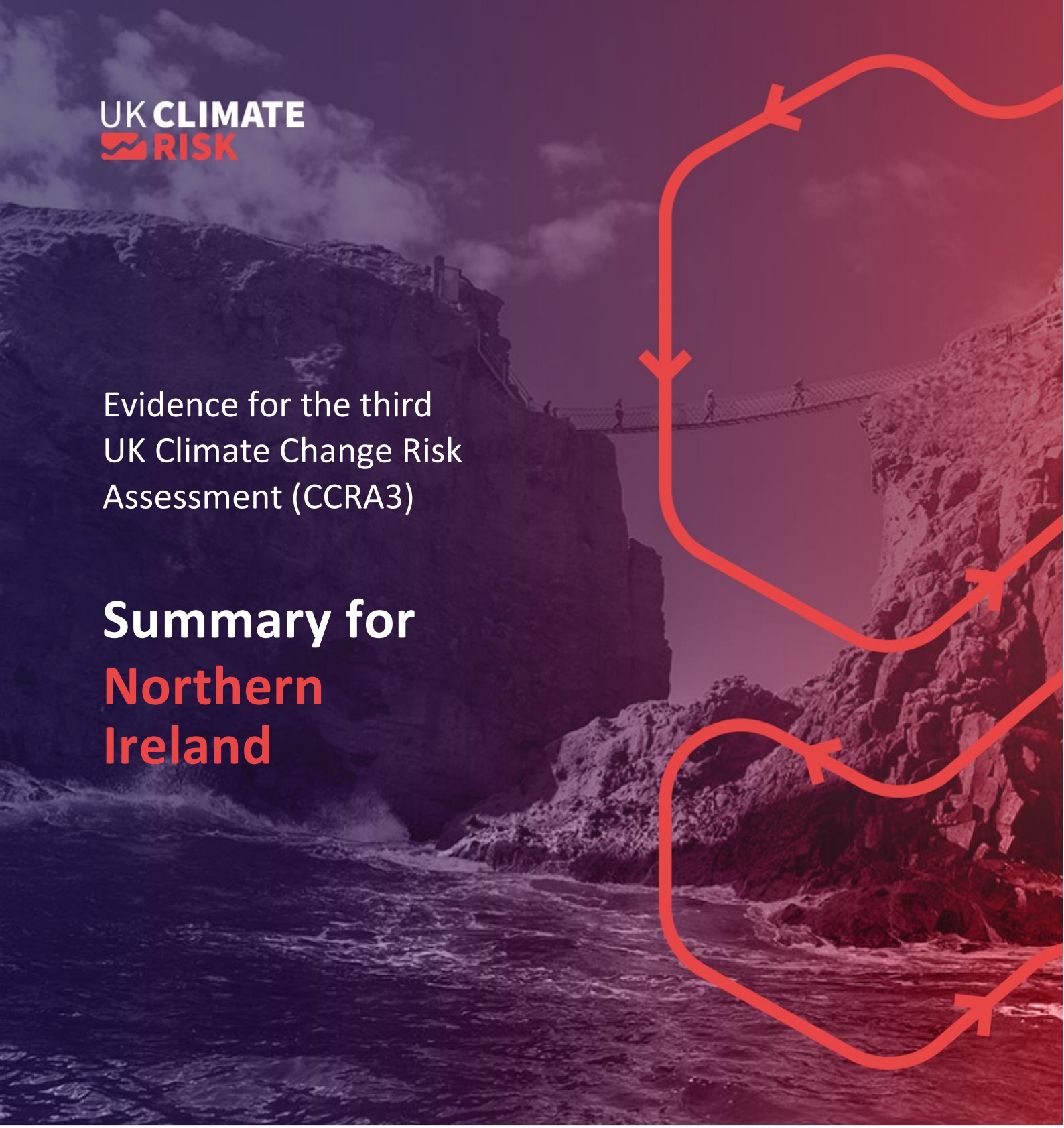


UK CLIMATE RISK

Evidence for the third UK Climate Change Risk Assessment (CCRA3)

Summary for Northern Ireland

Author: Climate Northern Ireland
Image: Rope Bridge, Carrick-a-Rede

Summary of climate risks and opportunities for Northern Ireland

The Independent Assessment used to help inform the third UK Climate Change Risk Assessment (CCRA3) assesses 61 risks and opportunities from climate change to Northern Ireland, including to business, infrastructure, housing, the natural environment, our health and from the impacts of climate change internationally. Risks categorised as "More action needed" and "Further investigation" are more urgent than "Watching brief" and "Sustain current action". Of these 61 risks and opportunities, more action is needed now to address 31 of them, further investigation is needed for 19, sustaining current adaptation action is only deemed appropriate for five of the risks or opportunities and six have been classified as watching brief. Of the 61, six issues are deemed to be both a risk and opportunity, four of which are associated with the natural environment and each of these require more action or further investigation. There are also eight opportunities that could arise from climate change in Northern Ireland, with four of these also related to the natural environment.

While many of the risks and opportunities are similar in urgency and magnitude across each UK nation, in Northern Ireland, the lower level of quality evidence available and in some sectors, relatively limited climate related policy in force, increase the uncertainty around future climate change impacts (although there are many policies in development and baseline studies underway). Changing climatic conditions and extreme weather event impacts may also be exacerbated in future due to the degraded state of the natural environment and the interactions with external factors such as pollution, overfishing and land use.

In summary, risks in Northern Ireland that have a high future magnitude score and where more action is required now to address them, after considering any existing adaptation responses, include the following:

- Risks to terrestrial species and habitats from changing climatic conditions and extreme events, including temperature change, water scarcity, wildfire, flooding, wind, and altered hydrology (including water scarcity, flooding and saline intrusion).
- Risks to terrestrial species and habitats from pests, pathogens and invasive species.
- Risks to soils from changing climatic conditions including seasonal aridity and wetness.
- Risks to natural carbon stores and sequestration from changing climatic conditions, including temperature change and water scarcity.
- Risks to and opportunities for agricultural and forestry productivity from extreme events and changing climatic conditions (including temperature change, water scarcity, wildfire, flooding, coastal erosion, wind and saline intrusion).
- Risks to agriculture from pests, pathogens and invasive species.
- Risks to forestry from pests, pathogens and invasive species.
- Risks to freshwater species and habitats from changing climatic conditions and extreme events, including higher water temperatures, flooding, water scarcity and phenological shifts.
- Risks to marine species, habitats and fisheries from changing climatic conditions, including ocean acidification and higher water temperatures.
- Risks to marine species and habitats from pests, pathogens and invasive species.
- Risks and opportunities to coastal species and habitats due to coastal flooding, erosion and climate factors.
- Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures.
- Risks to infrastructure services from river, surface water and groundwater flooding.
- Risks to transport from high and low temperatures, high winds, lightning.
- Risks to health and wellbeing from high temperatures.
- Risks to people, communities and buildings from flooding.
- Risks to cultural heritage.
- Risks to business sites from flooding.

- Risks to business locations and infrastructure from coastal change from erosion, flooding and extreme weather events.
- Risks to UK food availability, safety, and quality from climate change overseas.
- Risks to the UK from international violent conflict resulting from climate change on the UK.
- Risks to international law and governance from climate change overseas that will impact the UK.
- Risks from climate change on international trade routes.
- Risk to UK public health from climate change overseas.
- Risk multiplication from the interactions and cascades of named risks across systems and geographies.

The rest of this report outlines the risks and opportunities in Northern Ireland associated with climate change, their urgency scores, the evidence for this and the benefits for further action in the next five years.

Contents

1. Introduction

About

This report is a summary of the implications for Northern Ireland of the evidence for the third and latest UK Climate Change Risk Assessment (CCRA3) Technical Report. The UK Government is required by the Climate Change Act 2008 to conduct such an assessment every five years, to inform the UK National Adaptation Plans for England, Scotland, Northern Ireland and Wales. This is the third such national assessment and the second time the UK Government has asked its independent advisers, the Climate Change Committee to prepare the initial Independent Assessment Technical Report. The timescale, process and outputs that form the CCRA3 Technical Report are illustrated on the following page.

The process is complex – involving over 450 experts - and has produced a large volume of information which is why a range of materials are provided alongside the CCRA3 Technical Report to summarise the results spatially and thematically. An Advice Report is also provided as part of the Independent Assessment to give the formal advice from the Committee to the Government, which is then required to publish its own assessment (the CCRA3 Government Report) in 2022.

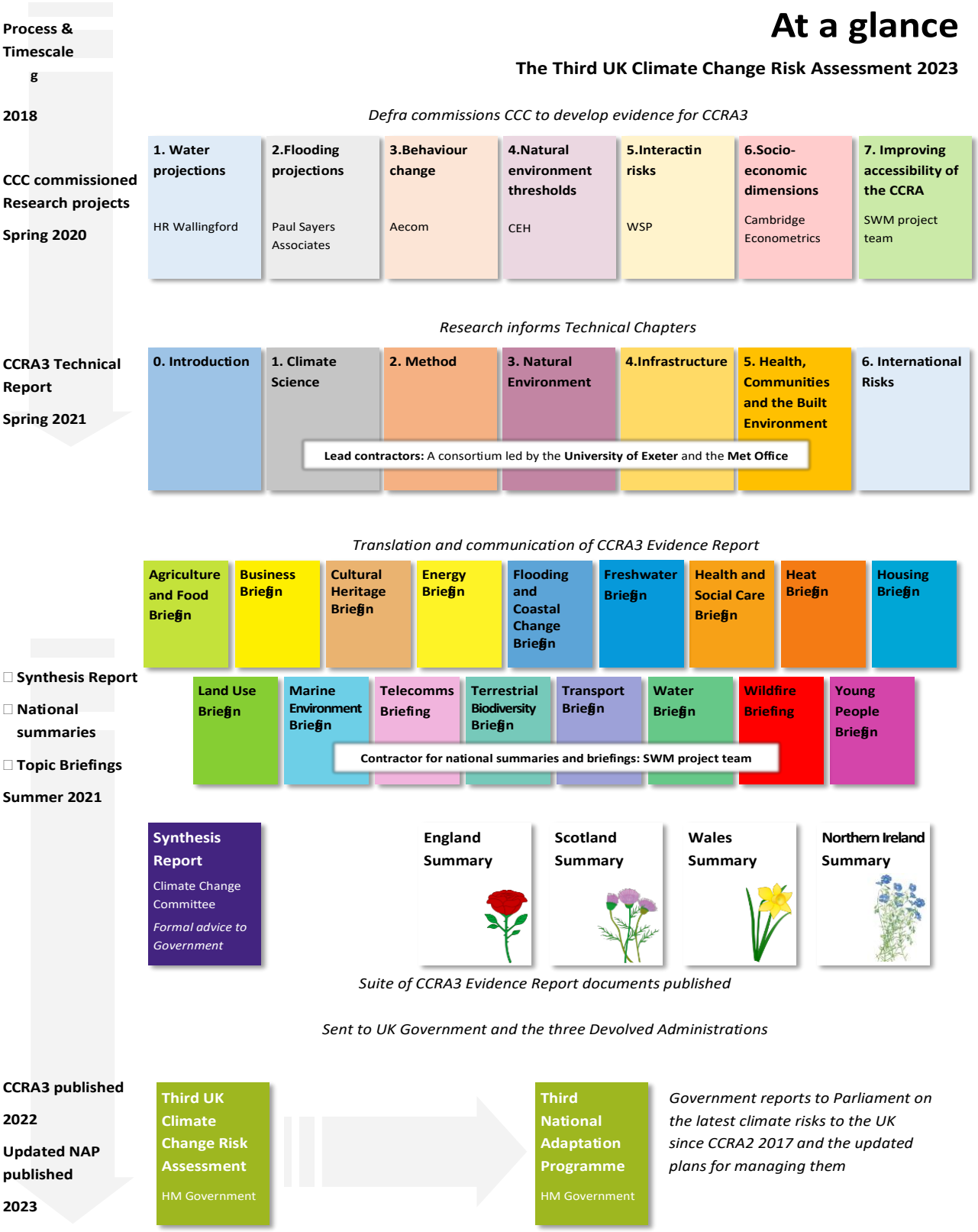
61 specific risks and opportunities were assessed in detail in the Technical Report and each one given an urgency score. As climate risks and adaptation actions vary across the UK, the urgency scores also vary which is why summaries have been produced for England, Scotland, Wales and Northern Ireland to capture the risk scores and highlight the differences accordingly. The summary highlights the most urgent risks, those which require more action taking and/or require more investigation and the less urgent risks where current action is sufficient or where a watching brief is required.

This report does not provide a detailed assessment of policy, and readers wanting further information about this for each risk should consult the relevant technical chapter. This summary provides signposting showing where you can find this information at the end of each risk. These summaries should also be used as a guide to the overall CCRA3 Technical Report findings rather than being seen as 'the risk assessment' for each UK nation. They summarise the nature of each risk or opportunity rather than what specific responses should be taken forward.

Audience

The main audience for this summary is the Northern Ireland Executive, its departments and their agencies. It may also be of interest to a much wider audience across the public, private and voluntary sectors where the changing climate is likely to affect plans, projects and operations increasingly over time.

Overview of CCRA3 process, timescale and outputs



Application

This summary should be used to inform the national climate change adaptation plans of the Northern Ireland Executive and be used to help Government understand how the changing climate is likely to impact on its many other programmes and investments so that appropriate adaptation measures can be integrated as required. Local government and other bodies operating at a local level in Northern Ireland may also find this summary helpful in producing or revising their own local climate risk assessments or climate resilience plans. Further, more localised risk assessments may be required however, or existing assessments reviewed in the light of these latest national level findings.

The context for climate change adaptation in Northern Ireland

The Climate Change Act 2008 stipulates that the Government must assess 'the risks for the UK from the current and predicted impacts of climate change'. Reports must be prepared and be submitted to the UK Parliament by the UK Government and the devolved administrations of Northern Ireland, Scotland and Wales. The first UK National Adaptation Programme, covering the UK for reserved matters and England only for devolved matters, was published in 2013 and updated in 2018 following the second UK Climate Change Risk Assessment. The Department of Agriculture, Environment and Rural Affairs (DAERA), who is responsible for coordinating the government cross-departmental response to the risks and opportunities relevant to Northern Ireland in the CCRA Technical Report, lead development of the Northern Ireland Climate Change Adaptation Programme (NICCAP). The first NICCAP was produced in 2014 and it was recently updated to cover 2019-2024.

The CCRA seeks to answer the question, 'based on the latest understanding of current, and future, climate risks/opportunities, vulnerability and adaptation, what should the priorities be for the next UK National Adaptation Programme and adaptation programmes of the devolved administrations?'

To answer this question, each of the risks is assessed in a three-step urgency scoring process:

- What is the current and future level of risk?
- To what extent is the risk going to be managed?
- Are there benefits of further action in the next five years, over and above what is already planned?

The analysis for each risk or opportunity is based on the evidence available to the team of authors that worked on each technical chapter and supplemented by additional research projects commissioned specifically for the CCRA3 Technical Report. Authors of the Technical Report have been supported to do this through a series of consultations and workshops on risks, and reviewing the draft technical chapters and factsheets with officials and organisations in Northern Ireland. Chapter authors have also been supported to reflect the specific contexts in each devolved administration through research and expert judgement commissioned through the Climate Change Committee.[1]

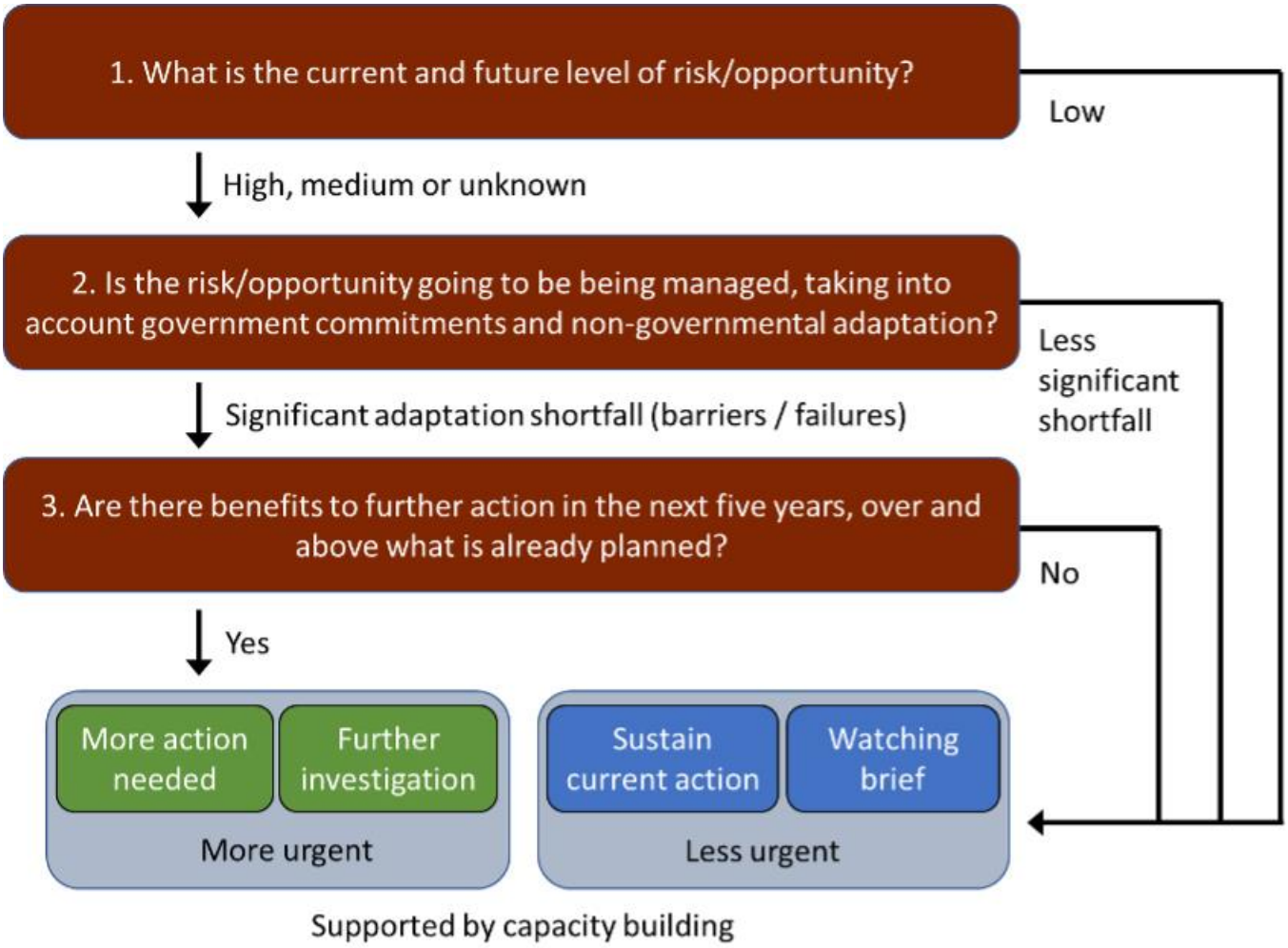
[1] For Northern Ireland, University of Exeter, on behalf of the UK Climate Change Committee, commissioned Climate NI to provide specific Northern Ireland policy advice and support to chapter authors on the risk assessment.

Based on the evidence available, supplemented by expert judgement where necessary, each risk has been assigned one of four urgency categories as follows (see 'Method' technical chapter for more information):

The urgency scores and colour coding used in this summary

Category	Description
More action needed	New, stronger or different Government action, whether policies, implementation activities or enabling environment for adaptation – over and above those already planned – are beneficial in the next five years to reduce climate risks or take advantage of opportunities. This will include different responses according to the nature of the risks and the type of adaptation: Addressing current and near-term risks or opportunities with low and no-regret options (implementing activities or building capacity). Integrating climate change in near-term decisions with a long life-time or lock-in. Early adaptation for decisions with long lead-times or where early planning is needed as part of adaptive management.
Further investigation	On the basis of available information, it is not known if more action is needed or not. More evidence is urgently needed to fill significant gaps or reduce the uncertainty in the current level of understanding in order to assess the need for additional action. *Note the category of 'Research Priority' in CCRA2 has been replaced with 'Further investigation' in CCRA3. This is because of some confusion following CCRA2 that 'research priority' only denoted that more research was needed, when in fact the urgency is to establish the extent to which further adaptation is required.*
Sustain current action	Current or planned levels of activity are appropriate, but continued implementation of these policies or plans is needed to ensure that the risk or opportunity continues to be managed in the future.
Watching brief	The evidence in these areas should be kept under review, with continuous monitoring of risk levels and adaptation activity (or the potential for opportunities and adaptation) so that further action can be taken if necessary.

The methodology and process of the CCRA3 Technical Report and risk assessment process is as follows:



2. Climate change in Northern Ireland

Observed changes that show how the climate is already changing

Variable	Change in Northern Ireland
Average annual temperature	Increase of 0.7°C from mid-1970s to mid-2010s
Annual mean rainfall	Increase of 6.4% from mid-1970s to mid-2010s
Weather extremes	UK-wide increase in extreme heat events Little evidence yet on changes in extreme rainfall
Sea level rise	UK-wide increase of ~1.4mm per year since 1901 (16cm to date)

Temperature

Across Northern Ireland, average annual land temperature in the decade 2010-2019 was 0.7°C warmer that the period from mid-1970s to mid-2010s. The 21st century has so far been warmer overall than any of the previous three centuries, reinforcing the attribution of UK warming to increasing greenhouse gases. Winter 2019 was the third warmest winter for Northern Ireland since 1884.

Rainfall

There has been a small observed increase in annual mean rainfall in recent decades. In Northern Ireland between the period of the mid-1970s to mid-2010s and 2010-2019 there was an increase of 6.4%, from an average of 1099mm per year to 1169mm per year.

Weather extremes

The latest climate science suggests that the effects of climate change on daily extreme rainfall events are only just beginning to emerge. However, the evidence of extreme maximum summer temperatures is becoming clearer, as reflected by how many of the UK's record extreme monthly temperatures have been set in the most recent decade along with a tendency for more heatwaves in recent years.

Sea level rise

Observed sea level rise is also difficult to determine for each country. A UK-wide sea level index suggests that sea level has risen by between 1.2 and 1.6mm per year since 1901. National variations are predicted in future as outlined in the following section.

How could Northern Ireland's climate change in future?[2]

The changes in climate that we are already experiencing are projected to continue and intensify. In the second half of the century, the amount of change that occurs will depend strongly on how successful we are in reducing greenhouse gas emissions globally.

The latest set of projected changes in climate for Northern Ireland come from the 2018 UK Climate Projections as shown in the table below.

	2050s **RCP2.6 (50th percentile)**	**2050s** **RCP6.0 (50th percentile)**	**2080s** **RCP2.6 (50th percentile)**	**2080s** **RCP6.0 (50th percentile)**
Annual Temperature	+1.1 °C	+1.2 °C	+1.2 °C	+2.1 °C
Summer Rainfall	-11%	-11%	-10%	-15%
Winter Rainfall	+3%	+3%	+7%	+10%
Sea level rise (Belfast)	+14cm	+16cm*	+27cm	+58cm*

Temperature

Annual temperatures in Northern Ireland are projected to rise between approximately 1.2°C by the 2050s and between 1.2 and 2.1°C by the 2080s from a 1981-2000 baseline average, based on the methodology set out above and depending on greenhouse gas mitigation between now and then. Risks associated with rising temperatures, such as more extreme heatwave events causing impacts on people's health and wellbeing, are likely to become more prevalent as a result of these projections, with their magnitude depending on the degree of change that is experienced.

Northern Ireland will experience hotter, drier summers, with greater extremes

Although temperatures are projected to increase in both summer and winter, warming is expected to be greatest in summer. Summer rainfall is projected to decrease, although extreme downpours will be heavier despite the overall drying trend.

[2] 'These values are taken from the UKCP18 probabilistic projections and represent a central (median) estimate of 30-year average change in each variable from a 1981-2000 baseline. Two emissions scenarios are used; RCP2.6 (roughly equivalent to a global warming +2°C above preindustrial scenario by 2100) and RCP6.0 (roughly equivalent to a global warming +4°C above preindustrial levels by 2100). *The exception is Sea Level Rise, where the RCP8.5 scenario is used, as for marine projections this is closer to a +4°C global warming scenario. The full likely range of change (i.e. 10 -90th percentile) in each average variable is not shown here but is available from the full UKCP18 database. It is important to note that because these projections show average changes for a 30-year period and only the central estimate, changes in individual years would show a much greater range of change and could be significantly higher (or lower).

Rainfall

There is a difference in expected rainfall trends in future in Northern Ireland, depending on the season. In winter, rainfall is expected to increase by approximately 3% by the 2050s and by between 7 and 10% by the 2080s from a 1981-2000 baseline, depending on global efforts to reduce greenhouse gas emissions. This is projected to lead to an increase in the likelihood of flooding of infrastructure, business and homes. Conversely, summer rainfall is projected to decrease by approximately 11% by the 2050s and by between 10 and 15% by the 2080s. Periods of water scarcity are likely to become more prevalent under these scenarios, leading to possible implications in agriculture and industry, for example.

Northern Ireland will experience warmer, wetter, winters

These changes do not mean that cold snaps and/or severe snowstorms cannot or will not occur in the future. The 'Beast from the East' caused considerable disruption in early 2018, and similar cold/snow events remain a possibility despite the overall warming trend. Winters are projected to become wetter, in terms of both the total amount of rainfall and the number of wet days.

Sea level rise

Using scenarios for Belfast, sea level is expected to rise by between approximately 14 and 19cm by the 2050s and by approximately between 27 and 58cm by the 2080s, compared to a 1981-2000 baseline and depending on greenhouse gas mitigation. Sea level rise will lead to an increase in likelihood of associated risks, such as flooding of coastal communities and coastal erosion impacting people, habitats and species. There are regional variations in projected sea level rise primarily due to vertical land movement caused by rebound from the last ice age.

The risks associated with these projected changes in Northern Ireland's climate are outlined overleaf and are summarised throughout the rest of this document.

3. Summary of the risks and opportunities for Northern Ireland

Natural Environment and Assets			
Risk or Opportunity	Risk number and Receptor	Nature of risk/opportunity	Urgency Score
RISKS	N1. Terrestrial species and habitats	Changing climatic conditions and extreme events, including temperature change, water scarcity, wildfire, flooding, wind, and altered hydrology (including water scarcity, flooding and saline intrusion)	More action needed
RISKS	N2. Terrestrial species and habitats	Pests, pathogens and invasive species	More action needed
RISKS	N4. Soils	Changing climatic conditions, including seasonal aridity and wetness	More action needed
RISKS	N7. Agriculture	Pests, pathogens and invasive species	More action needed
RISKS	N8. Forestry	Pests, pathogens and invasive species	More action needed
RISKS	N10. Aquifers and agricultural land	Sea level rise, saltwater intrusion	Watching Brief
RISKS	N11. Freshwater species and habitats	Changing climatic conditions and extreme events, including higher water temperatures, flooding, water scarcity and phenological shifts	More action needed
RISKS	N12. Freshwater species and habitats	Pests, pathogens and invasive species	More action needed
RISKS	N14. Marine species, habitats and fisheries	Changing climatic conditions, including ocean acidification and higher water temperatures	More action needed
RISKS	N16. Marine species and habitats	Pests, pathogens and invasive species	More action needed
RISKS & OPPORTUNITIES	N5. Natural carbon stores, carbon sequestration and GHG emissions	Changing climatic conditions, including temperature change and water scarcity	More action needed
RISKS & OPPORTUNITIES	N6. Agricultural and forestry productivity	Extreme events and changing climatic conditions (including temperature change, water scarcity, wildfire, flooding, coastal erosion, wind and saline intrusion).	More action needed
RISKS & OPPORTUNITIES	N17. Coastal species and habitats	Coastal flooding, erosion and climate factors	More action needed
RISKS & OPPORTUNITIES	N18. Landscape character	Climate change	Further investigation
OPPORTUNITIES	N3. Terrestrial species and habitats	New species colonisations	Further investigation
OPPORTUNITIES	N9. Agricultural and forestry productivity	New/alternative species becoming suitable	Further investigation

OPPORTUNITIES	N13. Freshwater species and habitats	New species colonisations	Sustain current action
OPPORTUNITIES	N15. Marine species, habitats and fisheries	Changing climatic conditions	Further investigation

Infrastructure			
Risk or Opportunity	Risk number and Receptor	Nature of risk/opportunity	Urgency Score
RISKS	I1. Infrastructure networks (water, energy, transport, ICT)	Cascading failures	More action needed
RISKS	I2. Infrastructure services	River, surface water and groundwater flooding	More action needed
RISKS	I3. Infrastructure services	Coastal flooding and erosion	Further Investigation
RISKS	I4. Bridges and pipelines	Flooding and erosion	Further investigation
RISKS	I5. Transport networks	Slope and embankment failure	More action needed
RISKS	I6. Hydroelectric generation	Low or high river flows	Watching brief
RISKS	I7. Subterranean and surface infrastructure	Subsidence	Further Investigation
RISKS	I8. Public water supplies	Reduced water availability	Sustain current action
RISKS	I9. Energy generation	Reduced water availability	Watching brief
RISKS	I10. Energy	High and low temperatures, high winds, lightning	Further investigation
RISKS	I11. Offshore infrastructure	Storms and high waves	Sustain current action
RISKS	I12. Transport	High and low temperatures, high winds, lightning	More action needed
RISKS	I13. Digital	High and low temperatures, high winds, lightning	Further Investigation

Health, Communities and the Built Environment			
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score
RISKS	H1. Health and wellbeing	High temperatures	More action needed
RISKS	H3. People, communities and buildings	Flooding	More action needed
RISKS	H4. Viability of coastal communities	Sea level rise	Further investigation
RISKS	H5. Building fabric	Moisture, wind and driving rain	Further investigation
RISKS	H7. Health and wellbeing	Changes in indoor and outdoor air quality	Further investigation
RISKS	H8. Health	Vector-borne disease	Further investigation
RISKS	H9. Food safety and food security	Higher temperatures (food safety) and extreme weather (food security)	Further investigation
RISKS	H10. Health	Water quality and household water supply	Further investigation
RISKS	H11. Cultural heritage	Changes in temperature, precipitation, groundwater, land, ocean and coastal change	More action needed
RISKS	H12. Health and social care delivery	Extreme weather	More action needed
RISKS	H13. Education and prison services	Extreme weather	More action needed
RISKS & OPPORTUNITIES	H6. Household energy demand	Summer and winter temperature changes	More action needed
OPPORTUNITIES	H2. Health and wellbeing	High temperatures	Further investigation

Business and Industry			
Risk or Opportunity	Risk number and Receptor	Nature of risk/opportunity	Urgency Score
RISKS	B1. Flooding of business sites	Increase in flood risk	More action needed
RISKS	B2. Coastal business locations and infrastructure	Coastal flooding, extreme weather, erosion and sea level rise	More action needed
RISKS	B3. Business production processes	Water scarcity	Further investigation
RISKS	B4. Business access to finance, investment and insurance	Extreme weather	Sustain current action
RISKS	B5. Reduced employee productivity in businesses	Infrastructure disruption and higher temperatures in working environments	Further investigation
RISKS	B6. Disruption to business supply chains and distribution networks	Extreme weather	More action needed
OPPORTUNITIES	B7. Changes in demand for goods and services	Long term climate change	Further investigation

International Dimensions			
Risk or Opportunity	Risk number and Receptor	Nature of risk/opportunity	Urgency Score
RISKS	ID1. Food availability, safety, and quality	Decreasing yields from rising temperatures, water scarcity and ocean changes globally	More action needed
RISKS	ID4. The UK's international interests and responsibilities	International violent conflict resulting from climate change overseas	More action needed
RISKS	ID5. Changes to international governance affecting the UK	Reduced international collective governance due to climate change and responses to it	More action needed
RISKS	ID7. International trade routes	Climate hazards affecting supply chains	More action needed
RISKS	ID8. Economic loss to the UK	Climate driven resource governance pressures and financial exposure	Sustain current action
RISKS	ID9. UK public health	Increase in vector borne diseases due to climate change	More action needed
RISKS	ID10. Risk multiplication to the UK	Interactions and cascades of named risks across systems and geographies	More action needed
RISKS & OPPORTUNITIES	ID3. Migration to the UK and effects on the UK's interests overseas	Climate-related international human mobility	Watching brief

OPPORTUNITIES	ID2. UK food availability and exports	Increases in productivity and areas suitable for agriculture overseas	**Watching brief**
OPPORTUNITIES	ID6. Increased trade for the UK	Arctic ice melt opening up new trading routes	**Watching brief**

The following sections of this report elaborate on this list of identified climate risks and opportunities to Northern Ireland's natural environment, infrastructure, population health and businesses mirroring the CCRA3 Technical Report. All information included in this document comes from the chapters that make up the Technical Report, unless specified otherwise. There is also a section dedicated to the potential risks and opportunities to the UK posed by expected climate change internationally. Under each risk heading there is a definition and description of the risk and then a summary of the actions that would be beneficial over the next five years.

