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Mainstreaming Climate Change Risk Management in Development

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INTERNATIONAL EXPERIENCE REVIEW

Climate change impacts and adaptation responses for the roads and bridges sector

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Version A

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1 INTRODUCTION

It is the purpose of this paper to review the UK experience in planning for climate change for the roads and bridges sector and to identify important lessons for the Nepal context. The UK experience has primarily been reviewed through the analysis of five major documents:

- **The Climate Change Act.** Received Royal Assent on 26 November 2008
- **Engineering the Future – Infrastructure, Engineering and Climate Change Adaptation** prepared by The Royal Academy of Engineering, the Institution of Engineering and Technology, the Institution of Civil Engineers, the Institution of Mechanical Engineers and the Institution of Chemical Engineers
- **Adapting to climate change in the UK - Measuring progress.** Second report of the Adaptation Sub-Committee of the Committee on Climate Change 2011
- **Climate Change – is the UK preparing for flooding and water scarcity?** Third report of the Adaptation Sub-Committee of the Committee on Climate Change 2012
- **UK Climate Change Risk Assessment.** Summary of the Key Findings 2012

2 THE UK EXPERIENCE

Climate Change was recognised by Government in the Climate Change Act of 2008 which set out a legal framework for ensuring that it meets its commitments to tackle climate change. The Act required that emissions be reduced and set a ceiling on the levels of greenhouse gases that can be emitted into the atmosphere.

The Committee on Climate Change (CCC) was set up as an independent body. Also established was the Adaptation Sub Committee (ASC) as a new expert body to advise the CCC on climate risk in the UK and to ensure that the Government programme for adaptation enables the UK to prepare effectively for the impacts of climate change.

The Adaptation Sub Committee has issued three reports for the years 2010, 2011 & 2012 and copies of these are attached in Annex A. The executive summaries and key messages from these three reports are outlined in this review report.

As a result of the Climate Change Act a study, “Engineering the Future – Infrastructure, Engineering and Climate Change Adaptation” an activity of the *Engineering the Future* partnership, was carried out on behalf of Defra by The Royal Academy of Engineering, the Institution of Engineering and Technology, the Institution of Civil Engineers, the Institution of Mechanical Engineers and the Institution of Chemical Engineers. This study is attached as Annex B and summarised in this review report.

A UK Climate Change Risk Assessment (CCRA) is to be conducted every 5 years. The first CCRA reported in January 2012. This report – Summary of Key Findings from the UK Climate Change Risk Assessment 2012 is attached as Annex C and summarised in this review report.

2.1 The Climate Change Act

The Climate Change Act received Royal Assent on 26 November 2008. This Act provides a legal framework for ensuring that Government meets its commitments to tackle climate change. The Committee on Climate Change (CCC) was set up as an independent body as part of the Act.

The Act requires that emissions are reduced by at least 80% by 2050, compared to 1990 levels. The 2050 target was raised to 80% from 60% following recommendations set out by the CCC in a letter to the Secretary of State in October 2008.

The Act also introduces legally binding carbon budgets, which will set a ceiling on the levels of greenhouse gases that can be emitted into the atmosphere. The CCC’s first report “Building a low-carbon economy” advises on the level of these budgets for the first three five year periods.

The CCC will monitor and report back to Parliament annually on progress made by Government in meeting carbon budgets. The CCC will publish its first progress report in September 2009.

The Climate Change Act 2008 also established the Adaptation Sub-Committee (ASC) as a new expert body to advise the Committee on Climate Change (CCC) on climate risks in the UK. The ASC will provide expert advice and scrutiny through that Committee to ensure that the Government’s programme for adaptation enables the UK to prepare effectively for the impacts of climate change.

The Climate Change Act 2008 sets the legal framework for adaptation policy in the UK:

- A UK Climate Change Risk Assessment (CCRA) is to be conducted every 5 years. The first CCRA will report in January 2012.

- A National Adaptation Programme must be put in place and reviewed every five years to address the most pressing climate change risks to England. The first Programme will be published in 2013.

The Government has the power to require public authorities and statutory undertakers (including the utilities) to report on how they have assessed the risks of climate change to their work, and what they are doing to address these risks. The first tranche of reports from public bodies and infrastructure providers will be happening between now and 2011 – 2012.

