



# Climate Resilience and Extreme Events

*Recommendations for building a  
resilient society*

**CIWEM**

106-109 Saffron Hill

London EC1N8QS

Charity registration No 1043409 (England and Wales)

SC038212 Scotland

[www.ciwem.org](http://www.ciwem.org)

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***CIWEM is the leading independent Chartered professional body for water and environmental professionals, promoting excellence within the sector.***







# 1. Summary

Awareness of climate change amongst the public and the desire for strong, collective action has never been higher. Coverage of the recent Extinction Rebellion protests and the “Greta Thunberg effect” has further increased public awareness of climate change. The risks caused by climate change are increasing and extreme weather events are becoming more frequent in the UK, resulting in considerable economic impacts. 2016 was the warmest year on record<sup>1</sup>. Record precipitation fell across England in December 2015. 2017 was the hottest year globally without El Niño since global records began<sup>2</sup>.

Recent efforts have focused most overtly on reducing greenhouse gas emissions to reduce warming. However, emissions to date mean that we are committed to future climate change regardless of the success of any mitigation efforts. We must prepare society to become resilient to the risks of a changing climate and more frequent extreme weather events. In certain places we must adapt land use practice, developments and behaviours to the changes, such as sea level rise, which will come.

Environment Agency Chair, Emma Howard-Boyd said in June 2019: *“Adaptation and resilience are the poorer cousins of climate change mitigation at the moment”*<sup>3</sup>. Chief Executive Sir James Bevan commented that without adaptation, *“one day the sea will come over the wall and a lot of people will die”* and the UK must plan for a *“different future”*<sup>4</sup>. The Committee on Climate Change has advised that *“The Government must raise the profile, and ramp up resources for adaptation.”*<sup>5</sup>

The UK Government has committed to achieving net zero emissions by 2050 through an amendment to the Climate Change Act which was passed on 26<sup>th</sup> June 2019. The Act is the legal instrument driving climate change action in the UK, and it sets out clear drivers for phased decarbonisation. However, it is far more ambiguous regarding adaptation and resilience.

The UK Climate Projections<sup>6</sup> have calculated that we face between 70cm (for a low emissions scenario) and 115cm (under high emissions) of sea level rise in London by 2100. It also advises significantly increased risk of flood, heat, drought and storminess. As a densely populated island with considerable historic infrastructure and development which was not designed to cope with such change, we must adapt our homes, our infrastructure and our approaches to future development. We must improve how we respond to events so that we can cope with such changes – developing our resilience. And we must do it more quickly than we are now<sup>7</sup>.

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<sup>1</sup> Committee on Climate Change(CCC). [Progress in preparing for climate change – 2017 Report to Parliament](#). 2017.

<sup>2</sup> Met Office. [2017: Warmest year on record without El Niño](#). January 2018.

<sup>3</sup> Flood and Coast Conference, 19 June 2019.

<sup>4</sup> Flood and Coast Conference, 18 June 2019.

<sup>5</sup> CCC. [Progress in preparing for climate change – 2019 Progress Report to Parliament](#). July 2019

<sup>6</sup> Met Office. [UKCP18 Fact sheets](#). 2018

<sup>7</sup> Environment Agency. [Climate change impacts and adaptation](#). November 2018

Much as there is clear consensus that we face no choice over whether we must decarbonise our economies, so our climate is changing and will continue to change. We will have to adapt. We can choose to do so in a planned manner to minimise the unfavourable impacts, or simply react as extreme events unfold. We must not lose sight of the importance of adaptation in the focus to achieve net zero. If we reach the ambitious target of keeping global heating to below 2°C above pre-industrial levels, this would still mean significant changes to our climate.

This picture is set out in the UK's Climate Change Risk Assessment (CCRA), which the government is required to present to Parliament every 5 years, and which is informed by the Committee on Climate Change. The last CCRA was published in 2017 and recognised such risks. Yet its programme for addressing the risks, the National Adaptation Programme, is inadequate as a mechanism to drive forward concerted adaptation in a strategic way<sup>8</sup>.

### Three urgent actions in the face of the climate emergency

1. We must **reduce our carbon emissions to slow the warming of our planet** (mitigation). Human civilisation has blossomed during a period of benign and static global temperatures, the bounds of which we have now stepped outside and are rapidly moving beyond. This is placing stresses on the systems which have supported this development of our civilisation.
2. We must **build our resilience to the shocks which are occurring**, and which will increase as the incidence and intensity of extreme events increase. **Resilience** may be defined as *"The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation."*<sup>i</sup>
3. We must **adapt to longer-term changes in our environment** brought about by climate change, recognising that we cannot protect or build resilience to an acceptable level against all impacts. For example, impacts such as sea level rise will mean that over the course of the next century and beyond, some coastal communities will become unviable in their current locations due to the impacts of erosion or frequent flooding. **Adaptation** may be defined as *"The process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities."*<sup>ii</sup>

<sup>i</sup> Intergovernmental Panel on Climate Change. Special Report: Global Warming of 1.5°C Glossary. 2018.

<sup>ii</sup> Intergovernmental Panel on Climate Change. Special Report: Global Warming of 1.5°C Glossary. 2018.

