

Joint submission from the Institution of Civil Engineers (ICE) supported by the Institute and Faculty of Actuaries (IFoA) to the National Resilience Strategy: Call for Evidence

Introduction

This response to the National Resilience Strategy: Call for Evidence has been prepared by the Institution of Civil Engineers (ICE), supported by risk expertise from the Institute and Faculty of Actuaries (IFoA). Our response focuses on critical infrastructure, how it is planned, delivered, managed, and maintained and the vital role it plays in supporting National Resilience. We welcome this call for evidence on an area of significant importance for the effectiveness of the country.

Framing the issues

1. We recognise that building resilience into infrastructure systems is necessary, however it is rarely adequately addressed. Addressing infrastructure resilience poses **the major challenges** for all stakeholders. It will be necessary to procure projects and operate and maintain infrastructure assets differently, improving the resilience of existing infrastructure.
2. Resilience needs to be analysed to identify the impact of a project on **interconnected infrastructure systems**. These systems should include both critical national infrastructure and strategically important regional infrastructure.
3. Most infrastructure that supports our national resilience already exists and will do so for many years. The first issue is to improve the **operational resilience** of existing infrastructure and its interconnected systems. The second issue is to optimise the impacts of new infrastructure on these existing systems.
4. The need to improve resilience of infrastructure systems is known¹. Examples of success and failure (often international) provide opportunities to identify lessons and understand the scale of benefits achievable. The potential impacts of climate change make adaptations of existing infrastructure vital to delivering national resilience.
5. The critical time in infrastructure development is at **“the front-end”** when considering major interventions decisions.² Resilience opportunities missed then may be lost as a ‘narrowing-down’ analytical process takes place.
6. Infrastructure projects typically focus on delivery ‘to time, cost and specification’. However, we recognise that decisions based on “best value” rather than “lowest cost” are needed when considering national resilience. Best value may be interpreted as the optimum cost that provides robust and flexible performance under a range of different future scenarios.
7. Adaptive pathways should be considered to optimise the timing of spending on resilience. This requires a much wider ranges of scenarios to be envisaged and analysed. The analysis will often be complex to ensure that the right resilience decisions are made, and expert advice will be needed to a greater extent than now.

The remainder of this paper is set out in line with the call for evidence and we address the questions raised in order, where we have relevant expertise and insight.

¹ <https://ieeexplore.ieee.org/document/7932183> (IEEE Systems Journal Volume 12 Issue 4. Dec 2018). "Integrated Approach to Assess the Resilience of Future Electricity Infrastructure Networks to Climate Hazards"

² <https://www.ice.org.uk/knowledge-and-resources/best-practice/tackling-key-front-end-issues-major-infrastructure>

1. How are you responding to this Call for Evidence?

- as an individual
- as an organisation

2. What is your email address?

policy@ice.org.uk

9. If responding on behalf of an organisation, what type of organisation is it?

- a business
- a trade body
- a third-sector organisation
- an academic institution or research body
- a community group
- a Local Resilience Forum
- other public sector
- other

11. Which organisation are you representing?

The Institution of Civil Engineers supported by the Institute and Faculty of Actuaries

12. Is your organisation defined as a Category 1 or 2 emergency responder as set out in the Civil Contingencies Act?

- Category 1
- Category 2
- My organisation does not come under this categorisation
- Don't know

13. If responding as a business or trade body, what business sector are you part of?

Civil engineering and actuarial professions

15. Where are you (or your organisation, if answering on behalf of one) based?

- England
- Scotland
- Wales
- Northern Ireland
- Throughout the UK
- Outside the UK

17. To what extent do you agree with the proposed vision of the Resilience Strategy?

- Not at all
- A little
- Somewhat
- A lot
- Completely

18. Please explain your view.

The vision is a good aspiration. However, by using the phrase "...to make the UK the most resilient nation..." places resilience above other considerations. That might suggest resilience should be developed at any cost.

19. Is there anything that you would add, amend or remove?

As noted above perhaps the vision might be more balanced as "...to make the UK a more resilient nation. We need to ..."

20. To what extent do you agree with the principles laid out for the strategy?

- Not at all
- A little
- Somewhat
- A lot
- Completely

21. Please explain your view.

The principles described are a good basis for consideration, however we feel there are additional important elements that should be recognised. Further comments are provided below on the suggested additions.

22. Is there anything that you would add, amend or remove?

Whilst the principles refer to investing in preparation there is little recognition of the need to place a value on resilience and adaptability. Without a framework to recognise the value these elements provide there is a risk that decisions are made more often than not on cost grounds. This may ignore projects and programmes providing greater resilience because of the lack of an immediate expected payback.

We would also recommend that additional focus is placed on evaluating the effectiveness of both the risk analysis that is undertaken to inform decisions, and of the actions taken to improve resilience. Without such evaluation there is a risk that ineffective approaches continue to be adopted resulting in a less resilient UK.

Risks are increasingly complex with growing interdependencies between systems. Knowledge in this area remains limited and considering resilience in an interconnected world should recognise not only the interconnectedness between countries but also between industries and other systems.

The DAFNI project³ (Data & Analytics Facility for National Infrastructure) is an excellent step forward in using data from across sectors to address interconnected risks. This is being watched with interest, and has great potential if the outputs and tools are able to be utilised for regional / sub-regional strategic planning and investment.

As an island nation with critical national infrastructure situated on the coast and major seaports processing trade that is essential to the UK's economy, coastal risks should be explicitly addressed in the National Resilience Strategy. With climate change driving sea level rise and increased frequency and severity of storms, these critical assets will be placed at

³ <https://dafni.ac.uk/>

further risk. This critical infrastructure is also often dependent on infrastructure and public / private organisations that may not be sufficiently resourced to manage them effectively, creating cascading risks.

Section 1 – Risk and resilience

23. Is there more that the Government can do to assess risk at the national and local levels? If so, what?

- Yes
- No
- Don't know

If so, what?

How to analyse and manage risk requires both method and organisation. Organisation requires the right culture, a centre for risk analysis, and effective access to decision-makers who have the capacity to make change.