Links are provided for readers wanting to find more detail of the assessment findings and the adaptation action that would be beneficial to be taken by the Government and their arm's length bodies and partners over the next five years to improve the country's resilience, knowledge and understanding. This will be useful for departmental and agency officials needing to work out the details of how to make changes in practice, and to universities and other research bodies wanting to offer their expertise in filling the identified research gaps.

Insight 1: Climate Change in existing Northern Irish National Government Policy

Northern Ireland does not have its own climate change legislation. However, in January 2020 the New Decade, New Approach deal from the restored Executive stated "The Executive should bring forward a Climate Change Act to give environmental targets a strong legal underpinning." The Northern Ireland Assembly declared a Climate Emergency in February 2020 and in July 2020 a non-legally-binding motion was passed by the Northern Ireland Assembly on climate change, on the "Introduction of a Climate Change Act within three months". In October 2020 a Private members climate change Bill was submitted to the Assembly and in December 2020, the Department of Agriculture, Environment and Rural Affairs (DAERA), published a consultation 'Discussion Document on a Climate Bill.' The Northern Ireland Statistics & Research Agency's Northern Ireland Environmental Statistics Report published in 2020 found that climate change was the biggest environmental concern for households in Northern Ireland in 2019/20.

Northern Ireland's second Climate Change Adaptation Programme (NICCAP2) (2019 -2024) focuses on key priority areas identified as requiring urgent adaptation action over the next five years. It sets the policies, strategies, and delivery plan actions by which Northern Ireland Civil Service (NICS)departments will deliver outcome objectives to achieve the vision of 'A resilient Northern Ireland which will take timely and well-informed decisions to address the socio-economic and environmental impacts of climate change'.

There is no specific legislation to manage coastal erosion risk management in Northern Ireland, such as the Coast Protection Act 1949 which regulates matters in England, Wales and Scotland. As such no central Government Department currently has legislative responsibility for it. DAERA and the Department for Infrastructure (DfI) commissioned a baseline study and gap analysis of coastal erosion risk management in Northern Ireland and there is further research currently taking place and planned including a Coastal LiDar Survey (remote sensing). This will provide a comprehensive baseline for monitoring coastal change and undertaking coastal vulnerability assessments.

Northern Ireland does have some existing national policies which take Climate Change into consideration including:

- The Strategic Planning Policy Statement for Northern Ireland (SPPS) which states how the planning system should help to mitigate and adapt to climate change.
- The draft Marine Plan has climate change as a Core Policy including specifically mentioning adaptation and additional relevant policies such as coastal processes.
- NI Water's Water Source and Supply Resilience Plan (2020-2042) which they plan to update using UKCP18 Climate Change Projections.
- Delivering Our Future, Valuing Our Soils: A Sustainable Agricultural Land Management Strategy for Northern Ireland, produced by an Independent Expert Group
- Protocol for the Care of the Government Historic Estate which requires all government and agencies to 'ensure that the historic environment is included in climate change action plans'.

Some gaps which new Northern Ireland legislation could cover which were included in the recent DAERA Discussion Document on a Climate Change Bill were:

- Adaptation Reporting Power - Public Body reporting in Northern Ireland. The UK Act does not give any powers to Northern Irish Ministers (by contrast with the situation in Wales) and no similar power is available under any other legislation.
- How Northern Ireland could contribute to the UK Net Zero Target for Greenhouse Gas Emissions.

- The potential of setting up an independent advisory body to provide advice and challenge function.

Currently a lot of policy is in flux in part due to the lack of Government for three years and also the external factors of Brexit and COVID-19. This means there are many policies in development (such as a Green Growth Strategy and Energy Strategy) and others out for consultation which are relevant to Climate Risks including:

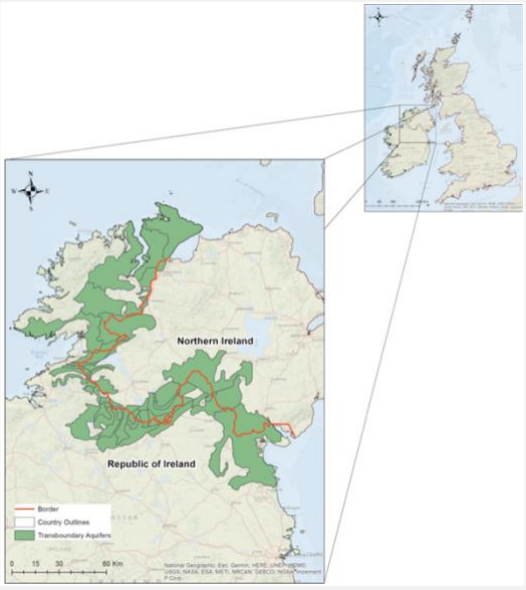
- Consultation on the Programme for Government draft Outcomes Framework
- Environmental Plans, Principles and Governance for Northern Ireland – Public Discussion Document
- A Clean Air Strategy for Northern Ireland – Public Discussion Document
- Consultation on draft Flood Risk Management Plan 2021-2027 second cycle

Insight 2: Northern Ireland relevant Transboundary Government Policy

It is difficult to predict the post Brexit future agreements in relation to climate risk transboundary policy. The Northern Ireland Assembly has full legislative powers over transferred matters, HM Government retains responsibility for excepted matters and areas which Northern Ireland can consent with the permission of the Secretary of State are reserved matters. In addition, there are many policy areas which are currently managed by cross border bodies or agreements with the Republic of Ireland. The bodies responsibilities are set under The North/South Co-operation (Implementation Bodies) (Northern Ireland) Order 1999:

- North South Ministerial Council
- Foyle, Carlingford and Irish Lights Commission
- Waterways Ireland
- InterTradeIreland
- Special European Union Programmes Body (SEUPB)
- Language Body
- Food Safety Promotion Board

There are six areas of cooperation where common policies and approaches are agreed in the North South Ministerial Council but implemented separately in each jurisdiction: Agriculture; Education; Environment; Health; Tourism & Transport.



An example is the River Basin Management Plan for the Republic of Ireland (2018–2021) which explicitly mentions cooperation regarding transboundary waters. There are three International River Basin Districts and 34 transboundary groundwater bodies shared between Northern Ireland and the Republic of Ireland that are currently managed jointly through the EU Water Framework Directive. There are uncertainties regarding the future status of groundwater management between Northern Ireland and the Republic of Ireland in regard to future UK environmental policy. Northern Ireland and the Republic of

Ireland do not currently abstract large quantities of groundwater from their aquifers. Climate change is starting to increase stresses upon water resources in these traditionally water rich regions as global temperatures rise.

Figure 1. Transboundary aquifers shared between Northern Ireland and Republic of Ireland, (modified from IGRAC and UNESCO-IHP 2015).

Insight 3: Climate Change in existing Northern Irish Local Government and Public Body Policy

NICCAP2 contains a chapter which sits outside government, titled 'Civil Society and Local Government Adapts'. The chapter is written by Climate NI, in conjunction with outside government stakeholders. It provides adaptation outcome objective delivery plans and actions that will be undertaken by Civil Society and Local Government sectors which will contribute to achieving NICCAP2's vision. Derry City and Strabane District Council is the first council area in Northern Ireland to adopt a Climate Change Adaptation Plan developed as part of the EU funded CLIMATE programme. A Net-Zero Carbon Roadmap for Belfast has also been published, developed as part of the Place-based Climate Action Network (PCAN). Seven out of the 11 councils in Northern Ireland are currently developing their Climate Change Adaptation Plans.

There are also some multi-agency policies in preparation and one example is:

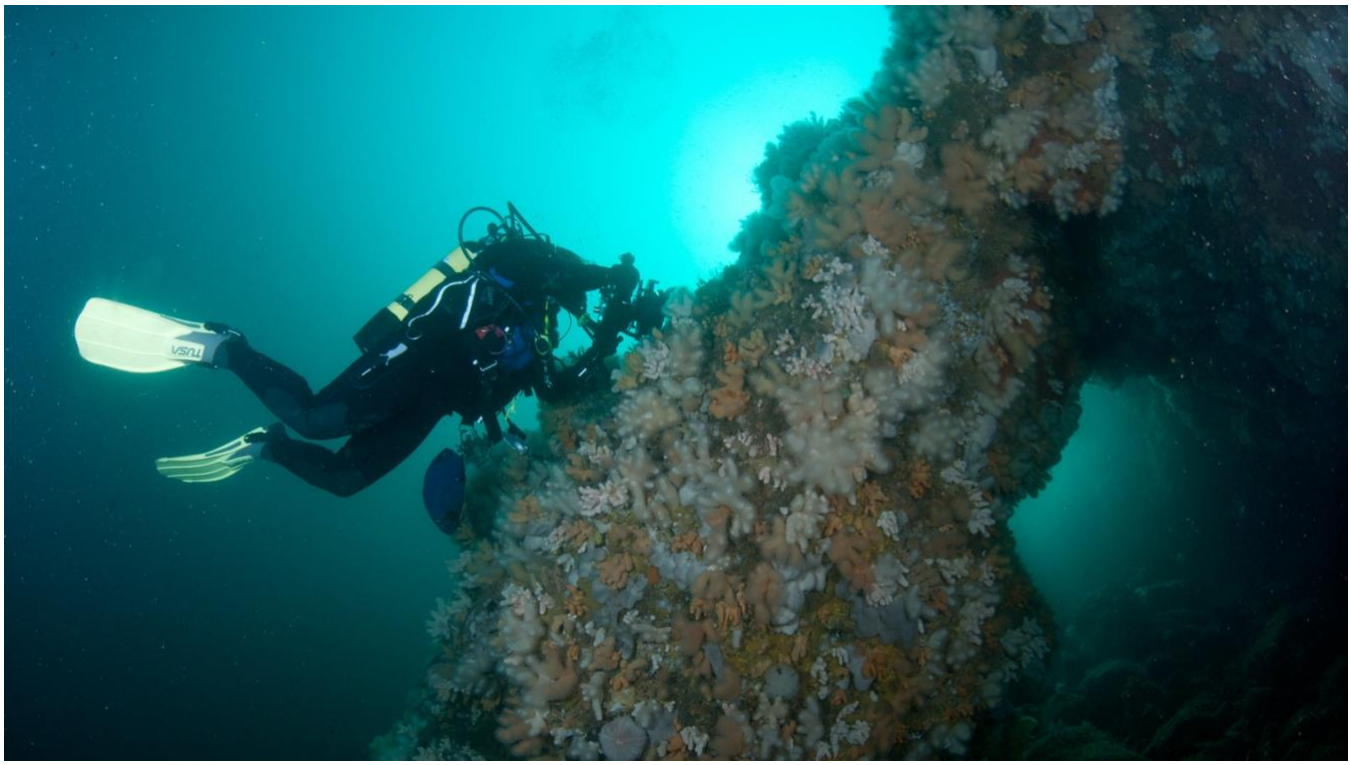
Living with Water in Belfast – An Integrated Plan for Drainage and Wastewater Management in Greater Belfast

In 2014, when it became clear that the drainage infrastructure across Belfast was unable to meet the requirements expected of it, the Northern Ireland Executive approved the development of a Strategic Drainage Infrastructure Plan (SDIP) for Belfast to:

- **Protect** against flooding by managing the flow of water through a catchment from source to sea.
- **Enhance** the environment through effective wastewater management and the provision of enhanced blue and green spaces to benefit local communities.
- **Grow** the economy by providing the necessary capacity in our drainage and wastewater management system to facilitate new development projects including house building.

Living With Water is a new approach to the provision of drainage and wastewater infrastructure for Northern Ireland which promotes holistic and integrated solutions that achieve multiple benefits at reduced cost and disruption. For example, by using open spaces and watercourses to enhance the environment, which promotes recreational opportunities and by sustainably managing water to help reduce flood risk. This is commonly referred to as blue and green infrastructure. Whilst the DfI is leading this programme, there are many partners from across central and local government who are working collaboratively through the Living with Water Programme (LWWP) to develop integrated and sustainable drainage solutions.

4. Natural Environment and Natural Assets



Chalk Arch with soft coral and endemic sponge communities off Rathlin Island, (photo Claire Goodwin)

This section examines the evidence regarding the key risks and opportunities from climate change in Northern Ireland for terrestrial, freshwater, coastal and marine natural environments and species, as well as for agriculture and forestry, landscape and ecosystem services. It recognises the key principles of the ecosystem approach, including the benefits of the natural environment for human wellbeing.

Climate change continues to affect the natural environment across Northern Ireland. A different framing and a larger number of risks have been included in the CCRA3 Technical Report than in the previous assessment. There is also a limited amount of new evidence for some risks making it difficult to assess their relative magnitude in many cases, especially across the different UK countries.

Most of the risk and opportunity urgency scores related to the natural environment have remained the same as in the CCRA2 Technical Report, but in some cases they have increased, as shown in the table below.

Risk/Opportunity/Risk and Opportunity	Urgency Score CCRA2	Urgency Score CCRA3
N2. Risks to terrestrial species and habitats from pests and pathogens and invasive species	Sustain current action	More action needed
N6. Risks to and opportunities for agricultural and forestry productivity	Research priority	More action needed
N7. Risks to agriculture from pests and pathogens and invasive species	Sustain current action	More action needed
N8. Risks to forestry from pests and pathogens and invasive species	Sustain current action	More action needed
N11. Risks to freshwater species and habitats from changing climatic conditions and extreme events	Research priority	More action needed
N14. Risks to marine species, habitats, and fisheries from changing climatic conditions	Research priority	More action needed
N16. Risks to marine species and habitats from pests, pathogens, and invasive species	Sustain current action	More action needed
N18. Risks and opportunities from climate change to natural heritage and landscape character	Watching brief	Further investigation

There follows a summary of all climate risks and opportunities in Northern Ireland related to the natural environment.

N1. Terrestrial species and habitats

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	N1. Terrestrial species and habitats	Changing climatic conditions and extreme weather events, including temperature change, water scarcity, wildfire, flooding, wind, and altered hydrology (including water scarcity, flooding and saline intrusion)	More action needed	Department of Agriculture Environment and Rural Affairs (DAERA)

Summary of risk definition and description

There is considerable evidence of the current and potential future effects of climate change and associated drivers on land dwelling flora and fauna across the UK and island of Ireland. This includes impacts on individual species and their distribution, as well as the composition and abundance of populations. Expected climate changes including droughts, waterlogging and wildfire can lead to losses or gains of species in a community or geographic area, while changes in distribution can represent opportunities for the receiving area.

Given this individualistic and mixed response it is hard to assess the magnitude of this risk for specific locations, habitats or species groups, but the potential for local or more widespread extinctions and losses means the current and future risk are both considered to be high. Some specific examples of changes in bioclimatic suitability are provided in the Natural Environment and Assets technical chapter, such as for the Irish Hare as well as species assemblages across the UK. Actions to increase the number and size of protected sites, restore vulnerable habitats, increase connectivity and create new habitats would have high adaptation benefits.

Some of the adaptation gap is being addressed by non-Governmental stakeholders, including the RSPB, National Trust, Woodland Trust (Case Study 1) and Ulster Wildlife, who under the INTERREG funded Collaborative Action for the Natura Network (in partnership with others), have been re-wetting over 1,000ha of raised bogs across Northern Ireland (see Insight 5). Rewilding, which often involves private landowners, would also support an ecosystem approach to the restoration of habitats and natural processes, as well as trying to address issues of connectivity to facilitate reactive adaptation.

While there is a range of policies and measures aimed at facilitating adaptation and reducing the impacts of climate change, there is a lack of evidence of their effectiveness, especially in the short term, thus more action is still needed.

Benefits of further adaptation action in the next five years

The CCRA2 assessment said that further action is needed now and into the future to increase current efforts to reduce existing pressures, improve the ecological condition of protected wildlife sites and restore degraded ecosystems, such as peatlands, wetlands and native woodlands. Ecological restoration can take many decades for some habitats, meaning that it can take a long time for adaptation actions to be realised.

The CCRA3 Technical Report emphasises that this has not changed and there is a need to take more flexible and integrated approaches to managing natural capital, including implementing shoreline management, catchment scale management strategies, and landscape scale initiatives to increase habitat extent and improve habitat condition and connectivity.

Climate change could also be more explicitly accounted for in conservation planning at site level and more widely. This may include modifying conservation objectives and planning for and anticipating necessary changes in spatial distribution, for example by identifying more resilient species that could thrive in particularly challenging environments. Site level conservation objectives and plans will need to be reviewed to assess whether management is appropriate for new or potential species to thrive. It is important that planning begins in time for action to be effective. Northern Ireland is restoring its peatlands and other ecosystems, such as ancient woodlands, but climate change adds another component to the need for these conservation actions to take place urgently and extensively across the country.

The All-Ireland Pollinator Plan 2015-2020 (a new version is currently being developed) recognises that pollinators are vulnerable to climate change, but that its impacts on them are difficult to predict. Increasing the connectivity and quality of pollinator friendly habitats are suggested for enabling the movement of pollinators in response to climate change.

Given the state of flux around many policies, decisions made in the next few years will have a profound effect on the natural environment for decades to come. Much of Northern Ireland's natural environment is degraded with many species and habitats at risk and successful adaptation will not be possible without significant investment in restoring natural areas. Equally, investment in nature recovery will be at risk if climate change adaptation is not fully embedded into planning from the start. It is essential that adaptation is consistently factored into decision making alongside climate change mitigation and the protection of biodiversity from the start. The concept of nature-based solutions has become increasingly prominent in thinking on climate change adaptation and mitigation. A true nature-based solution addresses societal challenges, such as climate change with benefits for both people and biodiversity.

The UK's Net Zero carbon target, not only involves mitigation, but also offers the potential to build climate change adaptation into land management and to greatly increase ecological resilience. It is, however, essential to ensure that nature-based solutions are at the heart of Net Zero actions and that other actions that may contribute to our Net Zero carbon target, such as an increasing use of biofuels, do not present an even greater risk of habitat loss or damage.

While there are some policies and measures aimed at facilitating adaptation and reducing the impacts of climate change, such as within the NICCAP2 there is a lack of evidence of their effectiveness, thus significantly more action is still needed. Consistent, long-term monitoring and assessment will also be vital to inform adaptive management and build a robust evidence base for further action.

Case Study 1: Ancient Woodland Restoration

In Northern Ireland, woodland covers only about 8% of land area and the remaining ancient woodland covers only about 0.04%. Faughan Valley is designated as an Area of Special Scientific Interest and a Special Area for Conservation in part for the ancient and semi natural oak woodland and the flora and fauna that live there.

The ancient woodlands of Northern Ireland have been decimated by centuries of clearance, exploitation, invasive species and the effects of a changing climate. However the fragments in Faughan Valley which remain are being reconnected including planting of new hedgerows and trees linking 1,000 acres of woodland in the valley which will also reduce the threat of flooding in the catchment and tree disease, thanks to National Heritage Lottery funding for restoration action by the Woodland Trust and partners. In order to prevent increased connectivity spreading any invasive species or diseases, the reconnected woodlands will be carefully managed and monitored (also see N2).

Five woodlands have been selected for restoration which started in 2020 as a first phase of a long term ambition to see the woods of the Faughan Valley move into favourable condition. Three of the woodlands are in private ownership with the remaining two owned by The Woodland Trust Northern Ireland.

Source: Woodland Trust
Image: Dave Scott

N2. Terrestrial species and habitats

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	N2. Terrestrial species and habitats	Pests, pathogens and invasive species	More action needed	DAERA

Summary of risk definition and description

Pests and invasive species have negative impacts on species and habitats but involve native and non-native species respectively. Pathogens are native or non-native species that cause disease and can include their vectors. Many of the drivers of change and adaptation options for native pests and pathogens also apply to invasive non-native species (INNS), hence information provided here is highly relevant to both. The relationship with climate depends on the individual pest or pathogen but includes maximum and minimum temperature, precipitation, humidity and potentially wind direction. Changes in these risks are primarily influenced by socioeconomic drivers, including cross-border trade, within-country movements, biosecurity measures and land use change.

New and emerging pests, diseases and INNS have been identified as important risks due to their negative effect on both biodiversity and on agriculture and forestry (see N7, N8 and N9). The future magnitude of this risk in Northern Ireland is assessed as being medium by the 2050s, increasing to high in the 2080s in a +4°C at 2100 scenario. There are a range of all Ireland and Northern Irish policies complying with current levels of EU regulations for specific pests and widely spread species. For example, information on invasive species in Northern Ireland is available via the Invasive Species Ireland website, a collaboration between DAERA and the Irish National Parks and Wildlife Service. However, there is a shortfall in adaptation making it unclear how this is going to be addressed. Thus, more action would be beneficial. The Invasive Species Ireland website provides information on biosecurity risks, legislation and management options for invasive species on the island of Ireland and the catalogue of pests and pathogens of trees on the island of Ireland provides a valuable baseline on plant pests in Ireland including in the context of climate change.

Benefits of further adaptation action in the next five years

- Consider changing the Government's current definition of INNS to include species that arrive in Northern Ireland because of climate change.
- Enhanced monitoring and surveillance of pests, pathogens and INNS would be beneficial.
- Greater collaboration between UK-wide, European and international pest risk and surveillance organisations would be helpful, especially because of potential changes to England's international trade portfolio.
- Early responses to pests, pathogens and INNS to prevent them becoming established would be beneficial, as economic and environmental management costs are higher once they are established.
- Further research on the likely responses and resilience of native species and habitats to high-risk pest and pathogens resulting from climate change and trade and adaptation options to manage these risks would also help.
- More integrated cross-sector policy initiatives, for example across agriculture, forestry, natural environment and human health, can also help to implement good practice and share tools and resources.

N3. Terrestrial species and habitats

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
OPPORTUNITIES	N3. Terrestrial species and habitats	New species colonisations	Further investigation	DAERA

Summary of risk definition and description

As species respond to climate change by moving and/or expanding their ranges towards the Poles, they could colonise new areas. This can occur in one of two ways. Either the species can be new to the UK or Ireland, although the level of migration is restricted as they are both islands. If it interacts negatively with native species, or alters habitat condition, then it is considered an INNS or a pest (see N2). The alternative is that the species may be new to a UK country or region. In both cases, they can enhance species richness and contribute to community adaptation to climate change. Also, while both scenarios can be consistent with climate change, often it is a complex situation involving other drivers.

The current and future opportunity is assessed as medium, partly because there is little evidence of the long-term effects of such movement, but it is likely that an increasing number of more mobile species will disperse in response to climate change. Many of these will not be able to fulfil their dispersal potential for a number of reasons including lack of dispersal routes and suitable habitat availability, thus further investigation is required to facilitate species movement and consideration given as to how to integrate them into conservation.

Benefits of further adaptation action in the next five years

DAERA was committed to leading on the production of Conservation Management Plans (CMPs) for 95% of Special Areas of Conservation by December 2020 across Northern Ireland within the second Northern Ireland Climate Change Adaptation Programme. CMPs will aim to help maintain Northern Ireland's network of habitats by contributing to their resilience and by helping to support a full range of biological diversity. The CMPs will help to address risks to species and habitats' ability to respond to changing climatic conditions. They will also contribute to Northern Ireland's ability to exploit opportunities gained from new species colonisation. At the time of writing, it is not possible to assess the extent of the impact of the CMPs on new species opportunities.

These may be further enhanced by carbon offsetting and Government funding in support of implementing the UK Net Zero carbon target. There are however risks from intensive forestry and biofuel production if carbon alone is a driver. It is important, therefore, that the development of Net Zero and adaptation policies are not contradictory.

It will still be beneficial to develop new approaches to establishing species in new locations and adapting objective setting and condition assessments to reflect changing distributions, for which there are no plans or funding at present.

N4. Soils

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	N4. Soils	Changing climatic conditions, including seasonal aridity and wetness	More action needed	DAERA

Summary of risk definition and description

As with CCRA2, risks to soils are identified as requiring more action in Northern Ireland. The magnitude of risk increases from medium at present to high by the 2050s on all pathway scenarios and, although awareness of this threat has improved, the necessary adaptation responses are not yet commensurate with this level of risk.

Climate is one of the key factors influencing soil formation, processes and properties, therefore changes in climate can be expected to have a significant impact on soils and their key functions. Temperature, precipitation, evapotranspiration and wind can all impact on soil productivity. Soils are extremely complex and can vary even at field level, with over 700 soil types present in the UK, adding to uncertainties around the scale and specifics of the change that is likely to be seen.

In Northern Ireland, the recent development of a Sustainable Agricultural Land Management Strategy recognises the existing unsustainable use of soils and identifies recommendations to address these problems. For example, less than 10% of farmland in Northern Ireland has an up-to-date soil analysis and 64% of soils are not considered to be at optimum pH. The strategy also calls for a "culture of behavioural change created by the provision of personalised information to empower farmers through measuring and managing the performance of their land". Although the strategy only contains limited references to the need for adaptation in the context of improved 'resilience against extreme events', it is notable for proposing a progressive roadmap that recognises the synergies between production gains and improved environmental outcomes. In particular, it highlights current issues with poor soil quality and sub-optimal grass utilisation, together with a significant proportion of land with insecure tenure, and proposes making soil health a central focus of the strategy complemented by considerable improvements in soil and water monitoring (including use of GPS and LiDAR technology) and land manager engagement in policy development (see N6).

EJP Soil is a new European Joint programme on agricultural soil management contributing to policy and solutions to key societal challenges including food security, climate adaptation and mitigation. AFBI's (Agri-Food and Biosciences Institute) work will contribute to developing state-of-the-art knowledge on soil carbon sequestration and soil health in Northern Ireland (see Insight 4).

Benefits of further adaptation action in the next five years

Given the importance of soils for maintaining biodiversity, regulating water flows and quality, recycling nutrients, carbon storage, landscape character, cultural value and provision for ecosystem services, there are significant benefits to ensuring good health of Northern Ireland's soils in future.

The Sustainable Agricultural Land Management Strategy for Northern Ireland is a start in providing a road map for change. As such, an integrated land use policy linking agricultural and forestry productivity with measures that improve soil health and resilience based upon good knowledge of the potential of different soil types and their key functions would be beneficial. This would also need to include further integration of adaptation and mitigation strategies based upon long-term planning, including for ambitious land use policies such as woodland expansion and

new bioenergy crops. Improved support for land managers would also be beneficial, in terms of access to benchmarking data and advice how to improve soil health outcomes consistent with improved use of public payments to soil health tracking and outcomes. With greater technical support to improve soil health, benefits would also be through improved connection of land managers back to their soil and therefore encourage more bottom-up adaptation initiatives based on different local contexts.

Insight 4: Climate-smart sustainable management of agricultural soils

EJP Soil is a new European Joint programme on agricultural soil management contributing to policy and solutions to key societal challenges including food security, climate adaptation and mitigation, sustainable agricultural production, ecosystem services and restoration and prevention of land and soil degradation. AFBI (Agri-Food and Biosciences Institute) is the UK partner on the project. AFBI's work will contribute to developing state-of-the-art knowledge on soil carbon sequestration and soil health in Northern Ireland.

The AFBI has joined forces with 25 institutions from 24 EU countries to deliver a European Joint Programme focusing on agricultural soils. The project aims to establish a baseline of available knowledge and tools in partner countries to help identify research priorities for climate-smart sustainable management of agricultural soils. From this baseline they will construct a roadmap that will function as a research agenda to allow strategic decision making in science, policy and implementation across Europe.

Under the EJP Soil initiative, AFBI will soon start work on a number of projects in Northern Ireland. These projects complement the work commissioned to AFBI from DAERA. They will involve multiple EU partners and will focus on 'Soil organic carbon sequestration potential of agricultural soils in Europe' (CarbpoSeq); 'Sensor data for downscaling digital soil maps to higher resolutions' (SensRes); Stocktaking for Agricultural Soil Quality and Ecosystem Services Indicators and their Reference Values and designing Innovative Soil Management Practices across Europe (i-SoMPE).

A key output for EJP SOIL is that farmers, landowners, land managers and industry will get access to context-specific guidelines for sustainable soil management practices, technology and tools for carbon level accounting. The project will also identify data gaps and priority needs for new knowledge and enhance evidence-based recommendations for policy-making at European and regional levels.

Source: AFBI
Image: Pixabay

N5. Natural carbon stores, carbon sequestration and GHG emissions

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS & OPPORTUNITIES	N5. Natural carbon stores, carbon sequestration and GHG emissions	Changing climatic conditions, including temperature change and water scarcity	More action needed	DAERA

Summary of risk definition and description

This topic focuses on risks to our natural carbon stores from climate change, and potential opportunities especially associated with better alignment of climate change adaptation and mitigation strategies. In addition to Carbon Dioxide, this assessment also includes the two other greenhouse gases (GHG) associated with the natural environment, which are Methane and Nitrous Oxide. It also covers the full range of environments, these being terrestrial, freshwater, coastal and marine.

As with CCRA2, this topic requires more action, arguably even more so now with the recent UK commitment to Net Zero carbon emissions by 2050. The magnitude of risk increases from medium at present to high in future, but currently there is only limited inclusion of adaptation planning with carbon and GHG emissions assessments. Partly this is due to limited information, also indicating a need for further research.

Peatland areas (see Insight 5) which contain the largest store of carbon-rich soils, are now the focus for considerable restoration efforts because surveys suggest much of the extent is in degraded condition (most commonly due to past drainage but also due to peat extraction for horticulture and fuel etc.), meaning they act as carbon sources rather than sinks. Peatland restoration is being implemented at a range of sites but as yet there is no national strategy or target for delivery.

'Blue carbon' represents marine and coastal habitats and species that sequester and store carbon which include saltmarsh, maerl beds, kelp forest, and seagrass beds (Zostera) and offshore shelf sediments. Blue carbon is not currently included in the UK GHG Inventory (although this is technically possible in terms of UNFCCC Wetlands Guidance) and concerns have been expressed that further degradation exacerbated by climate change will release this carbon (or result in carbon not being sequestered) increasing atmospheric Carbon Dioxide.

Benefits of further adaptation action in the next five years

More action is required to integrate adaptation and mitigation policy agendas, including:

- More targeted actions to restore degraded carbon stores, particularly peatlands.
- More strategic approach to land use planning, integrating agriculture and forestry, based upon linking net GHG gains with other multiple benefits.
- More research needed to account for climate change risks to carbon stores in UK GHG projections.
- Better integration of blue carbon in adaptation and mitigation planning and reporting.
- More investigation of integrated adaptation and mitigation benefits from nitrogen use efficiency in agriculture.
- Systematic programme of soil carbon monitoring.