<sup>8</sup> Committee on Climate Change. [The new National Adaptation Programme: Hit or miss?](#) July 2018

Whilst we have a certain luxury in having time to take a planned approach to adaptation, we must begin to do so concertedly, now. We must ground our thinking and approaches in the fact that we are in a new era of rapid change, the like of which humanity has never experienced before. The associated social, economic and environmental issues mean that we will need to redesign and change much of our infrastructure and our approaches to development. We must be far-sighted; long-term in our thinking and short-term in our implementation.

The Chartered Institution of Water and Environmental Management (CIWEM) is the leading royal chartered professional body dedicated to sustainable management of the environment, globally.

With experts in managing water resources and drought, flood and coastal erosion risk, the urban environment, major infrastructure, land use and nature, CIWEM is ideally placed to convene the range of skilled practitioners and experts necessary to address the challenges faced by our changing climate. Practitioners<sup>9</sup> have described a 'resilience dividend' which can range from £5-12 for every £1 invested, for businesses, cities or even nations who effectively plan for resilience.

Appended to this document is a summary of presentations and discussion held in spring 2019 at the CIWEM conference Climate Resilience and Extreme Incidents, illustrating the range of adaptation and resilience challenges and the approaches that different bodies and infrastructure providers are taking to address these. It should be noted that presentation summaries are provided by CIWEM and not transcripts or abstracts provided by the speakers.

This conference identified that there are considerable opportunities to improve approaches across the UK. Adaptation is a devolved matter and there is scope to learn from the way in which devolved nations are approaching the challenge. It also illustrated that adapting to climate change, and building resilience is complex and requires a prioritised, strategic approach which is SMART (specific, measurable, achievable, relevant and time-bound).

It also found that there is considerable work going on across a range of sectors but there would be significant benefits to be achieved in greater coordination, investment and strategic planning through a government-led multi-sector approach.

Adaptation is the responsibility of Defra and its agencies, but many resilience priorities, such as housing and infrastructure, are outside of Defra's control. Challenges also remain in incentivising private sector investment in resilience measures when returns are considered to lie in the medium to long-term.

Delegates and speakers were asked to consider three overarching questions throughout the conference: What would a well-adapted, resilient society look like? How do we make that happen? And are the mechanisms currently in place (such as the Climate Change Act and the National Adaptation Programme) adequate to deliver this resilient society? If not, what should be put in place?

The recurring themes in the responses canvassed can be summarised as follows:

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<sup>9</sup> Mott Macdonald. [Resilient Cities](#). 2017

## **a) What would a well-adapted, resilient society look like?**

A well-adapted and resilient society would be well-informed and engaged with climate change. Individuals would be aware; with a clear understanding of the main risks they face and what *they* can do about them (e.g. where to get help and when). They would understand how to use resources wisely or access resilience measures and products (e.g. Property Flood Resilience).

Society at large would understand that it is not possible to protect against all extreme events such as flood, drought, storm or heat waves, but that there are many actions that can be taken, both individually and collectively, to prepare for them and respond quickly.

There would be coherent and cohesive resilience strategies at both national and local levels, providing a framework for cross-sectoral action. Whilst extreme events would be better understood, a lack of detailed understanding of extremes would not preclude action where the consequences of not acting introduced significant risk to human life or of economic impact.

Extreme events should be anticipated and prepared for. There would be long-term investment in assets, planning and regulation, emergency response and recovery. There would be effective collaboration across different sectors to achieve common goals, for example between Lead Local Flood Authorities, Water and Sewerage Companies and Government working together towards flood resilience.

## **b) How do we make that happen?**

Education and information are crucial to building a climate resilient society. We should develop a central advice repository focused on risks and practical actions, aimed at individuals and SMEs particularly. Promotion of exemplar sites and communities, their experiences and the benefits they achieve, would be an important element of the dialogue.

Social contracts that are fair, which deliver for all communities and are based around proactive community engagement must be developed. This is essential in order to bring communities with decision makers and demonstrate shared responsibility. Approaches and language should not be top-down and paternalistic, but genuinely involving and supportive.

We should implement tested recovery and emergency response plans and encourage greater strategic co-ordination of approaches, responsibilities and actions. We must look to international experience and learn lessons from locations that already frequently experience the conditions that UK society will see in the future.



**c) Are the mechanisms currently in place (such as the Climate Change Act and the National Adaptation Programme) adequate to deliver this resilient society? If not, what should be put in place?**

After 10 years of the Climate Change Act, adaptation and resilience is still not being delivered or prepared for extensively enough and the most recent National Adaptation Programme (NAP) falls far short of what is needed. Whilst the Climate Change Act is rightly upheld as a best practice example of national climate legislation, it does not deal well enough with adaptation and resilience; it is almost entirely mitigation focused.

The NAP should be a more active, dynamic programme, and resilience and adaptation reporting should be required far more widely. The mechanisms which do drive reporting are lacking in full coverage of risks, and there is no clear monitoring and evaluation of progress. We need a considerable increase in the level of ambition, scope, and action.



## 2. Discussion and recommendations

Climate change is now widely recognised as the biggest issue of our time and poses enormous risk to humans and biodiversity. Direct action by striking school children and Extinction Rebellion have resulted in the UK's parliaments each declaring climate emergencies, alongside a swathe of councils and organisations. The UK Government has responded by committing to a net zero emissions target of 2050.

In Autumn 2018, the Intergovernmental Panel on Climate Change's (IPCC) Special Report<sup>10</sup> warned that by 2030 global greenhouse gas emissions should be on a sharp downward trajectory to meet net zero emissions by the 2050s. If this is not achieved, it is very likely that global mean temperature change will increase to over 2.0°C above pre-industrial levels. Even if the Paris Agreement target of limiting global temperature rise to below 1.5°C is met, the incidents and severity of extreme events will increase from today's levels.