The Cabinet Office's vision for a National Resilience Strategy and establishment of an embryonic Situation Centre (SitCen) to provide analytical support, provide important steps towards an effective UK risk management system.

Climate change risks need to have timescales attached (however uncertain) which facilitate adaptive pathways (see response to question 55) that optimise the timings of actions to improve resilience.

Prospective investors need to understand the degree of resilience of the projects they are considering. We suggest, therefore, that for each new project the sponsor should publish a Resilience Statement. This would not be a box-ticking exercise but would be project specific, containing meaningful information. It would summarise the significant risks to which the project is exposed and give the sponsor's views on the likelihood, timescale and impact of each risk. It would also summarise any further mitigation options which might be practicable, with an indication of their costs. As well as helping prospective investors, the production of such a Statement would encourage the sponsor's project team to focus on the project's resilience. Prospective users of the infrastructure who read the Statement might also have useful views and practical suggestions on resilience for the sponsor to consider before a final decision is made on whether to proceed with the project.

24. Is there more that the Government can do to communicate about risk and risk appetite with organisations and individuals?

- Yes
- No

If so, what?

As noted in the response to question 22, in our experience a major challenge is increasing risk complexity. This appears a little understood and increasingly important aspect of risk.

A productive approach to understanding complexity is to devote far more effort to analysing case studies – of which there are many – and learning from them. A systematic approach to understanding complexity should become a major focus.

While much effort is devoted to risk analysis, often little appears to be done to evaluate its effectiveness and the effectiveness of subsequent actions. Undertaking evaluation allows improvements in assessment methods and understanding actions that are most effective, thereby creating the prospect of improved outcomes.

More specifically when considering infrastructure, an official Resource Centre should be established by the Government or the National Infrastructure Commission to ensure the provision of high quality data and information about resilience actions, including information about actions which investors themselves (and their managers) can do. For example, asset owners could be urged to insist on tests of emergency and evacuation

procedures being carried out every year, to provide extra resilience in serious situations, with results of such simulations made available. Investors could be encouraged to set up consultation processes with local communities to identify further resilience mitigation actions which may be desirable as time goes on, for example additional channels for the dispersal of flood waters near structures. Ways of measuring improvements in assets over a period as a result of further investment or better management could be recommended: one way might be through periodic surveys of users. Guidance could also be given on ways to minimise the likelihood of the project itself causing pollution or other environmental problems, such as increasing the flood risk in neighbouring properties. Tools could be recommended for reporting on such matters as ESG, resilience status, and social aspects, in such a way as to achieve consistency of reporting between investors and hence stimulate laggards to do better. (The [City Resilience Index](#) developed by Arup is an example of such a tool).

GRESB Infrastructure Assessments include a resilience module which has proven useful at both a fund level as well as at the individual project level. A number of other assessment tools exist (IFC's Operating Principles for Impact Management (OPIM), IRIS+ by the Global Impact Investing Network, Standard for Sustainable and Resilient Infrastructure (SURE) etc.); however, the rating agencies should strive for a harmonised way of rating infrastructure. At present, ESG/sustainability/resilience scores do not match up across different agencies.

Resource Centres of this kind have already been established elsewhere in the world, for example in Argentina, Brazil, Europe, the USA (and specifically Silicon Valley), and we should do something similar in the UK, with the aim of making investment in infrastructure as easy as possible for insurance companies and pension funds which do not have their own staff resources to sift out all the information which is available on-line. It would be highly desirable to have a standard set of definitions, which would facilitate analyses of investors' reports as part of an assessment of the general state of resilience of the nation's infrastructure. We understand that work is going on in South Africa to develop agreed definitions of climate finance and impact criteria, based on the Final Report on EU Taxonomy (2020) by the Technical Expert Group on Sustainable Finance, available at [TEG final report on the EU taxonomy \(europa.eu\)](#). The tool is meant to help investors, companies, issuers and project promoters navigate the transition to a low-carbon, resilient and resource-efficient economy. The South African report goes a step further by outlining minimum social safeguards that must be complied with as well (SA labour law and positive social impact) – see: <https://sustainablefinanceinitiative.org.za/taxonomy/>

Perhaps the definition of a green or sustainable economy, as used to develop the taxonomy, could be expanded to include governance (e.g., terrorism financing and cybersecurity) and social sustainability as well. If the UK had a Resource Centre, it would be able to build on this work and issue appropriate guidance.

In view of the great uncertainty that exists regarding resilience risks, and in particular the speed and impacts of climate change, it would be desirable for the UK's proposed Resource Centre to publish a range of possible future climate scenarios for investors to consider, perhaps rationalising the scenarios that are already used in certain areas. For example, the Bank of England (and other central banks) have a set of scenarios for financial firms to use to as a stress test. Providing a consistent set that is also linked to the latest Intergovernmental Panel on Climate Change Assessment Report would greatly help investors. This would provide a greater degree of clarity on the future outlook and would assist them in doing their own risk appraisals for their physical assets, considering both physical and transition risks. At present some scenarios are published by various bodies but there is no single generally accepted basis which investors can use in a consistent way in discussions with other parties.

The Environment Agency's public flood and coastal risk data, maps and online communications are an excellent example of providing information to the public on risk and resilience. However, due to the complexity of this data and funding available, these maps are often out of date and do not always consider new resilience investments such as flood defences. Publicly available coastal erosion risk data is also significantly out of date (the data is from 2012). Given the number of critical national assets on / planned for / dependant on the coastal zone, this may introduce additional risk.

Provision of such risk and resilience assessments on a common framework are likely to be very helpful to potential investors in infrastructure projects. This may stimulate additional interest in infrastructure investment due to the greater understanding of the challenges involved.