2.2 Infrastructure, Engineering and Climate Change Adaptation

The *Infrastructure, Engineering and Climate Change Adaptation – ensuring services in an uncertain future* report was published by the UK Royal Academy of Engineering in February 2011. The report addresses the climate change threats and adaptation responses for the various engineering sectors in the UK. A detailed summary and comment on the report is provided in Annex D and the key messages are summarised below:

General

- Climate change mitigation has an impact on infrastructure
- Adaptation requires responding to both long term effects and to acute and extreme events
- Interdependencies need to be managed
- Resilience is required in all sectors
- Managing infrastructure is a systems issue and system resilience is required
- Long term Government planning is required
- Regulations and design standards need revision
- There must be information sharing

Recommendations

- Prioritisation of vulnerabilities. Need to distinguish between short and long term effects
- Mapping of severe weather events is required
- Interdependencies can cause cascade failures
- Regulatory changes are needed
- Adaptation requires a long term perspective
- Infrastructure is a system of systems. Government need to make strategic decisions about infrastructure as a whole
- Sector resilience is interdependent

Adaptation within the Transport Sector

- Systematic risk assessment should be undertaken by sharing and using accurate asset registers and information systems developed for other purposes
- Complex risk analysis, rather than analysis of isolated parts of the infrastructure, or analysis of single risks, will be essential.
- Changes to design standards and operating practices will be required
- Adaptation should be incorporated into routine maintenance & lifecycle replacement

- There must be coordination of knowledge across transport modes and common standards and treatment protocols for addressing issues common to different transport areas, e.g. drainage and subsidence.

Prioritisation

- Prioritise “pinch points”
- Resilience of systems of several sectors is required
- Resilience built into system at “pinch points”

Barriers to implementing adaptation options

- Currently the ‘risk’ of over-investment in unnecessary resilience is seen as greater than the risk and consequences of failure.
- There are a large number of climate effects which are not properly understood or are not yet quantified at a sufficient level of certainty to support any specific changes in infrastructure.
- Availability of funding is as ever a challenge and the current and future economic circumstances in which infrastructure will exist is highly uncertain.

2.3 First report of the Adaptation Sub-Committee of the Committee on Climate Change

The First report of the Adaptation Sub-Committee of the Committee on Climate Change titled *How well prepared is the UK for Climate Change?* was released in September 2010. The report provides a first national assessment of progress on preparing for climate change, based primarily on analysis of central government activity. The report will be updated as further information becomes available, including the Climate Change Risk Assessment and the first tranche of adaptation reports from public bodies and infrastructure providers.

2.3.1 What steps should the UK be taking now to adapt?

Early action will help ensure that decisions made today do not close off options and make it harder to adapt in the future. The report suggests that the UK should focus early adaptation efforts on decisions:

- (i) that are sensitive to present-day climate variability and therefore where preparing for climate change will provide both immediate and future benefits; and
- (ii) that have long-lasting consequences, including decisions about long-lived assets (for example buildings and infrastructure), decisions that may cause irreversible changes (for example loss of biodiversity), and decisions that may have systemic and far-reaching effects (for example developing in one part of the floodplain with knock-on effects downstream).

A challenge in this whole area is making decisions in the face of considerable uncertainty. In applying these criteria, the report identified five priority areas for early action:

- 1. Taking a strategic approach to land use planning** – for example to (i) ensure that new buildings and infrastructure are sited in areas that minimise exposure to flood risk, do not increase flood risk to others, and do not create a legacy of flood defence or water supply costs; (ii) manage competing pressures on land – urban, natural and agricultural – in response to a changing climate; and (iii) enhance green space where effective in the design

of towns and cities to help manage surface water drainage and cope with rising temperatures and heatwaves.

2. Providing national infrastructure (energy, water, transport, waste and communications) – for example to ensure it can cope with rising temperatures; it is resilient to potential increases in certain extreme weather events, such as storms, floods and droughts; and it takes account of changing patterns of consumer demand in areas such as energy and water use, travel and consumption.

3. Designing and renovating buildings – for example to ensure they can cope with rising temperatures and floods and minimise water use through appropriate use of construction materials and through better design.

4. Managing natural resources sustainably – for example by using water more efficiently; improving and extending ecological networks so that species can adapt and move as the climate changes; and making space for water along rivers and the coast.