However, the current focus and action on emissions reduction, whilst hugely welcome, risk distracting attention from the fact that adaptation and resilience measures are essential even with ambitious decarbonisation. It is essential that the new political appreciation of the urgency of action on climate change extends to acting on resilience and adaptation, as we are already locked into considerable change which will have far reaching implications for our economy, society and environment.

Climate change is unusual in the context of other natural hazards, as we have clear visibility that it will happen. Even if we do not know exactly how much (because the pace and extent of decarbonisation are yet to bear out), we know what the lower bounds of any scale of impacts will be. And these are sufficiently large to require considerable action in order to manage the associated risks.

We therefore have time in which to take a planned approach to adaptation and resilience. This should be equally ambitious as action on decarbonisation to slow warming and should be conducted in parallel with these efforts.

The luxury of time to take a planned approach should not be mistaken for the ability to kick the can down the road on difficult decisions and ambitious action. Only if the UK is well-adapted, can it thrive as a leading nation on climate change and low carbon technologies, as is targeted in its Green Growth and Industrial Strategies. So, we must be long-term in our thinking and planning, but start acting concertedly in the near-term.

As well as the need for increasing expenditure on resilience measures, the current mechanisms for delivering it are not sufficient. The National Adaptation Programme must be stronger and drive progress further. The current NAP is little more than a summary of actions already in train which are not prioritised and are not measurable, and therefore aren't progressing resilience to the required degree. The forthcoming Environment Agency Flood and Coastal Erosion Risk Management and the National Infrastructure Strategy will help to take this forward, but the overarching strategic, coordinating framework remains inadequate.

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<sup>10</sup> Intergovernmental Panel on Climate Change. [Special Report: Global Warming of 1.5°C](#). 2018.



It's important that the NAP contains a clear and concise vision of what a well-adapted England looks like. Conference delegates highlighted the lack of a clearly defined vision as a barrier to effective resilience. Crucially, the NAP should not plan adaptation measures to maintain the status quo but must recognise that change is inevitable over coming decades given the increasing nature of climate risks. It should therefore establish approaches that will enable adaption to all potential levels of future climate change as there is no guarantee that the Paris Agreement targets will be met.

At the conference, speakers discussed the main challenges to increasing resilience in the UK, particularly the lack of strategic leadership and an integrated, long term and ambitious programme.

The importance of emergency response as extreme events become more frequent was also discussed, and the role that local government has in encouraging leadership and working in partnership with infrastructure.

As well as the challenges, delegates also heard about how a range of bodies are working to increase their resilience, for example, major infrastructure providers are increasingly factoring in resilience measures into their capital upgrade programmes.

Communities, particularly those at risk of flooding, are increasingly determining their own resilience pathways through local groups. However, those in deprived areas are still much more vulnerable and strategic governance and leadership is essential to ensure that those in disadvantaged areas are able to increase their resilience to risk.

Resilience is hugely complex and inter-connected, and as a result, it is difficult to see a clear picture of resilience, and research is particularly important for assessing resilience and setting priorities.

Our recommendations for building a well-adapted and resilient society, following the presentations at the event, are as follows:





## Our recommendations for building a well-adapted and resilient society

### 1. Government-led

*Much of the delivery of adaptation and resilience doesn't require extensive research and thinking. The challenges for adaptation have been well articulated. Pilot initiatives will be beneficial in many areas, however in the main what is needed is a very strong policy steer from government which makes it clear that **bodies at all levels of society must factor adaptation and resilience into their investment planning and maintenance programmes.***

- Government should increase annual average investment in resilience significantly, particularly regarding flood risk management. The benefits to justify such investment should be more than just avoided damages; adaptation should be used to drive regeneration in places too for example.
- Adaptation is much more varied than mitigation and there is not a one size fits all solution. Centralised frameworks, strategies and resources are required to enable and promote appropriate local-level action.

### 2. Infrastructure

*Government must require that infrastructure – from housing development through to critical infrastructure – **deliver best practice on resilience as standard.** Government must lead and enable this philosophy using all instruments at its disposal, from standard setting through to support.*

***MHCLG, Homes England, the Infrastructure and Projects Authority, Treasury, Defra and its agencies must all embed a resilience philosophy in their plans, policies and ways of working** to ensure that over coming decades our infrastructure – which in many instances is likely to last to beyond 2100 – is resilient, adaptive and fit for a changing future. Resources – particularly within local authorities who are at the forefront of shaping development – should reflect this need appropriately.*

- The retrofitting of 29 million existing homes, for example with flood resilience, and water-efficiency measures, to adapt them to our future climate should be an infrastructure priority.

- Further work must be undertaken to translate high-quality UKCP18 data about our future climate into a usable format for practitioners to base investment level decisions on.
- Infrastructure operators should implement a staged replacement of assets as they are retired with those which can perform better, enabling a multi-year pathway towards improved resilience.
- It's crucial for operators to understand their exposure to risk and to establish how their operations will be impacted by climate change, in order to build resilience into their systems.
- Agriculture can be viewed as essential infrastructure, providing an invaluable resource to society. Integrated water management is essential to build agricultural resilience, where drought and flooding are considered jointly, and silos removed.