N6. Agricultural and forestry productivity

Natural Environment and Assets				
Risk or Opportunity	**Receptor**	**Nature of risk/opportunity**	**Urgency Score**	**Risk Owner**
RISKS & OPPORTUNITIES	N6. Agricultural and forestry productivity	Extreme events and changing climatic conditions (including temperature change, water scarcity, wildfire, flooding, coastal erosion, wind)	More action needed	DAERA

Summary of risk definition and description

This topic covers the implications of climate change for the productive capacity of agriculture and forestry, notably for crops, livestock, milk, timber and other fibres. This potentially could impact not only land managers and rural communities but also the whole population through changes in domestic food supply and other commodities. This risk increases from medium at present to high in future, with a significant adaptation gap in addressing this risk, especially for agriculture. In Northern Ireland, the 2014 'Going for Growth' strategy, which aims to enhance production capacity, has recently been complemented by a Sustainable Agricultural Land Management Strategy. It includes a progressive roadmap that recognises the synergies between production gains and improved environmental outcomes (see Insight 6).

Insight 5: Ulster Wildlife- Re-wetting peatlands

Peatland restoration is being implemented at a range of sites in Northern Ireland but as yet there is no national strategy or target for delivery.

As part of its work with the INTERREG funded Collaborative Action for the Natura Network, Ulster Wildlife have been re-wetting peatlands: specifically, within 1,000+ha of active raised bogs in Special Areas of Conservation in Northern Ireland and 50ha of blanket bog in the cross-border SAC Cuilcagh Mountain-Anierin Uplands. Long-term GHG monitoring studies in Ireland indicate that re-wetting of peatlands (i.e. drain blocking) could be an effective mitigation strategy with more stable 'older' rewetted sites appeared to be more resilient to increased temperatures.

Northern Ireland is particularly important for active raised bog conservation in a UK context as it has 25% of the little that remains of this internationally endangered habitat (formally listed in Annex I of the EU Habitats Directive).

Re-wetting is carried out by installing dams (peat, plastic and peat/timber) in drains. The work is informed by LiDAR capture of conditions across the bogs and subsequent analysis of that data as well as digital terrain and digital surface models to pinpoint exactly where active peat formation can be maximised.

Source: Dr Trish Fox
Image: Benbrack Lough, Rosin Grimes (Ulster Wildlife)

Since CCRA2, more evidence has become available on this risk and, in combination with that used for the previous assessment, suggests that the urgency rating should now be 'More Action Required' because of the significant lead time to develop and implement actions in the land use sector. However, important knowledge gaps also remain which highlight the importance of continuing research on adaptation.

Insight 6: Agricultural Land Management in NI

The 2014 'Going for Growth' strategy, which aims to enhance production capacity, has recently been complemented by a Sustainable Agricultural Land Management Strategy developed by an expert working group. Although the latter only contains limited references to the need for adaptation in the context of improved 'resilience against extreme events', it is notable for proposing a progressive roadmap that recognises the synergies between production gains and improved environmental outcomes. In particular, it highlights current issues with poor soil quality and suboptimal grass utilisation, together with a significant proportion of land with insecure tenure, and proposes making soil health a central focus of the strategy complemented by considerable improvements in soil/water monitoring (including use of GPS and LiDAR technology) and land manager engagement in policy development. Based upon these developments, it is proposed that production capacity could be enhanced so that in terms of grass utilisation this would achieve at least one extra tonne of dry matter per hectare and with improvements in grass and silage quality of 5 to 8%.

Image: Sheep in Antrim, NI. Unsplash

The increased risk to agricultural land from flooding also is intended to be included in post-CAP plans for each administration, including a greater role for Natural Flood Management (NFM) in addition to protection for better quality farmland, although implementation details are still in development. It is therefore not yet clear whether current cost-benefit formulas used in options appraisal for flood and coastal erosion protection will be further refined to include the strategic value of the best quality farmland.

Best and Most Versatile Land (BMV) is the land which is most flexible, productive and efficient in response to inputs and which can best deliver future crops for food and non-food uses such as biomass, fibres and pharmaceuticals. Northern Ireland has a baseline of 65 Ha of BMV coastal land which is not predicted to be at significant risk of flooding

(frequency of 1 in 75 year or greater) with continuation of current adaptation policies. However, for the 3,442 Ha of BMV land near freshwater (fluvial), there is a significant risk of flooding (frequency of 1 in 75 year or greater) with continuation of current adaptation policies between 10% by 2050 under the +2oC global warming by 2100 scenario and 37% under a +4°C global warming by 2100 scenario.

Benefits of further adaptation action in the next five years

In terms of adaptation planning, there are critical decisions to be made on the long-term sustainability of some types and modes of agricultural production in their current locations, and in some cases whether investment could be moved towards new areas that are likely to be more climate resilient in the longer term, especially in the context of water availability. This challenge also emphasises the importance of recognising that agriculture and forestry enterprises are businesses.

Opportunities would arise through the development of an effective strategy to address the historical productivity gap in agriculture in Northern Ireland including skills, training and knowledge exchange, rural infrastructure and connectivity and delivering R&D at farm level. A major impetus for this strategy would be to better link adaptation and mitigation across the land use sector, including a combined pathway to the 2050 Net Zero carbon target outcome. This Net Zero target has identified amongst its key measures sustainably increasing crop productivity and livestock grazing intensity. The challenge is, therefore, to achieve this in a changing climate and to make additional space for woodland expansion on former agricultural land.

One of the solutions to manage the risks associated with climate change would be crop diversity which may conflict with the assumed land optimisation agenda for Net Zero. However, there are also considerable synergies that can be delivered in improved use and management of land to deliver combined production and Net Zero goals whilst also aiming to avoid negative consequences.

The following would be useful to provide an improved assessment capability:

- It would be useful for Northern Ireland to update its Agricultural Land Classification mapping in the light of climate change as a key strategic adaptation planning tool.
- Regular systematic surveying on the uptake of adaptation practices in the UK, including for different farming and forestry systems and locations, and integration with related land use datasets such as the National Forestry Inventory or agricultural census data.
- Application and trialling of near-term climate forecasts as related to productivity issues.
- Climate information tailored to crop breeding programmes.
- A more comprehensive assessment of climate resilience and robustness of different land use options in the context of changing water availability, including risks and opportunities for both rainfed and irrigated farming systems.
- Address key knowledge gaps – e.g. grasslands.
- Better integration of adaptation pathways with Net Zero pathways.
- Combined use of climate projections with socioeconomic scenarios to place UK domestic production in an international context.

N7. Agriculture

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	N7. Agriculture	Pests, pathogens and invasive species	More action needed	DAERA

Summary of risk definition and description

Invasive species are, by definition, harmful to other species or habitats, disrupting the wider ecosystem. They do not include invasive pathogens which are harmful diseases or disease-causing agents. Invasive species can be native or non-native. The CCRA3 technical report focuses on invasive non-native species due to their status in international agreements. Many of the drivers of change and adaptation options for native pests and pathogens also apply to INNS, hence information provided in the CCRA3 technical report here is highly relevant to both. The relationship with climate depends on the individual pest or pathogen but includes maximum and minimum temperature, precipitation, humidity and potentially wind direction. In addition, socioeconomic factors are highly influential, both management factors at farm level and large-scale drivers such as trends towards globalisation of trade and travel.

The risk is assessed as increasing from medium at present to high in the future in Northern Ireland and has increased in urgency from the CCRA2 from Sustain Current Action to More Action Needed. The current risk assessment procedures provide some adaptive capacity that can reduce this risk but nevertheless there is scope for more urgent action to improve preparedness. DAERA has developed the Northern Ireland Plant Health Risk Register (mentioned in the NICCAP2) which is a local prioritised list in which plant diseases and pests are prioritised based on local Northern Ireland factors monthly. It is a tool for government, industry and other stakeholders to prioritise action against pests and pathogens which threaten our crops, trees, gardens and countryside.

The Northern Ireland Government assessed progress from their first Invasive Species Strategy and stated that the majority of targets within the 30 key Actions had been achieved and steady progress was being made towards non-time limited targets. In 2018 the Invasive Alien Species implementation plan was revised. The importance of ongoing biosecurity and surveillance for ensuring the vitality of the agriculture sector is also strongly recognised in Northern Ireland, although no new measures specifically related to climate change adaptation have yet been defined. Current strategies do not include consideration of future climate risks including the potential impacts of 4°C global warming at 2100.

Higher temperatures could increase the incidences of the parasite Haemonchus contortus and the implications for lamb production and, under the +4°C at 2100 scenario, this could cost 10% of present lamb production value in Northern Ireland. Wind patterns may also bring more Culicoides midges and the diseases and parasites they bring from continental Europe to the UK and/or the island of Ireland.

It is very likely that EU-exit will have important implications for this risk through modified trade arrangements and associated adjustments to regulatory regimes, but details on these changes remains very limited at present. In addition, we have very limited information on how COVID-19 may modify this risk beyond general increased public awareness of the severe consequences that arise from spread of pathogens.

Benefits of further adaptation action in the next five years

For INNS, as shown by figure 2, it is much more effective to prevent introduction and establishment rather than attempt to mitigate spread and resulting impacts. The same principles apply for averting introduction of problem pathogens.

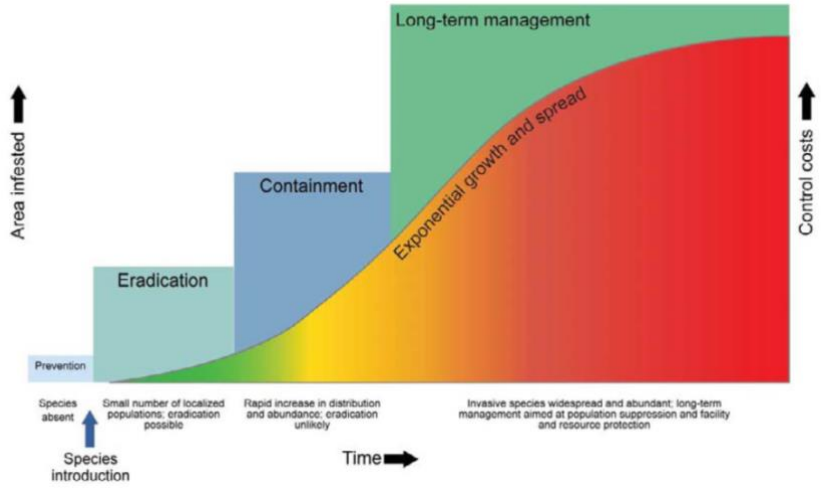


Figure 2: The invasion curve for invasive species with control costs increasing as INNS become more widespread and abundant (source: Environment Audit Committee 2019)

- Further assessment of climate factors in risk assessments would be beneficial in early warning.
- Quantitative analysis of climate change on crop pathogens remains limited and a more systematic programme of analysis is therefore useful to inform development of disease management plans, such as plant breeding, altered planting schedules, chemical and biological control methods and increased monitoring for new disease threats.
- Improved monitoring of pest and disease levels in crops and livestock could be used to provide more updated advice to growers, including best practice guidance on pest and pathogen biosecurity and management strategies.
- In addition, identification of plant and animals having greater natural resistance may be used in breeding programmes.
- Better awareness of emerging risks and associated contingency planning.
- Urgent action would be beneficial to improve preparedness, including improved surveillance, especially in the context of the need for enhanced international co-ordination following EU-exit and associated trade agreements.

N8. Forestry

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	N8. Forestry	Pests, pathogens and invasive species,	More action needed	DAERA

Summary of risk definition and description

Pests, pathogens and INNS present serious risks to forest productivity, with consequences for livelihoods and businesses, and for the multiple ecosystem services that forests provide. The combined effect of risk factors (climate and non-climate) indicates the magnitude of this risk is increasing in Northern Ireland from medium today to high by the 2050s. Across the limited set of known risks, this risk is assessed as increasing from medium at present to high in the future.

In Northern Ireland, the importance of enhanced biosecurity has been recognised, including the role of the Plant Health Risk Register (led by DAERA) but emphasis remains on support for existing measures. In 2018 the Invasive Alien Species implementation plan was revised but again explicit reference to climate change risks is limited. A recent catalogue of 'Pests and Pathogens of Trees on the Island of Ireland' now provides a good reference source.

However, like threats to agriculture, at present Northern Ireland has no measurable goal for managing and reducing the impact of existing plant and animal diseases. There is an increased awareness of the long-term issues, which can have lock-in risks in the forestry sector, due to the legacy of past decisions such as large monocultures of certain species (notably Sitka spruce), primarily based upon production criteria, and the resultant implications for wider ecosystems services such as water quality, biodiversity and amenity value.

Benefits of further adaptation action in the next five years

The need for cross-sectoral coordination and surveillance would benefit from more action and research especially focussed on the following issues:

- Surveillance for emerging risks.
- Further modelling of risk reduction measures.
- Further assessment of climate factors in risk assessments would be beneficial in early warning.
- Understanding current and future risks from non-native species, vectors and pathogens.
- Assessing management options for pests and diseases which have become resistant to current pesticides.
- Improved biosecurity, especially at entry ports of entry.
- Changes to plant purchasing and sourcing practices.
- Increased emphasis on disease and pest resilience.
- Further investigation of management initiatives to enhance resilience, such as diversification.

N9. Agricultural and forestry productivity

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
OPPORTUNITIES	N9. Agricultural and forestry productivity	New/alternative species becoming suitable	Further investigation	DAERA

Summary of risk definition and description

This opportunity is defined in the broader sense to include climate-related developments that are occurring through new species and varieties, together with new opportunities for agriculture. It also includes the potential for movement of existing species in one UK country or region into another country or region, therefore presenting novel opportunities in the new location. In each of these cases, agricultural or forest productivity may be enhanced.

The level of opportunity is assessed to increase from medium at present to possibly high in future, although evidence is rather limited. Much of this opportunity remains unrealised, probably due to a lack of decision making at multiple levels, therefore it is recommended as a priority topic for further Investigation.

There is presently limited information on the establishment and spread of new crops and other exotic produce, especially in a spatial context. Prominent examples that have featured in the news include chickpeas, quinoa, vines, soya, and lentils. Other crops known to have been grown recently in the UK include peaches, apricots, tea, sunflowers, sweet potatoes, watermelons and walnuts, whereas exotic produce have recently extended to include truffles.

Forestry Commission (FC) data indicate that ca.25% of trees planted in FC forests are currently less-traditional species. This includes species that are fast growing and therefore provide opportunities for enhanced productivity but may also present additional risks, such as from wildfire (e.g. eucalyptus). Climate warming is also allowing expansion in the use of some established productive species into new areas (e.g. Douglas fir).

Benefits of further adaptation action in the next five years

Currently crop breeding mainly focuses on yield and disease resistance but future climate change is not generally systematically considered (but see Insight 7). More detailed scoping and investigation of opportunities would be beneficial, which is also consistent with changing patterns of land capability and individual crop suitability across Northern Ireland, factoring in the risks already outlined. A major gap in knowledge and knowledge exchange appears to exist for opportunities for fruits, vegetables and horticultural crops in a future climate. More systematic investigation would be advantageous, including outreach activities and collation of existing and new knowledge on species.

Insight 7: InnoVar

The InnoVar project is led by AFBI and other UK partners including DAERA, the Animal and Plant Health Agency, and ADAS. The project aims to identify crop varieties that can maintain performance with lower agro-chemical inputs and under more extreme climatic conditions.

The project has received almost €8M of funding and will run over the next 4.5 years, representing a large EU consortium of 21 partners from ten countries. It will benefit local stakeholders through drawing together expertise and knowledge from across crop science, bioinformatics, soil science, meteorology, and computer science to develop and deliver methods and tools to achieve greater efficiency in variety testing processes and in the use of resources on-farm. This will enable farmers across Northern Ireland, the Republic of Ireland, the UK and the EU to maximise the potential of their land, in terms of both the yield and environmental sustainability (including adaptation to climate change and environmental resilience).

InnoVar initially focusses on wheat and will then apply the same approach to provide roadmaps for other crop groups with more detailed work on grass, maize, and legumes. Using cutting-edge technologies to develop Next Generation Variety Testing (NGVT) including phenotyping, phenomics, genomics, and machine learning harmonised variety testing across Europe will be undertaken so that average yields can approach potential yields through the use of 'fit-for-purpose' regional varieties.

One of the main outputs for the project includes designing an app to provide a decision support system to empower growers to select crops that are best suited for their agro-climatic region, end-use, and growing scenarios. The app will develop the concept of High Performance Low Risk (HPLR) variety selection.

Source: AFBI

N10. Aquifers and agricultural land

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	N10. Aquifers and agricultural land	Saltwater intrusion	Watching brief	DAERA

Summary of risk definition and description

This risk defines the threat that saline intrusion, as associated here with sea level rise, poses for coastal aquifers and agricultural land. The risk is currently low at present and most likely to remain low in future unless a much greater rate of sea level rise was to occur than most estimates expect.

Current risk management procedures should remain adequate to adapt to the risk subject to further review. However, evidence is rather limited for this issue and further research on changes in exposure and vulnerability would be beneficial, including in the context of the latest scientific data on sea level rise. Current information would suggest that saline intrusion in coastal aquifers is a lesser issue for Scotland and Northern Ireland because the underlying geology means that surface water resources dominate over groundwater resources, and because relative sea level rise has been generally lower due to local land uplift. Some water bodies are shared transboundary resources that are managed with the Republic of Ireland, but again there are no known issues at present regarding saline intrusion for these water bodies.

Abstraction is regulated by Northern Ireland government policy and licensed by the regulatory authorities in accordance with the water quality requirements of the Water Framework Directive. At the time of writing there are uncertainties regarding the future status of groundwater management between Northern Ireland and the Republic of Ireland in regard to future UK environmental policy post Brexit so a transboundary groundwater agreement may be beneficial.

Benefits of further adaptation action in the next five years

Northern Ireland is assigned a 'Watching Brief' assessment due to the lesser scale of risk exposure, although here current evidence is also more limited as consistent with assumed lower exposure and vulnerability to this risk. This would be an appropriate risk to further investigate the operational use of adaptation pathways related to changes in sea level rise, precipitation patterns and safe abstraction rates.

There are some potential future adaptation measures identified which would be beneficial:

- Liaise with water companies and water users to further investigate spatial and temporal patterns in risk exposure and vulnerability.
- Continue to monitor and report on impacts for aquifers to assess whether risks are increasing.
- Develop forward projections based upon different climate change and socioeconomic scenarios to assess robustness of regional and national resources and implications for adaptive resource management.

N11. Freshwater species and habitats

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	N11. Freshwater species and habitats	Changing climatic conditions and extreme events, including higher water temperatures, flooding, water scarcity and phenological shifts	More action needed	DAERA

Summary of risk definition and description

Freshwaters provide the UK with a wide array of socioeconomically important ecosystem services including water supply, pollution removal, and recreational potential. The annual value of these services to the UK has been estimated at approximately £39.5bn and this is likely to be an underestimate. Freshwater habitats are particularly vulnerable to changes in water availability and higher water temperatures in the face of climate change. These risks could lead to aquatic species exceeding their thermal tolerance or bringing about detrimental habitat changes including algal blooms, loss of sensitive species, changes in hydrology, and changes in timing of life cycle stages (phenology) and species composition. Some birds, such as those associated specifically with lakes, could also be affected by changing air temperatures. The risk to freshwater ecosystems was not included separately in CCRA2 but this has been re-assessed due to increasing evidence of how climate change could affect freshwater species.

In Northern Ireland, 31.3% of river water bodies were classified as 'good' status or better as part of Water Framework Directive reporting in 2018. There has been a significant decline in lake status. In 2018, five of the 21 lake water bodies were classified as 'good' or better and 16 lake water bodies were classified as 'moderate' or worse. In 2020, only one of the 21 lake water bodies were classified as 'good' or better status and the remaining 20 lake water bodies classified as 'moderate' or worse.

Lake sediments can act as a long-term carbon sink therefore carbon sequestration may be considered a nature-based solution to contribute to Net Zero targets. However, carbon burial and processing within fresh waters will be affected by ecosystem state and pressures acting upon it.

It should be noted that the limited amount of new evidence has made it difficult to assess the magnitude of the risk related to each devolved administration, distinct from the UK. The magnitude of current and future risks is judged to be medium by the 2050s and high for the 2080s if there is 4°C global warming at 2100, due to the likelihood of greater changes in water temperature, river flows and water quality. Given the currently incomplete knowledge of climate impacts on freshwater ecosystems, and the current shortfall in adaptation measures, more action is recommended combined with further investigation on the scale of risk and effectiveness of these measures.

Benefits of further adaptation action in the next five years:

The NICCAP (2019-2024) states that River Basin Management Planning, to meet the targets of the Water Framework Directive, takes account of findings from the latest Climate Change Risk Assessment. Programmes of measures within these Plans are to address potential climate change impacts on the Northern Ireland water environment. Furthermore, the Programme promises to identify future areas for riparian planting. From Northern Ireland's 450 river catchments, there is a desire to see 60 - 80 catchments targeted with the necessary equipment to monitor water quality on an hourly basis. Despite uncertainty over post Brexit regulation, the EU will expect the management of all transboundary river basins.

Further suggestions:

- Prioritise research on the responses of freshwater habitats and species to climate change in conjunction with other change processes and to highlight the implications for meeting water management objectives.
- Develop policy-relevant indicators of climate change impacts on fresh waters.
- Investment in long-term research capability to detect ongoing and emerging impacts with reference to baseline and historic variation.
- Funding and support for projects that work with natural processes to manage flood risk, ecosystem status, and ecosystem services.
- Ensure the good ecological status of water in Northern Ireland and transboundary river basins.

N12. Freshwater species and habitats

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	N12. Freshwater species and habitats	Pests, pathogens and invasive species	More action needed	DAERA

Summary of risk definition and description

The impacts of an increase in pests, pathogens and INNS on freshwater ecosystems are similar to the impact on other assets outlined earlier in this document and include competition with native species, predation, introduction of disease, harmless airborne pathogens becoming more infectious and habitat alteration, which can lead to increased river flooding and economic costs. Direct management costs of freshwater INNS have been estimated at over £46m in Northern Ireland.

The current level of risk for Northern Ireland is assessed as medium, seven out of the 11 widespread INNS are associated primarily with freshwater or wetland habitats. Human interactions and activities are the most significant factors in the spread of INNS, with temperature being a relatively insignificant factor in most cases. However, future projections under the high emissions scenario suggest currently unsuitable locations increasingly will become suitable, and hotspots of invasion suitability will be around major cities and river systems.

Benefits of further adaptation action in the next five years

As with terrestrial species (see N2) enhanced monitoring, surveillance and early response measures to manage the freshwater risks of pests, pathogens and INNS would be beneficial, with international co-operation important post EU-exit. Cross-sectoral collaboration would improve the effectiveness of adaptation actions. While further research would enhance our understanding of the role of climate change in this risk and any specific adaptation actions required.

N13. Freshwater species and habitats

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
OPPORTUNITIES	N13. Freshwater species and habitats	New species colonisations	Sustain current action	DAERA

Summary of risk definition and description

The colonisation of new species has the potential to enhance species richness and contribute to community adaptation to climate change. However, the opportunities from climate change are assessed as low for Northern Ireland, both currently and in the future, as there is low evidence of these opportunities to date and climate change is likely to a play smaller part in the benefits of colonisation compared to other factors. Many of the adaptation actions that are taken to combat the risk to freshwater species will facilitate species realising opportunities and thus sustaining current action is recommended. There is only limited evidence of which freshwater species could benefit from a changing climate at this stage in Northern Ireland.

Benefits of further adaptation action in the next five years

Maintaining current adaptation as detailed is sufficient, unless there is a desire to promote any opportunities, such as the arrival of rare and/or iconic species, in which case specific actions might be valuable.

N14. Marine species, habitats and fisheries

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	N14. Marine species, habitats and fisheries	Changing climatic conditions, including ocean acidification and higher water temperatures	More action needed	DAERA

Summary of risk definition and description

Marine ecosystems are impacted by climate change through both direct and indirect effects on the distribution and abundance of species groups. This includes plankton, invertebrates, fish, seabirds, marine mammals and habitats.

This risk topic covers all negative impacts below the intertidal zone, except for pests and pathogens (covered in N16), and is one of the largest risks in the CCRA. The evidence indicates that more action is required. The magnitude of risk increases from medium at present to high in future, although with notable uncertainties. Nevertheless, there is confidence that major changes will occur to the marine environment even if the details are less certain and more action needs to be taken to better prepare for this now. As significant change is already occurring, these actions are very likely to have short-term as well as long-term benefits.

The general pattern for future change is likely to be the further replacement of cold-water species with warm-water species, with the rate of change dependent on climate change scenario and regional sensitivities. The reduction of pH has been more rapid in UK waters compared to the whole North Atlantic which may impact corals, molluscs and seaweeds including maerl.

Plankton communities can show rapid responses to changes in nutrients, salinity, and temperatures, with changes in abundance varying regionally and by group for both phytoplankton and zooplankton. Whilst fisheries show the general large-scale pattern of northward movement of species, historic overfishing pressures have been the dominant influence, although in the last ten years some commercial fish species have increased in abundance from very low baselines.

The Northern Ireland Marine Plan was published for public consultation in April 2018 and includes climate change as one of its core components. The Marine Protected Area (MPA) network has been significantly expanded in terms of designated area (now at 2,566km2) in recent years and the next stage will involve identification of necessary management measures to bring the network into 'favourable condition' (currently only 115km2 is assessed as favourable). Northern Ireland is also involved in the MarPAMM project to trial new approaches to MPA management. Regarding fisheries, there was a consultation in 2014 for a new Fisheries Bill however the Fisheries Act (Northern Ireland: 2016) covered the enforcement of EU rules rather than a full update. With regard to Water Framework Directive E. Coli standards, only two out of nine shellfish water protected areas (SWPAs) achieved compliance in 2019.

Benefits of further adaptation action in the next five years

- Further development and regulation of the MPA network as associated with present biodiversity requirements and expected future shifts in distributions.
- Reduction of non-climate pressures such as pollution and overfishing to maximise potential for species and habitat resilience.
- Further development of habitat restoration initiatives.

- A clearer assessment and implementation of sustainable fisheries yields in the context of present and future climate change.
- Improved monitoring schemes to better assess progress on biodiversity and fisheries goals.
- Further research on the climate sensitivity and interactions of plankton to fisheries, seabirds and mammals.
- Further research on the sensitivity of UK aquaculture species to multiple climate change drivers.

N15. Marine species, habitats and fisheries

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
OPPORTUNITIES	N15. Marine species, habitats and fisheries	Changing climatic conditions	Further investigation	DAERA

Summary of risk definition and description

This topic assesses climate-related opportunities in the marine environment, including biodiversity and fisheries, with an emphasis on 'new' species for UK waters as distinct from ongoing shifts in existing UK species. As N14 showed, there are major changes expected in the marine environment meaning the level of opportunity may increase from medium at present to high in future, although there is considerable uncertainty and evidence at present. Much of this opportunity currently appears unrealised therefore further investigation is recommended to improve adaptive capacity.

Currently, there are also no discernible differences that reflect how this opportunity could be realised specifically in Northern Ireland compared to other UK nations. For biodiversity, the continued future conservation of MPAs will be important in providing habitats where new species of high biodiversity value can become established and hence opportunities could be realised, as there is strong evidence that providing habitats in good condition aids in the movement of species.

Some potential new commercial fish species are unfamiliar to UK consumers compared to traditional species which may limit demand for these new species despite increased numbers and the potential for sustainable harvesting. For biodiversity conservation, there is often limited awareness of changing opportunities and sometimes a preference for attempting to conserve the status quo or to restore to a past position. Monitoring and data collection also remain poor, with 12% of UK stocks being of unknown status, with notable data limitations existing for nearly all elasmobranch (shark and ray) stocks, which means for fisheries, understanding of catches is poor due to low levels of effective monitoring at sea.

Benefits of further adaptation action in the next five years

- For biodiversity, further investigation linked to developing the role of MPA would maximise opportunities to enhance biodiversity value.
- For fisheries, opportunity would arise through assessments linked to improved data on current and projected movements of key species together with sustainable yield assessments.

N16. Marine species and habitats

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	N16. Marine species and habitats	Pests, pathogens and invasive species	More action needed	DAERA

Summary of risk definition and description

This topic assesses pests, pathogens and INNS for the marine environment. As with other risks to the marine environment, there is considerable uncertainty for this topic, more so for pathogens, but nevertheless this risk is assessed as increasing from medium at present to high in future. The current institutional risk assessment procedures provide some adaptive capacity that can reduce this risk but there is an urgency for more action to improve preparedness and address some of the key uncertainties.

The primary risk factor for initial establishment of harmful species and microorganisms in the UK is transport by ships, usually associated with international trade. Climate change is therefore acting as an additional risk factor, principally through its influence on warming of seas, which can encourage establishment and spread of pests, pathogens and INNS at a magnitude not experienced previously.

A horizon scan of invasive alien species around the island of Ireland, found that crustacean species (freshwater and marine) were the taxa most commonly identified as a threat due to their multiple pathways of introduction, their ability to act as ecosystem engineers and their resulting high impacts on biodiversity. The most likely marine invader was identified as warm-water barnacle (*Hesperibalanus fallax*), with pom-pom weed (*Caulacanthus okamurae*), American razor-clam (*Ensis leei*), Brush-clawed shore crab (*Hemigrapsus takanoi*), the sponge *Celtodoryx ciocalyptoides* and Asian shore crab (*Hemigrapsus sanguineus*) also identified in the top 40 overall threats.

A further concern regarding aquaculture, is the impact of antimicrobial resistance (AMR) because antibiotics are commonly used in feedstuff to control bacterial infections. Meta-analysis across several countries has shown an association between aquaculture-related AMR and climate warming.

Northern Ireland collaborates with the Irish Republic on an all-Ireland approach to INNS, which includes the threat from marine species. The 'Invasive Alien Species Strategy for Northern Ireland' aims to address knowledge and awareness gaps, and minimise introductions and spread of INNS, whilst also aiming to eradicate and control existing problem species, also through a partnership and capacity building approach. The Marine Plan for Northern Ireland (2018), which could also provide a strategic pathway to build adaptive capacity for this risk, is yet to be adopted by government.

Benefits of further adaptation action in the next five years

Pest species and INNS once established, are very difficult and costly to eradicate in the marine environment. Similarly, for marine pathogens, land-based management methods of quarantining, culling, and vaccinating are not successful. Potential useful actions include:

- Collect long-term data to better understand how marine pests, pathogens and INNS are affected by extreme events, climate variability and climate change.
- Improve horizon scanning and modelling capability for INNS and pathogens, including through international collaboration.
- Improve public awareness, including further use of citizen science.
- Improve understanding of factors that contribute to disease-resistant organisms.
- Improve understanding and contingency planning for emergent risks, especially for novel pathogens.

N17. Coastal species and habitats

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS & OPPORTUNITIES	N17. Coastal species and habitats	Coastal flooding, erosion and climate factors	More action needed	DAERA

Summary of risk definition and description

Coastal habitats occur at the boundary of terrestrial and marine environments and include both intertidal and supratidal environments notably saltmarsh, machair, shingle, saline lagoons, sand dunes and sea cliffs. In addition to their biodiversity value they provide many ecosystem services, such as flood and erosion protection, fisheries, climate regulation and tourism opportunities.

Coastal flooding and erosion are driven by extreme water levels which arise as combinations of four main factors: waves; astronomical tides; storm surges and relative mean sea level. The scale of flooding and erosion is dependent on the underlying coastal morphology (topography, rock type, slope of beach etc.) and the influence of rainfall and high levels of river discharge including increased sediment supply can also be significant in some estuaries.