25. How could the Government make risk assessment and data more accessible by frontline personnel in an emergency?

26. How does your organisation assess risks around unlikely or extreme events, when there is limited or no data?

There will continue to be a need for infrastructure projects to be prioritised, so that resources are devoted to those which will produce the most worthwhile benefits for society, and private investors will expect that sufficient analyses have been carried out by sponsors to ensure that this happens. Despite all the uncertainties about the future, cost-benefit analyses using risk adjusted discounted cash-flow techniques remain the best tool available for project appraisals, but it is essential that a wide range of possible scenarios should be considered in the model, not just a “most likely case”. The various risk mitigation options which are identified will be fed into each scenario, to see which options are most worthwhile and cost-effective. Where the choice of the best mitigation option differs from one scenario to another, it will be necessary for a judgement to be made on which option to adopt. Prospective investors should be given access to these appraisals on request.

Specialist techniques can be used when studying extreme events. For example:

- The analysis can employ probabilistic techniques in evaluating frequencies, timings and impacts.
- Extreme value theory can be used to take a set of observed extreme events (such as maximum temperatures over the last 100 years) and identify any trends in order to estimate the probability of a given maximum (possibly greater than any experienced in the past) occurring within specified future time periods.
- Sensitivity analysis may be necessary for the key estimates of the probability and impact of each scenario, given the uncertainties.
- Brainstorming by groups of widely experienced people may help in the development of extreme scenarios and events which need to be considered, and in the identification of possible trends in their likelihood and impact.
- In the context of exploring a range of scenarios, not every extreme event will have disastrous consequences, but foreseeable disaster risks should be given special attention and exploration in depth. Given the catastrophic impact if such events occur, it is important to treat estimates of them that have a low probability with caution, because such estimates may well turn out to be wrong when the risks are fully explored. Resilience measures should therefore be adopted for foreseeable disaster risks as far as reasonably possible, even if this involves extra cost.

One of the challenges in project appraisals which aim to take account of social considerations is how to evaluate in financial terms the social effects (both positive and negative) of new infrastructure. There are various ways in which these evaluations can be done, but one systematic approach would be to work from first principles. This would start by considering the expected numbers of people affected significantly by the project's positive and negative impacts and attributing a plausible average financial value for each person. Then adding the results of a similar calculation for the people affected less significantly with a much smaller financial value per person. It would, of course, be necessary to test the result of varying these average financial values to see if the adoption of different values would make any important differences to the results of the appraisal.

Example: A new road will benefit 20,000 people significantly, worth £300 p.a. each to them on average, and 150,000 people slightly, worth £30 p.a. each on average. It will cause severe inconvenience for 1,000 people worth £900 p.a. each on average and moderate inconvenience for 20,000 people worth £100 p.a. each on average. The positive benefits are worth £10.5m per annum and the social costs £2.9m p.a., so the net social benefit is £7.6m p.a. If the value of each benefit figure is reduced by one-third and the value of each social cost is doubled, there is still a net social benefit but it is only £1.2 m p.a.

Similar approaches can be used to place a financial value on the social cost which would be incurred if the asset were to be destroyed or out of service for a significant period. The results may influence decisions about the cost which it is worth incurring to mitigate resilience risks.

27. How could the current local risk assessment process, managed through Local Resilience Forums, be strengthened to help local partners?

Resilience forums are excellent examples of cross sector collaboration. Local Authorities play a key role in these forums and are often responsible for co-ordinating local stakeholders around strategic planning. However, these Local Authorities vary in terms of the resources available, and may need to deploy their limited resources to address other key local challenges (such as deprivation, regeneration etc.) Although funding is made available in emergencies, the resources are often not available to deliver effective cross-sector collaboration and planning around resilience. This is often particularly apparent on the coast, where there are significant assets and risks, but Local Authorities are typically smaller and their limited financial resources are focussed on the challenges facing coastal communities and economies.

Section 2 – Responsibilities and Accountability

28. Do you think that the current division of resilience responsibilities between Central Government, the Devolved Administrations, local government and local responders is correct?

Yes

No

Please explain your answer

There is a distinction between critical national infrastructure and strategically important regional infrastructure. It is important that resilience is considered for both of these, as locally important infrastructure can have critical impacts on significant numbers of people.

There is a challenge defining responsibility for the identification and management of regional / locally important infrastructure, for example linear water, waste/surface water, bridges, etc. There are also hazards posed to local communities from dams, rail, industrial sites and the like. Clearer roles and responsibilities around assessment of the asset risk, recognition of impact on connected assets, responsibility for maintenance and oversight of the area's infrastructure portfolio may help improve the resilience of such networks.

As an example, a lack of clarity around responsibilities in terms of coastal resilience is often reported. There is clarity during emergencies and related planning, but the Environment Agency's 'strategic overview' of the coast is not defined. This is also made challenging by the number and diversity of coastal Local Authorities (and other organisations and partnerships), which will take a variety of approaches around resilience, planning and strategy. More clarity around non-emergency roles is important in the face of climate change and sea level rise.

29. How can the UK Central Government, Devolved Administrations, local and regional forms of government and local responders better collaborate on resilience?

At the regional and sub-regional level, there are challenges with addressing interconnected risk and enabling collaboration with utilities / infrastructure providers. Silo-isation and a lack of joined-up investment remains a challenge. Better frameworks and incentives that enable this collaboration will be crucial as climate change drives multiple risks. Local Enterprise Partnerships have played a key role in this, but other solutions may be required in parallel.

30. What role, if any, should the UK Central Government have in assuring that local areas are effectively carrying out their resilience responsibilities, whilst also respecting local responsibilities?

Local Resilience Forums are effective, but do not always have the capacity to take a long-term strategic approach. Facilitating practical cross-sector collaboration and co-delivery with utilities / infrastructure providers is an example of critical work that is not always deliverable. It is also important that these forums are diverse and representative groups that reflect the communities they are working for and the nature of the environment and assets at risk. More resources / funding and active participation by Government in these groups will help enable and support more effective cross-sector collaboration.

31. The primary legislative basis for emergency management is the Civil Contingencies Act 2004 (CCA). Specific questions on the CCA are covered in Annex A. The UK's resilience also depends on legislation covering specific risk areas including, for example, the Terrorism Act 2000 and the Climate Change Act 2008, amongst others. What do you consider the advantages and disadvantages of the current legislative basis for resilience?