### **3. Emergency response**

*Emergency response will become even more crucial as extreme events become more frequent, and the ability of communities to recover quickly will require a multi-level joined up approach.*

- Resilience planning for extreme events must be a priority across a wider range of risk management authorities. Such events will happen more frequently, and lessons must be learned from recent experience, and acted upon. Extreme events do not comprise a single element of risk, for example, during a period of heavy snow, freeze-thaw can occur as well as freezing temperatures and transport disruptions.
- Emergency management is vital for resilience, but it can't and won't stop extreme events from happening. We must therefore improve our management of them and implement effective community engagement strategies which enable individuals to cope with shocks.

### **4. Communities**

*Communities are at the heart of resilience and adaptation. They bear the impacts of extreme events and in certain places will face the need to make significant changes to adapt to climate change. These impacts are often more profoundly felt in communities which are disadvantaged.*

***There is a need to develop greater trust between communities and decision makers, ensuring communities are listened to and actively involved in programmes and decisions which will affect them. A clearer social contract must be developed as a foundation for this, with communities understanding that they will be listened to and where responsibilities lie.***

*There are many examples of highly effective community level working and government at all levels must be committed to enabling this to work more widely, thereby tapping into pools of knowledge, experience and willingness to take action as extensively as possible.*

- Communities should be empowered to engage in their own resilience pathways to deliver place-based adaptation.
- Deprived communities are more vulnerable to the challenges of resilience and are unable to access information and resources. The disproportionate impact on the disadvantaged should be addressed as a priority.





### 3. Speaker Presentation Summaries

The following are summaries provided by CIWEM and not transcripts or abstracts provided by the speakers themselves.

#### **KEYNOTE: Defra**

**Sally Randall, Director, Floods and Water, Defra**

The future is set to bring climate change and population growth which pose threats of both drought and flooding. Managing these pressures will require a systems approach and strength in the economy, communities and the environment.

Lessons have been learnt from previous floods, droughts and freeze-thaw events but as the risks grow so must mitigation and adaptation actions. Adaptation is an important part of the response to hazards. The Environment Agency recognises that it is not always possible to prevent hazards from impacting individuals, making resilience and quick recovery important.

A place-based approach is key to managing risks. This is already being developed through Natural Flood Management and the Catchment Based Approach. For each place the mix of measures that is 'right' will look different, so it is important to work collaboratively to achieve the right balance.

Within the governance picture, Local Authorities are just as important as central Government. Lead Local Flood Authorities need to be supported in updating their strategies to reflect the most recent evidence. Improved flood resilience has been delivered to 155,000 homes out of a 300,000 target, with two years remaining to meet this full target. Defra will look to secure future government funding to continue this work. It is also important to enable private investment.

The Ofwat 2019 Price Review looked to improve resilience, introducing a common performance commitment on sewer flooding. The Water Resources Management Plan process encouraged water companies to reduce leakage and improve drought planning. Later this year the National infrastructure Committee is expected to review current resilience.

The National Planning Policy framework 2018 update strengthened flood risk protections for new properties and introduced a SUDS requirement with expectations on management. Following EU exit, the new approach to agriculture funding will include Natural Flood Management (NFM). Focus on improving the environment post-Brexit will also improve resilience.

A review of flood warning and response, published earlier this year, showed good progress in recent years. All houses in flood risk zones are to be brought into the warning system. There is also focus on improving property level resilience to speed recovery. Flood Re has increased the availability of flood insurance to high flood risk properties. In two years, it has backed 150,000 households to gain insurance from a range of providers.

Due to the long-term needs driving Defra's activity, work in the areas covered will continue despite political uncertainty. Work is currently focused on dry weather, sustainable abstraction and efficient water use. In autumn 2019 a policy statement on Defra's flood and coastal management approach is due to be published. Alongside the Spending Review and National Infrastructure Committee's conclusions on resilience, this will provide a strong future framework for flood and coastal risk management.



## Climate Resilience and Extreme Incidents

### **Julie Foley, Director of Flood Risk Strategy and National Adaptation, Environment Agency**

The Environment Agency is the principal flooding and coastal erosion risk management body in the country, with other integrated broader roles covering water, biodiversity, fisheries and planning. It's an adviser, regulator and an infrastructure provider; well placed to talk more than ever before about climate change.

Consequently, the EA's Chair and Chief Executive have been making headline-grabbing speeches calling for greater action. We need a different approach and philosophy; short-termist approaches risk lock-in and unintended consequences. So, looking to 2100, we need to work with communities to plan for a range of climate futures.

The EA's new [long-term investment scenarios \(LTIS\)](#) show that with optimum investment, we can prevent a rise in property damages over the next 50 years even under high climate scenarios. There is new guidance for planners and for the appraisal of flood risk schemes from [UKCP18](#). This will need over £1billion annual average investment (AAI), but when set in the context of the threat, and that overall AAI on UK infrastructure is £63billion, it looks less daunting a figure. And defences at work during the last major east coast surge avoided an estimated £37billion in economic damage and protected half a million households.

If we make this investment, it is essential that we factor in more economic growth, a larger population and, of course, the effects of climate change. Even then, despite avoiding property damage, the number of properties at risk will double over the next half-century. The planning system is vital to protecting people. It is mature and refined and if properly implemented it can be very effective in managing future risk both through prevention and adaptation.