The risk is assessed as increasing from medium at present to high in future as it is especially influenced by the rate and magnitude of sea level rise, which the most recent assessments indicate may be at a higher rate and magnitude than assumed for CCRA2. At present, adaptation responses are inadequate to match the scale of the risk or even to realise potential opportunities for habitat creation. Therefore, this topic remains a priority for more policy action.

In Northern Ireland, there is less detailed information on coastal change than the other nations (see Insight 8 and Insight 10). However, it has been estimated that ca.20 - 30% of the coastline is either eroding or at risk of erosion and that 32% of the coast has some form of protection. No indicators are available yet for Northern Ireland for coastal squeeze (for example, sand dunes, intertidal flats and marshes and also maritime grasslands in clifftop locations). However there are estimates that 0.56 ha per year of Saltmarsh and 2.5 ha per year of sand dunes are being lost each year. The total extent of the intertidal environment in the UK has therefore decreased due to erosion from sea level rise and coastal squeeze from hard built structures preventing natural roll back, but no overall updated assessment of changes in the intertidal zone has been completed.

Surveys have indicated over a third of UK seabird species showed declines of 20% or more in breeding abundance since the 1990s, with the increase apparently increasing in the last decade. The UK breeding seabird index (based upon the populations of 13 species) in 2018 was 28% lower than at its starting date in 1986, and only slightly above its lowest level ever recorded.

Condition monitoring of coastal habitat areas also continues to show that much of it is in unfavourable condition around the UK. In Northern Ireland, saltmarsh habitat condition is not yet assessed for the Water Framework Directive although it has been assessed in England in 2016.

Many designated conservation sites are also at risk of more frequent flooding (which can sometimes be beneficial for some priority habitats), see figure 3 below.

Assets at significant risk in Northern Ireland	Baseline (Ha)	2050s 2°C	2080s 2°C	2050s 4°C	2080s 4°C
Most important habitats exposed to frequent flooding	1,078	18%	33%	38%	55%
Ramsar areas	234	24%	44%	51%	74%
Special Areas of Conservation	224	0%	0%	0%	1%
Special Protection Areas	621	22%	40%	47%	68%

Figure 3. Increase in designated areas at significant risk of coastal flooding (1 in 75 year or greater) for Northern Ireland (+2°C and +4°C at 2100 scenarios with low population: Sayers et al., 2020). NB. Risk is assessed to areas to landward of coastal defences but does not include changes in inundancy frequency and associated risk for habitats on seaward side. Reproduced from CCRA3 Natural Environment and Assets technical chapter.

In Northern Ireland, there is no legislation in place to specifically address coastal erosion or assign responsibilities. Instead coastal assets are looked after by the respective government department whose responsibilities most closely coincided with the property or asset at risk from erosion (the 'Bateman formula': DAERA, 2018). This piecemeal approach has tended to act against a strategic approach to coastal erosion risk management which is exacerbated by rather limited data and knowledge on current risks. Nevertheless, the responsibility for the appropriate management of coastal changes lies principally with DAERA and DfI, with DAERA responsible for nature conservation. Current efforts are focussed on collating baseline data to confirm the scale of the challenge for both flooding and erosion.

The recent baseline study and gap analysis of coastal erosion risk management also identified a lack of strategic coastal data and an ineffective current policy framework by comparison with other countries. DfI Rivers is currently undertaking a coastal mapping update study and a high-resolution 3D coastal topographic survey (LiDAR and satellite-derived bathymetry) has recently been commissioned, which will both aim to provide an improved monitoring baseline for risk assessment. Similarly, work underway through the UK-wide Coastal Flood Boundary Conditions Update project should provide improved and up-to-date data on extreme still water sea levels for flood risk mapping. The Northern Ireland Marine Plan (2018) includes climate change, coastal processes, land and sea interactions, and cumulative impacts as core components, all of which are highly relevant to the coastal environment, but the Plan is yet to be adopted by government. There has been no development of Shoreline Management Plans (SMP) in Northern Ireland (or an equivalent coastal planning mechanism), although there is an increasing awareness of the need to approach coastal issues more strategically and to improve data collation.

A particularly notable lead is being provided by the National Trust, one of the UK's largest landowners, through its 'Shifting Shores' initiative which establishes a consistent blueprint for adaptive coastal management across all its coastal properties (see Case Study 4).

Adaptation at governmental level in all administrations is not occurring at a speed and scale to match the climate change risk, both present and future. Priority habitats and species continue to be lost and ecosystem services degraded.

Benefits of further adaptation action in the next five years

When considering potential benefits of further adaptation action in is important to also consider points made within the other risks covering coastal erosion and coastal flooding which are (see also risks I3, H4, H11, and B2):

- A good quality baseline and monitoring survey of coastal change on which to base future projections would be beneficial.
- In addition to sea level rise, improved assessment of other coastal drivers at local and regional scale including waves and tidal dynamics, and additionally for estuaries to include changes in freshwater inputs (fluvial flows).
- Large-scale opportunity assessment of managed realignment based upon multiple benefits and a range of sea level rise scenarios, placing small local schemes in a regional context.
- Assessment of current habitat change for all priority habitats and future habitat change based upon a diverse range of climate change and management scenarios.
- Species and ecosystem function assessments for managed realignment and habitat restoration schemes to monitor ongoing change and progress in terms of their resilience against climate change.
- Integration of the above recommendations with development of SMP processes for Northern Ireland to show the links between evidence, policy, and implementation actions under different adaptation options and pathways (e.g. as defined by different sea level rise scenarios).
- A unifying issue for all of the above recommendations is the need for improved consistency in monitoring and change assessments (e.g. using a common protocol and Coastal Observatories working together) to facilitate better transparency in adaptation progress reporting across all the UK.

N18. Natural heritage and landscape character

Natural Environment and Assets				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS & OPPORTUNITIES	N18. Natural heritage and landscape character	Climate change	Further investigation	Dept for Infrastructure / DAERA

Summary of risk definition and description

This topic is broadly defined to include risks and opportunities relating to landscapes, landscape character and the historic environment (see H12). Due to this integrating effect of other risks and opportunities at landscape scale, this topic is assessed as increasing in magnitude from medium at present to high in future, especially with higher climate change scenarios.

Recent developments and a greater recognition of landscape character and the impact of climate change has allowed for a more refined assessment to be made of the risks and opportunities. Some important recent initiatives have also shown how adaptation could be integrated with landscape concepts, but evidence is still limited, therefore further investigation and trialling of these approaches is recommended.

Northern Ireland has a comprehensive assessment of both the 26 regional landscape character areas and the 24 seascape areas identified on the coast. This provides a good reference base from which to assess changes in the key characteristics that define these areas, but the information is yet to be updated based upon current knowledge of climate change risks, such as by using UKCP18 or CCRA2. Similarly, plans for designated Areas of Outstanding Natural Beauty (AONBs) are yet to be updated with robust climate change adaptation strategies.

Benefits of further adaptation action in the next five years

Collaboration between local and national government in developing a cross-scale planning framework for Landscape Character Assessment (LCA) that integrates climate change responses would be advantageous. There are an increasing number of examples where climate change has been integrated into LCAs, such as the LANDMAP and related projects in Wales. Some of these plans are also being further developed using concepts of ecosystem services and natural capital and are considering adaptation and mitigation initiatives in the context of enhancement of green and blue infrastructure.

Further investigation of public perceptions is also required. Use of 'landscape narratives' may be a useful process to better understand different perceptions of change to help reveal underlying understandings of nature, climate and human-environment relationships together with how this helps people rationalise different adaptation options. Support for existing pioneering approaches, linking climate-smart adaptation measures with Net Zero carbon emissions planning in the context of national planning frameworks, would also help.

5. Infrastructure

Train passing through tunnel along the north-west coast of Northern Ireland. © Eoin McConnell www.eoinmcconnell.com

Infrastructure is a key enabler of Northern Ireland's economy and underpins many key activities. This section uses the latest evidence collated in the CCRA3 Technical Report to update the level of risk and adaptation measures for 13 climate risks, including risks to energy, transport, telecoms and water infrastructure.

Flooding remains a key climate risk to infrastructure in Northern Ireland with the latest climate projections indicating a greater risk of heavy precipitation. Infrastructure services in Northern Ireland are at risk from river, surface water and groundwater flooding as well as coastal flooding and erosion. Several flood events have highlighted, with increasing confidence, the magnitude of such risks and their interacting risks and consequences. However, it is now evident that some limited progress has been made across the infrastructure sector in both assessing and adapting to the risk via a suite of flood protection measures. Risks to Northern Ireland's transport infrastructure from slope and embankment failure and climate hazards such as high and low temperatures, remain a significant concern.

While significant progress has been made, an adaptation shortfall appears to remain for storms, lightning and high winds in the energy sector.

A key consideration is the lifespan of infrastructure assets. Infrastructure is mostly designed for longevity and means that much of the infrastructure in existence today will be in place for the remainder of the century. Hence, there is a need to consider implications both for existing (potentially retrofitted) and new infrastructure.

The interconnected nature of infrastructure systems means that any unmitigated risk has the potential to have a propagating impact across the network, or lead to cascading failures across multiple networks. The consequences of cascading risks have far-reaching social and economic disruption beyond the initial impact. This interaction between risks is becoming better understood but research is still required.

Finally, there will be implications for many of the climate risks detailed in this chapter in relation to achieving the UK's Net Zero emissions target. In particular, the anticipated infrastructure transformation in response to delivering Net Zero goals will encompass significant changes in energy generation and transport, as detailed in figure 4.

	Risk affected	**Examples of changes associated with Net Zero**	**Implications for UK Infrastructure Risk**
Transport	I1, I2, I5, I12, I13	• Electrification of rail and road transport (electric vehicles) including smart charging infrastructure. • Use of alternative fuels. Hydrogen for Rail; low carbon alternatives such as biokerosene for Aviation. • Increased active travel (walking, cycling etc.). • Increased use of public transport. • Increased use of blue infrastructure (e.g. London Blue Ribbon Network)	• Increased reliance on electricity and ICT with associated potential for cascading risks from weather-related damage and disruption to this infrastructure. • New flood risks to new infrastructure (e.g. electric vehicle charge points). • As yet unassessed risks associated with new infrastructure (e.g. Hydrogen production, distribution and storage) • Health and safety risks to increased numbers of cyclists and pedestrians from extreme weather.
Land use	I2	• Afforestation. • Changed farming practices (e.g. low carbon / restoring peatlands).	• Potential to reduce infrastructure flood risk management and reduce extreme river flows and their impact on hydropower output (although afforestation is also vulnerable to droughts). • Conversely, flood risk could increase due to increased debris in rivers.
Energy and Water Supply	I1, I3, I8, I9, I10, I11, I13	• Potential quadrupling of low carbon electricity needed to meet demand from other sectors incl electrolysis (BEIS 2020). Rising from ~300TWh/year in 2017 to 600 TWh/year under the CCC Further Ambition Scenario with potential for further electrification up to 1300 TWh/year. • Increased use of renewables: wind, solar, bioenergy with carbon capture and storage (BECCS). • Development of a Hydrogen industry. • Increased development of bioenergy supply chains. • Smarter control systems to improve efficiencies. • Reductions in the demand for fossil fuels. • Changes in water demand due to a changing energy mix.	• Increased reliance upon electricity supply increases the consequences of power outages. • Uncertain projections for future wind generation. • Increased significance of loss of offshore infrastructure to electricity supply. • Increased requirements for water for Carbon Capture and Storage (CCS) and Hydrogen increases vulnerability to water restrictions or coastal erosion and sea level rise if they are sited on the coast. • Bioenergy crops can be impacted by drought resulting in undersupply. • Changes in the spatial distribution of supply to accommodate greater renewable generation. • Increased dependencies (e.g. on ICT) makes cascade failures to other networks more probable.

			• Changes in water quantity and distribution needs to accommodate a changing energy mix.

Figure 4. Potential changes associated with Net Zero and implications for UK infrastructure risks. Reproduced from CCRA3 Business and Industry technical chapter.

Some of the risks and opportunities affecting infrastructure have remained the same, but in some cases their urgency has increased as shown in the table below. None of the risks in Northern Ireland have reduced in urgency.

Risk, Opportunity or Risk and Opportunity	Urgency Score CCRA2	Urgency Score CCRA3
I10. Risks to energy from high and low temperatures, high winds, lightning*	Research Priority/ Sustain current action	Further Investigation
I11. Risks to offshore infrastructure from storms and high waves	Watching brief	Sustain current action
I12. Risks to transport from high and low temperatures, high winds, lightning*	Sustain current action	More action needed

*These risks were split between hazards rather than infrastructure asset in CCRA2, but overall, the risk levels for each have increased.

There follows a summary of all climate risks and opportunities for Northern Ireland related to infrastructure.

I1. Infrastructure networks (water, energy, transport, ICT)

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I1. Infrastructure networks (water, energy, transport, ICT)	Cascading failures	More action needed	Dept for Infrastructure

Summary of risk definition and description

Infrastructure networks do not operate in isolation, with services reliant on power, fuel supplies, and Information and Communication Technologies (ICT). This means that vulnerabilities on one network can cause problems on others, both within and beyond the infrastructure sector. Given the wide-ranging nature of the linkages, a full understanding of the impacts of cascading failures is difficult to ascertain. However, recent international research has indicated that the vulnerability of interconnected systems may be significantly underestimated. Across the UK examples of cascading failures in the infrastructure sector include, coastal flooding causing power infrastructure inundation, and power supply interruption leading to impacts on travel and freight operations.

Overall, the CCRA3 Technical Report states that the current magnitude of this risk is high with high confidence, with disruption in urban areas potentially impacting on hundreds of thousands of people. The risk is high magnitude both now and in future. The latest NICCAP contains an objective for transport and network services to be resilient to the impacts of flooding and extreme weather. The importance of interdependencies is mentioned throughout the document, though no specific actions are included to address cascading risks specifically.

Benefits of further adaptation action in the next five years

Common standards of resilience (such as ISO 14091) would assist investment planning and help emergency planners better understand the potential for service disruption from assets in their area. A better understanding of cascade failures and improved arrangements for sharing data and information on critical interdependence risks would significantly reduce the adaptation shortfall and assist in creating the appropriate institutional conditions for adaptation.

Opportunities to address this risk include engaging with local and regional authorities and organisations including Category One responders and infrastructure providers, to share information across geographical and organisational boundaries. Specialist networking groups such as the Infrastructure Operators Adaptation Forum (IOAF) are important in facilitating discussions between infrastructure organisations and government, raising awareness, promoting collaboration and potentially increasing preparedness to reduce vulnerability. Government can play a key role in adopting a systems based approach to planning for resilience by providing infrastructure operators with information and a regulatory framework that supports adaptation at network level rather than at the level of individual assets.

I2. Infrastructure services

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I2. Infrastructure services	River, surface water and groundwater flooding	More action needed	Dept for Infrastructure

Summary of risk definition and description

River and surface flooding is a perennial risk to infrastructure in Northern Ireland, with each season adding new evidence to underpin the significant magnitude of the threat. In Northern Ireland, the number and length of infrastructure assets at significant risk of surface water or river flooding is shown in figure 5 below.

Infrastructure Asset	**Exposure to surface water flooding (1:30 or greater)**	**Exposure to river flooding (1:75 or greater)**
Water sites (no.)	382	91
Sewage treatment works (no.)	0	0
Power stations (no.)	3	0
Electricity substations (no.)	6	1
Rail length (km)	183	87
Rail stations (no.)	3	0
Landfill sites (no.)	0	0

Figure 5. Number or length of infrastructure assets currently exposed to 'significant' surface water or river flooding in Northern Ireland. Reproduced from Infrastructure technical chapter.

In terms of future risk, railway lines are the only infrastructure type in Northern Ireland projected to increase in risk from river flooding (under a low population and no additional adaptation 'reduced whole system' scenario). Risk increases by 50% by the 2080s with 4°C global warming at 2100. All other infrastructure types are projected to decrease in risk. Freshwater sites, electricity substations, railway lines and railway stations are projected to see an increase in risk from surface water flooding. By the 2080s in a +4°C at 2100 scenario, this increase in risk ranges from 49% for freshwater sites to 137% for railway lines. The risk to power stations is projected to decrease under all scenarios.

The evidence highlights that despite some progress with flood defences, the risk is still not being managed effectively (i.e. being maintained at today's level in the future) and that there exists an adaptation shortfall which will require government intervention to overcome. The risk of flooding to infrastructure assets is of high magnitude now and in the future.

The draft Flood Risk Management Plan (FRMP) for the period 2021 – 2027, aimed at managing and mitigating the risk of flooding within Areas of Potential Significant Flood Risk (APSFR), is to be produced and made available in Northern Ireland, has been published for a six-month public consultation from (December 2020 until June 2021); the FRMP will be finalised by December 2021. The Plan focuses on 12 APSFRs which were previously identified in the 2018 NI Flood Risk Assessment (NIFRA 2018). In addition, nine 'Transitional Areas of Potential Significant Flood Risk' (TAPSFR), identified as APSFR in the 2011 Preliminary Flood Risk Assessment (PFRA), have been determined to ensure continuity between FRMPs and facilitate implementation of any outstanding commitments arising from delivery of objectives and measures within the 2015 – 2021 FRMPs. For Northern Ireland, 'medium probability' scenarios have been considered in assessing the impacts of climate change on flood risk for the 2080s epoch.

The DfI has produced a technical assessment of future flood risks in the Northern Ireland Flood Risk Assessment 2018. It identifies areas of potential significant flood risk. DfI's mapping analysis highlights an additional 248 key service and transport infrastructure assets are at risk from climate change.

Benefits of further adaptation action in the next five years

In Northern Ireland, NI Water recently published 'Our Strategy 2021-2046' which recognises the climate emergency as one of six strategic risks for the next 25 years. Most of the urban areas in Northern Ireland are served by combined sewers that carry both sewerage and surface water which is inefficient and results in pollution and floods. NI Water plan to gradually transform the sewerage network by taking every economically viable opportunity to disconnect surface areas from existing combined sewers, for example when laying a new storm sewer to service a new development. In many locations this will help free up capacity in combined sewers for new connections without having to lay new or combined sewers. NI Water will actively promote the use of green infrastructure such as sustainable drainage systems (SuDS) in new developments by providing clear guidance to developers. NI Water will retrofit SuDS where it helps to reduce the risk of flooding and facilitates storm separation.

DfI sits on the UK Coordination Group (chaired by DEFRA) as competent authority for the implementation of the EU Floods Directive in Northern Ireland. As a requirement of the EU Floods Directive, DfI Water and Drainage Policy Division along with its stakeholders is currently preparing the second cycle of Flood Risk Management Plans for Northern Ireland. Climate change is an aspect which must be considered in this planning cycle. The plan identifies the objectives and measures that will be undertaken to manage the risk of flooding and sets out how the relevant authorities will work together with communities to manage flood risks. Currently Northern Ireland allowances for flood risk management and development planning (primarily allowances for increased sea level rise, river flows and rainfall intensities along with associated planning advice) are based on UKCP09 information but the desire for Northern Ireland is to move to new allowances based on UKCP18 information, which will be supported through the UK Coordination Group.

Further adaptation action to be considered:

- Development of consistent indicators of resilience to flood risk across all critical national infrastructure sectors and networks.
- Promote the use of blue and green infrastructure solutions into developments such as road junctions.
- Implement SuDS.
- Bring forward the adaptation of electricity substations.
- Implement policy, such as the Northern Ireland Flood Risk Management Plans for the period 2021-2027, which will be published in December 2021.
- Support decision making with tools and information e.g. utilising UKCP18 information when reviewing allowances for increased mean sea level rise, river flows and rainfall intensities along with associated planning advice.

In addition, there are a range of low-regret measures that have been identified, including:

- Supporting decision-making by providing tools and information.
- Screening climate risks (climate risk management) in public and private investments.
- Enabling infrastructure resilience through policy and regulation.
- Encouraging the disclosure of climate risks and uptake in commercial finance.
- Supporting innovative risk spreading (insurance).

I3. Infrastructure services

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I3. Infrastructure services	Coastal flooding and erosion	Further Investigation	Dept for Infrastructure

Summary of risk definition and description

Coastal flooding and erosion are driven by a combination of the sea level and extreme water levels, which arise as combinations of four main factors: waves; astronomical tides; storm surges and relative mean sea level. The scale of flooding and erosion is dependent on the underlying coastal morphology (topography, rock type, slope of beach etc.) and the influence of rainfall and river discharge may also be significant in some estuaries.

Global mean sea levels are currently rising at an accelerating rate. Coastal erosion which has always occurred around the UK will become worse as sea levels rise. Current projections for sea level rise in Northern Ireland are between 27 and 58cm by 2080, with larger rises considered possible, due to potential marine ice sheet instabilities. Coastal flooding and erosion risk to infrastructure services has therefore grown. Overall however, the consequences of flooding have been tempered due to improvements in flood defences, together with advances in flood forecasting, warning and emergency response and spatial planning. However, notable coastal flooding incidents have still occurred and significantly impacted infrastructure along the coast. Rail networks tend to be exposed to significant coastal flooding, as well as a number of sewage treatment works.

Evidence from the Infrastructure chapter in the CCRA3 Technical Report quantifies the current number of assets or length of infrastructure exposed to a 1:75 chance of annual coastal flooding for major receptors including clean and wastewater sites, electricity generation sites and transport networks (see figure 6). The assets facing the largest risks from coastal flooding are rail lines and station, and sewage treatment works.

Infrastructure Asset at 1:75 or greater risk of coastal flooding (present day)	**Northern Ireland**
Water sites (no.)	11
Sewage treatment works (no.)	0
Power stations (no.)	0
Electricity substations (no)	0
Rail length (km)	20
Rail stations (no.)	3
Landfill sites (no.)	0

Figure 6. Number or length of infrastructure assets currently exposed to 'significant' coastal flooding across the UK. Reproduced from CCRA3 Technical Report Infrastructure Chapter.

In Northern Ireland, there is no legislation in place to specifically address coastal erosion or assign responsibilities or SMPs. Current efforts are focussed on collating baseline data to confirm the scale of the challenge for both flooding

and erosion. The recent baseline study and gap analysis of coastal erosion risk management in the country identified a lack of strategic coastal data and an ineffective current policy framework by comparison with other countries (see N17 and Insight 8 below for more information).

In Northern Ireland, there is less detailed information on coastal change than the other nations (see Insight 8 and Insight 10). However, it has been estimated that 19.5% of the coastline is either eroding or at risk of erosion and that 32% of the coast has some form of manmade protection. It is projected that, in the absence of further adaptation and in a +4°C at 2100 scenario (low population growth), by 2080 the length of railway track exposed to coastal flooding could potentially double in Northern Ireland (100% increase). Projections for other infrastructure assets do not change in the future, or show a decrease in risk.

The risk is medium both now and in future, with mean sea level and extreme water levels expected to increase during the 21st century and beyond. Without further adaptation the projected increases in extreme water levels will significantly increase coastal flood and erosion risk. As a result of the medium projected magnitude for this risk, and the view that current and announced adaptation is partially managing risk, it has been scored as further investigation needed. Beneficial actions could include achieving a better understanding of current and future risk, monitoring and evaluation of the projected impact of current policies and actions and the creation of 'what if' scenarios of high rates of change.

Benefits of further adaptation action in the next five years

When considering potential benefits of further adaptation action it is useful to also consider points made within the other risks covering coastal erosion and coastal flooding which are (see also risks N17, I3, H4, H11, and B2).

The available evidence indicates that the risk to infrastructure services from coastal flooding and erosion is not currently being managed in Northern Ireland. Several barriers exist, which prevent both private and public operators from undertaking the appropriate level of adaptation to coastal risk and therefore typically require government intervention, either through information, incentives, regulation or in some cases directly providing adaptation. The NICCAP mentions plans by Translink to complete a study on the effects of expected mean sea level rise on coastal assets using UKCP18 to inform long term decisions on its management of track assets.

- In addition to sea level rise, improved assessment of other coastal drivers at local and regional scale including waves and tidal dynamics, and additionally for estuaries to include changes in freshwater inputs (fluvial flows).
- Large-scale opportunity assessment of managed realignment based upon multiple benefits and a range of sea level rise scenarios.
- Integration of the above recommendations with development of SMP processes for Northern Ireland to show the links between evidence, policy, and implementation actions under different adaptation options and pathways (e.g. as defined by different sea level rise scenarios).
- A unifying issue for all of the above points is the benefits of improved consistency in monitoring and change assessments (e.g. using a common protocol and Coastal Observatories working together) to facilitate better transparency in adaptation progress reporting across all the UK.

Insight 8: Baseline Study and Gap Analysis of Coastal Erosion Risk Management in NI

The DfI and DAERA commissioned the Baseline Study and Gap Analysis of Coastal Erosion Risk Management in Northern Ireland report which was published in 2018. The primary aim of the study was to undertake a baseline and gap analysis of the data currently held or available which could be utilised to inform coastal erosion risk management; to complete an initial preliminary vulnerability assessment of the Northern Ireland coastline to erosion; gather an understanding of the needs of stakeholders and decision makers with a marine and coastal interest; and to identify future areas of work required to inform a policy on coastal erosion.

The primary conclusion from that assessment was that there is currently insufficient data to reliably inform coastal management decision-making.

The study found that the following priorities should be considered to bring the understanding of coastal erosion in Northern Ireland to a satisfactory level:

- Improve coastal erosion baseline for NI;
- Deliver a coordinated monitoring programme on coastal change;
- Collate, manage and make key information accessible; and
- Develop evolving robust coastal erosion vulnerability mapping.

In response to the study the coastal forum, whose membership includes DfI, DAERA, the seven councils with a coastline, and the National Trust, have started working collaboratively to address these tasks mentioned in the study. A draft coastal forum work programme has been developed. As part of that, a project is under way to provide a comprehensive coastal survey and vulnerability assessment. The survey, which is led by DAERA, will provide a comprehensive data baseline for NI's coast, and subsequent surveys and will develop a picture of how and when the coastline is changing.

Image: Coastal defences at Annalong (Andrew Cooper)

I4. Bridges and pipelines

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I4. Bridges and pipelines	Flooding and erosion	Further investigation	Dept for Infrastructure

Summary of risk definition and description

Currently, no systematic quantitative assessment of climate risks to bridges or pipelines for the UK exists, so it is not possible to adequately assess the differences in risk between devolved administrations in detail. Results are limited to the identification of weather events and environmental hazards which underlie the risk, such as rainfall, temperature and erosion for pipelines, and increased hydrostatic pressure and scour for bridges. Further research would be beneficial to define links between the forecasted risk and the actual impact at the local, regional and national level, including how rainfall and flooding, wind, erosion, land and ground movement could affect bridges and pipelines. Therefore, further investigation is needed given the low quality of available evidence. Risk magnitude has been assessed as medium now and in future.

Some modelling has been completed for bridges in the UK as a whole, that states that increased winter precipitation and river flows will increase scour at bridges, potentially increasing the rate of failure to an average of one bridge per year in the UK. Bridges also have significant potential for lock-in of climate risks due to their long service lives (50 - 100 years), and high cost of retrofitting, making them priority assets for adaptation. Overall, detailed analysis has not been carried out and no modelling completed for pipelines at all.

Benefits of further adaptation action in the next five years

For pipelines potential adaptation measures include:

- Improving drainage in areas that regularly flood; monitoring of river and coastal erosion.
- The development of flood, coastal and updated contingency defence measures.
- Re-routing lines from high-risk areas, and structural upgrades to existing infrastructure.

For bridges, the most significant adaptation is likely to come through:

- Changes in maintenance operations.
- Improving collaboration with emergency managers.
- Recognising emergency management as an integral function of managing infrastructure.
- There are also some adaptation interventions already being implemented around issues such as scour and drainage which would represent a good starting point for a framework to embed adaptation into decisions and investments.

The NICCAP refers to the Design Manual for Roads and Bridges and states the DfI is contributing to the review and update of the Manual which will consider the latest climate change projections from UKCP18.

I5. Transport networks

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I5. Transport networks	Slope and embankment failure	More action needed	Dept for Infrastructure

Summary of risk definition and description

Increased incidence of high rainfall combined with preceding periods of dry weather and subsequent cracking are expected to lead to an increase in incidents of slope failure within the transport network. Rainfall is seen as the main trigger of deterioration and extreme weather is expected to increase the rate of these deterioration processes, albeit with some uncertainty. Therefore, the current and future risk magnitude is medium and more action is needed overall. Climate variability has brought more extreme weather conditions that have triggered slope failures across the UK, especially during the extreme events of 2012. Field observations, centrifuge model testing and numerical models are methods to measure or simulate embankment behaviour; all can be supported by laboratory testing and an understanding of soil behaviour. For example, in County Down hydrogeological processes caused unexpected instability and quick conditions during the excavation of a 25m deep cutting through a drumlin.

In future, modelling shows that soil moisture fluctuations will lead to increased risk of shrink-swell related failures. This is likely to be the most significant geological hazard to UK infrastructure. A LiDAR survey of the Irish Rail network shows that slope vulnerability to shallow planar type failures is expected to increase with predicted changes in climate such as more intense and longer rainfall events with longer dry periods between.

Case Study 2: Translink reducing risk to rail infrastructure

Translink have undertaken activities to understand the risk to their infrastructure and how to adapt to these risks.

- Translink has committed to a continued geotechnical inspection regime for road and rail embankments.
- Upgrading the management and infrastructure of their sites in order to adapt to climate change including culverts on the Coleraine to Londonderry line and on the Larne line which have been sized to the latest design requirements for expected flow.
- In a project with Coca Cola they replaced three bridges and strengthened embankments on both the Dublin and Antrim Branch lines. This scheme was completed to ensure that these areas were future proofed for climate change predictions.
- There is an ongoing programme of repairs to structures and repairs following storm damage which includes activities such as rock armouring and masonry repairs.
- Asset management initiatives include ongoing maintenance of 28 'hotspot' areas on the rail network. These are areas of potential flooding that are managed prior to, during and post heavy rainfall.
- Translink have carried out a risk analysis on cuttings and embankments using available flooding information, follow weather forecasts and manage these assets during heavy rainfall periods with additional inspections and by reducing train speeds.

Benefits of further adaptation action in the next five years

More action to ensure that projected increases in heavy rainfall are factored into long-term renewal programmes would be beneficial, especially for the rail network. Additional adaptation actions could include:

- Improved numerical tools for infrastructure asset owners to predict failures.
- Improved instrumentation and monitoring systems to detect pre-failure slope behaviour linked to decision support systems.
- More detailed characterisation of engineered soil assets.
- Continued use of slope inspection programs.
- Greater use of soft engineering techniques such as vegetation management to reinforce vulnerable slopes.
- Enhanced maintenance of drainage systems for roads and railways and increasing drainage capacity in new road infrastructure.

I6. Hydroelectric generation

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I6. Hydroelectric generation	Low or high river flows	Watching brief	Dept for Infrastructure

Summary of risk definition and description

Hydroelectric power is vulnerable to low flows and extreme high river flows. Low flows reduce power output, whereas extreme high river flows damage generation equipment and associated infrastructure, including spillways and weirs. Damage from extreme high river flows can be exacerbated by debris carried by the river. More modest high flow can, however, improve output.

The CCRA3 Technical Report identified there are few major hydro power producers in Northern Ireland, hence this risk is scored as watching brief. Risk is low now and in the future, assuming there is not a significant increase in hydro power installations.

Benefits of further adaptation action in the next five years

For new schemes, ensuring climate impacts are considered in both site selection and design will enable owners to maximise the system outputs under future climate and minimise risks of damage.