Advantages

The current legislative basis provides clarity over roles and responsibilities for planning and responding to emergencies, which are vital steps in reducing the impact of emergencies as and when they occur.

Disadvantages

However, the current legislative basis does not cover the need to develop resilience in advance of emergencies and hence reduce the likelihood of emergencies arising and/or their subsequent impact. This could be supported by improved evaluation to understand what is working well and what is failing, and requirements for resilience development plans to be produced by infrastructure owners and updated every 5 years.

The current legislative basis is silent on the role of owners, operators and developers of critical national, and regionally important, infrastructure. The effectiveness of the CCA would be enhanced by introducing an obligation critical national, and regionally important, infrastructure providers to demonstrate that they have both considered and addressed resilience in their plans to develop new, and maintain existing, infrastructure.

Section 3 – Partnerships

32. Do you think that the resilience of CNI can be further improved? If so, how?

Yes

No

How could the resilience of CNI be improved?

Due to the impacts of climate change and coastal location of much of the UK's energy infrastructure, CNI is at risk of direct impact of sea level rise and storms. Indirect risks include impacts to local transport infrastructure and utilities, which may be managed by resource constrained local authorities or other public/private organisations. Understanding these interconnected micro and macro risks and those dependent on the resilience of key nodes is crucial. Mechanisms that incentivise cross-sector collaboration (for example funding for infrastructure projects that is only available to public/private partnerships) and joint planning at the sub-regional level could be effective.

We suggest that consideration should be given to setting up a new system of resilience assessments of fixed physical structures throughout the UK. The structure owners, whether public or private, would arrange for the assessments to be made, based on specifications laid down by law. Local Governments would become responsible for ensuring that assessments were made of the resilience and vulnerabilities of the structures in their own geographical areas and for deciding on whether any remedial actions are needed.

Each assessment would specify any impact which the structure's failure might have on other infrastructure within the geographical area, as well as any important uncertainties about the state of the structure. Each assessment would also report on connections (in either direction) with events and infrastructure in other geographical areas; where these connections exist to any significant extent, Central Government and Devolved Governments would decide on any actions necessary, looking at the group of structures concerned as part of an integrated system for providing services in a group of areas.

To spread the work out over a number of years, Central Government would establish a timetable for assessing each kind of structure. Rules would specify when reassessments would have to be made: these rules could vary according to the nature and severity of any vulnerabilities disclosed.

The principles outlined in Articles 4 to 8 of Regulation (EU) 2019/941⁴ are an example of this process applying to electricity supply. This includes an assessment that considers the potential impacts of the loss of one item of infrastructure (N-1) to determine the vulnerability of the infrastructure systems and help identify where further action is required to improve resilience.

Article 10 of the regulation describes a risk-preparedness plan which could also be adopted more widely across infrastructure assets.

33. Do you think the introduction of appropriate statutory resilience standards would improve the security and resilience of CNI operators? Why? How would such standards define the necessary levels of service provision? Are there any risks associated with implementing such standards?

Yes

No

Please explain your answer

Standards would be an added value in order to help push a harmonised approach to resilience at a systemic level.

How would possible statutory resilience standards define the necessary levels of service provision?

What are the risks (if any) of implementing statutory resilience standards?

Standards need to be considered carefully, as standards hold the specific issue of becoming easily obsolete in a fast-changing practice environment (such as the one of resilience); and create a sense of "static rule" that would be counterproductive to resilience - which requires an agile operational environment and a certain level of innovation.

There is also a risk of inapplicability or inability to comply with standards across a broad spectrum of CNI owners/operators/supply chains if standards are overly specific or prescriptive.

Any standards should require CNI operators to publish at least every 5 years their plans to improve resilience, identifying any investment required, and Government should have a duty to publish its response to those plans.

34. What do you think is the most effective way to test and assure the resilience of CNI?

Full scale ("real" rather than virtual simulation-based) stress tests have proven extremely insightful in California and New Zealand for example. Virtual simulations are also very helpful complementarily to test a wider range of scenarios. CNI operators should also periodically commission resilience studies involving external experts, to envisage a wide range of possible future scenarios and the resulting vulnerabilities, and any action required.

⁴ <https://www.legislation.gov.uk/eur/2019/941/contents>

35. To what extent do you think regulators should play a role in testing the resilience of CNI systems and operators?

- No role
- A limited role
- A substantial role

Please explain your answer

Resilience of critical national, and regionally important, infrastructure would be enhanced by periodic independent inspection and reporting like the system applied under the 1975 Reservoir Act⁵.

36. During an emergency, what do you think should be the role of the operators of CNI in ensuring continued provision of essential services (e.g. water, electricity, public transport)?

37. How can the Government support CNI owners or operators during an emergency?

Government can support CNI owners or operators through provision of clear and consistent roles and responsibilities and supply chain priorities, and the facilitation of communication between interdependent CNIs and supporting organisations.

Criteria of emergency response service delivery performance could be also set out by the government and regulations of prices in times of crises to help society recover could also be envisaged.

The Government should also undertake advance planning of possible supply chain shortages for CNI and ensure the maintenance in the UK of sufficient stocks of critical supplies to last for at least 2 months. The Government should plan in advance for the distribution of these supplies in various circumstances including widespread disruption to transport networks. There should be contingency planning of where critical supplies can be obtained if stocks run out, and contracts need to be in place in advance (including international contracts) to ensure that these supplies will flow in a timely way if necessary. In cases where there is doubt about the ability to obtain timely flows of supplies, there should be advance planning about the possibility of substituting supplies of other products or services. Government planning should also consider the possibility of workforce shortages in an emergency and plans should be drawn up in advance for augmenting the available workforce, for example by retraining, by bringing back retired people, or by using the army. Planning also needs to prepare each system of CNI for the possibility of increased demand if other systems of CNI are out of action for an extended period.