There are technical and social challenges with building ever bigger defences thus we need a broader response to delivering resilience. And whilst targets under the current 6-year settlement are to protect an additional 300,000 homes, the benefits of Flood and Coastal Erosion Risk Management (FCERM) extend far wider. Taking transport as an example, for every person affected by flooding, 16 more are impacted by wider disruption. The [National Resilience Review](#) showed that 41% of transport and utility infrastructure and 50% of water treatment works were at risk of flooding.

So, homes and development must be planned and delivered in the right way and the EA plays an important advisory role in this. FCERM investment can unlock [significant regeneration](#) if new communities are resilient.

Yet we cannot always prevent flooding. Whilst we have a world class forecasting and warning service with 1.4 million people signed up, this will be expanded to all at high risk. And while 5 million people are at risk of flooding from rivers and the sea, only, 1/3 of them are aware of their risk. This needs to improve. And surface water remains a challenge. Local authority capacity is constrained, and the data and evidence are less strong than for river and coastal flooding. Yet it is here that most risk lies.

The new FCERM Strategy will seek to make better links between flood and drought risk management, exploring opportunities to better align respective planning cycles to achieve win-wins. We must continue to be world-leading in these aspects of climate resilience.



## Housing: reducing emissions and preparing for climate change

**Gemma Holmes, Senior Analyst, Adaptation Sub-committee, Committee on Climate Change**

The [2008 UK Climate Change Act](#), focused on mitigation and adaptation, included a requirement for a risk assessment to be carried out. The [2017 UK Climate Change Risk Assessment](#) identified 6 priority risk areas, three of which covered housing.

To meet its climate change targets the UK needs to reduce emissions levels by 80% of the 1990 level. Whilst progress is being made on this front, largely from the phase out of coal power, there are areas where emissions are not falling fast enough, including housing.

The report [UK housing: Fit for the future?](#) was published February 2019 by the Committee on Climate Change. The report shows that uptake of energy efficiency measures has stalled, homes aren't being adapted to climate change risks such as flooding and there has been an increase in heat related mortality levels linked to poor building design and mal-adaption. The forthcoming review of building regulations this year must urgently address overheating risks.

The report outlines low-cost, no regret options for new and existing homes to help meet to challenges associated with climate change and result in financial savings, health benefits and environmental improvements. The costs to builders of installing sustainable measures in new builds is considered too small to impact viability and of benefit to developers in avoiding retrofit costs at a later date.

Measures for existing homes include: insulation, double or triple glazing with shading, low carbon heating, draught proofing, high energy-efficient appliances, high water-efficient devices, green space, flood resilience and resistance.

Measures for new homes include: high levels of airtightness, more fresh air, triple glazed windows and external shading, low carbon heating, more ambitious water management and cooling, flood resilience and resistance, sustainable construction and site planning.

The report's five recommendations to government are to address:

1. Performance and compliance- greater inspection and enforcement of building standards.
2. Skills gap- tackling the low carbon skills gap through training designers, builders and installers.
3. Retrofitting existing homes- making the adaptation of the 29 million existing homes a UK infrastructure priority.
4. Building new homes- ensuring new homes are low carbon, energy and water efficient and climate resilient.
5. Finance and funding- making sure funding needs, particularly of low carbon heating and building control, are addressed by Treasury.

# UKCP18 National Climate Projections

**Fai Fung – UKCP18 Climate Services Manager, Met Office**

The Met Office published their latest climate projections at the end of 2018. UKCP18's findings are based on the most advanced emerging science, and peer reviewed by an international panel. UKCP18 moves beyond climate trends. Building up upon the conclusions of UKC09, it translates global climate change statistics into changing seasonal weather characteristics for the UK.

The headline findings are:

- Greater chance of warmer, wetter winters and hotter, drier summers.
- Sea levels have been rising and will continue to rise under all emissions pathways.

## *Temperature*

All areas of the UK will experience warming, and warming is likely to be greater in the summer than the winter. There is a similarity with warming between all scenarios over next couple of decades. By mid-century, the chance of hot summers will be around 50% regardless of emissions scenario – we are locked into a certain amount of change. Beyond 2050 the chance of a warmer summer more strongly depends on emission scenario.

UKCP18 shows how the chances of extreme events, like that of summer 2018, may change in the future by amounts that depend on future emissions of greenhouse gases.

## *Precipitation*

Rainfall patterns across the UK are not uniform and vary on seasonal and regional scales, and this will continue. Winter precipitation is expected to increase but will still have relatively dry winters. Summer rainfall is expected to decrease significantly, but when it rains in summer it's likely to be more intense. Year to year precipitation will be very variable which reinforces the need for wide ranging adaptive approach.

## *Sea-level rise*

UKCP18 projected sea level rise is higher than UKCP09, due to new treatment of land ice contribution to sea level rise. In London, sea level rise by end of century for even the low emission scenario is very likely to be in range of 0.29m – 0.70m. Under a high emissions scenario it is likely to be 0.53 – 1.15m.

Climate projections at 2.2km resolution will be launched in 2019. Particularly important for intense summer rainfall – to aid urban flood risk planning and building design and thermal performance.

The projections for the future climate for the UK show significant changes to the current state, even under the lowest emissions scenario, highlighting the need for essential and significant adaptation measures for the UK to become a resilient society. The data and understanding must inform planning and action.