An understanding of how climate change may exacerbate failure mechanisms would help to inform the design of new schemes and inspection and maintenance regimes of existing and future installations.

I7. Subterranean and surface infrastructure

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I7. Subterranean and surface infrastructure	Subsidence	Further Investigation	Dept for Infrastructure

Summary of risk definition and description

Ground subsidence can occur due to shrinking and swelling of clay soils due to changes in soil water content and can also occur due to collapse of pre-existing cavities in the ground such as voids in soluble rocks and mine workings. Damage to infrastructure often occurs as a result of interaction with vegetation and associated water content changes. The majority of damage from subsidence occurs to residential and commercial property. However, transport infrastructure and buried infrastructure is vulnerable to damage and disruption due to climate change driven subsidence effects.

The formation of sinkholes under road and rail infrastructure can be precipitated by prolonged or extreme rainfall. Areas underlain by soluble rocks are most vulnerable though the collapse of poorly capped and filled mineshafts can exhibit the same effects. Indeed, many areas of the UK have a rich heritage of mining which can lead to collapse or subsidence of the overlying surface. There are over 2,400 known abandoned mine workings in Northern Ireland, containing vertical shafts and horizontal adits extending underground to great distances.

The current risk is deemed low, rising to medium in future. Confidence in this assessment is low as no further quantitative evidence has been identified since CCRA2 on the potential future risk. Insufficient evidence is available to adequately differentiate between risks in the devolved administrations of the UK. The urgency score of further investigation has been assigned to Northern Ireland for this risk. There is a need to concentrate on systematically assessing and quantifying the extent to which current plans will reduce risk to a low magnitude across the possible range of future climate scenarios (+2 to +4°C at 2100 scenario, and across the 10-90th uncertainty range within each scenario) or whether more action is needed to achieve this.

Benefits of further adaptation action in the next five years

- More detailed information on sub-surface composition would assist in predicting future behaviour but would be costly to achieve.
- Quantifying the uncertainty in soil properties would be beneficial.
- Removal of trees from railway embankments has been shown to reduce shrink-swell movement though this comes at a cost of reducing the reinforcement effect of tree roots and increases in pore water pressure leading to loss of stability.
- Increased ground and weather monitoring and the use of real-time decision support tools has been proposed as a potential method to mitigate the risks of shrink-swell.

I8. Public water supplies

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I8. Public water supplies	Reduced water availability	Sustain current action	Dept for Infrastructure

Summary of risk definition and description

The UK faces an increased demand for water in a changing climate. Research indicates that the UK currently has a supply-demand surplus of 950 Ml per day. However, without adaptation and under a central population scenario, a deficit across the UK of between around 1,220 and 2,900 Ml per day (+2°C and +4°C at 2100 scenario range) is projected by the late century, equating to the daily water usage of around 8.3 to 19.7 million people. Adaptation efforts in the sector are advancing, driven by five yearly Water Resource Management Plans which take an outlook of at least 25 years. These currently demonstrate a commitment to a number of ambitious targets to reduce leakage, reduce per-capita consumption and outline a range of options to improve resilience via new water supply infrastructure.

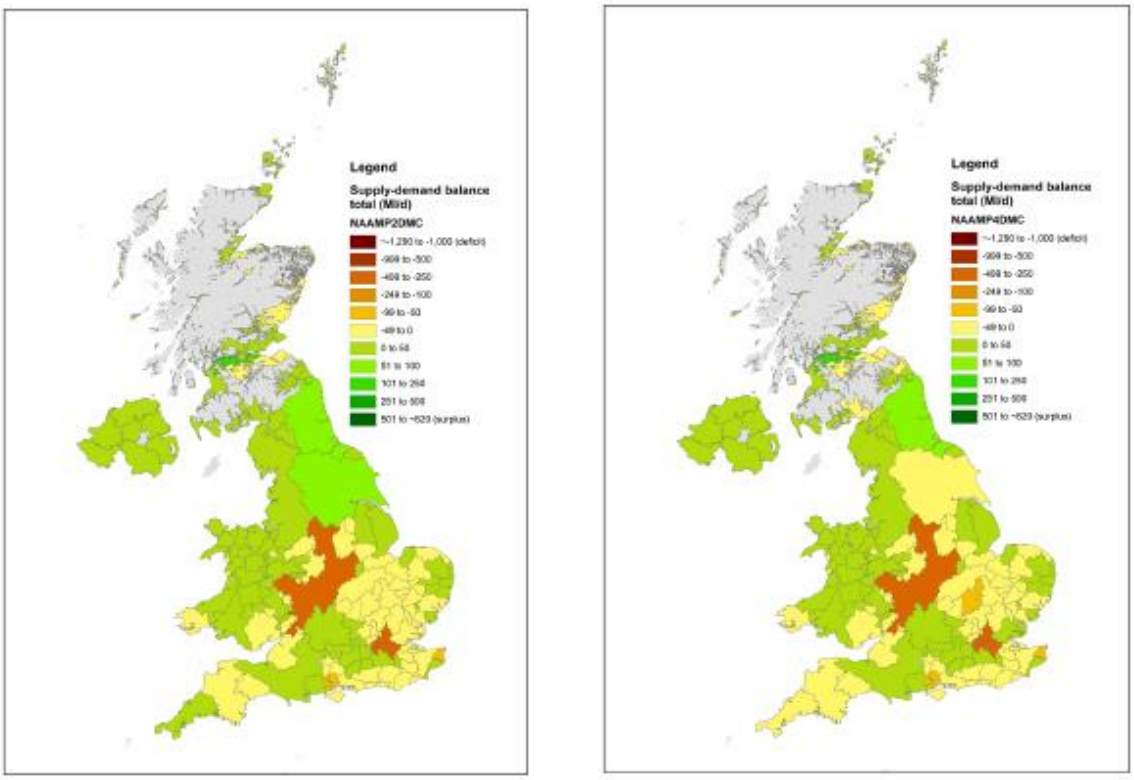


Figure 7. Supply-demand balance in the mid-century, in a +2°C (left hand side) and +4°C (right hand side) at 2100 scenario, central population projection and assuming no additional adaptation action, at the water resource zone scale (HR Wallingford, 2020). Grey indicates areas reliant on private supply.

Updated projections of future water availability for the UK have been produced which provide analysis for the potential impact of climate change at a number of different scales. All water resource zones in Northern Ireland

remain in supply-demand surplus in the mid-century, in both +2°C and +4°C at 2100 scenarios under central population projection and assuming no additional adaptation action. Surpluses are also projected in all water resource zones (figure 7). Northern Ireland has an overall supply-demand surplus by the late century under the central population scenario and for both 2°C and 4°C global warming at 2100. The southern water resource zone in Northern Ireland is projected to have a supply-demand deficit in the late-century, in both +2°C and +4°C at 2100 scenarios under central population projection and assuming no additional adaptation action (figure 8).

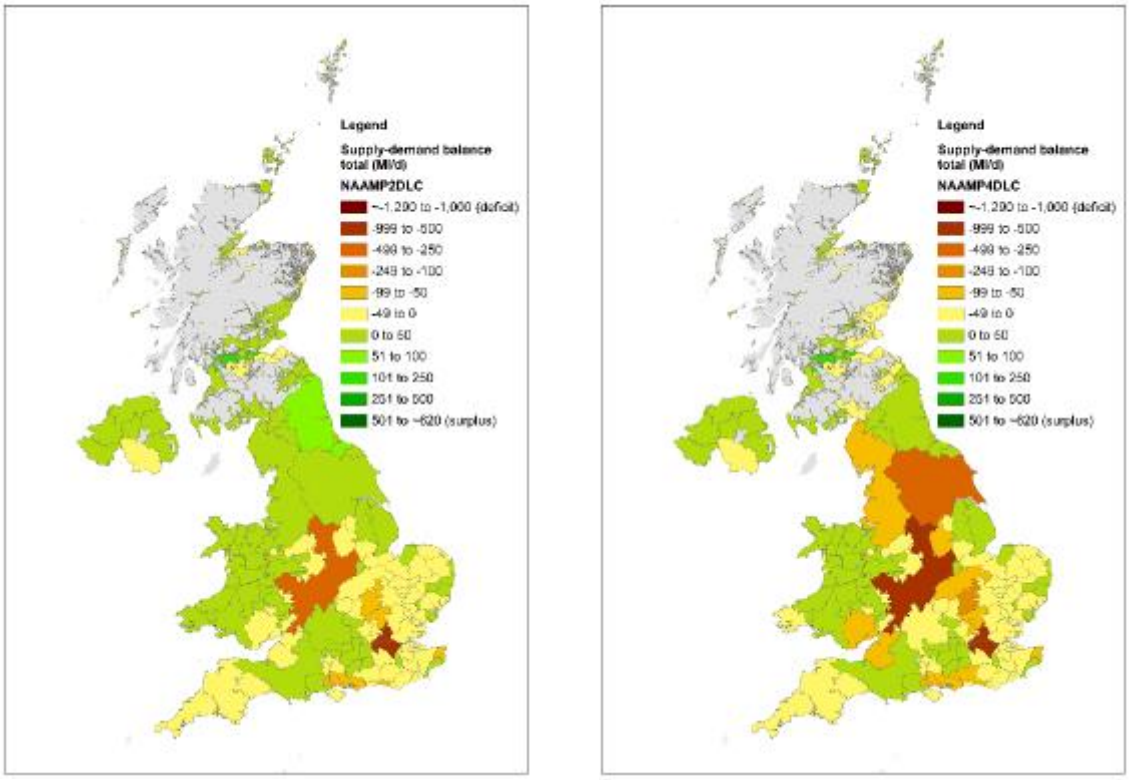


Figure 8. Supply-demand balance in the late-century, in a +2°C (left hand side) and +4°C (right hand side) at 2100 scenario, central population projection and assuming no additional adaptation action, at the water resource zone scale (HR Wallingford, 2020). Grey indicates areas reliant on private supply.

Regarding climate impacts on reservoir integrity, climate change projections are presently not used to inform the risk assessment or inspection regime for reservoirs in Northern Ireland so this remains an area for future attention. Evidence from the CCRA3 Technical Report projections of future water availability suggests that current and announced adaptation will manage risk in Northern Ireland. The urgency score for Northern Ireland is sustain current action, owing to the lower level of current and future risk.

Benefits of further adaptation action in the next five years

The CCRA3 Technical Report water resources project finds that the only scenarios that result in a significant UK wide supply-demand balance surplus are the ones in which additional adaptation action is taken to reduce demand or where the current and announced adaptation scenario is applied to the central population.

The Water and Sewerage Services Act (NI) 2016 requires the preparation and review of a Water Resource and Supply Resilience Plan, which considers adaptation measures in response to climate change predictions to calculate supply-demand balance for the water supply. At a regional level, in 2014 the Northern Ireland Executive approved the development of a Strategic Drainage Infrastructure Plan (SDIP) for Belfast, an outcome of a consultation on "Living with water in Belfast". NI Water has a legislative requirement to produce a Water Resource Management Plan (WRMP) and a Drought Plan as part of its forward planning process. These two plans have been combined into the Water Resource and Supply Resilience Plan (WR&SR Plan) 2020. The WR&SR Plan shows how the company will manage and develop water resources to make sure there is enough water to meet future supply needs. The WR&SR Plan considers changes in population, housing, water usage and incorporates predicted changes to the climate. This includes how water supplies would be maintained during critical periods such as severe winters, drought and includes a drought plan. NI Water recommends revisiting the plan using UKCP18 climate change projections to provide an improved understanding of future hydrological conditions in Northern Ireland.

I9. Energy generation

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I9. Energy generation	Reduced water availability	Watching brief	Dept for the Economy

Summary of risk definition and description

Thermal power generators, including energy from waste plants sited inland, are the main type of generation vulnerable to reduced water supply. However, the UK's commitment to Net Zero emissions by 2050 will see a significant turnover in current thermal plants and thus reduce the potential risk of the current plants on the system, thus the key issue is on the climate risk to the new generation of power plants that will deliver the Net Zero commitment.

No studies specific to Northern Ireland were found. All Northern Ireland's large thermal power generation is coastal. Projections of future catchment water availability suggest there could be reductions in catchment water availability by mid-century in some catchments of Northern Ireland under a pathway to 2°C global warming at 2100. This would have implications for the siting of any future thermal generation plant.

Current and future risk for Northern Ireland is low. Changes to the energy mix introduced by Net Zero policy could potentially increase this risk if the technologies that are favoured have high water demand. Future water availability should be considered in selecting sites for these plants. Current and announced adaptation is expected to partially manage this risk as plans exist that consider the risks of water scarcity in the future for new developments, but there is a lack of evidence on what measures could be taken by existing energy generation sites that rely on freshwater if scarcity increases in the future. Specifically, more analysis is needed for hydrogen and biofuel production to understand the risks.

Benefits of further adaptation action in the next five years

The Strategic Planning Policy Statement states that planning systems should help adapt to climate change through avoiding development in sites vulnerable to climate impacts. Currently abstraction licensing is managed by Northern Ireland Environment Agency (NIEA). While water should remain abundant for the existing sites located on the coast and near major estuaries, if new plant, reliant on freshwater, were to be built their operations could become constrained if freshwater availability reduces.

It would be beneficial to keep the evidence for risks to energy generation due to higher water temperatures and/or reduced river flows under review, with long-term monitoring of risk levels and adaptation activity as advised in CCRA2 and additional consideration of how an expansion in the hydrogen and biofuel production in the UK would affect vulnerability to reduced water availability.

I10. Energy

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I10. Energy	High and low temperatures, high winds, lightning	Further investigation	Dept for the Economy

Summary of risk definition and description

There is limited evidence published since CCRA2 that provides additional information on the magnitude of existing or future risks to the energy sector from high and low temperatures, wind and lightning. However, further evidence on the effects of climate change on wind and lightning in general conclude the effects are uncertain.

The future risks related to the energy sector are also influenced by the future profile of energy demand and supply together with the resilience of society and the economy to constraints on or interruptions to supply. Differing generation and supply technologies have their own profile of vulnerability to weather and climate and therefore the balance of these technologies in future will influence the energy sector's vulnerability to climate change. Infrastructure policies can also have profound impacts on resilience. There is some evidence of how, currently, energy infrastructure is affected by extremes of weather, such as reducing the amount of energy generated from thermal generators and solar PV cells (caused by hot temperatures), line faults (caused by cold temperatures, snow and ice), damage from debris caused by (wind) and power cuts caused by (lightning).

Future modelling has been carried out especially on the impacts of temperature. For example, a reduction in output for solar PV of between 1 - 3% and thermoelectric generation of 5 - 14% is possible in future due to increasing temperatures, but the ramifications of this is less certain due to the implications of the UK's Net Zero carbon target on the future energy mix. The future changes to the impacts of lightning strikes and wind are uncertain and not discernible by nation. Therefore, the current and future risk magnitude is high but with significant uncertainty, hence further investigation is required.

Benefits of further adaptation action in the next five years

A better understanding of the risks from passing specific thresholds that affect energy supply would be beneficial. For example, ICT supporting telemetry components in the national gas grid have been found to have a maximum operating temperature of 40°C (where external temperature and the load on the asset are contributing factors). Summer operation of some facilities is already being affected and this will be exacerbated by projected increases in summer temperatures.

Regarding high winds, further investigation of the future risks of damage from falling trees would be beneficial, alongside a watching brief on the evidence regarding potential changes to wind speeds in future due to climate change. Further investigation on activities being implemented to protect assets from increased lightning strikes would also be helpful. Recent years have shown that multiple events (e.g. concurrent lightning strikes) can have severe knock-on impacts on energy supply, and scenario studies looking at the effects of different hazards (high winds and lightning, or high temperatures and lightning for example) would be prudent.

I11. Offshore infrastructure

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I11. Offshore infrastructure	Storms and high waves	Sustain current action	Dept for Infrastructure

Summary of risk definition and description

Offshore infrastructure includes equipment used by the oil and gas industry, wind, tidal and wave energy, and gas pipelines and power cables on or under the seabed. Their vulnerabilities because of storms and high waves include the destabilisation or degradation of mechanical structures, reduced energy output and operating periods, damage to cabling systems during storms and prevention of access for maintenance and inspection activities. The current risk to offshore infrastructure is low, based on a good level of evidence within the CCRA3 Technical Report which has not changed much since the previous CCRA2.

In future, the risk is allocated as medium magnitude, however there is less evidence to support this. It has been categorised as medium due in part to increasing offshore renewable energy infrastructure and the presence of a large fleet of oil and gas platforms which may be repurposed for carbon capture and storage (CCS). There is a data gap on the current failure rates and structural performance for wind turbines, as well as uncertainty about potential future changes in loading and therefore stability and machine degradation. Since offshore infrastructure is designed for 30 - 40 year life, and the consenting period plus construction is five years, decisions now affect the capacity and resilience of offshore infrastructure and energy supply in 2060. The high reliance on offshore wind and subsea cables adds vulnerability to the electricity grid and resilience of these will be a key factor in achieving the UK Net Zero target.

Changes to mean sea level rise, wave height and wind speed could exacerbate the above impacts in the future. There is no documented evidence of any difference in the risk to offshore infrastructure in Northern Irish waters compared to assets off other coasts.

Benefits of further adaptation action in the next five years

Potential adaptation measures include changes to the design loads, extreme wave elevation and accessibility of offshore infrastructure for maintenance and crew transfer. Given the anticipated expansion of offshore renewable energy in order to meet the UK's Net Zero emissions targets and current uncertainties about changes in marine conditions as the climate changes, further investigation into the potential changes in relevant climate metrics including wind and wave heights would better inform design and siting choices.

I12. Transport

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I12. Transport	High and low temperatures, high winds, lightning	More action needed	Dept for Infrastructure

Summary of risk definition and description

Evidence that demonstrates how extreme temperatures, high winds and lightning strikes can affect the rail, road, air and water networks is plentiful. The current risk is medium rising to high in future and the CCRA3 Infrastructure technical chapter states that the risk is not currently being fully managed across the system.

Rail

Heat can cause rails to buckle, overhead cables to sag, signals to fail and maintenance from being performed. Railway assets tend to demonstrate threshold temperatures beyond which failures manifest. Once the track is laid this resilience can reduce as the ballast moves and settles. Wind can disrupt rail operations by blowing branches, trees and debris onto the line. Lightning can cause damage to electronic equipment, line-side trees and buildings as well as cause risk of line-side fires.

Road

High summer temperatures can increase thermal loading on bridges and pavements causing expansion, bleeding and rutting. Wind affects road operations, with high sided vehicles becoming unstable in gusts of wind over 45mph (particularly on exposed bridges). High winds can also damage roadside furniture such as traffic signs, and blow nearby vegetation onto the road. There is a general lack of quantified data on the impact of high and low temperatures, wind and lightning on road infrastructure.

Air Travel

Higher temperatures can cause problems with runway conditions and the flashpoint of aviation fuel. These factors, combined with changes in air density, would result in greater fuel usage and potentially longer runways for take-off. Overheating of standing aircraft occurs at temperatures above 25 - 30°C and requires the use of aircraft Auxiliary Power Units (APU) or preconditioned air to cool aircraft. Snow and ice can cause severe disruption to operations.

Water

High wind speeds lead to the suspension of port operations including halting crane operations.

The understanding of current and future risk from climate impacts is varied across different transport modes and climate hazards. While there are examples of good practice within individual transport modes such as road and rail and emerging activities taking place, the approach to managing climate risks across transport infrastructure is not comprehensive.

Benefits of further adaptation action in the next five years

Actions being taken to reduce risk by the rail industry are likely to be reducing vulnerability in some areas, but evidence is currently lacking. This may be due to the current indicators of resilience which may not directly indicate how the physical vulnerability of assets is changing. Enhanced weather incident reporting, asset condition monitoring and revised standards would help with this gap. In Northern Ireland, as referenced in the NICCAP, Translink plan to carry out a detailed tree survey which will examine the risk of tree related incidents due to high wind events. Translink have also committed to carry out a project to update the Stress-Free Temperature records for rail and to identify locations that could be at risk during extreme heat.

Evidence is lacking for current or future adaptation action for road, air and water transport infrastructure in Northern Ireland.

For local roads, it is not clear whether there has been a systematic evaluation of climate change risks. Similar to rail, it is recommended that better indicators of climate resilience for roads, port and airports are developed.

For existing infrastructure, improved monitoring and information and improvement of maintenance practices and operations are considered low-regret adaptation options. For new infrastructure, there are opportunities for mainstreaming climate change adaptation into planning and design, to avoid retrofitting later.

I13. Digital

Infrastructure				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	I13. Digital	High and low temperatures, high winds, lightning	Further Investigation	Department of Finance (DoF)

Summary of risk definition and description

ICT is critical to the operation of wider infrastructure networks as well as underpinning business activities, access to key services and wider communication. Risks to digital associated with climate change are considered to currently be of low magnitude, rising to medium under different climate futures. However, the evidence to support this is of low quality. While there is a general understanding of the interactions between ICT infrastructure and weather, quantitative projections assessing how climate change will affect the frequency and magnitude of these interruptions are lacking. Further attention to the climate resilience of this sector and quantitative information on current and future risks under climate change is needed to better assess its vulnerability and exposure to climate change.

Climate-related risks have the potential to disrupt the availability and reliability of digital technology via:

- Failure of telecommunications leading to reduced capacity in a wide range of other essential services.
- Mobile base station power failure because of extreme weather.
- Local outages, given consumer reliability on digital technology today.
- Ground shrinkage can lead to failure of electricity, gas and water pipes, thereby damaging co-sited ICT infrastructure.
- High summer temperatures, as well as rapid fluctuations in temperature and humidity, pose challenges to data centres, which need to be kept cool to operate.
- Poorer performance of radio systems due to heavy rainfall.
- Greater international communication disruption due to increase sea temperature.

Data from Ofcom identifying outage incidents to networks and services between 2016 and 2017 showed that 1% (5 out of 648) of incidents were caused by severe weather (flood, storms or snow). In particular, the edges of networks where diversity is at its least are at risk of failure, typically near sparsely populated areas, or remote locations such as islands, where loss of ICT for communication or control of other systems can cause significant problems. The implications of outages caused by weather for loss of emergency services communications, business revenue and social disruption indicates medium magnitude.

The accessibility to both internet and mobile network coverage in Northern Ireland is about 5% of premises without access to download speeds of 10Mbit per second and 1% without mobile call service. If this is taken as an indicator of the potential numbers of customers currently on the edges of networks and so more liable for disruption. Without a better understanding of the exposure of ICT infrastructure across the UK it is difficult to differentiate the magnitude between the devolved administrations, and more action is needed to assess how climate change will affect the frequency and magnitude of interruptions to digital services.

The magnitude score of this risk is low at present and rises to medium in the future. Further investigation is needed to assess how climate change will affect the frequency and magnitude of interruptions to digital services across Northern Ireland and whether more action is needed.

Benefits of further adaptation action in the next five years:

Currently, adaptation is reactive or unplanned due to the short life span of equipment. The most vulnerable assets requiring protection are masts, cables and buildings.

The risks to digital from extreme heat, high winds and lightning are acknowledged in the NICCAP though there are no actions listed that relate to improving resilience of digital infrastructure specifically. The programme also states that digital infrastructure services in Northern Ireland operate independently from the Government with providers having their own responsibility to develop and monitor climate change resilience strategies. This includes business continuity measures in relation to climate change impacts, such as the provision of essential services which enables them and their customers to function.

Further adaptation would include incorporating digital infrastructure into existing infrastructure climate adaptation plans, recognising the criticality of ICT provision for wider infrastructure and society. Further information is also needed to identify and protect assets at risk of flooding and wildfires together with a better understanding of future impacts on radio communication systems.

6. Health, Communities and the Built Environment

Image: Belfast City Hall (Unsplash)

This section summarises evidence regarding the key risks and opportunities posed by climate change for the population of Northern Ireland, with a particular focus on health and wellbeing, communities and the built environment. The evidence is divided into 13 climate risks and opportunities and the risks are either focussed on climate hazards (for example heat or flooding) that affect multiple sectors, or on particular policy areas (for example health systems or food safety). Policy areas relevant to this section are largely devolved. These include: communities and planning, buildings, the health system, the social care system, health protection, and education and prisons.

The risk of flooding to people, communities and buildings remains the most severe climate risk for the UK. Economic impacts (expected annual damage per individual) are higher in Northern Ireland (and the other devolved regions) than in England. Climate change is also likely to increase the risk to building fabric from damp, high winds and subsidence. Hospitals and other health care services will experience service disruption due to direct impacts from extreme weather, and through the detrimental effects of extreme weather on people's health and well-being.

High temperatures also affect a very wide range of health and social outcomes. All countries in the UK are experiencing a warming trend and heatwaves in recent summers have caused disruptions to daily activities, including hospital services and education.

Most of the risks and opportunities affecting health, communities and the built environment have remained the same compared to CCRA2, **H2** Opportunities for health and wellbeing from higher temperatures has decreased from More Action to Further Investigation for Northern Ireland, but in some cases risk urgency has increased as shown in the table below.

Risk, Opportunity or Risk and Opportunity	Urgency Score CCRA2	Urgency Score CCRA3
H9. Risks to food safety and food security	Watching Brief	Further Investigation
H10. Risks from water quality and household water supplies	Sustain Current Action	Further Investigation
H12. Risks to cultural heritage	Research priority	More action needed
H13. Risks to health and social care delivery	Research priority	More action needed

It should also be noted that the COVID-19 pandemic may have long-term implications for the resilience of the health and social care sector. The pandemic has caused an additional stress on the health and social care system due to increased demand (likely to last until 2022) and additional pressures on local finances (likely to last longer term). More positively, the impacts of COVID-19 may have raised awareness of the importance of understanding major threats that can disrupt lives and livelihoods, including low probability, high impact flood events.

The following provides a summary of the 13 identified climate risks and opportunities for Northern Ireland related to health, communities and the built environment.

H1. Health and wellbeing

Health, Communities and the Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	H1. Health and wellbeing	High temperatures	More action needed	Dept of Health

Summary of risk definition and description

- High temperatures affect a very wide range of health and social outcomes.
- The 2018 and 2019 heatwaves revealed a lack of planning for high temperatures.
- Interactions between risks from combined exposures from air pollution, drought and wildfires have been increasingly recognised.
- There is increasing evidence about the risks of overheating in buildings and the effectiveness and limitations of strategies for space cooling.
- There is still little preventative action being taken to address health risks from overheating in buildings and restrictions associated with the COVID-19 pandemic may have increased exposure to heat as people had to spend more time indoors during hot weather.

Projections for the UK show increases of average summer temperatures, the number of hot days and heatwave events. High temperatures increase the risk of acute mortality and can increase the risk of injury from accidents, which is of particular of concern for workers in the health and social care, prison and educational sectors. High temperatures can adversely affect the health of pregnant women, particularly increasing the risk of preterm birth. Poor indoor environments may also contribute to a reduction in work performance in adults, with especially negative impacts on wellbeing and comfort, leading to staff absence and a decline in satisfaction and productivity.

Northern Ireland does not currently have a heatwave plan. There has been limited epidemiological analysis of the health impacts of hot weather in Northern Ireland. Projections have estimated that in 2020 there would be around 1.6 heat-related deaths per 100,000 population (which with a population of 1.89 million equates to 30 heat-related deaths per year). Climate change is likely to increase heat-related mortality in Northern Ireland. Projections estimate that heat related deaths will increase to around 30 - 115 per year by 2050 and 55 - 135 per year by the 2080s assuming no population growth.

Northern Ireland dwellings are at risk of overheating. Whilst there is limited information available about current levels of overheating, new research shows that existing Northern Ireland homes, of widely used construction typologies, are likley to overheat by mid-century onward. Evidence suggests that some housing types would require mechanical cooling or significant interventions such as solar shading to ensure comfortable internal temperatures. Dwellings with higher energy efficiency ratings and those built more recently are expected to have higher summer internal temperatures.

Design and construction strategies used to meet Net Zero, such as energy efficiency and reduced ventilation, tend to increase overheating risk unless designed appropriately with adequate ventilation installed. Whilst loft and wall insulation can help to prevent heat penetration through roofs and walls, once heat has entered a home, insulation can reduce heat loss through the building fabric at night and increase overheating risk. New evidence illustrates overheating risks in buildings that are speciifcally designed to have low carbon emissions, such as Passivhaus dwellings which combine mechanical ventilation with heat recovery (MVHR). Occupant behaviours, such as window opening, also play a role in overheating risk, but occupant decisions can be influenced by other factors such as security. The present and future magnitude of this risk is high in Northern Ireland. The major policy gap across all the

UK nations is including measures to prevent overheating in Building Regulations or other housing policy for new and existing buildings.

Benefits of further adaptation action in the next five years

For housing to be suitable for future climates, there is a requirement for coordinated action and optimisation of outcomes against a range of objectives. The evidence indicated that decarbonisation and adaptation policies and strategies are not well aligned.

There is no upper limit for indoor temperatures for workplaces and other key buildings in Northern Ireland. Building regulations could be updated to address overheating in new dwellings and to coordinate with any decarbonisation and adaptation policies and strategies which are developed. The Department for Communities (DfC) is developing a new Housing Strategy, which will set out targets for new homes in Northern Ireland and would ensure that these homes are designed appropriately for future climates. Retrofit and re-use of older buildings could consider building use and the characteristics of building fabric to avoid overheating. Government could introduce an integrated plan to reduce overheating risk in existing and new homes, alongside decarbonisation. Belfast City Council and many other bodies are exploring how to deliver an urgent and ambitious housing retrofit programme which is driven by Net Zero carbon targets.

Climate change presents several additional risks for housing such as flooding and damp and it can be more effective and less expensive to address all these risks at the same time through retrofitting, as well as other risks such as fire prevention and energy efficiency. Continuous preventative planning to include long term risks would also have benefits. Other potential solutions include more investment in adaptive management approaches, better building design and planning guidance for enhancing green space and urban cooling measures, including nature-based solutions, have the potential to reduce urban heat islands and moderate outdoor temperatures.

H2. Health and wellbeing

Health, Communities and Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
OPPORTUNITIES	H2. Health and wellbeing	High temperatures	Further Investigation	Dept of Health

Summary of risk definition and description

The key factors associated with this opportunity include the following:

- The physical and mental health benefits of increased physical activity and contact with nature are well established. As summer temperatures rise, opportunities for more outdoor activities could increase but at present there is limited evidence of the extent of this.
- Increased time outdoors may increase Vitamin D exposure which is important for bone health and the immune system.
- The introduction of new crops such as soya, lupins, borage and evening primrose may have potential to improve nutrition.
- The burden of ill health from cold homes remains significant in Northern Ireland and is a priority for public health and local government action.
- A minor benefit associated with milder winters is potential reduction in the risk of mould growth, provided there is sufficient ventilation to remove moisture from the indoor air.

However, the opportunities that could arise are currently limited in their understanding and, as such, the opportunity is low in magnitude now and most likely low in future, therefore further investigation is required. It should be noted that warmer, wetter summers will limit some of the future benefits and opportunities.

Benefits of further adaptation action in the next five years

There would be benefits from further investment in research as well as strategies to increase physical activity and improve mental health from greater outdoor recreation and active travel due to warmer temperatures, particularly in areas with limited existing provision. For example, it would be beneficial if design of the built environment encouraged physical activity and contact with nature. Interventions could lead to large economic benefits in terms of societal welfare from three components: lower resource costs i.e. avoided medical treatment costs, increased opportunity costs from gains in productivity, and the avoided pain or suffering, concern and inconvenience to family and others. A no-regret option would be to investigate these potential benefits and look at the possible interventions to help deliver these. Any increased attention on managing the risks from heat should not lead to a subsequent decline in attention to managing the risks from cold. Both heat and cold related health impacts will require health service interventions in the future.