5. Effective emergency planning – for example by making better use of probabilistic weather forecasts to anticipate extreme weather events more effectively; creating plans that reduce impact on and ensure continuation of care for the most vulnerable groups in society during heatwaves and floods; and developing business continuity plans based on high-quality climate risk information so that businesses can cope better with disruptions to their supply chains during floods and damage to assets from severe weather. Taking steps in these priority areas will have wider benefits. For example fully-functioning infrastructure, including secure water supplies, and well-designed hospitals and care facilities, are all key to promoting human health and well-being.

2.3.2 Key messages of the report

1. What steps should the UK be taking to adapt? Preparing for climate change today will reduce the costs and damages of a changing climate and allow UK businesses, the public sector, the third sector and individuals to take advantage of potential opportunities.

Early action will help make the UK better prepared for today's climate and ensure that decisions made today that have long-lasting consequences do not close off options and make it harder to adapt in the future. The report identifies five adaptation priorities for the UK – land use planning, providing national infrastructure, designing and renovating buildings, managing natural resources, and emergency planning.

2. What progress has been made so far? The UK has started to build capacity for adaptation, with evidence of growing awareness of the risks and appropriate responses, particularly in public sector organisations. This compares favourably with progress in other countries, with some examples of good practice in adaptation decision-making. However, from the evidence reviewed, the report concludes that capacity building is not yet systematically translating into tangible action on the ground to reduce the UK's vulnerability to climate change.

3. What further action is required? Action by local authorities, public sector agencies, businesses and individuals will be essential to ensuring that the UK is preparing adequately for a changing climate. The report advises that the Government should work to remove barriers and provide stronger signals to enable action by others, including:

- establishing a process for defining adaptation outcomes, for example what level of flood risk is acceptable;

- helping deliver these outcomes by: (i) promoting greater capability and capacity in priority areas where progress has been slow, and (ii) ensuring decision-makers have practical tools and information to quantify key climate risks and manage uncertainties;
- ensuring that the new delivery arrangements, for example in land use planning and infrastructure provision, allocate responsibilities for adaptation clearly and provide for sufficient cooperation by organisations at landscape or catchment scale; and
- considering how upcoming policy reforms can support adaptation, for example in the White Papers on water, the natural environment and public health, and in any review of building regulations.

4. What will the ASC do to help? In order to fulfil their statutory duty, the Adaptation Sub-Committee will monitor the achievement of adaptation outcomes and the delivery of adaptation measures by organisations, and use this to assess the nation’s preparedness.

2.4 Second report of the Adaptation Sub-Committee of the Committee on Climate Change

The second report of the Adaptation Sub-Committee of the Committee on Climate Change titled *Adapting to climate change in the UK - Measuring progress* was released in 2011. The report provides the second assessment of the UK’s preparedness. The report develops a set of indicators against which to assess and track the UK’s preparedness.

The headline messages of the report are:

- **The UK is coping with the current climate, but some sectors such as water supply are near their limits.** Vulnerability to climate change is potentially increasing as a result of patterns of development in some areas and demographic trends such as the ageing population.
- **There are low-regret actions that could be taken now to reduce vulnerability** – for example measures to improve water efficiency, reduce damages to buildings from flooding, and protect buildings from overheating in summer. These measures would save householders money today. However, we found limited evidence of uptake of such measures, particularly in existing homes, reflecting barriers to action. This indicates the need for new policy approaches.
- **Climate risks appear not to be fully incorporated into some major strategic decisions**, such as land use planning and investment in water infrastructure. Embedding climate change more fully into decision-making could reduce future adaptation costs, such as building new flood defences and maintaining existing defences, and also ensure that climate risks are appropriately balanced against other risks and benefits.

2.5 Third report of the Adaptation Sub-Committee of the Committee on Climate Change

The third report of the Adaptation Sub-Committee of the Committee on Climate Change titled *Climate Change – is the UK preparing for flooding and water scarcity?* was released in 2012. The report applies the toolkit developed in the first two reports at a national level to two of the largest risks to emerge from the UK’s first Climate Change Risk Assessment (CCRA): flooding and water scarcity. Climate change is likely to increase the frequency and severity of floods and droughts. Without action to prepare, this could lead to increasing costs and unnecessary damage and disruption.