# The National Infrastructure Commission Resilience Study

Manuela Di Mauro - Senior Technical Advisor, National Infrastructure Commission

Following the publication of the first [National Infrastructure Assessment](#) in July 2018, the Chancellor has asked the NIC to carry out an in-depth study on resilience. The scope covers energy, transport, digital, water and wastewater, and the Government is obliged to respond to its recommendations.

There are difficulties in addressing resilience without having a clear and agreed objectives of what “good” resilience looks like. What do we mean by resilient and how do we get where we want to get? Resilience should mean resilient to future and current changes in climate – it is a key driver for future change and challenges. Infrastructure resilient to future climate change is crucial for a functioning society. The NIC haven’t defined resilience in an effort to not pre-determine importance of factors, but a literature review of definitions suggests **absorb**, **recover** and **adapt** are key features. A resilient system is an adaptable one. Resilience is not a fixed property but is **dynamic**, changing over time as pressures and system properties change.

The importance of empowering communities to engage in their own climate resilience and choose their own pathway should be emphasised. The Government has an enabling role through funding and awareness raising. Interdependencies have been reported several times in the past (including the most recent CCRA) as creating an issue with resilience capabilities, but now the NIC want to pinpoint exactly what the barriers are to address interdependencies.

Some suggested barriers to addressing interdependencies are:

- Regulatory frameworks
- Differing length/scope of funding cycles
- Different frameworks for valuing resilience
- Sharing and accessing data, and ensuring that data available is of adequate quality or format

## *Current approaches: UK practice*

Government sets resilience objectives for economic regulators in issuing Strategic Statements of Priorities, with resilience recently introduced in water and digital sectors. An overall picture of resilience is difficult to draw, and it is important to understand why. The capability of infrastructure operators to respond to extreme events is not in the public domain. There are challenges when trying to balance cost/benefit with customer willingness to pay. The customer perspective is challenging where risk appetite varies, and concepts of risk/resilience are unknown.

Because of these issues, the government role in setting policies around resilience is particularly important but there is no shared, high level objective. Government definitions often refer to “satisfactory” or “acceptable” resilience, but there is no clear guidance on what is considered “satisfactory” or “acceptable” or how to define these. Responsibilities around resilience are across different departments.



## A Railway Fit for the Future

**Lisa Constable, Weather Resilience and Climate Change Adaptation Strategy Manager, Network Rail**

Understanding appropriate and acceptable levels of service which are expected of the railways during extreme events is vital, given the £billions involved in maintaining a resilient network. The costs to Network Rail of disruption resulting from extreme events are high and relate largely to water and heat-related extremes.

The disruption associated with the damage caused to the line at Dawlish cost £63million in repairs and operational response and £28million in disruption payments. Damage to Lamington Viaduct in 2016 resulted in £46million repairs and operational response and £40million in disruption payments. The Watford landslide in 2016 resulted in derailment and collision with thankfully no fatalities. Resilience to water-related extreme events is therefore essential.

Heat resulted in a 40-50% increase in asset failures during the summer of 2018 with costs between £35-40million up to August/September. Impacts are most pronounced early in the season as later in the season most likely failures have already occurred and have been repaired.

Normal performance sees 89-93% of services running without disruption. During extreme weather this can drop down to around 70%. Some of the biggest challenges lie on 'adverse' weather days when nominally the weather is normal but trains struggle to operate reliably, seeing around a 3% drop in service.

Network Rail are mapping asset failure risk across all of their assets and climate change will amplify this risk, potentially moving towards an unacceptable performance profile. This represents a real challenge. There is a need to deliver infrastructure which is better able to withstand future weather, and which can be recovered rapidly.

Network Rail are approaching this challenge by replacing assets on renewal with those which can perform better against these needs, enabling a multi-year pathway towards improved levels of resilience. There is a range of interdependence between different asset types and other sectors which may impact upon the sequencing of renewal.

All new major projects require climate change risk assessments to inform options development and asset functions all have climate change risk assessments to inform associated policies, standards and procurement processes for the next investment round. This approach is now providing considerable volumes of data and information to cascade through the process.

Future developments are focused around mapping hotspots of extreme weather asset risks and developing a greater understanding of what resilience to ensure an acceptable level of service costs in the long-term.

## Consumers' experiences of water supply interruptions following the freeze-thaw events of March 2018

**Karen Gibbs, Senior Policy Manager, Consumer Council for Water**

In February 2018 the 'Beast from the East' storm hit the UK. The first weekend of March saw many water pipes damaged by freeze-thaw events leaving over 200,000 customers with loss of supply as water companies worked to repair them.

The Consumer Council for Water (CCWater) conducted research on how these supply interruptions were managed. The research looked at seven company areas using six focus groups and covered preparedness, communication and compensation.

CCWater found that the approaches taken by different companies had varied and resulted in different levels of customer satisfaction, indicating lessons to be learnt to improve future service.

The four key lessons for water companies were:

1. Water companies' customer communications were poor
2. Alternative emergency water supplies were inadequate
3. Not all vulnerable customers were identified and cared for
4. Businesses suffered from inadequate communication, inadequate emergency supplies and insufficient compensation

With the event occurring on a weekend, call centre capacity was noted to be insufficient. Social media was used as a mass communication method. However, 51% of those participating in the research didn't use the internet and 49% felt they had not received any information from their water company. This showed a need for dissemination of information through a variety of channels including an on the ground presence.

