to infrastructure occurring because of interaction with vegetation and associated water content changes. This form of subsidence is regarded as the most damaging geological hazard in Britain today.

22% of Category 1 rail lines, 29% of major train stations and 9% of the major road network are in areas of high susceptibility for shrink-swell subsidence. This can disrupt rail track alignment, leading to speed restrictions and travel disruption, and damage highway pavements, though this is considered a lower risk due to more modern compaction methods being used for construction of the road network.

Network Rail reported £40m in costs due to subsidence in the period 2006 – 2016 and, whilst subsidence was not one of the most frequent weather-related events, it was amongst the highest in terms of costs per incident.

The formation of sinkholes under road and rail infrastructure can result from prolonged or extreme rainfall, particularly in vulnerable areas underlain by soluble rocks.

Water, gas and electricity pipelines are frequently co-located beneath or alongside transport corridors, which can result in interacting risks.

For example, shrink-swell fracturing can occur in a water pipe, leading to local flooding and erosion, potentially forming a sinkhole impacting on nearby roads.

The current overall risk is deemed low rising to medium from the 2050s across the UK.

Beneficial actions in the next five years include:

- **Production of more accurate and consistent data for understanding the linkages between subterranean and other types of infrastructure, and understanding potential adaptation strategies, which is mainly limited to monitoring at present.**
- **Quantifying the uncertainty in soil properties.**
- **Increased ground and weather monitoring and the use of real-time decision support tools as a potential method to mitigate the risks of shrink-swell subsidence.**

Further details on this risk: Infrastructure Technical Chapter, risk I7



7. Risks to transport from high and low temperatures, high winds, lightning (I12)



Evidence that demonstrates the impacts of extreme temperatures, high winds and lightning strikes on rail, road, air and water transport networks is plentiful. Documented impacts include:

- High temperatures: buckling of rail lines, line sag and rail speed restrictions, damage to bridges and pavements, deterioration of airport runways, road surfaces and disruption of communications and IT services leading to transport delays. The impact of high temperatures on the rail network was responsible for over £20 million in compensation payments to TOCs between 2006 and 2016. High temperatures also result in exposure of outdoor transport staff to heat stress.
- High winds leading to disruption of rail operations due to debris on lines, damage to road infrastructure, closure of bridges, and suspension of port and vessel operations. Wind accounted for approximately £145 million in compensation payments between Network Rail and TOCs between 2006 and 2016. High-sided vehicles also become unstable in gusts of wind over 45mph, particularly on exposed bridges.
- Lightning strikes on railways damaging electronic equipment, line-side trees and buildings, and causing line-side fires. £40 million was paid in compensation payments to TOCs due to the impact of lightning on the rail network between 2006 and 2016.

Modelling suggests a worsening of many of these risks under future climate change scenarios, though the changing risks from

extreme winds and lightning are difficult to estimate. Local roads are particularly vulnerable as they make up the vast majority of the UK's road network, cover a wide range of geographic locations with more varied microclimates. The magnitude of the risk is considered medium at present, rising to high across the UK from the 2050s. Although there are examples of good practice within individual transport modes, the approach to managing climate risks across transport infrastructure is not yet being undertaken from a mobility or whole-systems perspective.

Assessment of the risk for future electrified transport systems that will be required to meet the UK's Net Zero emissions commitments will be important.

Beneficial actions in the next five years include:

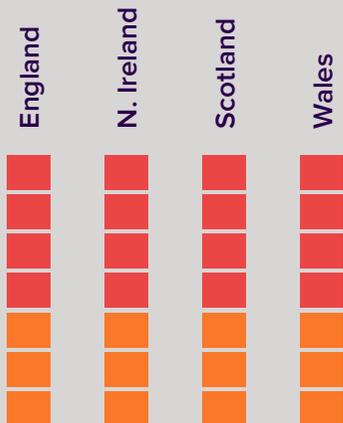
- **Develop improved indicators of climate resilience for road, rail, ports and airports.**
- **Mainstream climate change adaptation into planning and design of new infrastructure, to avoid future retrofitting, alongside improved monitoring, maintenance practices and operations, to avoid lock-in.**
- **Improve weather and climate services, including early warning systems, through use of digital platforms, remote sensing and real time network management.**
- **Revise standards for railways to align with future climate projections.**