The key messages of the report are:

- **Exposure to flooding.** The Government and local authorities should ensure more robust and transparent implementation of planning policy in relation to development in areas at risk of flooding.
- Development in the floodplain grew at a faster rate than elsewhere in England over the past ten years.
- While much of this development is well protected from flooding by the presence of community defences, one in five properties built in the floodplain were in areas of significant flood risk. Design features at the site level should have helped to make this development more resilient to flooding.
- The current “build and protect” approach to floodplain development will leave a legacy of rising costs of protection and flood damage in the face of climate change. These long-term costs may outweigh the benefits of development in some locations.
- **Protecting existing properties from flooding.** The Government should support sustained and increased investment in flood defences from public or private sources; or in the absence of this identify ways to manage the social and economic consequences of more frequent flooding.
- Current levels of investment in flood defences and uptake rates of protection measures for individual properties will not keep pace with the increasing risks of flooding. Climate change could almost double the number of properties at significant risk of flooding by 2035 unless there is additional action.

2.6 UK Climate Change Risk Assessment

2.6.1 Summary of the Key Findings 2012

The UK Government published the UK Climate Change Risk Assessment (CCRA) on 25 January 2012. The assessment was the of its kind for the UK and the first in a 5 year cycle. The CCRA reviewed the evidence for over 700 potential impacts of climate change the UK. Analysis was undertaken for over 100 of these impacts across 11 key sectors - including transport - to assess their likelihood, the scale of their potential consequences and the urgency with which action may be needed to address them. Key findings of the assessment are summarised below:

The global climate is changing and warming will continue over the next century. The latest projections for the UK show increases in summer and winter temperatures, increases in winter rainfall, decreases in summer rainfall (although small increases are also possible), more days of heavy rainfall and rising sea levels.

The UK is already vulnerable to extreme weather, including flooding and heatwaves. Continued action is needed to manage these risks even if additional pressures due to climate change are not taken into account.

Flood risk is projected to increase significantly across the UK. Increases in the frequency of flooding would affect people’s homes and wellbeing, especially for vulnerable groups (e.g. those affected by poverty, older people, people in poor health and those with disabilities), and the operation of businesses and critical infrastructure systems. Annual damage to UK properties due to flooding from rivers and the sea currently totals around £1.3 billion. For England and Wales alone, the figure is projected to rise to between £2.1 billion and £12 billion by the 2080s, based on future population growth and if no adaptive action is taken.

UK water resources are projected to come under increased pressure. This is a potential consequence of climate-driven changes in hydrological conditions, as well as population growth and the desire to improve the ecological status of rivers. By the 2050s, between 27 million and 59 million people in the UK may be living in areas affected by water supply-demand deficits (based on existing population levels). Adaptation action will be needed to increase water efficiency across all sectors and decrease levels of water abstraction in the summer months.

Potentially, there are health benefits as well as threats related to climate change, affecting the most vulnerable groups in our society. These are likely to place different burdens on National Health Service (NHS), public health and social care services. For example, premature deaths due to cold winters are projected to decrease significantly (e.g. by between 3900 and 24,000 by the 2050s) and premature deaths due to hotter summers are projected to increase (e.g. by between 580 and 5900 by the 2050s). Other health risks that may increase include problems caused by ground-level ozone and by marine and freshwater pathogens.

Sensitive ecosystems are likely to come under increasing pressure. Although some species could benefit, many more would be negatively impacted. These impacts would have knock-on effects on habitats and on the goods and services that ecosystems provide (e.g. regulating water flows, pollination services).

Potential climate risks in other parts of the world are thought to be much greater than those directly affecting the UK, but could have a significant indirect impact here. These risks include effects on global health, political stability and international supply chains.

Some changes projected for the UK as a result of climate change could provide opportunities for agriculture and other businesses, although not outweighing the threats. For example, there are potential benefits for crop growth (assuming water is not a limiting factor) and hence food production, while climate change may also encourage more efficient use of resources and the development and provision of products and services that can help manage climate risks.

Despite the uncertainties related to future climate change and its impacts, the evidence is now sufficient to identify a range of possible outcomes that can inform adaptation policies and planning. Decision makers need to consider uncertainties and to allow flexibility in their policies and plans. Specific climate change guidance is available in many sectors that describes suitable methods and tools for assessing future risks and adaptation options.