Most customers did not receive alternative supplies during the period of interruption and less than half of those who did felt it was adequate. Alternative supply was a particular issue in regard to vulnerable customers as water company definitions of vulnerable were not wide enough; missing, for example, those who had recently been discharged from hospital.

Looking at compensation the research found that over half of customers were unaware that they were due compensation. However, 84% were satisfied with the compensation they received. The level of compensation varied across companies. There is a Guaranteed Standards Scheme in place, but some companies chose to pay more. Ofwat has since made compensation recommendations which several companies have taken up.

Particular issues for businesses were confusion between wholesalers as to who was responsible for supply and having to argue for appropriate compensation to cover business losses.

The [CCWater research](#) and [Ofwat review](#) are both published online.

## Flood Risk Resilience at Gatwick Airport

**Michael Symons, Technical Director, Jacobs and Ian Waghorn, Water Quality Manager, Gatwick Airport Ltd**

Gatwick Airport was until recently the world's busiest single runway airport, handling 46.1 million passengers and 284,000 aircraft per annum.

Its location was chosen because of its flat topography but this presents particular resilience challenges. The topography is due to its location in an extensive floodplain of five rivers and streams. This presents a range of challenges, but two principle risks relate to flooding, and frost and ice.

Frost and ice require the management of significant quantities of de-icing chemicals that must be kept out of the local watercourses. Runoff water is pumped into storage lagoons which provide a buffer through the winter against limited capacity at Thames Water wastewater treatment works.

Flooding is a particular risk at Gatwick. On Christmas Eve 2013, 65mm of rain fell at Gatwick in 18 hours, along with high winds affecting the airport and causing disruption. Flooding impacted ground lighting substations and the pit and duct system for cabling was overwhelmed, resulting in failure of electrical systems in the North Terminal. This caused major disruption and reputational damage and the resulting [McMillan Report](#) making 27 recommendations for improvement. Most recommendations related to communications, recovery and contingency planning and have successfully informed event response, such as the December 2018 drone event.

Flood resilience and alleviation schemes were developed and implemented in a number of locations, alongside increased generator provision to ensure backup power for extreme events. Not only is Gatwick in flood zones 2 and 3, but its flat topography and large areas of hard surface mean that surface water flooding is also a risk, which climate change will exacerbate through more intense summer storms.

Managing flood risk under these scenarios required a longer-term, strategic approach, with a dedicated flood risk management strategy and higher resolution flood risk maps than standard Environment Agency maps, in order to define the risk accurately.

Gatwick are now employing a phased approach to making more than 100 assets more flood resilient, as part of an iterative process. This has involved defining each asset, from a terminal all the way through to a switchboard.

The flatness of the topography at Gatwick has introduced particular modelling challenges as it can be difficult to predict exactly where water will flow. Detailed knowledge of all assets has been required, including the historic use of assets, which may impact upon their resilience in their current guise. Experience has shown that small details can catch you out, so high levels of detail have been fundamental to improving Gatwick's levels of resilience.



## Enabling resilient UK energy infrastructure: natural hazard characterisation technical volumes and case studies

**Erika Palin, Manager- Science for Impacts, Resilience & Adaptation, Met Office**

Natural hazard events can be dangerous and damaging. Floods and heatwaves are well known natural hazards but combination hazards, where events include multiple hazards, pose an increasing threat.

Risk can be expressed as the combination of the hazard, vulnerability and exposure. Climate change will impact the risk that humans, the built environment and nature face.

Infrastructure is particularly high value and must be protected for health and safety and economic reasons. It is important that regulations and design optimise resilience.

The Met Office has recently undertaken research into enabling resilient UK energy infrastructure in partnership with EDF Energy and Mott MacDonald, with assistance from others.

The Energy Technologies Institute Natural Hazards Project was completed through three phases: a literature review, additional research and development and delivery of the technical volumes and case studies.

The 5 main risk knowledge gaps found were: hail, lightning, space weather, marine biological fouling and hazard combinations.

The project output is 12 technical volumes on known risks, regulations and best practices. Climate change is addressed within the volumes. Five case studies are also included to represent the 11 hazards addressed. The case studies represent different geographies, covering inland, onshore and offshore, coastal, estuarine and river areas.

The extensively peer reviewed technical volumes are being hosted on the [IMechE](#) and [ICHEME](#) websites and will be updated as needed. The technical volumes were designed to be accessible for use by those looking to improve their practices.

Though the technical volumes have been designed specifically for the UK energy sector, they may also hold relevant information for other sectors.

# Greater Manchester's Resilience Challenge

**Dr Kathryn Oldham OBE – Chief Resilience Officer, Greater Manchester Combined Authority**

The first challenge when trying to build resilience is what does resilience mean? Everyone has different approach. It is an emerging area, in which there is ongoing academic work. 100 Resilience Cities defines urban resilience as 'the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience.'

Why is urban resilience important? Greater Manchester is growing by 10%, there is an increased urbanisation trend, and globalisation and interdependence across the world. This has implications on the spread of disease, supply chain disruption, migration of people, and climate change.

Integrated emergency management is an important feature of the ability to cope with shocks but in the present prevention agenda is underplayed. In this context it is prevention of service failure in event of extreme event rather than upstream work to prevent extreme event. Local government play a key leadership role in responding to emergencies.

It's important to understand what you are being resilient to. Shocks, stresses and disruption which lead to change. Heatwaves are an underestimated risk in the UK, the worldwide impact is huge, and they directly and indirectly kill millions of people annually. A changing climate is resulting in an increase in the likelihood of extreme weather events, as well as exacerbating a wide range of stresses Greater Manchester faces.