The second NICCAP includes an acknowledgement of the potential health opportunities from warmer temperatures, though the actions listed are focussed on reducing fuel poverty (see H6). DAERA is currently developing Northern Ireland's first overarching Environment Strategy with a view to seeking Executive endorsement at the time of writing. The Strategy will form part of the multi-decade 'Green Growth Framework' and is intended that the Strategy will be adopted as Northern Ireland's first Environmental Improvement Plan (EIP) under the UK Environment Bill. The Environment Strategy and EIP will include short, medium and long-term targets to improve the natural environment including health and wellbeing.

H3. People, communities and buildings

Health, Communities and the Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	H3. People, communities and buildings	Flooding	More action needed	Dept for Infrastructure

Summary of risk definition and description

- The risk of flooding to people, communities and buildings is still one of the most severe climate hazards for the population, both now and in the future. The main associated risks are death or injury, long-term and severe impacts on mental health and wellbeing, damage to property, disrupted access to employment, education and health services, and illness from water-borne pathogens or chemical contaminants.
- The dominant source of flood risk is from rivers but if current levels of adaptation continue, surface water and coastal risks will increase in their relative contribution to Northern Ireland's flood risk. Groundwater continues to have a limited contribution at national scale, although will be important locally.
- Considerable advances have been made regarding the strategic management of flood risk at national and local levels since the last CCRA.
- Key challenges relate to continued development on the floodplain, the management of surface water flooding via SuDS, the low take up of Property Flood Resilience (PFR) and the lack of UK-wide standards.
- The risk magnitude remains high now and in the future in Northern Ireland with more action needed due to the scale of the risk.

Northern Ireland's communities and buildings remain at a high risk from flooding:

- According to the Northern Ireland Flood Risk Assessment 2018, approximately 45,000 properties (c. 5%) in Northern Ireland are located within either the 1% Annual Exceedance Probability (AEP) fluvial floodplain or in areas at risk of flooding from a 0.5% AEP surface event with a flood depth greater than 300mm.
- About 33,000 people in Northern Ireland are currently at significant risk of flooding
  - c. 10,000 from fluvial
  - c. 1,000 from coastal
  - c. 22,000 from surface water
- Belfast is one of 10 UK local authority areas which accounts for 50% of the socially vulnerable people living in areas at flood risk.
- Economic impacts (expected annual damage per individual) are higher in Northern Ireland (and the other devolved regions) than in England. There is also spatial variation within UK countries as socially vulnerable neighbourhoods are less likely to have insurance, which leads to significant disadvantage when combined with lower household incomes and exposure to more frequent flooding.
- Direct expected annual damages from flooding in Northern Ireland for residential properties are currently around £21.3m, which equates to a high magnitude score.
- However, significant floods have occurred since CCRA2 in Northern Ireland, including the August 2017 flood of the Foyle and Faughan River Catchments which caused 4,000 properties to flood. The clean-up costs of this flooding event were estimated to exceed £30m (see Case Study 3 and Case Study 5).

In future, climate change will increase the number of properties at risk of flooding from all sources, and these could be in areas that have not previously been at risk of flooding. The largest increase in risk in Northern Ireland is related to coastal flooding, which is projected to increase by 550% by 2080s (in a high population scenario and with 4°C global warming at 2100) (see figure 9).

In addition to climate change, housing need and economic growth will drive more development and exacerbate flood risk. Building within the floodplain needs to be minimised, and properties developed in flood risk areas should incorporate appropriate resilience measures and sustainable drainage design for the lifespan of the development.

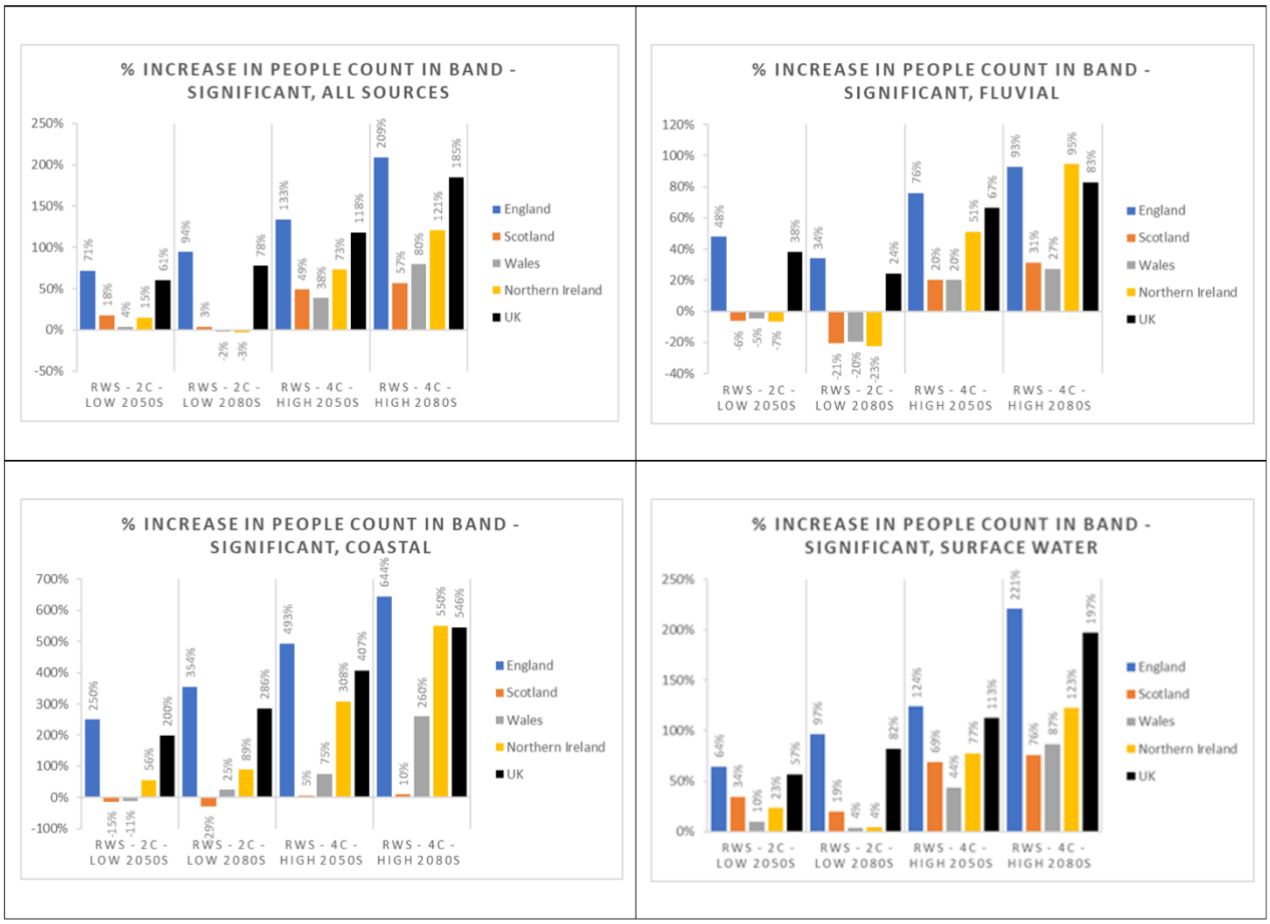


Figure 9. Increase in people at significant risk of flooding (all sources) for the Reduced Whole System scenario, low population growth +2ºC global warming at 2100 and high population growth +4ºC global warming at 2100, for the 2050s and 2080s. Reproduced from CCRA3 Health, Communities and Built Environment technical chapter.

Benefits of further adaptation action in the next five years

Flood risk is not being addressed fully in Northern Ireland. However, various approaches are in place to tackle flooding through prevention, protection and preparedness (see Insight 9). Further benefits would be realised by the following:

- Conventional flood defences remain the most important flood risk management strategy alongside natural flood management and property protection.
- Effective spatial planning remains the only measure that can avoid flood risk caused by development.
- Given the scale of national expenditure needed to address flood risk effectively, there may also be a case to consider development of national minimum standards for flood resilience provision. This would inform expectations and roles of governments and generate fuller public engagement about the respective roles of different actors in reducing risk and taking precautionary measures, as well as help to promote community level responses that would build resilience.
- The lack of a statutory requirement for SuDS across the UK and lack of monitoring in all jurisdictions remains a continued challenge. With surface water flood risk projected to increase under all scenarios and the need to

achieve biodiversity (and soon environmental) net gain in all new development, there is a strong argument for greater enforcement. Integrated management across multiple organisations is required to increase capacity of drainage infrastructure and implement and retrofit SuDs in new and existing neighbourhoods.
- Recognition of the role of low income and poor health as key drivers of flood vulnerability.
- Introducing new metrics focused on reducing social vulnerability to flooding in UK government and devolved administration outcome measures would help further mitigate the social costs of flooding.
- More research would be beneficial regarding property flood resilience up-take, effectiveness and future potential in Northern Ireland.

A draft Northern Ireland Flood Risk Management Plan (FRMP) for the period 2021-2027, aimed at managing and mitigating the risk of flooding in Northern Ireland has been published for a six-month public consultation (December 2020 to June 2021). The Plan focuses on 12 APSFR identified in the 2nd cycle NI Flood Risk Assessment. DfI is primarily responsible for arterial drainage and flood protection and implementation of the Water Environment (Floods Directive) Regulations (NI) 2009. In 2013/14, some £6m was spent on flood defence schemes. Total capital expenditure on flood and coastal erosion risk management in 2015/16 was £24.7m, almost a 20% increase since 2010/11 (£20.7m).

The Homeowner Flood Protection Grant Scheme in Northern Ireland is a government funded flood grant scheme which entitles homeowners to get 90% funding of flood protection measures up to a value of £10,000. The additional 10% of the cost and any extra cost above £10,000 must be funded by the homeowner themselves. A review of this grant scheme is currently underway.

The Civil Contingency structures in Northern Ireland provide an effective mechanism to deliver co-ordinated emergency flood response with the Civil Contingencies Group, providing strategic leadership. There are three regional level multi-agency Emergency Preparedness Groups, with the purpose of ensuring an appropriate level of preparedness to enable effective multi-agency response to emergencies which have a significant impact on the public. The Regional Community Resilience Group (RCRG) was established in 2013 to help local communities prepare for and respond to weather related emergencies. The RCRG develops a consistent approach to community engagement to help individuals and communities to be better prepared and more self-reliant during emergencies.

Insight 9: SPPS & Flooding

The use of SuDS in new developments is promoted as the preferred approach under 'Planning and Flood Risk' within the Strategic Planning Policy Statement for Northern Ireland (SPPS). The Regional Development Strategy 2035 (RDS) also proposes that SuDS should be encouraged as part of significant development proposals. Local Authority Local Development Plans (LDPs) are required to take account of the RDS and to conform to the SPPS, both of which encourage the use of SuDS for new developments. However, this has not translated into widespread uptake of SuDS. Local authorities, including Belfast City Council, are working to address the gap between the policy aspirations and take-up on the ground.

Investment in flood defence schemes has increased, with a spend of £24.7 million in 2015/16. Flood risk management plans are in place which highlight the flood hazards and risks in the 20 most significant flood risk areas in Northern Ireland. The plans aim to manage the adverse consequences that flooding could have on human health, the environment, cultural heritage and economic activity. The Homeowner Floor Protection Grant Scheme (under review in 2020) entitles homeowners to 90% funding of flood protection measures up to £1,000. There are three Emergency Preparedness Groups that comprise multi-agency partnerships to manage natural hazards such as flooding. The Regional Community Resilience Group develops a consistent approach to community engagement to help individuals and communities be better prepared and more self-reliant during weather realted emergencies.

Case Study 3: Review of the North West Flooding Event 2017

The Review of the North West Flooding event in 2017, was conducted was to identify lessons learned and consider measures required to potentially mitigate the impact of any future flooding. The review was jointly led by the DfI, The Executive Office and Derry City and Strabane District Council, and gathered evidence from emergency responders, the voluntary sector, government organisations, and special interest groups including community representatives and elected members.

The flooding in the North West on the 22nd and 23rd August 2017, has been described as some of the worst flooding to affect the area in almost 30 years. Approximately 60 - 70mm of rain, equivalent to 63% of the average August rainfall, fell in this area in the space of eight to nine hours causing many watercourses to rise to unprecedented levels in a very short period of time.

This resulted in extensive flooding across the local area with homes, businesses, agriculture, infrastructure, services, heritage and biodiversity adversely affected, some of which included:

- 400 homes and businesses affected.
- 210 roads either closed or impacted.
- 5 Bridges washed away & 89 bridges requiring repair.
- 2,900m flood defences damaged.
- 1,497 calls to Flood Incident Line.
- Agriculture affected – livestock drowned, land damage and erosion.
- £12m in estimated costs to the DfI

The review acknowledged that the combined multi-agency response was timely and effective but that the severe flooding had a profound, and in many cases lasting impact on the lives of local people, businesses and agricultural land in the areas affected. As a result, 14 recommendations were made to further enhance resilience of people, communities and buildings to future flooding, some of which included: online mapping systems, community resilience groups, support for farming communities, emotional support and wellbeing for both urban and rural communities, information sharing, and financial assistance to local councils. Derry City and Strabane District Council have now produced the first local authority Climate Change Adaptation Plan in Northern Ireland.

Source: Dfl North West Flooding Review 2018
Image: A5 Flooding, August 2017 (Dfl)

H4. Viability of coastal communities

Health, Communities and the Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	H4. Viability of coastal communities	Sea level rise	Further investigation	Dept for Infrastructure

Summary of risk definition and description

Sea level rise is expected to threaten the long-term viability of some coastal communities in the UK. This risk is focused on coastal change, that is, the physical change to the shoreline caused by coastal erosion, coastal landslip, permanent inundation or coastal accretion that is of such severity that the long-term sustainability and viability of coastal communities (which also includes those living working or visiting coastal locations) is threatened.

Risks to the viability of coastal communities from sea level rise was identified as a risk in CCRA2. The UKCP18 projections, which were published after CCRA2, suggest greater sea level rise than identified in UKCP09 projections. Sea level rise does not operate in isolation. It is the combination of sea level rise with storminess and coastal processes such as sediment movement and erosion that creates a risk of such magnitude that it can threaten the long-term sustainability of whole communities.

Consistent data is not collected at the national level on the number of properties lost to, or at risk of coastal erosion so it is difficult to compare between the nations. The most recent mapping of Northern Ireland estimates 32% of the coast is manmade structures and 68% is natural and about 19.5% of the Northern Ireland coastline is currently at risk from erosion. Approximately 5,675 people or 2,720 households are at risk of coastal flooding in Northern Ireland. No evidence has been identified in relation to communities in Northern Ireland whose current viability is threatened by coastal change, and therefore the current magnitude score is low. However, 50% of the coastline of Northern Ireland has a high likelihood of functional change by 2100 and over the next century, including over 400m of the dune system at Murlough which could be lost.

With the increase in potential risk, the magnitude score is low for the 2050s and medium for the 2080s but with low confidence as further research is required to fully understand the level of coastal change in Northern Ireland.

Insight 10: 3D Coastal Survey of Northern Ireland

DAERA have commissioned a Northern Ireland 3D Coastal Survey; extending into the marine environment with a satellite derived bathymetric survey and a pilot bathymetric LiDAR survey; to create a detailed 3D elevation model of the coast that will aid the development of future coastal management policies. This is building on the research areas identified in their initial baseline study and gap analysis of coastal erosion risk management.

Rapid Airborne Multibeam Mapping System (RAMMS) technology will be used for the first time in the UK to acquire satellite-derived bathymetry (SDB) to collect LiDAR bathymetry data (to c.10m depth) to identify areas most at risk from coastal erosion and marine flooding. The data will be used to create highly accurate 3D Digital Terrain and Surface Models (DTM / DSM) with a spacing of up 25cm and high detailed aerial photography processed to 10cm resolution. The datasets will be made available through Geographical Information System (GIS), desktop mapping and other specialist software packages and will be compatible with other DAERA datasets including Ordnance Survey mapping.

Source: DAERA
Image: North Coast

Benefits of further adaptation action in the next five years

When considering potential benefits of further adaptation action in is important to also consider points made within the other risks covering coastal erosion and coastal flooding which are (see also risks N17, I3, H11, and B2):

Whilst there have been positive recent developments in national and local strategy regarding the management of coastal change across the UK, this action is still insufficient to manage the future levels of risks down to low magnitude levels. It would be beneficial to build on the baseline work happening now in Northern Ireland and bring in integrated adaptation planning and SMP development and delivery.

Coastal flood and erosion management is driven by integrated engineering, planning, insurance and preparedness activities. In recent years, there has also been increasing emphasis on community or individual led activities to increase resilience. In addition, it would be beneficial to improve mapping and modelling (see Insight 10), as well as facing up to the challenge of the potential future loss and impacts on communities from coastal erosion and flooding.

Fundamentally it would be beneficial for a system level change including a thorough review of current governance and delivery to ensure a strategic approach to managing the Northern Ireland coastline rather than the current patchwork of roles, responsibilities, policies and plans.

H5. Building fabric

Health, Communities and the Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	H5. Building fabric	Moisture, wind and driving rain	Further investigation	Dept for Communities

Summary of risk definition and description

This risk is primarily concerned with homes and costs to households, resulting from damage to dwellings from moisture, high winds, subsidence, and insect damage. In addition, damp buildings cause harm to health and wellbeing, and damage to dwellings from high winds can also risk injury. The analysis for this risk is largely described at the UK level. Climate risks to building fabric include:

- Damp or excessive moisture due to flooding and intense rain.
- Damp buildings causing harm to occupant health and wellbeing.
- Insufficient building regulations and standards to manage risks from moisture and damp.
- Structural damage and injury due to high winds.
- Subsidence caused by drought and dry soil.
- Costs to homeowners for repair.

The evidence, and therefore the analysis, available for this risk was limited so it is difficult to separate out how this risk is likely to change in future, specifically in Northern Ireland. However, there is high confidence that current building regulations are inadequate for addressing moisture and damp in buildings. Figure 10 summarises the likely future impacts on building fabric due to climate change.

Future change to climate variable	Projected future impact
Increases in precipitation	• Requirement for increased ventilation to remove indoor moisture. • Winter ingress in building fabric after heavy rainfall events. • Increased water penetration of vertical walls in dwellings. • Increased indoor moisture detrimental to health of occupants.
Increases in temperature	• May help to reduce moisture content, although likely to be counterbalanced by precipitation increases. • Minor benefit of higher surface temperatures could reduce risk of mould growth but would likely be counterbalanced by an increase in air moisture content.
Increases in windstorms	• Climate change is likely to lead to increases in wind driven rain. Wind-driven rain is associated with storms and the intensity of rainfall in storm events is projected to increase (although there is limited evidence available to illustrate the impact of climate change on storm frequency and location).

Increase in heatwaves	• This could lead to an increase in subsidence and tends to be a greater risk for older properties, and new developments on clay soils.

Figure 10: How climate change could affect building fabric (Recreated from Health, Communities and Built Environment technical chapter).

Benefits of further adaptation action in the next five years

Improving housing quality has multiple benefits as there are direct benefits to health and wellbeing in addition to reducing household costs. The burden from damp homes is high. There are also potential benefits to a more integrated, whole-house approach, accounting for the changing climate and potentially greater risks over time. However, there appears to be a lack of economic evidence on potential options.

Net zero policies that improve energy efficiency in housing can affect risks associated with moisture. Creating low energy buildings with increasing amounts of insulation and airtightness can lead to an increased risk of moisture-related damage to the structure and internal environment. Without considering additional ventilation this can lead to higher indoor vapour and mould growth.

The most obvious adaptation response to windstorm risks is insurance, but adaptations to homes could prove cost effective where damage is minimised and for new builds it is easier to consider the siting, orientation, design and materials used in advance of construction.

In Northern Ireland, there is currently no evidence that future climate risks are considered in relevant buildings standards and wider planning, building design and retrofit. This lack of long-term policy is likely to be locking-in climate risks to new and retrofitted buildings.

H6. Household energy demand

Health, Communities and Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS & OPPORTUNITIES	H6. Household energy demand	Summer and winter temperature changes	More action needed	Dept for Communities / Department for the Economy.

Summary of risk definition and description

Household heating demand dominates energy use in buildings at present. Temperature is a driver of household energy demand and household energy costs can make up a significant proportion of costs to families. Heating demand is important because it represents a large potential positive economic benefit of climate change in Northern Ireland. Changes in household energy costs are also important because they are not equally distributed and related to concerns about current and future fuel poverty.

The risks and opportunities to household energy demand associated with temperature changes include the following:

- Climate change will reduce future heating demand and the magnitude of this opportunity is high in the future in Northern Ireland.
- The opportunities from reduced heating costs are not being fully realised and there is insufficient action being undertaken to understand and take advantage of the future warmer climate.
- The future level of benefit is uncertain and depends on numerous factors such as socioeconomic factors, building standards and energy prices.
- There is limited data for future cooling demand in Northern Ireland but higher temperatures in summer may increase the potential need for cooling.
- Net zero policies will have big interactions with these risks and opportunities which may present additional costs to households to increase energy efficiency.

Household energy can make up a significant proportion of costs to families so reductions in heating demand due to temperature changes could provide a positive economic benefit, particularly for the 21.5% of Northern Ireland households currently in fuel poverty. However, a reduction in fuel bills from warmer temperatures may not produce the anticipated benefits, because households may simply further turn up their heating (e.g. if they are below comfort levels) or may invest less in energy efficiency.

This risk also interacts with overheating in buildings (see H1). As potential increases for cooling demand, this could make it harder to achieve Net Zero as it is easier to design a new Net Zero energy system for a static climate than one that is changing. Also, the measures taken to improve dwelling energy efficiency have a direct influence on the potential for dwelling overheating.

The present and future magnitude score for the risk of increased summer cooling is low in Northern Ireland, but confidence is high for current day and low for the future so there could be higher magnitudes under warmer scenarios. The magnitude of the benefit of reduced in winter heating costs is high with high confidence, across all future periods and scenarios.

Benefits of further adaptation action in the next five years

Recent building standards, energy strategies and energy planning have not considered the implications of the warmer climate on future winter energy demand. Potential increases in summer temperatures are also not considered. The size of the potential for reduced household energy costs, lower emissions and better indoor environmental quality is enormous if an integrated approach is taken that looks at adaptation and emissions reduction together. At the same time, the fast pace of development of Net Zero carbon policies now could lock-in future options that do not represent the best approach if adaptation is left out. There is a need for better integration of this issue in Net Zero policy analysis, and in subsequent government intervention to deliver Net Zero.

There is a strong role for government in information provision, in providing R&D and demonstration pilots, and to create the necessary incentives to shape a low carbon and climate resilient future in this area. It is unlikely that households and the private sector will deliver Net Zero effectively, without the necessary information on future demand and the changing balance between winter heating and summer cooling. Information to help households and business/industry to recognise these beneficial changes, i.e. awareness raising, and to maximise these, would help realise the potential economic benefits.

This risk/opportunity has been highlighted in the risk assessment as particularly likely to benefit from an 'adaptive pathway' approach, meaning various policy choices are mapped out against different future climate change and Net Zero scenarios, and the choices are narrowed down over time as uncertainty decreases. Adaptive pathways are used routinely in the flooding and water sectors, but to date have not been used widely in energy policy.

H7. Health and wellbeing

Health, Communities and the Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	H7. Health and wellbeing	Changes in indoor and outdoor air quality	Further investigation	DAERA

Summary of risk definition and description

Weather patterns can affect the formation and dispersion of air pollutants. Climate change may also change emissions of some pollutants or precursors of health-relevant pollutants. The incremental change in risk from climate change only, compared to non-climate causes, is uncertain. Air quality issues have been divided into three areas based on the different policy approaches:

- Outdoor air quality associated with anthropogenic sources (including traffic, industry and agricultural sources) and wildfires. The main health-related hazard is particulates (PM2.5 and PM10), though ground level ozone also affects health and is the dominant hazard when considering future climate change impacts on air quality. Air pollution emissions from combustion are falling rapidly and are expected to decline significantly under Net Zero carbon scenarios, thus the baseline level of pollution and interactions with climate change will reduce the future risk for outdoor air quality. Modelling studies indicate that ozone levels may decrease but not under all scenarios.
- Indoor air quality is dependent on building characteristics, ventilation, emissions from indoor sources and external air quality. Indoor air quality could be affected by interventions for Net Zero that can affect the ventilation of buildings. There is very little evidence for the impact of climate change on indoor air quality. Although, higher temperatures may improve or reduce indoor air quality. If temperatures are higher people may open windows more which could provide increased air circulation. However, in instances of poor outdoor air quality this could reduce the quality of indoor air.
- Natural (non-anthropogenic) sources of air quality related to pollen and mould that affect health. Pollen risks are likely to change with climate change although the implications for health are not clear.

Despite lack of certainty around this risk the magnitude is medium in future and has been classed as requiring further investigation especially due to uncertainties regarding the effectiveness of air quality strategies and emissions controls.

Benefits of further adaptation action in the next five years

The main action that will have benefits in the next five years is the implementation of a Clean Air Strategy for Northern Ireland, at the time of writing there is a consultation on a Clean Air Strategy Discussion Document. The second NICCAP includes a reference to the potential risks from the changing climate on air quality but does not include specific actions to consider this further, beyond actions to improve air quality now.

Any actions that reduce levels of outdoor pollutants in general will also have a positive effect on future air quality. Considering health co-benefits and trade-offs of potential adaptation actions for air quality may be helpful, for example nature-based solutions and improving green spaces. Further research on the implications of climate change on wildfire and pollen risks, and their effects on health, would be beneficial. More research on the relationship between air pollutants and extreme heat would also be beneficial.

For indoor air pollution, it would be beneficial if existing ventilation standards could be updated and existing building regulation enforcement activities used. Consideration of how interventions to increase air tightness of buildings may worsen indoor air quality would be beneficial.

H8. Health

Health, Communities and the Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	H8. Health	Vector-borne disease	Further investigation	Dept of Health

Summary of risk definition and description

Some diseases transmitted by insects and ticks (vectors) are likely to change in prevalence in the future due to warmer temperatures changing the distribution of the vector in the UK as well as diseases acquired by people overseas and being brought back into the UK (see ID9). Information for current and future risks are only available at a UK level and are not broken down by country. However, the magnitude of the risk is low with low confidence levels now becoming medium in all the future scenarios for Northern Ireland. The key factors associated with this risk include the following:

- Lyme disease is present throughout the UK and cases may increase with climate change due to an extended transmission season and increases in person-tick contact.
- The risk of Culex-transmitted diseases, such as West Nile Virus, may increase.
- The risk of mosquito-transmitted diseases, such as Chikungunya and Dengue Fever is likely to increase in the UK. The risk that malaria may become established remains low.
- Exit from the EU may undermine actions to control vector-borne diseases through reduced access to international surveillance systems. However, at the time of writing, it not known whether the UK will have continued access to international public health surveillance systems such as those coordinated by the European Centre for Disease Prevention and Control (ECDC).

The Health Protection Service within the Northern Ireland Public Health Agency (PHA) has the lead role in protecting the population from infection and undertakes surveillance and monitoring of pathogens. It is not known what policies are in place within PHA to consider the increasing risk of vector-borne diseases with climate change.

Benefits of further adaptation action in the next five years: Disease and vector surveillance is a public good and there would be direct benefits to improve this. There are benefits of further action, with many low regret options to improve or modify monitoring and surveillance systems. The main benefits of further action are in enhanced monitoring and surveillance systems, including early warning, and these can be considered a low-regret option. Surveillance programs are highly cost effective. There are also studies that show that vaccinations for tick-borne encephalitis may be cost effective, although there is currently no vaccine for Lyme disease.

H9. Food safety and food security

Health, Communities and the Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	H9. Food safety and food security	Higher temperatures (food safety) and extreme weather (food security)	Further investigation	DAERA

Summary of risk definition and description

The key factors associated with this risk include the following:

- Climate change is likely to be an important risk for food safety.
- Increases in extreme weather patterns, variations in rainfall and changing annual temperatures will impact the occurrence and persistence of bacteria, viruses, parasites, harmful algae, fungi and their vectors.
- Climate change may affect food security through variability in access to food due to disruptions to the supply chain from arising weather events and climate hazards in the UK and abroad.
- The whole of the UK currently is lacking in specific policies to address the implications of climate change for food safety or food security.

Risks specific to Northern Ireland are hard to determine, but there is medium level-quality of evidence within the CCRA3 Technical Report of the impacts of climate change on food safety and security. Regarding food safety, there have been incidences across the UK of weather-related toxin presentations in shellfish which can be harmful for human health and it was indicated that quantifiable amounts were present in shellfish from south England where waters are slightly warmer.

In Northern Ireland, the Going for Growth Strategy proposes an integrated supply chain from farm to customer but does not explicitly address critical elements of the supply chain that are upstream from regional farm production processes such as imports of feed, fuel and energy, fertiliser and other agri-chemicals. For example, the poultry and pig factory farms, require imported feed. Modern beef stock are larger and require supplementary feed. This has resulted in an increased requirement for importation of energy and protein-dense feeds to supplement the traditional grass-based livestock systems.

In relation to food security, the UK relies on a robust agricultural sector and imports (see ID1). Temperature changes may impact some crops however precipitation variability, which is more of a risk in the north of the UK, is more of a concern. The UK imports 18% of fruit and vegetables from climate vulnerable countries. Extreme weather hazards can impact multiple production areas at the same time. This could impact consumption of fruit and vegetables with significant consequences for human health. It could also have an impact on food prices and quality. However, the uncertainty of all future risks is high, hence further investigation is required.

Benefits of further adaptation action in the next five years

For food safety, food regulations and education on food handling and safety, coupled with horizon scanning and continuous monitoring for emerging risks, are likely to be low regret options.

For food security, the private sector and Government both have a role to ensure a higher level of resilience along supply chains. Routine monitoring of food security across Northern Ireland is also essential to protect public health

and limit unecessary costs for the health and social care system. Predicting future climate risks to the food system will ensure vulnerable groups to food insecurity are protected and the impacts to public health are minimised.

The whole of the UK currently is lacking in specific policies to address the implications of climate change for food safety or food security, the introduction of a food resilience and sustainability act with legally binding targets has been proposed to improve resilience in the food system. Furthermore, a UK food production audit could be conducted.

H10. Health

Health, Communities and the Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	H10. Health	Water quality and household water supply	Further investigation	Dept for Infrastructure

Summary of risk definition and description

Mechanisms by which climate hazards may affect water quality in Northern Ireland include:

- Heavy downpours can increase the amount of runoff into rivers and lakes, washing sediment, nutrients, pollutants, rubbish, animal waste, and other materials into water supplies, making them unusable, unsafe, or in need of water treatment.
- High temperatures can affect concentrations of pollutants in water directly.
- High temperature and low flow can increase concentrations of pollutants.
- Sea level rise, heavy rainfall, and coastal erosion can increase pollution from historical landfills.

The key factors associated with this risk include the following:

- Higher rates of warming may lead to interruptions of household water supplies which would have health, social and economic impacts, particularly for vulnerable households.
- Climate change may increase the risk of contamination of drinking water through increased runoff and flooding events that overwhelm current water treatment approaches.
- Risks to health from contact with bathing water (sea, lakes and rivers) and harmful algal blooms may increase with climate change.
- Private water supplies are most vulnerable to current climate hazards that affect water quality and quantity.

Northern Ireland continues to maintain surpluses in public water supply in the middle and late century under a no additional adaptation scenario. NI Water has made significant improvements in water resilience for customers since 2012 and have published a new Water Resource and Supply Resilience Plan in 2020 The Plan aims to build on this work, ensuring continued high levels of leakage detection, sustained investment in water mains and water efficiency initiatives. It has taken the target Level of Service (LoS) as providing customer reliability of 97.5%, equivalent to accepting a water supply failure for one year in 40.