Significant gaps in evidence still exist. For example, further work is needed to improve understanding of the relationships between different climate risks and of how climate risk compares to risks from pressures such as population growth and land-use change.

3 LESSONS FOR NEPAL

Many of the key findings and messages highlighted by the five reviewed documents are relevant to the Nepal context including:

- All essential infrastructure is likely to be vulnerable to climate change
- When considering the impacts of climate change it is necessary to consider the **infrastructure of a country as an inter-dependent system** and not a number of different sectors.
- The country's infrastructure must be made more resilient to climate change
- Government must shape policy and regulation to **encourage collaboration across sectors**
- Adaptation requires responding to both long term effects and to acute and extreme events
- Long term Government planning is required
- Transport investment is subject to **cost-benefit appraisal formulae** that do not recognise climate change issues
- Regulations and design standards need revision
- Uncertainty is a barrier to change – the risk of investing in unnecessary resilience is seen as greater than the risk of failure
- Some disruption to transport may be unavoidable
- Limited resources will require decisions to be made regarding the allocation of funds to various parts of the roads network – different **sections of the road network should be prioritised** to ensure correct allocations of funds
- Risk assessment is inadequate at present – **systematic risk assessment** by using accurate asset registers will be essential to assess risks associated to climate change
- There must be information sharing
- Methods for **prioritisation of vulnerabilities** in the infrastructure system are needed for effective planning
- Adaptation measures should be incorporated into the **routine maintenance processes** and the **lifecycle replacement of assets**
- There are many vulnerabilities within the infrastructure system, and it is impossible to cover the cost of all adaptation measures needed for complete resilience. Therefore, it is necessary to **prioritise the various 'pinch points' where resilience is needed.**

The concerns in the UK about the interdependency of the infrastructure system as a whole are not immediately relevant to Nepal particularly in the way that the strategic road network in the UK is reliant on an uninterrupted electricity supply. However, as development advances, this will increasingly become a concern for Nepal as well and should be taken into consideration when looking at the threats from climate change in the longer term.

The following points are particularly important in the Nepal context:

Adaptation requires responding to both long term effects and to acute and extreme events: For DoR and DoLIDAR the extremely poor condition of their road pavements and drainage works means that assessing vulnerability is difficult and that much of the work required to increase the resilience of the road is not due to the threat of climate change but to lack of investment over many years. However there are many bridges which are of high value, in reasonable condition, and vulnerable to

acute and extreme events so the need for vulnerability assessment is high and the need for adaptation planning is high.

Long term Government planning is required: The Government of Nepal must make long term plans to rectify the huge backlog of maintenance/reconstruction work that is required to bring the existing road network to a sustainable level.

There must be information sharing: The collection of information required to monitor climate change and its sharing between all concerned agencies must be improved.

ANNEX A: FIRST, SECOND AND THIRD REPORT OF THE ADAPTATION SUB-COMMITTEE OF THE COMMITTEE ON CLIMATE CHANGE

ANNEX B: ENGINEERING THE FUTURE – INFRASTRUCTURE, ENGINEERING AND CLIMATE CHANGE ADAPTATION REPORT

ANNEX C: SUMMARY OF KEY FINDINGS FROM THE 2012 UK CLIMATE CHANGE RISK ASSESSMENT

ANNEX D: REPORT REVIEW

Report name: Infrastructure, Engineering and Climate Change Adaptation – ensuring services in an uncertain future