For the Greater Manchester Combined Authority (GMCA), building resilience means growing resilient individuals which are part of a resilient community which is supported by a resilient economy living in a resilient place. Key features of a resilience strategy include trying to recognise the role of communities and encouraging leadership in partnership with infrastructure providers and experts. It's crucial to build resilience into expanding urban environment and be ready to respond to emergencies.

## *Case study – a systems approach to resilience*

Pollution from the textile industry on moorland blanket bogs on Manchester fell as acid rain and degraded the top layer and impacting their health. This increases the risk of flooding and moorland fires, leading to poor health of citizens and the release of peat into the atmosphere during a fire. Peat is globally important as carbon store and its release contributes to stress of climate change.

# Building Resilient Communities, Now and in the Future

**Paul Cobbing, Chief Executive, National Flood Forum**

Climate change isn't an abstract concept in the future, it is happening now and it's all about people and people's lives, with very significant impacts. National Flood Forum (NFF) supports flooded communities, helping them take control of flooding in their life because very often while the water goes away, the fear doesn't.

The risk in setting out a new FCERM strategy is that it doesn't look broadly enough, focuses on familiar approaches and neglects to use a sufficiently diverse range of tools. NFF advocate 28 different tools.

Often, flooded communities don't like to hear about resilience because the current approach to resilience is too often top-down and couched in paternalistic language of informing and educating those impacted and is perceived as absolving government of responsibility and placing it on the communities themselves. An adaptive, long-term relationship with a narrative that will bring communities with decision makers is necessary to ensure effective resilience. Surveys of groups have shown that their perception of flood agencies is often not positive.

Communities are already showing leadership in hundreds of locations across the country. There are hundreds of flood action groups undertaking great work, yet there are many other locations where there aren't groups, but there is flood risk.

Planning is almost uniformly at the top of the agenda of flood action groups. Many are frustrated that their particular local knowledge may commonly be overlooked by planners in favour of more 'official' sources of data or models. They typically succeed despite the current system, not because of it. There is a need for a far more pronounced social contract based around the values of trust, respect and transparency.

These circumstances are most pronounced in areas where there is [flood disadvantage](#). There is a strong case for arguing that many flood risk management issues are equally (or more) regeneration issues. Those in deprived areas often struggle to get the interventions they need delivered because current approaches, from the ways that information is made available, the way funding calculators are geared, the struggle many still face to obtain insurance to the complexity of roles and responsibilities on urban drainage, make it a highly challenging process.

To tackle this, strategic governance needs to be improved. The [Flood and Water Management Act](#) talks about operational coordination and there is a need for more effective engagement of bodies such as LEPs and those focused on local health and education. This is starting to happen in locations including Manchester, Cumbria, Calderdale, and Somerset but much more is required.

Flood resilience is as much about social resilience as physical resilience. There is a pressing need for an evidence base which will underpin a social approach that meets the needs of communities otherwise the contract between government, agencies and communities will be one-sided.



# Climate Resilience in Agriculture

**Dr Mhairi Barnes, National Flood Management and Access Policy Adviser, NFU**

Farmers bear the brunt of the impacts of the weather and its uncertainty. Volatile weather has an enormous impact on agricultural land and water resource issues are of huge importance. Drought, water shortages and low river levels can lead to severe impacts on food security and supply. Farmers are often paid for their produce based on quotas. Water shortages mean crops might be stunted by a poor growing season, and therefore farmers might not meet quotas. Surplus water, such as the tidal surge of 2013, are also concerning to farmers, and can lead to crop loss, livestock loss and a costly clean-up operation when flood water recedes.

The importance of viewing agriculture as another part of infrastructure should be emphasised. Farming is worth £122billion to the economy and employs 4million people directly. In order to be resilient in times of a changing climate more needs to be done to recognise the importance of water for producing our food. This can be done nationally by our policy makers and also locally by raising awareness of water scarcity and developing on-farm infrastructure to allow for things like rainfall harvesting for irrigation etc.

Internal Drainage Boards (IDBs) play a key role in flood risk management at a local level. They have evolved over the last few decades to not only keep agricultural land drained but also to protect increasing urban areas. As well as protecting agricultural land to play a role in food security (which is becoming more important in a changing climate & after the UK leaves the European Union) but also other important infrastructure is in IDB managed areas, such as power stations, roads and railways. Despite this, agriculture is often overlooked when it comes to flood risk protection.

## *Adaptation*

Agricultural land is widely considered sacrificial to protect other vital infrastructure, but it has crucial role to play in society and its importance should be elevated. IDBs and farmers play a key role in this, without it the flood risk impacts across England, would be far more severe. With climate change impacts expecting to see a sea level rise of up to 1.15m by 2100, the importance of the collaborative workings of IDBs, farmers and landowners is crucial to protect people and property and ensure food security. No economic value is put on land sacrificed for flood defences.

## *Integrated Water Management*

IDBs pump out huge volumes of fresh water into the sea, which is problematic when there are drought problems upstream. Drought and flooding should be considered jointly. There are 3 main challenges associated with flooding and integrated water management: ensuring a clean water supply, producing food and ensuring the future of the environment.

The solutions to this are a long-term strategic approach to flood risk, greater recognition for the importance of agriculture to build resilience and sufficient and transparent funding for the future.





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