38. What role, if any, does your business or sector play in national resilience?

39. What are the risks that your business or organisation is most concerned about?

⁵ [Reservoir owner and operator guidance: inspection information pack - GOV.UK \(www.gov.uk\)](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/342222/Reservoir-owner-and-operator-guidance-inspection-information-pack-GOV.UK.pdf)

40. What information, tools or guidance could the Government provide to help your business better assess or prepare for these types of risk?

41. What is your business' approach to building resilience in any key supply chains that your business is part of?

42. How useful have vehicles such as Local Enterprise Partnerships, Growth Hubs and other local business support services been strengthening your organisations' resilience? Why?

- Not at all useful
- Somewhat useful
- Very useful

Please explain your answer

LEP funding has played a crucial role for funding coastal CNI projects that deliver wider economic and infrastructure resilience benefits, but which attract a relatively low score using the Defra funding calculator. Examples include the recently completed Bacton Gas Terminal sandscaping scheme in North Norfolk, and the Lowestoft Tidal Barrier flood risk management project.

43. What can the Government do to make collaboration between academic and research organisations more effective?

Incentivising the formation of cross sector partnerships with delivery bodies and stipulating the delivery of tangible outcomes in funding criteria can be an effective mechanism. The Environment Agency's Innovative Resilience Programme has utilised this model to pilot new resilience interventions on the ground.

44. Are there areas where the role of research in building national resilience can be expanded?

Depending on the outcomes from the DAFNI programme, better data is needed on interconnected and coastal risks (such as sea level rise) and how this will impact CNI and utilities networks (currently data is focussed on direct residential property directs, with less focus on systemic risks). Typically, the most useful data are held within private companies or proprietary data sets (such as those used by insurers). This is understandable given the commercial sensitivities and security risks, but research around how less sensitive data can be better shared to improve understanding of systemic and interconnected risk would enable better strategic planning and more effective infrastructure investments.

Three areas which may benefit from further research are:

- The combined risk from primary and consequential hazards or threats to CNI (The State of The Nation - Defending the Critical Infrastructure⁶ (ICE) provides the Atomic Weapons Establishment as an example)
- Concurrent or compounded threats to interconnected systems or supply chains, which increase the net vulnerability of CNIs, and the speed of recovery

⁶ https://www.ice.org.uk/getattachment/media-and-policy/policy/state-of-the-nation-critical-infrastructure-2009/SoN_DCireport_final_web.pdf.aspx

- Studies of actions in other countries to improve the resilience of their own infrastructure, identifying possible applications in the UK.

Section 4 – Community

45. Do you agree that everyone has a part to play in improving the UK's resilience? If not, why not?

Yes

No

If not, why?

46. Do you understand the types of emergencies that might impact you and other members of your community?

Yes

No

Unsure

47. What would help you better understand the risks that could affect your community?

48. Do you know where to access information about emergencies that could affect you?

Yes

No

Unsure

49. Have you considered the actions you might take to prepare for or during an emergency?

Yes

No

50. What has motivated you to plan or make preparations?

51. What has stopped you from planning or making preparations?

52. What would help you to be able to make a plan or prepare?

53. Have recent emergencies (e.g. COVID-19 pandemic, flooding, terrorist attacks) made you think differently about risks or changed the way you prepare for emergencies?

Yes

No

54. Are there any barriers in accessing local volunteering schemes or finding community groups that discuss local emergency planning? If so, what are the barriers?

- Yes
- No
- Unsure

If yes, what are the barriers?

Section 5 – Investment

55. How does your organisation invest in your approach to the risks outlined in this document? Is your investment focussed on particular stages of the risk lifecycle (for example, on prevention)?

Since infrastructure assets may be expected to be in service for many years, it is important for all concerned to understand the timescale of the identified resilience risks. Where the likelihood of occurrence of significant risk events or scenarios might be expected to increase as time goes on, an adaptive pathway could be adopted, under which only partial mitigation would be adopted initially, with the aim of taking further mitigation actions if and when the resilience risks are deemed to have increased. This approach has the great advantage of avoiding expense which might turn out to have been wasted if the likelihood of occurrence does not in the event increase or if technological innovations elsewhere shorten the asset's useful working life. Where an adaptive pathway is adopted, the design of the asset must be such as to keep the expense and disruption of the additional mitigation measures, if eventually needed, to a minimum. Moreover, there must be clarity in any contract between the sponsor and investors about which party will decide on whether and when to adopt the additional mitigation measures and which party or parties will bear the cost. Actuaries have developed techniques for developing and analysing appraisals of adaptive pathways for infrastructure projects – see details at

<https://www.actuaries.org.uk/documents/resilience-infrastructure-policy-briefing>

<https://www.actuaries.org.uk/documents/resilience-assessment-methodology>

Climate adaptation in response to flood and coastal risks is an area that is receiving increased attention and investment. However, maintenance of infrastructure assets (including those that CNI is reliant on such as coastal defences and transport) is typically underfunded. This is due in part to a focus on new larger capital investment programmes, but a reduction in real terms of revenue maintenance budgets. With much of our CNI reliant on post-war or even Victorian infrastructure, this poses a growing risk as they are put under additional pressure due to climate change, such as heat stress and high surface water run-off in our cities for example.

56. Has the COVID-19 pandemic impacted the way your organisation is investing, or will invest, in preparing for these risks?

- Yes
 - No
- If so, how?

57. Are there models of successful resilience investment? If so, to what extent could they be adopted in the UK?

The G20 Action Plan on Covid-19 Efforts promotes quality infrastructure investment as essential for the recovery and for post-recovery resilience. The proposals in that report aim to guide governments in their response to the pandemic by mobilising higher levels of investment in sustainable infrastructure for faster recovery, better resiliency and long-term preparedness for the future. As an example, Covid-19 clearly showed challenges to healthcare capacities, aged care

facilities etc. These social infrastructure assets are critical for building societal resilience, and are often overlooked compared to the mega infrastructure projects such as energy and transportation.