Further details on this risk: Infrastructure Technical Chapter, risk I12

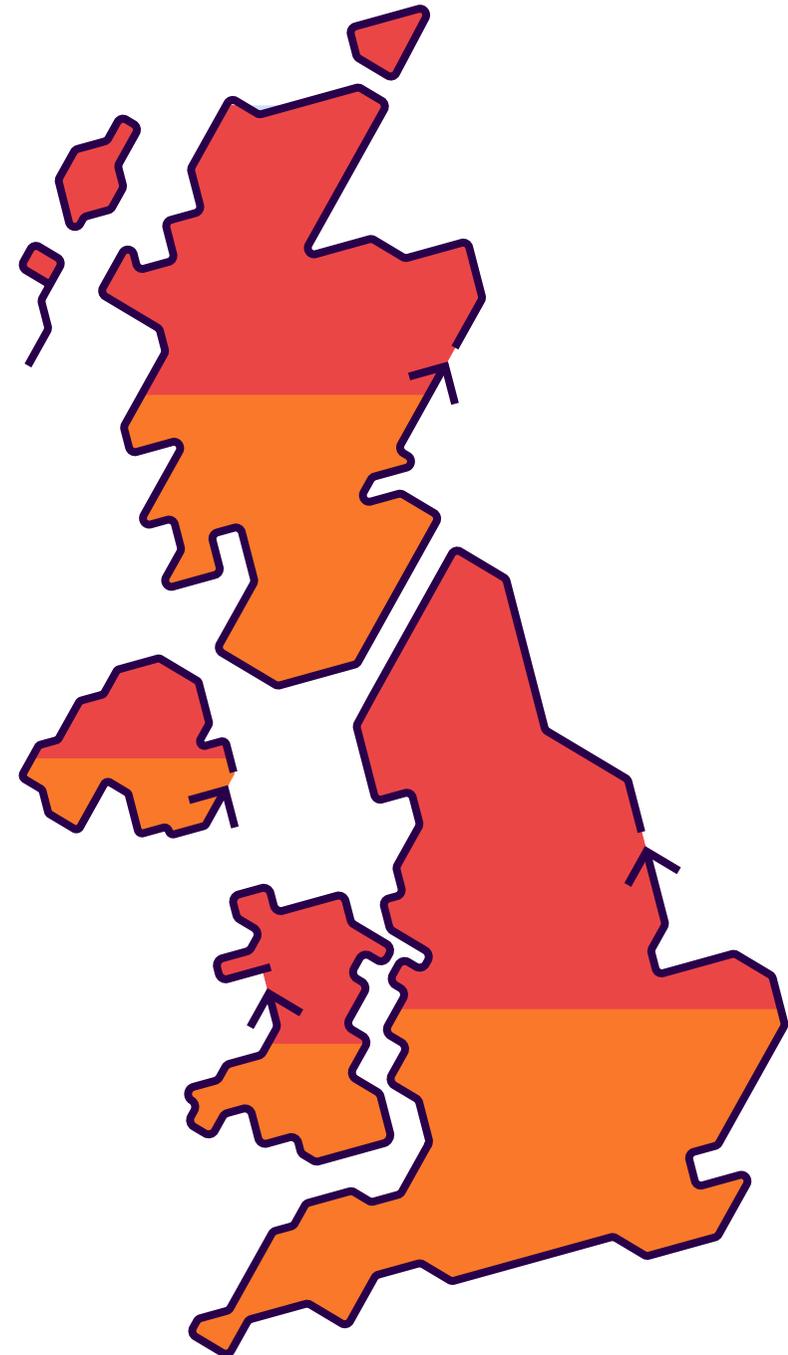
Variations across the UK

Key

- More action needed
- Further investigation
- Sustain current action
- Maintain a watching brief



Risk or opportunity	England	Northern Ireland	Scotland	Wales
Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures (I1)	●	●	●	●
Risks to infrastructure services from river, surface water and groundwater flooding (I2)	●	●	●	●
Risks to infrastructure services from coastal flooding and erosion (I3)	●	●	●	●
Risks to bridges and pipelines from flooding and erosion (I4)	●	●	●	●
Risks to transport networks from slope and embankment failure (I5)	●	●	●	●
Risks to subterranean and surface infrastructure from subsidence (I7)	●	●	●	●
Risks to transport from high and low temperatures, high winds, lightning (I12)	●	●	●	●



Background

The UK Government is required by the UK Climate Change Act 2008 to assess the risks and opportunities from climate change to the UK every five years and respond to the risks via a National Adaptation Programme, covering England. The devolved administrations also publish their own adaptation programmes in response to the risk assessment.

For this third UK Climate Change Risk Assessment, the Government's independent advisers on climate change, the Climate Change Committee (CCC), have been asked to prepare an independent risk assessment setting out the latest evidence on the risks and opportunities to the UK.

Over 450 people from more than 130 organisations have contributed to preparing the assessment. The risks have been assessed using the latest climate projections for the UK which were updated in 2018 by the Met Office. These briefings summarise some of the key topics that are assessed through the Technical Report, to enable readers to understand the key messages and where to find more detail.

Where to find more detail

Each risk or opportunity in this briefing has an identifier code linked to the full analysis, which is available in the CCRA3 Technical Report. Readers are encouraged to use these briefings to locate the parts of the Technical Report of most relevance to them.

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