Publisher: The Royal Academy of Engineering

Date of publishing: February 2011

Comment	Extract from Report
<p>Essential infrastructure is vulnerable to CC</p> <p>The challenge to a reliable system increases</p> <p>Infrastructure systems are interconnected – one sector at risk so are others</p> <p>Infrastructure system must be more resilient</p>	<p>Foreword by Rt. Hon Lord Henley</p> <p>Essential infrastructure which guarantees our energy and water supplies and enables safe and reliable use of road, rail and air transport is vulnerable to the effects of climate change.</p> <p>As our climate continues to change the difficulty in meeting the challenge of maintaining a robust and reliable infrastructure system increases.</p> <p>This is especially true as our infrastructure sectors have developed into highly technical and interconnected systems. If one sector is at risk, so are the rest. If floods damage our energy supply, all other services can be affected, causing a cascade of failure.</p> <p>To meet the challenge, we need an infrastructure system that is more resilient to climate change.</p>
<p>CC threatens critical infrastructure and the UK economy</p> <p>Government to shape policy and regulation</p>	<p>Foreword by Lord Browne of Madingley FREng FRS President, The Royal Academy of Engineering on behalf of <i>Engineering the Future</i></p> <p>Climate change is a reality. While efforts must continue towards mitigating its effects, there is a crucial need to adapt to the changing climatic conditions that are anticipated this Century. Extreme weather and long term climate change threaten critical national infrastructure and the UK economy, since a robust infrastructure is essential to economic functioning and growth.</p> <p>The adaptation programme needs Government to shape policy and regulation that will promote investment in infrastructure and encourage collaboration across sectors.</p>
<p>CC mitigation has an impact on infrastructure</p>	<p>Executive Summary</p> <p>The effects of climate change on infrastructure are not limited to changes in weather, but include the impact on infrastructure of efforts toward climate change mitigation, and climate induced changes in behaviour and demographics. These must be considered alongside other developments such as population growth and changes in the economic environment.</p>

<p>Adaptation requires responding to both long term effects and to acute and extreme events</p> <p>Interdependencies need to be managed</p> <p>Resilience required in all sectors</p> <p>Managing infrastructure is a systems issue. System resilience is required</p> <p>Long term Government planning is required</p> <p>Regulations and design standards need revision</p> <p>There must be information sharing</p>	<p>Adaptation to climate change requires two forms of response: dealing with long term effects on the infrastructure such as rising sea levels, and developing resilience to acute and extreme weather events such as flash flooding. Extreme events highlight the interdependencies in infrastructure as they are liable to lead to ‘cascade failure’ where the failure of one aspect of infrastructure, such as flood defences, can lead to other failures</p> <p>The interdependencies in infrastructure therefore need to be managed well, especially as infrastructure is becoming more interdependent.</p> <p>Resilience is thus required in all sectors to protect against cascade failure and to adapt the infrastructure against a slowly changing climate over the longer term.</p> <p>Managing national infrastructure is a systems issue, requiring collaboration, planning and sharing of information between sectors. Systems resilience, rather than sector resilience, is required to adapt to climate change.</p> <p>The infrastructure system also requires joined up management within Government, with long-term planning for adapting and maintaining Infrastructure</p> <p>Regulations and design standards are evidently in need of revision to reflect the uncertain climatic conditions that will be experienced in coming decades, setting probabilistic standards rather than absolute requirements for performance.</p> <p>Regulation must also be adapted to allow greater information sharing and collaboration across the supply chain to facilitate management of the infrastructure as a whole.</p>
<p>Prioritisation of vulnerabilities. Need to distinguish between short and long term effects</p> <p>Severe weather mapping required</p> <p>Interdependencies can cause cascade failures</p>	<p>Recommendations</p> <p>F1: Methods for prioritisation of vulnerabilities in the infrastructure system are needed for effective planning. There will be a need to distinguish between the short term effects of climate change, such as flash flooding, which in some situations may reluctantly have to be tolerated, and those that are sustained or persistent, such as rivers running low, where it may be more realistic to introduce counter measures economically.</p> <p>Not all parts of the country face similar risk levels or similar impacts. Regional maps of severe weather impacts mapped against critical infrastructure elements would be useful.</p> <p>F2: There are many interdependencies between the infrastructure sectors and failure in one area can very quickly lead to cascade failure. The interdependencies are in many cases quite straightforward: energy directly affects all other sectors which require power to function; workers in all sectors rely on transport to get to work and can only work</p>