Both economic and social infrastructure are necessary to many people's well-being. Economic infrastructure includes transport systems, power generation and distribution, water purification and distribution, telecommunications, commercial buildings (such as shops, offices and warehouses) and other income-generating facilities. Social infrastructure includes hospitals, schools, parks, cycle lanes, flood protection schemes, community centres and many other facilities requiring capital investment which meet people's needs but do not generally produce an income. Up to now there has been a tendency to regard economic infrastructure as the more important of the two, but there is starting to be increasing recognition of the importance of social infrastructure too. Both economic and social infrastructure need to be of good quality and resilient, particularly because of climate change.

Private investors can play a part in the development of economic infrastructure because an appropriate share of the income can pass to them to provide a return on their share of the investment: both the public sector and private investors have an incentive to work together to provide a suitable degree of asset resilience. In the case of social infrastructure it may sometimes be possible for public authorities to provide a guaranteed sustainable income for private investors, for example to pay a rent for buildings which the private investors have constructed (though the public authorities must be careful not to take on unaffordable financial commitments extending over many years as has sometimes occurred in the case of hospital trusts); here too the public and private sectors have an incentive to work together on resilience. In other cases, the lack of an income means that the whole financial burden of creating resilience for the services in question falls on the public authorities and the voluntary sector, and financial pressures often occur which mean that the financial support is withdrawn. This can have severe adverse consequences for users of those services.

Resilience should not only mean the robustness of the structure of an infrastructure asset, important though that is. A broader definition of resilience is that of "a sustainable integrated infrastructure system, which supports social and community needs both in normal times and in times of crisis." It is important to ensure that when one asset structure fails it does not take down the whole system. In future good infrastructure systems are likely to be made up of smaller, interconnected economic assets combined with social infrastructure.

Where an infrastructure system includes an income-generating asset in which the private sector invests, it might be possible in future to provide in the contract that a defined proportion of that part of the income which accrues to the private sector should be entirely devoted by the investor or concessionaire to the maintenance and development of the social infrastructure in that system. It would, of course, be necessary to specify a level of income for the investor which would provide the target rate of return he is seeking. For example, if this target could be achieved for the investor by sharing the project's income so that 50% goes to the public sector and 50% to the private sector, it might be possible to change the balance so that 45% goes to the public sector and 55% to the private sector, with a contractual "social infrastructure obligation" on the private investor to use his extra 5% exclusively for the maintenance and development of the community's social infrastructure. This would "safeguard" the 5% in a way which would not be possible if it remained subject to the emerging and variable financial pressures of the public sector.

It is important also to make more use of existing physical assets which are becoming "tired" or under-used. The refitting and/or repurposing of existing real estate can provide climate resilience, environmental benefits and improvements to biodiversity and human well-being. Much of this work could be done by the asset owners in the short-term, over the next few years, using private sector finance. Private investors and owners of real estate could be encouraged by local authorities to review their assets to see whether refitting or repurposing would be appropriate. The investment for such purposes can sometimes be justified in terms of the increased rent which is obtainable, but where the sums do not add up, a local authority could provide an additional income stream or relief from business rates in order to enable the work to go ahead.

More attention needs to be paid to natural infrastructure. In urban areas this includes rivers, parks, green roofs, sustainable drainage systems, street trees, roads, pathways, cycle paths, allotments, etc. Paying for the maintenance and development of natural infrastructure and ecosystem services would be one way in which any "social infrastructure obligation" placed on concessionaires or investors (see above) could be discharged. If a comprehensive system of information about natural infrastructure at local levels can be developed – as in the Netherlands – this would help asset owners to come forward with schemes for improvement, and would enable their achievements to be monitored and compared with others. Public authorities also need to play a part, for example by fining more severely those who pollute the waterways or dump rubbish.

Thus, it is possible to glimpse a future where the public and private sectors work together to improve the resilience of both economic and social infrastructure within an integrated infrastructure system.

Affording the cost of resilience

Each case will be different, but typically the introduction of greater resilience may have a significant cost. There will be a need to identify whether greater resilience is really necessary, if it could make the project too expensive to go ahead. One way of proceeding might be to adopt an “adaptive pathway” approach (see response to question 55). Alternatively, it could be decided to proceed regardless of the resilience risk, provided there are adequate back-up systems from other infrastructure if the worst happens (such as in the case of a new school or hospital). A third approach could be to consider whether there might be some entirely different ways of providing the service required by users, in more flexible ways which would allow easy and quick reconstruction or replacement if the original asset is put out of action – for example, in the recent pandemic it was found that online conferencing could largely replace commuting by road and rail. It might sometimes be possible for the costs of minor resilience measures to be met from grants from various sources, from local lotteries, from organised activities taking place adjacent to the asset, or from crowd funding,

Public-private partnerships

We believe that increased co-operation between infrastructure sponsors and investors, in public-private partnerships, will help to stimulate the achievement of greater resilience in individual projects, by tapping the ingenuity of commercially-minded managers who will bring forward new ideas combined with highly practical approaches to implementation. These ideas and practical approaches will include a focus on social infrastructure. We hope that new forms of partnership between the public and private sectors will emerge, and have put forward one idea for achieving greater co-operation in a way which will meet the needs of both parties; see

<https://www.actuaries.org.uk/system/files/field/document/InfrastructurePrivateFinanceCGL19February2021v2%20%28002%29.pdf>

Too many infrastructure projects have failed as a result of poor financial resilience and debt sustainability. Historically, advisors and investment banks (with their inherent motives) have set the parameters for debt and equity levels. Perhaps a better model would be for governments to prescribe the required levels of debt and equity finance. For example, in Spain, the government limits the debt on new infrastructure projects to 80%. An alternative option would be for governments to set a basis for stress-testing potential capital structures and project assumptions.

Governance

A useful report from the World Bank in 2019 (*Lifelines – the Resilient Infrastructure Opportunity*) contains many examples of resilience issues and their causes. It concludes that there need to be regulations and incentives for resilience, to encourage it to happen in practice (Chapter 11, pages 163-172). Studies should be made into how the UK can provide more incentives for achieving appropriate degrees of resilience, for both existing infrastructure and new projects.

[Lifelines : The Resilient Infrastructure Opportunity \(worldbank.org\)](#)

[Major Infrastructure Projects – Key Front-end Issues, at ICE Front End Issues Web Version.pdf \(actuaries.org.uk\)](#) .