Since the last CCRA in 2017 no incidences have been detected relating to disruption of water quality in private water supplies from climate-related events or hazards. No incidences of climate related failures of drinking water quality by public water supplies were reported from 2017 onwards. The magnitude score is low at present rising to medium in future for Northern Ireland. See N11 for more information on the current status of Northern Ireland freshwater bodies and ecosystems.

Benefits of further adaptation action in the next five years

Management of water quality would be improved by additional monitoring equipment, and 60 - 80 catchments could be targeted with the necessary equipment to monitor water quality on an hourly basis. There are likely to be benefits of further actions to improve water quality by reducing the risk of surface water flooding, such as the development of SuDS, catchment management and wetland creation. Nature-based solutions also help reduce this risk, as well as helping to reduce the effect of the urban heat island.

Increased consideration in emergency planning may also be beneficial, so that responses to emergencies (e.g. exposure to chemicals in flood waters, or private water supplies being cut off) can be ramped up quickly as needed. Further activities may be required to protect private water supplies too. Alongside this, there are a complementary set of water saving measures that can be introduced by homes, many of which are no and low-regret. Building standards could be updated to increase water efficiency in new homes. The government may consider enabling water companies to introduce compulsory metering.

H11. Cultural heritage

Health, Communities and the Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	H11. Cultural heritage	Changes in temperature, precipitation, groundwater, land, ocean and coastal change	More Action Needed	Dept for Communities

Summary of risk definition and description

This risk describes effects of climate change on cultural heritage, which includes moveable heritage (such as museum collections), archaeological resources, historic buildings and structures, cultural landscapes/associated communities, and intangible heritage (such as folklore, language and knowledge). The key factors associated with this risk include the following:

- Impacts of climate change on cultural heritage have already been observed.
- Risks and opportunities from climate change are evident, for example new heritage discoveries revealed by climate impacts.
- Assessments to scope risk to assets are necessary and should be used to support decision making.
- Continued monitoring is essential to inform risk management, especially for coastal sites.
- There is evidence that flood protection measures may do damage if not implemented appropriately.
- Coastal heritage is particularly at risk from climate change and heritage organisations and communities may need to accept the loss of some heritage assets. This process of loss is likely to be a powerful motivator for engagement and action on climate change. It also provides opportunities to understand sites and places in a way that might have otherwise not been possible, for example new heritage discoveries being revealed by climate driven impacts.
- Climate impacts that affect heritage assets may have knock on effects upon other sectors – including tourism, health and wellbeing, and natural environment and vice versa (see N17, I3, H4, and B2).

The current risks to cultural heritage relate to changes in precipitation, temperature increase, coastal processes and from unintended consequences of climate mitigation and adaptation activities in other sectors. Figure 11 outlines some observed impacts on cultural heritage from climate hazards across the UK. Examples from Northern Ireland include the risk of coastal erosion along 19.5% of the coastline, and immediate vulnerability in Strangford Lough and the Foyle estuary.

Climate hazard	Impacts on cultural heritage
Heavy rainfall	• Failure of rainwater disposal building envelope, with subsequent moisture/damp problems. • Possible increases in roof leakage due to modern roofing designs, including the addition of insulation at rafter level and associated waterproofing materials. • Waterlogging of gardens and archaeological sites.
Drought	• Increased risk of subsidence and shrink swell impact on buildings. • Drying of waterlogged archaeological sites. • Exposure of new archaeological sites. • Invisible deterioration of archaeological deposits (buried and full impact only apparent when excavated).

	• Changes in groundwater levels affecting parks and gardens. • Long term impact on resilience of plants and trees.
Flooding (fluvial, pluvial)	• Harm to buildings from water ingress. • More modern listed buildings may be at risk of catastrophic damage in a flood.
High summer temps	• Overheating of buildings leading to problems for fabric, building use and for sensitive collections. • Increasing demand for air conditioning, which increases problems such as condensation and deterioration of sensitive materials. • Increased visitor numbers, leading to some positive impacts.
New pest species	• More common and more rapid deterioration of stone and wood structures. • Risk of new pests able to metabolise building timbers. • Increased **bioturbation** of archaeological sites. • Increased water temperatures leading to new pests affecting marine archaeology. • Pests and diseases of landscape plants, including increased numbers and new variants. • Threats from pests and diseases such as **Xylella**, **Emerald Ash Borer** and **Plane Wilt** will have an impact upon our designed landscape.
Changed growing seasons	• Impacts on raw materials for repair of buildings. • Increased plant growth on historic structures.
Wildfire	• Potential loss of heritage assets. • Potential to discover new archaeological sites. • Changes to landscape management to reduce risk, e.g. fire breaks may harm cultural heritage.
Coastal change	• Greatly increased rate of loss of coastal assets. • Impact of adaptation schemes, e.g. construction of coastal defences. • Changes to salinity of groundwater affecting plant growth in historic landscapes, parks and gardens.
Oceanic changes	• Changes to water chemistry leading to breakdown of marine heritage.

Figure 11: Observed impacts on cultural heritage from climate hazards (Recreated from Health, Communities and Built Environment technical chapter).

Northern Ireland has identified significant implications for buildings from driving rain, wind and moisture impacts (e.g. Armagh Cathedral) and this is likely to increase with climate change. A strategic risk assessment of potential climate change impacts, specifically coastal erosion and flooding, on archaeological heritage in Northern Ireland, was conducted in 2013. Visible coastal erosion was present along around 15% of the Northern Ireland coastline and particularly vulnerable areas in the immediate term were Strangford Lough and the Foyle estuary. The dune system at Murlough could also be at risk.

Current actions being progressed by the DfC and DAERA's Historic Environment Division (HED) are as follows:

- DfC has drafted an Action Plan on climate change and the historic environment to include research and the development of appropriate guidance which is currently being considered internally.
- An action plan document for HED 2021-2022 relating to climate change has been drafted and is going through internal processes of agreement and endorsement.
- Hazard mapping for climate change is underway through a pan UK approach with the DfC's sister organisations; Historic Environment Scotland (HES), Historic England (HE), Cadw and led by the National Trust due for completion by end March 2021.
- An adaptation manual in conjunction with sister organisations as above is also underway which will relate specifically to managers of historic estates and buildings.
- Energy Efficiency guidance for historic buildings is ongoing and a draft for review will be ready by end of March 2021.

Condition surveys which consider climate change are being conducted on NI Water's Historic Sites, that will inform the development of a strategy on climate change and the historic environment. Individual local authorities have also conducted risk assessments and adaptation plans for the heritage sector. In 2019, Derry City and Strabane District Council conducted a review of the climate risks and vulnerabilities of its heritage assets and museum collections, assessed its current ability to adapt and identified actions to help improve the resilience of its heritage. Also see Case Study 4 for an example of National Trust actions to protect Mount Stewart.

The risk magnitude score is medium at present but rising to high in future. Confidence for this risk is lower in Northern Ireland than other nations as less widespread mapping and risk assessment has been conducted. The current 3D Survey of the entire NI coast down to 10m depth will help build the baseline of knowledge for coastal erosion (see Insight 10).

Benefits of further adaptation action in the next five years: When considering potential benefits of further adaptation action in is important to also consider points raised within the other risks covering coastal erosion and coastal flooding which are: (N17, I3, H4, and B2).

Further action would be beneficial to map climate related hazards, understand the vulnerability of different heritage assets to these hazards, and identify the types of assets and locations that are most at risk. This is challenging due to the complexity of ownership of heritage assets and the synergies with landscape, land management and the natural environment. Standardising data collation and facilitating sharing would help further understanding of risks and opportunities. The top priority challenges are deemed to be:

- Communicating the emerging prominence of 'managing loss' of heritage assets because of climate change and the need for more robust systems of prioritising assets for action.
- The need for longer-term data capture to better understand the impacts of climate change on heritage assets.
- Improved understanding on how to assess the collective impact of climate hazards, as damage will occur from multiple climate drivers.

Case Study 4: National Trust Shifting Shores

- In Northern Ireland, the National Trust manages 22% of the coast, 75% of which falls under a conservation designation. Managing coastal change is one of their key priorities. Through their Shifting Shores work they have been working towards:
    - Long term sustainable planning using shoreline management plans.
    - Investment in a science and knowledge led approach to shoreline management.
    - Raising awareness of a changing and dynamic coast and the impacts of climate change.
    - Working with others to inspire a network of paths around Northern Ireland's entire coastline.
- Some examples of them actively adapting and managing coastal change include at Anne's Point in Strangford Lough. In 2009, the Rivers Agency carried out breach works of the sea wall structure and an abandonment policy at Anne's Point, an area of land previously reclaimed for agriculture but no longer in use. This was the first and only sea defence abandonment by government in Northern Ireland. National Trust are planning to carry out adjustment works to support the development of a salt marsh habitat.
- At Mount Stewart, National Trust have enhanced the existing Sea Plantation on the shores of the lough; however recent climate change studies have suggested that the Sea Plantation will struggle to protect the property. As a result, the National Trust has begun a long-term plan to future-proof the property and in particular the gardens by preparing to allow tidal flats to encroach on what had previously been wetlands. To do this, National Trust have acquired land not at risk from extreme weather events and are preparing to relocate the car park. This site will then be replaced by a dense shelterbelt which will take over some of the role of the Sea Plantation.
- Source: Text adapted from National Trust Contributions to CCRA3 Technical Report

H12. Health and social care delivery

Health, Communities and the Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	H12. Health and social care delivery	Extreme weather	More action needed	Dept of Health

Summary of risk definition and description

Climate change will create disruption to health and social care services due to both the direct effects of floods, heatwaves and other extreme weather. This may directly damage buildings or disrupt the ICT and transport infrastructure upon which services rely. It may also indirectly increase demand for health and a social care services through the detrimental effects of extreme weather on people's health and wellbeing. These impacts will be felt across hospitals, residential and nursing homes for older people, respite centres for disabled people, home care services, and they may prevent people from accessing critical services, such as GPs.

Heatwaves cause problems with the functionality of hospitals as well as the thermal comfort of patients and staff. Impacts include:

- Discomfort or distress of patients, their visitors and staff.
- Equipment failure, such as failure of IT and essential refrigeration systems including morgue facilities.
- Disruption of laboratory services.
- Degradation or loss of medicine.

The second NICCAP highlights the risks to health and social care delivery from climate change, including from hazards such as extreme heat and flooding, but there are no specific actions listed in the programme to address these hazards in health and social care settings.

There are currently no systems in place for reporting instances of overheating in health and social care settings in Northern Ireland. There is some evidence that care homes and hospitals are already being affected by overheating, with some care homes installing air conditioning. Care homes have guidance for the temperature ranges (Revised Residential Care Home and Revised Nursing Homes Standard – 'the temperature in areas occupied or used by residents should be between 19°C - 22°C'). A stakeholder event held in 2015 found that there was limited action on health and social care on adaptation planning. Climate change adaptation was not seen as a priority. The ability to adapt older, existing health and social care buildings in terms of overheating can be difficult due the building design.

Figure 12 outlines the projected risk to these assets from flooding in the 2050s and 2080s depending on whether there is 2°C or 4°C of global warming at 2100 and on projected population changes. In all scenarios, significant increases in flood risk are expected.

	Present	2050s				2080s			
Population Proj		**Low**		**High**		**Low**		**High**	
Climate Future		**2°C**	**4°C**	**2°C**	**4°C**	**2°C**	**4°C**	**2°C**	**4°C**
NORTHERN IRELAND									
Emergency Services	27	33 (33-33)	37 (37-37)	35 (35-35)	38 (38-38)	35 (35-35)	40 (40-40)	38 (38-38)	43 (43-43)
GPs surgeries	99	128 (128-128)	130 (131-130)	130 (131-131)	133 (134-133)	126 (127-126)	133 (134-133)	133 (134-133)	144 (145-144)
Hospitals	11	16 (16-16)	16 (16-16)	16 (16-16)	17 (17-17)	16 (16-16)	17 (17-17)	17 (17-17)	19 (18-19)

Figure 12. Current and future flood risks for health and social care assets (reproduced from Health, Communities and Built Environment technical chapter).

Due to the number of assets at risk of overheating and from flooding, the magnitude of risk is medium for Northern Ireland, with a medium level of confidence, therefore more action is needed.

Benefits of further adaptation action in the next five years

There would be benefits to managing this risk strategically at a national level with regional and local level climate risk assessments carried out by Trusts, Health Boards, and local government social services, where these are not already happening. There are obvious potential benefits from ensuring new care homes and hospitals are designed for the future climate in terms of both flood risk and future temperatures, which is particularly important given the higher costs of retrofitting later. There are also potential options for retrofitting existing care homes and hospitals. Adaptive measures such as improved glazing, draught proofing, shutters, reflective surfaces, green cover and green space, and ceiling fans can help to reduce risk of overheating. Further investigation of the range of adaptation options available for mitigating risk in residential care buildings would be highly beneficial.

Monitoring of indoor temperatures and other indicators would be an additional response. Indoor temperature/ thermal comfort monitoring could be installed in a stepwise method, to monitor changes over times.

H13. Education and prison services

Health, Communities and the Built Environment				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	H13. Education and prison services	Extreme weather	More action needed	Dept of Education/ Dept of Justice

Summary of risk definition and description

This risk covers all aspects of the education sector (schools, universities, nurseries and other early years settings) and justice services (prisons, courts, secure units). The evidence base available to assess this risk is fairly limited so the analysis was completed on a UK wide basis, rather than for each devolved region.

Education

Most current evidence on climate risks and education relates to the impact of flooding, and the impact of heat in schools and on children's health and cognitive performance. As children are defined as an at-risk group, they are more vulnerable to climate hazards due to a limited capacity to respond to extreme events and reliance on teachers and other adults for support, knowledge and guidance, particularly at early school age.

The flooding risks to education are less well understood, but there is likely to be an increase in future particularly for surface water flooding. There is also concern that many school buildings have flat roofs which are more susceptible to damage from heavy rain. Figure 13 shows current risk and future projections to schools from flooding in Northern Ireland.

	Present	2050s				2080s			
Population Projection		Low		High		Low		High	
Climate Future		2°C	4°C	2°C	4°C	2°C	4°C	2°C	4°C
NORTHERN IRELAND (Total = 1,832)									
Schools	439	522 (521-522)	549 (548-549)	537 (536-537)	566 (566-566)	530 (530-530)	576 (575-576)	568 (567-568)	618 (618-618)

Figure 13. Flood risks for schools. Reproduced from CCRA3 Health, Communities and Built Environment technical chapter.

Modern schools often have more problems with increased risk of overheating than older schools due to their lightweight construction and large glazed areas. Older schools may also have problems after retrofitting as do schools with poor ventilation. Retrofits that addressed space heating in winter (with increased insulation) have not taken sufficient consideration of overheating during summer. Temperatures across the UK are expected to rise and schools are likely to fail against overheating criteria and standards. The magnitude will be less in Northern Ireland than England, and more likely to be experienced late in the century.

The Education Authority in Northern Ireland has developed severe weather emergency guidance for schools. During periods of severe weather, it is important that schools take steps to minimise the potential impact on buildings and facilities. The resources provide information about preventative measures that schools can take to minimise damage to the school estate in extreme weather conditions and how to protect school premises. The guidance is based on Met Office weather warning alert levels and gives information on the impact, likelihood and actions that the Education Authority and schools should take in response to extreme weather events at each alert level.

Prison services

There is no current evidence within the CCRA3 Technical Report on adaptation action for prison and justice services and the impact of climate hazards on buildings, inmate and staff health in Northern Ireland. However, The Ministry of Justice (MoJ) have published a climate change strategy which highlights the key risks to prisons in England and Wales, which is also likely to be relevant to Northern Ireland. Future risks are highlighted as being flooding, storms and drought (due to the risk of loss of building use and increased financial costs of repair or finding alternative accommodation for inmates).

UK prisons are vulnerable to high ambient temperatures and, in the summer, temperatures exceed comfortable conditions. A report included concerns from inmates during inspections which included difficulty of breathing, continuous heating, high ambient temperatures in cells and limited oxygen from poor ventilation. Currently, there is no systematic evidence monitoring the indoor temperatures inside prisons in the UK. Overheating is expected to be more of an issue in future.

In Northern Ireland, the magnitude of this risk is medium now and in the future, hence more action is needed.

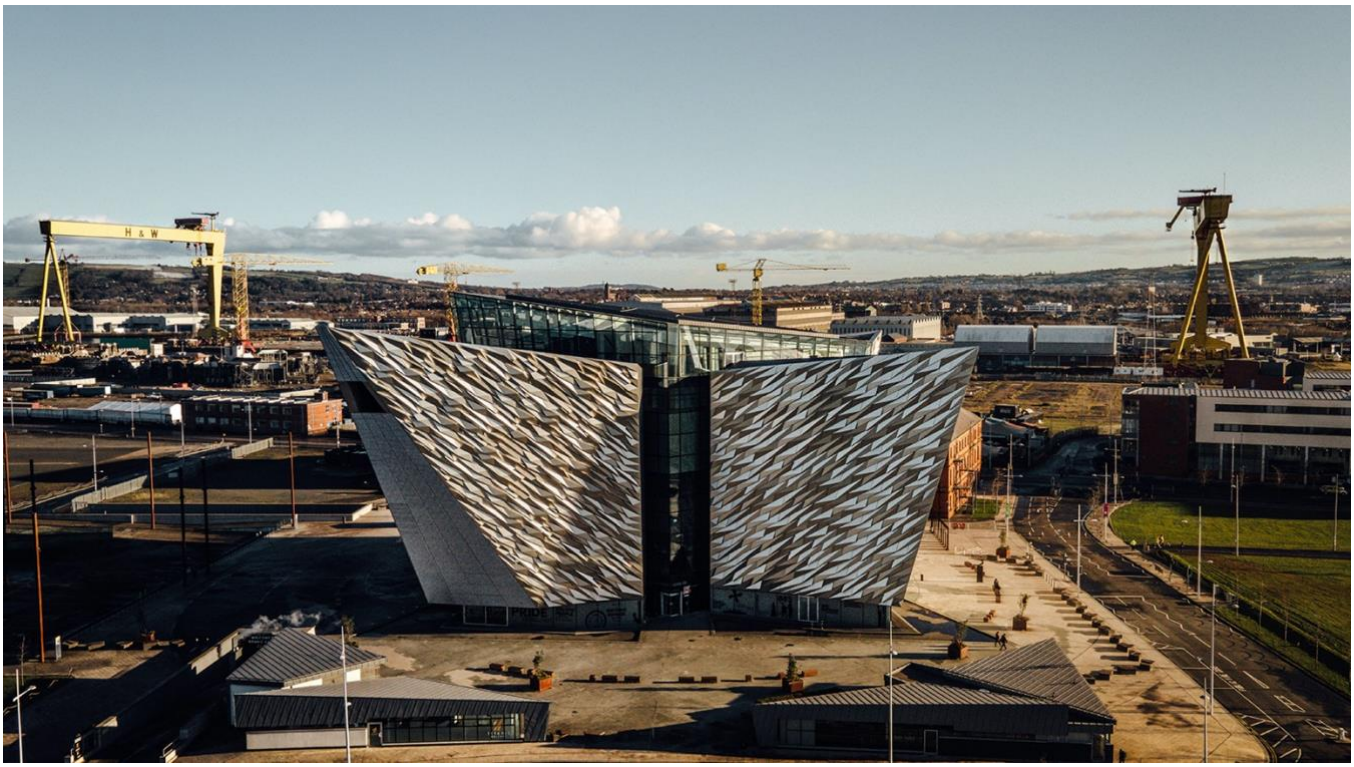
Benefits of further adaptation action in the next five years

Current building standards for Northern Ireland schools and prisons do not sufficiently address overheating. Further adaptation measures would be very beneficial to avoid lock-in with building designs and adapt to the future risks of overheating, flooding and other climate hazards. For example, use of rainwater attenuation tanks and ponds to store excess rainwater and regulate local temperature. Additional operational changes are scarce in the context of reducing flood risk in schools however, regular maintenance of roofs, gutters and drains will promote drainage of rainfall avoiding water pooling which may lead to damage. Additionally, schools could raise equipment to be above flood level and where possible have backup power generation to prevent power outages.

Long-term climate adaptation planning and response strategies are essential in the context of schools for not only the health, wellbeing and safety of students, staff and school personal but also promotes a more resilient, biodiverse and vibrant school environment. The first step for adaptation is developing a school climate adaptation plan with specific targets, strategies, tasks and roles to ensure its delivery and effectiveness. Across the education system many schools are limited in their resources, use older buildings and lack sufficient knowledge thus hindering effective climate adaptation planning to respond to and recover from extreme events.

For prisons, there are a set of similar adaptation options as those highlighted for schools, including both non-technical and technical responses. However, there is less evidence and no analysis of costs and benefits.

7. Business and Industry



Titanic Belfast Museum and surrounding docks. Photo: Unsplash

This section considers current and future impacts from extreme weather events or changing climatic conditions on business activity in Northern Ireland. The focus is on domestic (from climate change in the UK) risks. However, risk to UK businesses is mainly international and emerges via investments, supply chains, distribution networks and other business relationships (relying on adaptation outside UK control). We refer to international risks in this chapter and some others that are relevant are included in the International Dimensions Chapter, but the urgency scoring in this chapter is related to domestic risks only.

Flooding is the costliest hazard to businesses. Across the different types of flooding, surface water and drainage related risks tend to be less understood by businesses than flooding from rivers or the sea. Extreme windstorm events can also cause significant disruption and cause indirect losses, for example from failure of infrastructure or supply chains.

Heat impacts on businesses are recognised in the context of labour productivity but there is growing evidence of wider opportunities and risks. For example, high temperatures can cause irregularities for the cycle of agriculture such as for fruit farms, which can damage the quality of the crops or lead to lower yields.

Subsidence caused by drying clay soils may increase with hotter, drier summers and can affect the structural integrity of buildings and underground telecommunications cables, damaging assets and commercial buildings, in turn influencing business continuity.

The evidence base has increased since CCRA2, which broadly reflects growing awareness, regulatory pressures (particularly in the financial sector) and interest from investors, as well early movement by companies using the new reporting framework from the G7's Task Force on Climate-Related Financial Disclosures (TCFD). However, the evidence is still too limited for a systematic assessment of risks across sectors, company sizes and regions. Most of the risks and opportunities affecting businesses have increased since CCRA2. The changes in risk urgency are shown in the table below.

Risk, Opportunity or Risk and Opportunity	Urgency Score CCRA2	Urgency Score CCRA3
B1. Risks to businesses from flooding	Research Priority	More action needed
B2. Risks to coastal business locations and infrastructure from coastal flooding, extreme weather, erosion and sea level rise	Research priority	More action needed
B3. Risks to business production processes from water scarcity	Sustain current action	Further investigation
B4. Risks to business access to finance, investment and insurance from extreme weather	Watching brief	Sustain current action
B6. Risks to business from disruption to supply chains and distribution networks	Sustain current action	More action needed
B7. Opportunities for business from changes in demand for goods and services	Watching brief	Further investigation

There follows a summary of all climate risks and opportunities in Northern Ireland related to businesses.

B1. Flooding of business sites

Business and Industry				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	B1. Flooding of business sites	Increase in flood risk	More action needed	Dept for Infrastructure

Summary of risk definition and description

Current and future risk are significant, with high magnitude impacts expected across the UK. Action on flood protection, including business continuity is encouraging but given the scale of risk, and current levels of adaptation, as well as the wider implications for the economy and society at large, more action is needed.

The expected direct annual damages for non-residential properties in Northern Ireland at present is £42m, comprising of 6% of total UK damages.

Case Study 5: Review of North West Flooding August 2017

- The flooding was as a direct result of very heavy and persistent rainfall in the North West on 22nd and 23rd August 2017. 60-70mm of rain, equivalent to 63% of the average August rainfall, fell in the space of eight to nine hours causing many watercourses to rise, in some areas, to unprecedented levels in a very short period.
- There was also significant damage to infrastructure with 210 roads either closed or impacted and 89 bridges requiring remedial action because of the flooding. Flood protections also suffered widespread impacts with a total of 2900m damaged in numerous locations across the North West.
- The severe flooding had a profound, and in many cases lasting, impact on businesses, but no quantification of the impact has been made.
- Impacts to agricultural land were also very significant due to large amounts of debris being washed onto the land. 220 farm businesses were impacted, and fences were washed away in many locations.
- Issues were raised in relation to businesses being unable to claim for hardship payments like those provided to homeowners.
- In terms of lessons learned a review of emergency plans and business continuity plans has been recommended, as well as clarification of roles, responsibilities and hierarchy of command before, during and after floods.

Source: Business and Industry Technical Chapter

In the future, the expected annual damages for non-residential properties in Northern Ireland are to increase by 22% by 2050 and 33% by 2080 given present day levels under a +2°C by 2100 scenario and to increase by 39% by 2050 and 69% by 2080 under a +4°C by 2100 scenario, as can be seen in figure 15. These figures consider socioeconomic change in the form of population growth but not economic growth, and thus are potential underestimates of future damage. Without further action flood risk might significantly increase for many business premises by the middle of the century.

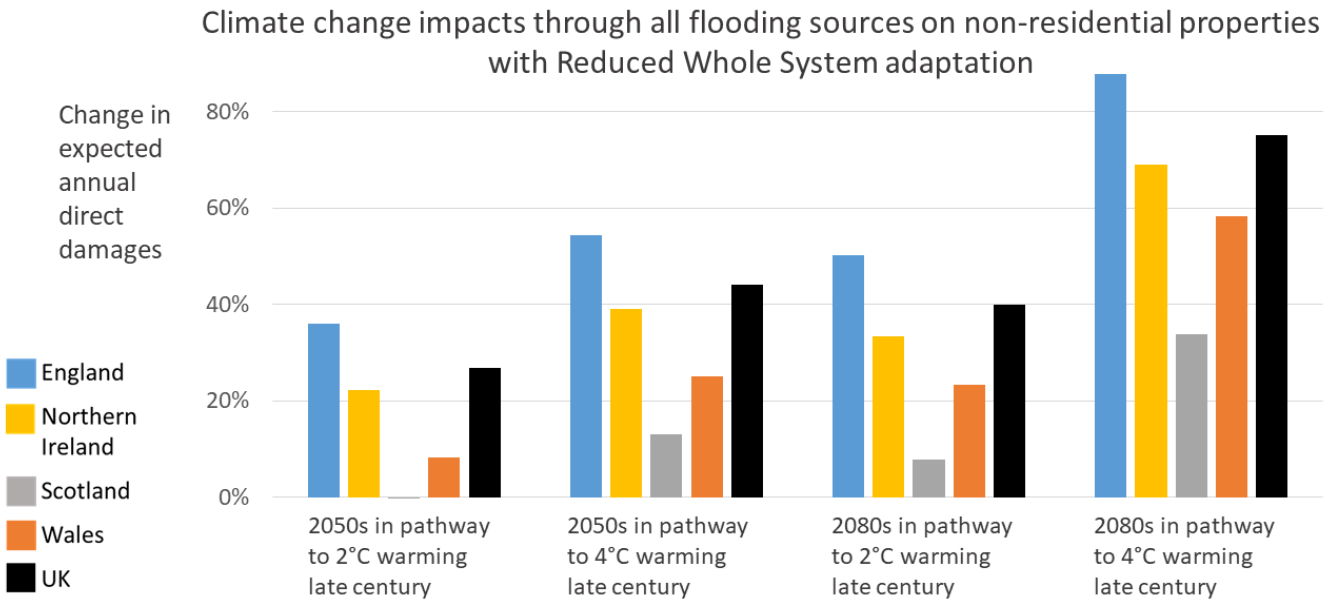


Figure 15. Future risks: Percentage change in expected annual damages to non-residential properties for a +2°C and +4°C at 2100 scenario, all sources of flooding, direct, £millions (%).

Given the expected annual impacts identified by Sayers et al. 2020 – (in the £tens of millions for Northern Ireland) the magnitude of this risk is high now and in the future. This is also supported by other evidence.

Business investment decisions have a high potential for lock-in for this risk, because of the location of investment and the rising risks of flooding outlined above. This is a particular risk if development continues to occur on the floodplain and where flood risk management measures are currently or will become insufficient to manage risks. There is perhaps a greater risk of lock-in to surface water flooding, just because these risks are more heterogenous and less well characterised than river floods and flood plains.

Thresholds including availability of insurance and costs of capital could increase magnitude even further unless risk levels are reduced through corporate as well as community-level adaptation action. In addition, several infrastructure risks also have the potential to cascade into business risks from flooding, mainly affecting productivity.

Benefits of further adaptation action in the next five years

There are almost certainly benefits from further action in the next five years from the low-regret actions to improve the evidence base and provide advice and support. Quantifying risks and impacts are difficult, particularly for individual business sectors, where data is often commercially sensitive.

However, if further adaptation measures are taken in addition to what is currently planned, then the UK-wide expected annual damages for non-residential properties will decrease by -5% by 2050 and increase by 1% by 2080 compared to present day levels of expected damage, under a +2°C at 2100 scenario. Figures for a +4°C at 2100 scenario are a 5% increase by 2050 and a 21% increase by 2080. In Northern Ireland however, figures increase by 15% by 2050 and increase by 24% by 2080 for a +2°C at 2100 scenario.

Businesses should also make use of the flood forecasting and warning services to plan for and respond to flooding in their areas. It is likely that improving the uptake of property flood protection by businesses will also have significant benefits in the next five years.

B2. Coastal business locations and infrastructure

Business and Industry				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	B2. Coastal business locations and infrastructure	Coastal flooding, extreme weather, erosion and sea level rise	More action needed	Dept for Infrastructure

Summary of risk definition and description

For most of the UK, a considerable amount of industrial and commercial activity, as well as infrastructure occurs along the coast. Flooding and coastal change risk to businesses is a medium risk now, is expected to rise to high risk in the future for Northern Ireland.

The current impact to coastal business locations is mainly driven by coastal flooding and extreme weather events, rather than coastal erosion. However, there is evidence that sea level rise could lead to a loss of coastal business locations and the infrastructure they rely on, that, for example, provide access, power and communications. Northern Ireland faces increasing risks from coastal erosion (c.19.5% of the coast is at risk of erosion) and marine flooding. However due to a lack of baseline evidence on coastal structure and processes it is difficult to assess this (see Insight 10). There is a lack of both historical coastal change data and risk information for coastal businesses and infrastructure in Northern Ireland, limiting the potential for effective preparatory decision making. Rates of coastal change, the effects of storms, the seasonal behaviour of the coast, interactions between beaches and dunes, and the possible impact of coastal structures are not known. This leaves existing and future businesses and infrastructure providers in an uncertain and unpredictable environment.

The expected annual damages for UK-wide non-residential properties from coastal flooding is expected to increase by 30% by 2050 and 73% by 2080 given present day levels, under a +2^{o}C at 2100 scenario and increase by 82% by 2050 and 181% by 2080 under a +4^{o}C at 2100 scenario.

Figure 16 shows the projected percentage change in the annual damages to non-domestic properties expected to be affected by coastal flooding in future.