<p>Regulatory Changes needed</p> <p>Adaptation requires long term perspective</p> <p>Infrastructure is a system of systems. Government to make strategic decisions about infrastructure as a whole</p> <p>Sector resilience is interdependent</p>	<p>if water supplies are maintained. However, the energy infrastructure is critical – all other sectors are reliant on a supply of electricity.</p> <p>F5: Regulatory changes are needed to develop and implement necessary adaptation plans. In particular, regulations must be developed to deal with probabilistic rather than absolute scenarios.</p> <p>Adaptation to climate change requires a long term perspective and the suitability of quinquennial regulatory reviews focused on driving current efficiency should be reconsidered. The interaction with European and International regulation should also be recognised.</p> <p>F6: The infrastructure should be dealt with as a system of systems. Mechanisms are required to enable Government to make strategic decisions about the infrastructure as a whole. Regulators will need to work together in planning changes required by climate change adaptation.</p> <p>Resilience in one sector is dependent on resilience in another, so modelling infrastructure systems and scenario planning is essential to ensure that vulnerabilities in one sector do not compromise others. Sharing of data and collaboration across the supply chain will be requisite for such systems-level planning.</p>
<p>UK summer temperature to rise by 3-4°C</p> <p>Summer rainfall to decrease by 11 to 27%</p> <p>Sea level to rise by 36cm.</p> <p>Extreme weather events more likely</p>	<p>UK Climate Projections</p> <ul style="list-style-type: none"> • Average UK summer temperature is likely to rise by 3-4°C by the 2080s. In general, greater warming is expected in the southeast than the northwest of the UK, and there may be more warming in the summer and autumn than winter and spring. • Average summer rainfall across the UK may decrease by 11% to 27% by the 2080s. While this is the average, there will be a big change in rainfall between the seasons, with winters becoming wetter and summers drier. • Sea levels are expected to rise. The central estimate (taking into account land movement) sea level is projected to rise by 36cm in London by the 2080s. • Extreme weather events are likely to become more common.
<p>Systematic risk assessment required</p> <p>Changes to design standards and operating practices</p>	<p>Adaptation within Transport Sector</p> <p>Systematic risk assessment, by sharing and using accurate asset registers and information systems developed for other purposes, will be essential to assess risk from climate change. Complex risk analysis, rather than analysis of isolated parts of the infrastructure, or analysis of single risks, will be essential.</p> <p>Amendments to design standards and operating practices will be required: e.g. it will be important to incorporate adaptation into business-as-usual maintenance routines; adapt to changing climate over the lifetime and replacement cycle of assets</p>

<p>Adaptation incorporated into routine maintenance & lifecycle replacement</p> <p>Coordination of knowledge</p>	<p>Adaptation measures should be incorporated into the routine maintenance processes and the lifecycle replacement of assets. Some major infrastructure may require significant investment to meet adaptation requirements</p> <p>There must be coordination of knowledge across transport modes and common standards and treatment protocols for addressing issues common to different transport areas, e.g. drainage and subsidence. It would be valuable to have more information about the regional affects of climate change, mapped against the location of critical infrastructure assets. Location of future flood risk is of critical importance.</p>
<p>Prioritise “pinch points”</p> <p>Resilience of systems of several sectors is required</p> <p>Resilience built into system at “pinch points”</p>	<p>Prioritisation</p> <p>There are many vulnerabilities within the infrastructure system, and it is impossible to cover the cost of all adaptation measures needed for complete resilience. Therefore, it is necessary to prioritise the various ‘pinch points’ where resilience is needed. A precondition for this is a common method for categorising and prioritising vulnerability. However, resilience is understood in different ways in different sectors, which is a barrier to categorisation and prioritisation.</p> <p>It is of benefit to consider resilience in terms of the ability of the infrastructure to function in a given set of scenarios. Whilst this method is already used within sectors, it is essential to use it to assess the resilience of infrastructure systems, where several infrastructure sectors are affected.</p> <p>In planning adaptation measures it is essential to prioritise those ‘pinch points’ where cascade failures are likely to be initiated. Resilience, and the ability to recover from failures, should be built into the system at these points.</p>
<p>Uncertainty is a barrier to change</p> <p>Climate effects not properly understood</p> <p>Funding is uncertain</p>	<p>Barriers to implementing adaptation options</p> <p>Uncertainty is perceived as the biggest single barrier to change. Currently the ‘risk’ of over-investment in unnecessary resilience is seen as greater than the risk and consequences of failure.</p> <p>There are a large number of climate effects which are not properly understood or are not yet quantified at a sufficient level of certainty to support any specific changes in infrastructure</p> <p>Availability of funding is as ever a challenge and the current and future economic circumstances in which infrastructure will exist is highly uncertain.</p>