Growing numbers of investors may wish to be satisfied that project sponsors have carried out such a process and that it has included a full assessment of the infrastructure’s flexibility, adaptability and resilience to cope with changing future conditions.

We would encourage the Government to review and strengthen the whole system of governance and resilience incentives in the UK.

58. Are there examples of where investment (whether by the Government, by businesses or by individuals) has driven improvements in resilience?

There are several recent investments that have utilised a blend of private investment/ contributions with LEP investment plus multi-Government department and Local Authority funding to improve investments. These include:

- The largely privately funded Bacton Gas Terminal sandscaping scheme to help secure 25-30% of the UK gas supply plus deliver wider regional infrastructure benefits.
- The Lowestoft tidal barrier flood risk management scheme, that will deliver a flood resilience project in a privately owned port while it remains operational, supporting the offshore energy operations and enabling other

government investments to be resilient (such as major transport and regeneration projects), protecting jobs and supporting the creation of additional employment and economic growth.

Section 6 – Resilience in an interconnected world

59. Where do you see the UK's resilience strengths?

Water companies

Water Companies have been very proactive in responding to the need for resilience within the Water Industry. High level strategic planning for resilience is managed through planning within the Water Resources Management Plans (WRMPs), the equivalent Drainage Waste Management Plans (DWMPs), and through the company Business Plans submitted at Price Reviews. Water companies are also mandated through legislation as well as through specific deliverables through the Water Industry National Environment Programme (WINEP).

A significant focus around Resilience and Water Resource Planning has been the Strategic Regional Water Resources Solutions – SRO programme managed through RAPID - Regulators' Alliance for Progressing Infrastructure Development (RAPID). RAPID being the collaboration of Ofwat, Environment Agency and the Drinking Water Inspectorate. RAPID was setup in response to recognising the increasing pressures on water as a resource and the need for a collaborative, integrated approach to develop the national water resources infrastructure. The SRO programme has formed a significant focus recently for Water Companies and has been a focus of the PR19 and green recovery plans submitted to Ofwat.

Resilience is a significant focus not just for Water Resources but as part of the need to protect critical infrastructure and establishing sustainable solutions to the wastewater sector as well. Water companies have been focussing more and more on resilience through AMP7 and leading into AMP8, from the need to looking at catchment management focused, blue green solutions to resource management through to ensuring assets of critical national importance are protected.

Reservoirs

In response to the Toddbrook Reservoir Safety Incident in 2019, a Defra commissioned report by Professor David Balmforth made several recommendations on improvement in best practice of the management and supervising of water reservoirs in the UK.

In 2020, the Environment Agency brought together the Toddbrook Actions Support Team, whose collective responsibility was the implementation of the recommendations of part A of Professor Balmforth's review. The team is comprised of 4 engineers and project managers from across the UK civil engineering industry.

The team has worked on the development of a total of 7 deliverables, developed with the support and assistance of the EA and subject matter experts. These 7 deliverables have the overall aim of improving best practice on UK reservoirs, specifically in areas ranging from dam spillway inspection to the development of documentation as part of duties under the Reservoirs act 1975.

The seven deliverables are:

- A guide to reservoir spillway design.
- A guide to reservoir spillway examination.
- A research paper on reservoir spillway failure mechanisms.
- Guidance on a well-structured package of information to be made available for reservoir inspections.
- Guidance to inspecting engineers.
- Guidance to supervising engineers.
- Guidance to reservoir owners.

The first deliverable on guidance to reservoir owners on a package of information to make available for statutory inspections was published on gov.uk in July 2021. It can be viewed here:

[Reservoir owner and operator guidance: inspection information pack - GOV.UK \(www.gov.uk\)](https://www.gov.uk/guidance/reservoir-owner-and-operator-guidance-inspection-information-pack)

The remaining guidance documents are scheduled for publications at various times between now and spring 2022.

This guidance could also form the basis for establishing the best practice principles more broadly for all owners of CNI.

60. Are there any approaches taken by other countries to resilience that you think the UK could learn from?

Several examples are mentioned in the preceding responses of approaches taken internationally which might be applicable in the UK. There are more examples and studies described by the Coalition for Disaster Resilient Infrastructure⁷. Whilst this is still in the early stages, only forming in late 2019, this may provide a useful resource for ongoing improvements in the approach to resilience. Further examples have been reported by our members:

A. An adaptive pathway. In an area of Assam, India, which is liable to flooding every year it was decided to reconstruct the dwellings as stilt houses built in bamboo. A flexible joinery system allows the homeowners to shift the floor higher in case of overflowing. <https://www.designboom.com/architecture/seeds-disaster-resilient-bamboo-housing-assam-india-10-07-2019/>

B. Designing for resilience. In South Africa an Environmental Impact Assessment conducted ahead of the expansion of the port in Durban resulted in changes to the originally proposed design, to make the port higher to cope with rising sea levels, and the development of an environmental management plan to address heavier rainfall and winds. A similar assessment ahead of building the Cape Town Stadium in 2010 resulted in the identification of noise mitigation measures which were incorporated into the design.

C. Designing for resilience – evaluating benefits and costs. The Colombian port Muelles el Bosque in Cartagena is at risk of sea level rise which would lead to flooding of the causeway that links the island where ships berth to the mainland areas of the port. Flooding disrupts movements of goods and the port cannot operate when the causeway is flooded. Depending on the rate of sea level rise, this could cost the port between 3 and 7 percent of its net income by 2030, or up to \$2 million. The costs of adapting to sea level rise are significantly lower. In the case of this Colombian port, raising the causeway by a recommended 20cm would cost approximately \$380,000. <https://library.pppknowledge.org/PPIAF/documents/2874/download>

D. Sharing the cost of resilience. The costs of resilience risks have sometimes been shared between the public and private sectors. In 2016, Washington DC Water and Sewer Authority (DC Water) issued an Environmental Impact Bond (EIB) to finance nature-based storm water infrastructure. The EIB is a 30-year tax-exempt municipal bond, which will allow DC Water to pay interest near its municipal rate. In addition, the EIB structure provides investors with a financial premium if the project outperforms its target, and it provides DC Water with a corresponding financial risk share payment if the project underperforms. The structure allows DC Water to pilot the cost-effectiveness of nature-based solutions for urban flood management.

⁷ <https://www.cdri.world/>

Source: (OECD 2018, Climate-resilient Infrastructure, p.33

<https://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf>)

E. Ecological resilience solutions. Ecosystem-based Adaptation encourages the use of ecological infrastructure as a complement or substitute for built infrastructure. It includes healthy mountain catchments, rivers, wetlands, coastal dunes and nodes and corridors of natural habitat, which together form a network of interconnected structural elements in the landscape. A very useful OECD paper appears at [policy-perspectives-climate-resilient-infrastructure.pdf \(oecd.org\)](https://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf). This gives examples from many different countries, some of which would be applicable in the UK. For example, instead of building costly flood protection barriers for a town through which a river flows, it might be possible to divert the river upstream so that it floods fields instead, at a lower capital cost.

61. Which of the UK's international relationships and programmes do you think are most important to the UK's resilience?

62. What international risks have the greatest impact on UK resilience?

Supplies of goods and services – risks to availability and price. Workforce – inability to recruit workers from overseas because of visa restrictions. Importation of diseases and variants which reduce workforce availability. Cyber attacks, war, and imported terrorism and sabotage.

63. How can the UK encourage international partners to build resilience to global risks?

Develop international agreements to provide mutual assistance when crises occur.

Annex – Civil Contingencies Act

64. Does the definition below reflect your understanding of an emergency, and if not how does the definition need to be expanded within the CCA?

- Yes
- No

65. Is the current designation of Category 1 and 2 responders appropriate? If not, what would be the merits of changing the identities and/or status of responders within the CCA?

- Yes
- No

66. Are there gaps in critical representation of responder organisations?

- Yes
- No

67. Should elected local figures (e.g. Council Leaders, MPs, Metro Mayors, Police and Crime Commissioners) have greater involvement in emergency planning and preparative exercising, response and recovery and in what way?

- Yes
- No

68. Are the current duties on Category 1 and 2 responders, as described in the CCA, appropriate? If not, please list the duties which should be added, adjusted or removed.

- Yes
- No

Duties to be added

Duties to be adjusted

Duties to be removed

69. Does the framework set out in the CCA provide sufficient clarity of the different roles and responsibilities of Category 1 and 2 responders?

- Yes
- No

70. If the answer to the above question is no, how could this be made clearer within the CCA?

71. There are currently no provisions for collective oversight and assurance of resilience organisations within the CCA as they are reviewed by independent or organisational audit regimes. Are existing mechanisms for oversight and assurance of organisations involved in resilience adequate?

- Yes
- No

72. If the answer to the above question is no, please explain why this is the case, providing evidence to support where possible.

73. Should the CCA mandate review of local contingency plans covering a range of risk scenarios?

- Yes

No

74. If you answered yes to the question above, please rank the options below based on which you think would be most appropriate. For other options, please add to the text box below.

Peer review
Independent review
Lead Government Department review

75. Do the arrangements as set out in the CCA provide the LRF Chair and Secretariat with sufficient means by which they can effectively coordinate contingency planning of Category 1 and 2 responders in their area?

Yes
 No

76. Enforcement remains an option under the CCA but would only be used as a last resort. We expect all public bodies and local responders to meet the highest standards in performing their duty and these standards are routinely upheld by their own organisational rules and processes. A Minister of the Crown may use High Court or Court of Session proceedings to enforce duties under Part 1 of the CCA upon a Category 1 or 2 responder. Is this the right way to enforce obligations under the CCA if duties are not met?

Yes
 No

77. Does the CCA sufficiently consider recovery arrangements? If not, how could this be improved?

Yes
 No

78. Are the responsibilities related to information sharing and cooperation sufficient for ensuring an effective multi-agency response?

Yes
 No

79. How could we improve the effectiveness of LRFs (non-legislatively)?

80. Are LRFs/Strategic Coordinating Groups (SCGs) fulfilling a sufficient role in terms of planning, response and recovery? If not, what are the barriers to this?

- Yes
- No

81. Should specific duties be placed upon central government in Part 1 of the CCA, and if so, what would these be?

- Yes
- No

82. Would you like to note anything in regards to Part 1 of the CCA that is not captured by the questions above?

83. Scotland, Wales and Northern Ireland: The CCA applies to the whole of the UK, but with some variations for Scotland, Wales and Northern Ireland. Part 1 is applicable to the equivalent organisations in Scotland and Wales, but applies only to a limited number of organisations in Northern Ireland. The CCA extends to Scotland, Wales and Northern Ireland in accordance with their devolution settlements and civil contingency arrangements. Are the responsibilities and duties set out in the CCA fit for purpose for Northern Ireland?

- Yes
- No

84. Are the responsibilities and duties set out in the CCA fit for purpose for Scotland?

- Yes
- No

85. Are the responsibilities and duties set out in the CCA fit for purpose for Wales?

- Yes
- No

Annex – Civil Contingencies Act Part 2 & Statutory Guidance

86. The CCA sets out strict conditions which must be met for emergency regulation to be made - this is known as the 'triple lock'.

Are these conditions still appropriate and, if not, how could the 'triple lock' be improved?

- Yes
- No

87. Should the regional coordinator role be retained? If yes, why is this the case, and who should be eligible to fill the position?

- Yes
- No

88. Would you like to note anything in regards to Part 2 of the CCA that is not captured by the questions above?

89. The following questions are on the Statutory Guidance which accompanies the Civil Contingencies Act 2004 ('CCA'). Are there institutions and positions that have come into existence after this CCA was developed which should be included in the statutory guidance? For example, Police and Crime Commissioners and Combined Authority Mayors ('Metro Mayors').

- Yes
- No

90. Would you like to note anything in regards to the statutory guidance of the CCA?

- Yes
- No