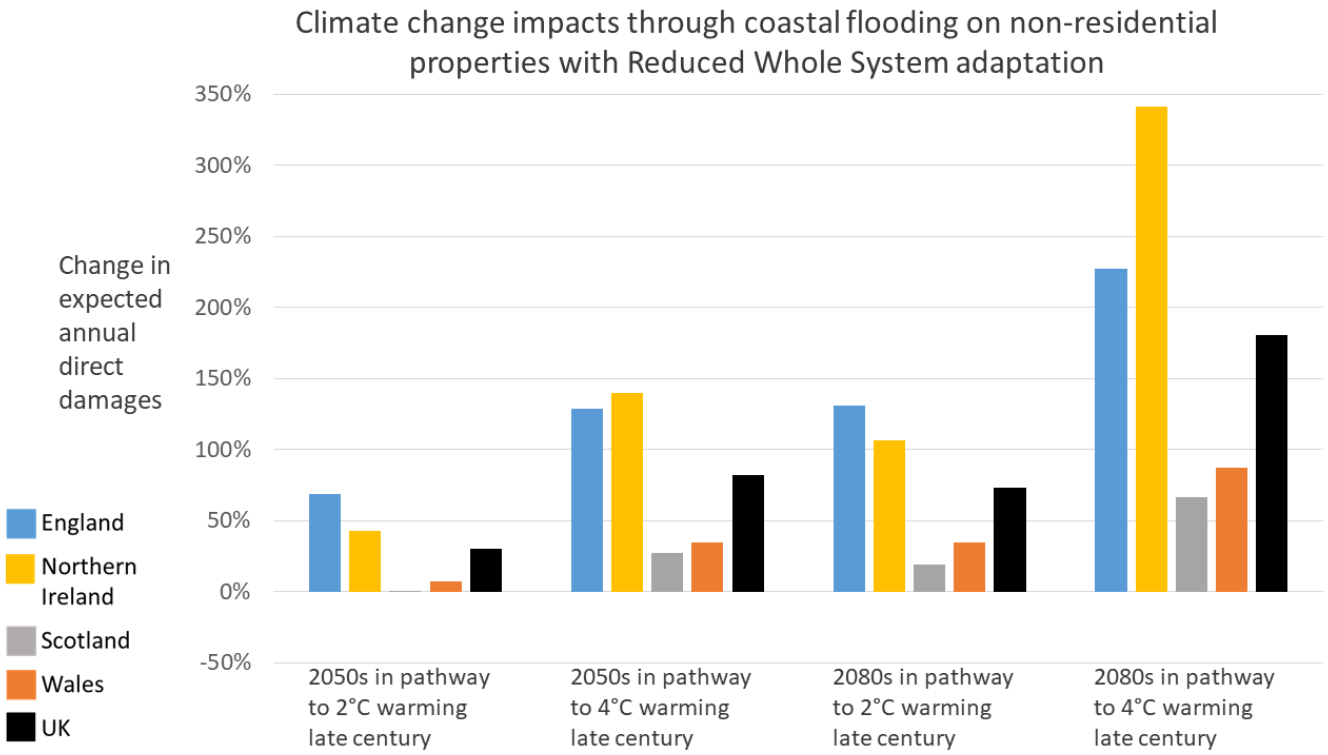


Figure 16. Future risks: Percentage change in expected annual damages to non-residential properties for a +2°C and +4°C at 2100 scenario - coastal flooding, direct, £millions (%). Reproduced from CCRA3 Business and Industry technical chapter.

As with the previous risks, business investment decisions have a high potential for lock-in for this risk, because of the location of investment and the rising risks of coastal flooding. Business investment decisions with long lifetimes taken in the next decade or two, notably around buildings and infrastructure assets, face potential risks if future climate change is not considered.

More action is needed to better understand and respond to the levels of risk and adaptation required for businesses. Thresholds associated to risk from coastal change include design and engineering thresholds for coastal flood protection infrastructure and business decision thresholds for levels of acceptable risk or investment criteria. Cascading risks for businesses arising from the failure of critical infrastructures after flood damage are increasingly recognised.

Benefits of further adaptation action in the next five years

When considering potential benefits of further adaptation action it important to also consider points raised within the other risks covering coastal erosion and coastal flooding which are: (N17, I3, H4, and H11).

In Northern Ireland, no SMPs have been developed to date. Ad-hoc measures are in place to protect the coastline against flooding and erosion. All reports identify the urgent need for accessible coastal data (processes, beach profiles, wave data etc.) to underpin decision making in Northern Ireland. The NICCAP draws on the detailed 2018 Baseline Study and Gap Analysis of Coastal Erosion Risk Management NI which identifies lack of coastline erosion data and monitoring as a priority to inform future coastal management policy (see Insight 8).

Some coastal communities, businesses and infrastructure may need to change in structure, focus, organisation, and location to become viable under future climates. Yet there is a lack of urgent and open public engagement with this

need for change. There are also opportunities to businesses from coastal change. Depending on the designation, the opportunity exists for businesses to bid for coastal partnership funding to redevelop the coastal area. There is also the potential for business opportunities to emerge from habitat creation, or new approaches to construction to enable communities to 'live with rising seas'. Coastal properties could also be purchased and repurposed to generate income, e.g. wind farms, temporary holiday lets.

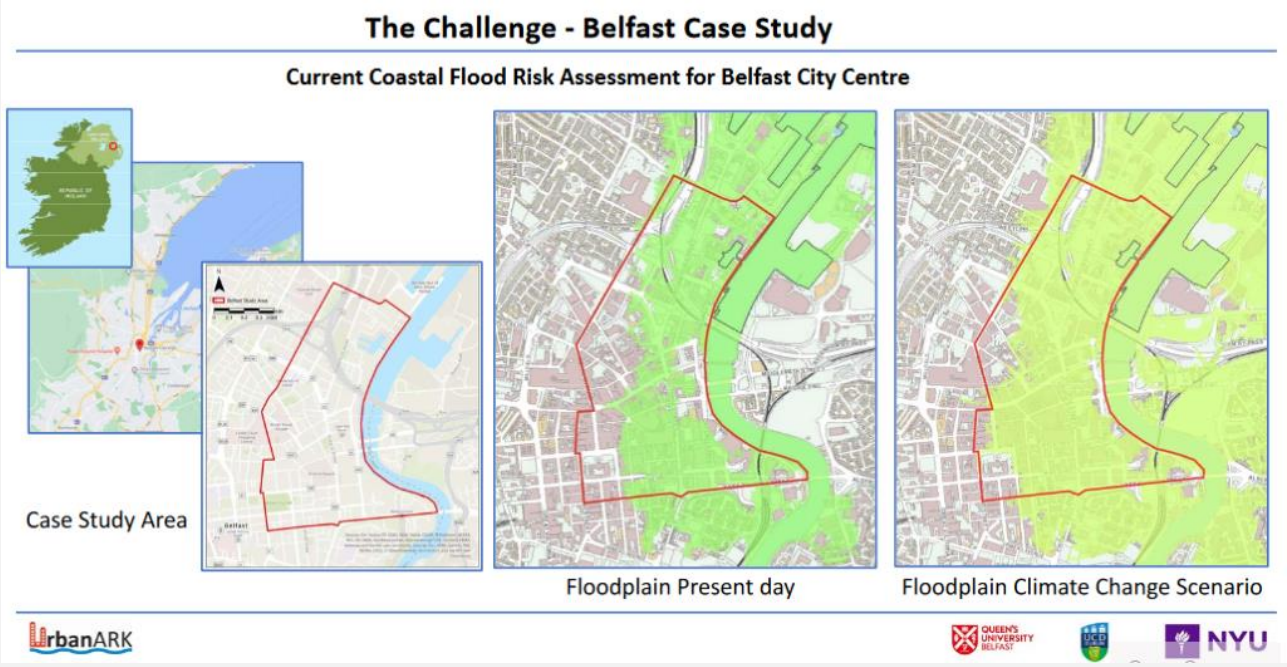
The following most frequent adaptation strategies reported by companies in the context of coastal risks are as follows:

- Investing in 'hard' engineering solutions, for example upgrades to flood protection, new water saving devices and heat reduction in offices.
- Developing and implementing enhanced business continuity plans that consider current and future risks including regular reviews and tests.
- Investing in ecosystem-services and green solutions to reduce risks, for example natural water storage/drainage, green roofs, and tree planting.

Some potential benefits of these and other adaptation measures and policy interventions include:

- Transparency about protection levels and protection limits to avoid false sense of security.
- Link future risks into coastal management and development visions of coastal communities to set realistic expectations and increase public engagement.
- Ensuring business support takes the impacts of climate change into account e.g. Invest NI provides property support across a range of business parks and works with statutory bodies over its plans to reduce the risk of flooding. Invest NI accepts that in the future some business parks may fall victim to incidents of flooding and with that there will be implications for it as the landlord and for its tenants.
- Investments in community resilience.
- Research into business opportunities in high-risk coastal locations.
- Reduced financial instability.
- Community engagement, for example strategic planning for caravan park businesses and their inhabitants needs to be inclusive. This would ensure adaptation strategies are most suited.

Insight 11: Coastal Flooding in Belfast – UrbanARK Project



Enhancing Flood Risk Management for Urban Coastal Communities Using LiDAR Applications.

Globally, floods are a major hazard, with wide-ranging social, economic and environmental impacts. This threat is growing annually, especially in coastal areas due to accelerating mean sea level rises, as well as increasing population growth coupled with new construction in flood-vulnerable areas. Flooding and coastal change risk to businesses is a high risk now and is expected to remain a high risk in the future in Northern Ireland.

The UrbanARK project is a collaboration between Queen's University Belfast, University College Dublin and New York University under the US-Ireland Research and Development Programme aimed at developing immersive, virtual reality applications to enhance emergency management and preparedness of urban communities and businesses, including infrastructure assets and networks that are at risk from coastal flooding events. UrbanARK explores the use of high-resolution airborne and mobile ground-based LiDAR scanning to identify and survey high-risk underground spaces. The LiDAR data is then used to refine flood prediction models and to develop immersive virtual reality applications as a communication tool to support communities and emergency planners.

Image: Map images of coastal flood plain in Belfast City area and case study area of the project - to highlight the challenge faced in Belfast from Coastal Flooding

Source: Dr. Ulrich Ofterdinger, QUB

B3. Business production processes

Business and Industry				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	B3. Business production processes	Water scarcity	Further investigation	Dept for Infrastructure

Summary of risk definition and description

Water is used by businesses for cooling and heating, washing products, dissolving chemicals, suppressing dust and as a direct input to products. Water intense manufacturing sub-sectors such as chemicals and chemical products, basic metals, paper and paper products, beverages and food products are more vulnerable to water scarcity. Water is also being used by people working in businesses for drinking, washing and sanitary purposes like domestic users. The degree to which businesses will change their water requirements due to socioeconomic circumstances is highly uncertain but potentially a significant driver of risk. If not well managed, risk of water shortage is projected to become material in investment and employment for water-intense sectors. As such, water scarcity risks require further investigation due to significant gaps in analysis with the magnitude of risk being low now, but medium to potentially high in the future.

In Northern Ireland at present, there is a surplus of around 170 Ml per day in the public water supply but it is not known what percentage of water is used by businesses. Data is also currently unavailable on the amount of direct abstraction from freshwater sources for business use in Northern Ireland. The Water Resource and Supply Resilience Plan published by NI Water runs several assessments of water scarcity risks. Although the report shows that for most of Northern Ireland there is expected to be sufficient water over the next 25 years it indicates possible shortages at the end of that period unless demand management and other adaptation action is implemented. Without adaptation action there is increased likelihood of water use restrictions being applied with impacts on households and business.

The CCRA3 Technical Report Business and Industry Technical Chapter states that Northern Ireland's supply-demand balance in the mid-century could be between 170 Ml per day and 10 Ml per day depending on the extent of climate change and population growth and assuming no additional adaptation to today. The supply-demand balance for medium population projections is between 120 and 100 Ml per day for +2°C and +4°C at 2100 scenarios respectively. In the late-century Northern Ireland's supply-demand balance could be between 162 Ml per day and -47 Ml per day depending on the extent of climate change and population growth and assuming no additional adaptation to today. The supply-demand balance for medium population projections is between 120 Ml per day and 80 Ml per day for +2°C and +4°C at 2100 scenarios respectively. Where the policy is to keep the environmental flows fixed at the same absolute volume that they are today, one of the catchments in Northern Ireland is unable to meet its environmental flow requirements without the addition of discharges to the river network.

The coincidence of hot weather with drought can potentially exacerbate risks and severe water scarcity could have impacts on people, who would then perhaps not be able to work, and potential for reduced demand for products and services.

Benefits of further adaptation action in the next five years

Evidence has found that there are high benefits (although also high potential costs) of further action to reduce the risk of water scarcity. The costs and benefits do not just fall under the category of businesses but are part of a larger picture of action to reduce demand and increase supply across business, infrastructure, and households, with an aim of protecting and enhancing the natural environment. There are also a complementary set of demand-side measures that can be introduced by businesses, many of which are no-regret and low-regret. As a rule, reductions of 30% in water bills are usually achievable at little or no cost for sites that have not previously tried to save water, and as much as 50%, or more, if projects with capital investment payback periods of up to two years are included.

Some simple steps to adaptation include increased collaboration between wholesale and retailers through Water Resource Management Plans, improving meter reading and quality of water consumption data and increased coordination during unplanned events and incidents.

Further, there needs to be a strong framework for the sustainable management of water, for example, by:

- Targeting efforts to bring non-compliant farmers into compliance and that ensuring basic legislation is sufficient to support further achievement of good health, as defined by the Water Framework Directive.
- Reforming abstraction licensing to ensure environmental needs are met as a function of every licence and that abstraction charges encourage efficient use.
- Continuing investment in the Catchment Based Approach including by exploring ways to encourage private sector support and funding.

Some of the key business benefits of handling water stewardship effectively include reduced water related business risk, increased drought preparedness, reduced carbon emissions from supply and heating of water, continuity of supply from sourcing locations for retail businesses, cost savings associated with water efficiency, strong engagement with the local community and reputational benefits.

B4. Business access to finance, investment and insurance

Business and Industry				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	B4. Business access to finance, investment and insurance	Extreme weather	Sustain current action	Dept for the Economy

Summary of risk definition and description

There is a risk that access to finance, investment, insurance, and capital for businesses are negatively impacted by climate change through decline in availability and affordability of insurance, a reduction in the value of assets and investment and increased credit risks and cost of capital. Across Northern Ireland this is currently a medium risk but has the potential to rise to high magnitude in future.

Moreover, risks and opportunities to financial services can be distinguished between those arising from sudden and slow-onset physical events, which generate increased losses for insurers and slower-onset events such as increasing insurance needs, reduced value of real-estate assets but increased infrastructure investment needs and mortgage defaults or growing capital needs for resilience.

This interplay between financial flows and physical climate risks can impact financial stability. Although these climate risks are currently low to moderate, they are expected to increase under any future warming scenario given the scale of physical damages expected to impact assets, products, and services both in Northern Ireland, the UK and internationally. The UK is particularly vulnerable due to the interaction between climate hazards and financial leverage in the country as a global financial hub.

While comprehensive and detailed assessments of the UK's financial sector exposure are missing, there is significant amount of new evidence largely driven by the regulatory efforts of the Bank of England and Prudential Regulation Authority (PRA) that allows more insights into current and future impacts from climate risks. For instance, there are organisations, such as the Climate Financial Risk Forum (CFRF), co-chaired by the Financial Conduct Authority and the PRA, which are providing UK-specific assessments of financial risks.

In terms of domestic risks, flooding is the most significant risk to the financial system with financial impacts on insurance, mortgages, and investment. However, the impact of windstorms is less clear. It is recognised that storms are having a significant impact on businesses through damage and disruption to business infrastructure, which can lead to an immediate financial shock to the business, requiring investment and access to capital. Estimated pay-outs from the impacts of storms Ciara and Dennis are £149 million, with 61,000 domestic property claims, totalling £77 million, 9,000 commercial property claims at £61 million and 3,500 motor claims at £11 million. However, there are some future trend studies that indicate a reduction to windstorm losses in the UK under future climate scenarios.

Figure 17 illustrates that windstorm loss projections are region specific, with Northern Ireland projected to see relatively high losses compared to other areas of the UK.

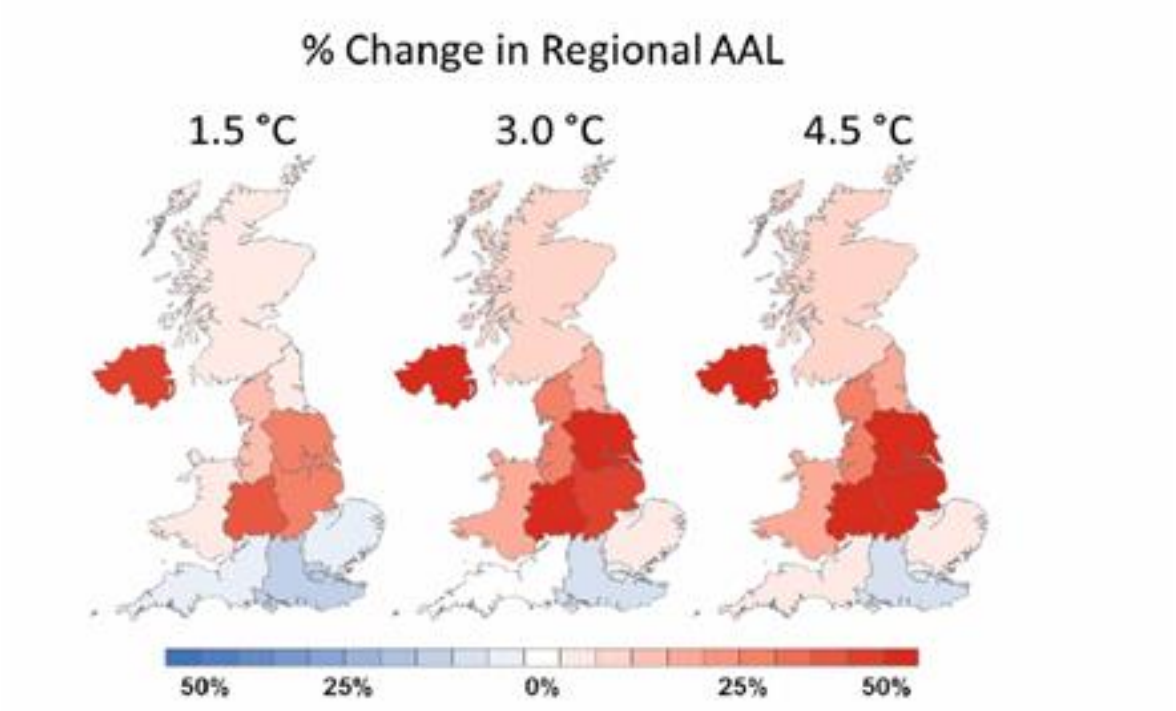


Figure 17. Windstorm loss projections for different temperature trajectories. Reproduced from Business and Industry technical chapter.

The main risks of lock-in are associated with long-lived investments, that have a degree of irreversibility. This can include financial investments, thus there is a risk of lock-in to those that provide the capital for these investments, i.e. the financial markets, and in particular the risk of stranded assets.

When considering investment risks, an important observation is the need to consider regional differences: "From a physical risk perspective, while average risks can be low, certain buildings may be high risk from one or more hazards. Assessing the outliers can allow investors to mitigate risks for particular assets by ensuring that building design is fit-for-purpose; transferring the risk through insurance; or, at the extreme, offloading the risk by selling the asset." Aside from this, it is difficult to determine how this risk varies between UK nations and uncertainty on how it will change in future is low and sustaining the current action to address it is advised at present.

Benefits of further adaptation action in the next five years can include the following:

- Impose requirements on banks and insurers. Regulators could prescribe additional capital on a case-by-case basis, for instance if a financial institution does not adequately monitor and manage climate related risks.
- Broadening scope of existing regulations to encourage more scenario-based analysis among financial institutions on a regular basis.
- Insurability and risk-sharing agreements between private and public financial institutions, similar to that seen in flood insurance, to meet financing gaps.
- Disclosing and reporting. Further standardisation and clarification on scenario analysis models are required so comparisons can be made.
- Financial and physical risk metrics. Unless physical risk is being reduced through more adaptation investment and action, damages will occur leading to financial implications.
- Incorporating risk reduction and data into insurance requirements.
- Financing adaptation. Further research is required in new products, such as resilience bonds, which would use premium discounts for long-term planning, such as investment in sustainable infrastructure.
- More collaboration between different parts of the financial system.
- Digital investments. Predictive modelling and decision-making based on algorithms has potential to change the way businesses view, understand and analyse risks, as well as adopt adaptive behaviours.

B5. Reduced employee productivity in businesses

Business and Industry				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	B5. Reduced employee productivity in businesses	Infrastructure disruption and higher temperatures in working environments	Further investigation	Dept for Infrastructure

Summary of risk definition and description

A changing climate has the potential to affect productivity, potentially both negatively and positively, as well as indirectly through infrastructure disruption and higher temperatures in working environments. In this risk, employee productivity relates to work output, as opposed to labour productivity which refers more to workplace efficiency or output per worker, per job and per hour. Current magnitude is low but may become medium to high by the end of the century.

There are also risks associated with extreme high temperatures, which can have negative impacts on employees' health and wellbeing and ability to commute to work. There is some evidence that businesses are experiencing these impacts already. The risks are likely to vary widely across business sectors or geographies, with factors such as the type of work, for example construction or industrial processes, whether it takes place indoors or outdoors and the local built environment and infrastructure factors, for example passive ventilation, all playing a role. The COVID-19 related shift to home working also creates a new risk, particularly for those employees working from homes prone to overheating.

Workers engaged in certain occupations, for example heavy outdoor manual labour, are likely to be at the greatest risk of heat stress. Recent evidence from the social care sector points to detrimental impact of heat on staff wellbeing. A case study of an older and a modern care home in London reported that staff found the summertime thermal conditions more uncomfortable than the residents did.

Only a limited number of studies have considered the impacts of higher temperatures on productivity in the UK and there is therefore considerable uncertainty about the magnitude of impacts and the degree of the risk to the UK both now and in the future and differentiating this between nations. One study estimates a 2% reduction in labour productivity by the end of the century.

Business decisions today about design and operation of office buildings and sites will determine future risk levels and are important given the lifetime of these investments. Similarly, the literature has clear thresholds associated with types of work, and levels of work output (for different types of indoor and outdoor work) and wet bulb temperature, a combined measure of heat and humidity exposure. There are also potentially synergies and trade-offs with Net Zero, particularly through air conditioning as adaptation increases energy use, and the use of refrigerants with high global warming potential which could leak. There is also the potential for feedback loops to be created in urban areas, with heat islands being worsened by the excess heat from air conditioning units.

Benefits of further adaptation action in the next five years

There is some information on various adaptation options to reduce heat in commercial buildings and linkages to the information available for domestic buildings (see H1, for example).

Some opportunities for labour productivity adaptation are also identified, such as transition to new ways of working, including remote and flexible working, and low carbon and energy efficiency buildings to maintain employee productivity. These behavioural changes have been tested and employed by various businesses because of the COVID-19 pandemic, but longer-term behavioural change is yet to be seen. Moreover, there are occupational and sectoral differences in the uptake of new ways of working, with some professions lending themselves better to flexible working than others.

Better collaboration and stronger governance between business, building owners, Government and infrastructure operators would help facilitate adaptation and may also deliver benefits in the next five years.

B6. Disruption to business supply chains and distribution networks

Business and Industry				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
RISKS	B6. Disruption to business supply chains and distribution networks	Extreme weather	More action needed	Dept for Infrastructure

Summary of risk definition and description

Weather is already a significant cause of supply chain disruption across all sectors with exposure to climate hazards set to increase. It is not just individual companies that are exposed to supply chain risks. Adverse weather has the potential to affect the profitability of entire sectors through impacts on local and global supply chains. Some action has been taken by business and there are opportunities from advances in technologies and from the learning and increased focus on supply chain resilience following the COVID-19 pandemic. However, it is unclear if this will keep pace with the increasing risk or how effective it will be specifically in managing climate or weather-related disruption. The magnitude of risk is currently medium, but considered unknown in future. Therefore, more action is needed but with a low certainty in the evidence, which is skewed towards larger companies, the food sector and self-reporting.

For example, industries that are part of the food system rely on agriculture, which is particularly exposed to weather and climate and long distribution networks, with 50% of food consumed in the UK imported from 180 different countries. Similarly, risks from pests and diseases, long term soil erosion, port closures, power outages, acidified oceans disrupting cod habitats and reproduction, negative effects of extreme heat on workers, and financial pressures on the supply chain, particularly farmers, in the wake of severe events could all increasingly find their way to UK businesses via supply chains.

Supply chain risks can be locked in if UK companies invest in transport routes, distribution hubs or production centres that are more exposed or vulnerable to climate hazards. It is not clear from the evidence if these factors are considered in investment decisions of this nature. However, there is some evidence that other priorities may be leading to trends that increase lock in. The London School of Economic (LSE) Business Survey suggests UK businesses are exposed to weather related supply chain risks through dependencies on suppliers and transport networks in equal measure. However, the latter may be more significant in Scotland, Wales, and Northern Ireland due to dependence on a limited number of transport hubs.

In the UK, heavy rainfall and surface water flooding and heating and high temperatures are the weather types that cause the greatest number of weather-related supply chain disruptions, causing significant negative impacts. Climate change is likely to contribute to an increase in exposure to supply chain disruption by driving an increasing frequency of adverse weather events and evolving climate hazards both in Scotland, the rest of the UK and overseas. However, risks specific to Northern Ireland are more difficult to determine.

Benefits of further adaptation action in the next five years

Most further actions involve capacity building, institutional changes, or the development of new strategies, technologies, or ways of working, which will take time to develop, test and implement. Therefore, there is a benefit to put these in place within the next five years even where the climate-related risks are not immediate.

Regarding the agriculture sector in Northern Ireland, the Going for Growth report proposes an integrated supply chain from farm to customer, but does not explicitly address critical elements of the supply chain that are upstream from regional farm production processes, such as, imports of feed, fuel/energy, fertiliser and other agri-chemicals.

Strategies that businesses can take to build resilience include:

- Product diversification or geographical diversifying.
- Scenario analysis to ensure plans are robust under different plausible outcomes (by explicitly defining and separating external scenarios from internal plans). It is impossible to plan for 'black swan' events, which includes some freak weather events, but it is possible to plan and test for generic unpredictable events.
- Ensuring risks are incorporated into risk registers and management programmes so that optimal resources and opportunities to improve corporate performance and earnings can be identified.
- Intensification in the use of storage facilities.
- Making more use of technology to predict, monitor, record, measure, or report supply chain disruption solutions and communicate with suppliers. For example using automated communication and notification systems, Business Continuity Management (BCM) platforms, incident management platforms or social media monitoring (favoured by small and medium sized enterprises (SMEs)).
- Expanding firm level insurance coverage of physical risks to supply chains, including by use of new products such as non-damage supply chain insurance plans and parametric insurance (e.g. when pay outs are based on a drought duration index or rainfall data rather than losses) or captive insurance solutions. The latter can improve climate resilience by strategically funding risk exposures preparing for a worst-case scenario in the face of increasing frequencies and by accessing reinsurance markets and alternative capital markets to fund less predictable risks.

There is a role for both the public and private sector in driving resilience through supporting/ incentivising their own supply chains to implement adaptation measures by:

- Requiring physical risk disclosures.
- Setting contractual arrangements that take adaptation into account.
- Using resilience criteria with choosing suppliers as part of procurement processes. For public sector procurement, the Public Services (Social Value) Act provides a potential tool by requiring commissioners of public services to think about how they can also secure wider social, economic, and environmental benefits.
- Helping suppliers reduce their own risks. For example, the water stewardship approach provides companies with a means of committing resource and using influence to support good water practices in areas of weak governance.
- Promoting business continuity, with a particular focus on strategies that achieve multiple goals including resilience and sustainability for which there may be market failures. For example, distributed manufacturing, seasonal produce, and local sourcing have a role to play in achieving both sustainability and resilience goals.
- Supporting improved climate and location-based information and integration with other types of information.

B7. Changes in demand for goods and services

Business and Industry				
Risk or Opportunity	Receptor	Nature of risk/opportunity	Urgency Score	Risk Owner
OPPORTUNITIES	B7. Changes in demand for goods and services	Long term climate change	Further investigation	Dept for the Economy

Summary of risk definition and description

Climate change will affect the production costs and demand for certain goods and services, increasing the profitability of some and decreasing that of others. The adaptation services sector in the UK is slow growing compared to other countries, but there is an opportunity for the Government to support its accelerated growth. Businesses that anticipate changing markets may be able to gain an advantage, but various barriers exist that could prevent this (e.g. upfront cost barriers to entering new markets, as well as inertia, especially for SMEs) and suggest a role for government intervention. The current magnitude of opportunity is low, rising to medium by the end of the century, although there is low confidence in this evidence.

Overall, there appears to be a much better understanding of business opportunities arising from a shift to a low-carbon future and the Net Zero transition than with regards to opportunities arising from adaptation to physical risks as indicate during stakeholder discussions as part of the UKCCRA3 workshops. In a report based on its surveys, CDP reported that 225 companies had identified between them US $236billion in revenue globally from the provision of adaptation goods and services. As discussed in the different examples below, whilst current opportunities exist, the extent to which these can be capitalised rest on factors such as: demand response, turnover time, adjustment of product lines, alongside quality and design of products and services, retraining and restructuring of the workforce, organisational culture, and agility. Moreover, most opportunities are coupled with risks or threshold effects, with many parallels to be drawn from the COVID-19 crisis and post-recovery opportunities. A range of UK-wide, sector specific opportunities are discussed in the literature including in agriculture, forestry, marine, shipping, seafood, construction, retail, tourism, climate advisory, consulting, accounting services finance and heritage. Whilst several possible opportunities for new or expanding sectors are known by stakeholders, there is little or no literature available quantifying the size or potential future for these industries.

Across the UK, there is evidence of further opportunities in the construction industry as businesses change their premises to adapt to climate change. This provides an opportunity for an increase in repairs, maintenance, or clean-up contracts. For the heritage sector particularly, increasing temperatures and extreme weather events intensify the need for repair and maintenance of heritage sites. Therefore, more will need to be spent on the materials industry (sandstone, slate etc) and on sector-specific skills (employees to repair traditional and historic buildings). Recent evidence shows that many Northern Ireland farms have diversified, expanding business into other crops they do not currently grow and using land for business activities beyond traditional farming, this is an area where more opportunities may be realised.

There are some lock-in risks, which may prevent realising new opportunities. There are particular risks related to land use change to take advantage of new forms of food production, notably relating to land use change. For retail and consumer spending, there are also risks locking in maladaptive products and services, such as air conditioning. Each potential opportunity also comes with threshold effects, either in terms of biophysical thresholds (e.g. thresholds for suitability for new crops, comfort levels for beach tourism), but also potential investment return thresholds, when it makes sense for the private sector to enter and scale-up.

Benefits of further adaptation action in the next five years

Given the low level of understanding of the opportunities to business from climate change, and the likely barriers to small businesses to enter new markets, there is likely to be a role for Government in providing evidence and supporting businesses to transition to new functions as the climate changes.

Identifying opportunities in increased demand for goods and services, such as climate advisory or adaptation products, are important to make a business case for climate adaptation in the next five years.

Across the UK there appears to be significant opportunities linked to retrofitting of the building stock. Most initiatives such as the smart energy programme, are currently aimed at achieving low carbon targets. Using these investments to also increase climate resilience of buildings would bring employment and profitability to construction and advisory services.

This requires greater evidence, such as case studies, and further investigation into emerging sectors, such as in the retail sector. Business capacity needs to be assessed post COVID-19 to determine whether these opportunities will be realised and what barriers exist.

8. International dimensions

Queen Mary 2 (Unsplash)

This section represents the second CCRA analysis of risks and opportunities for the UK from the observed and projected impacts of global climate change. It covers a broad range of initial climate drivers and impacts including food production, violent conflict, human mobility, health and governance.

It includes the risks that climate change impacts overseas present for the UK, and UK interests. Many of these impacts are transmitted through the flow of goods, finance, people and information. Whilst ultimate control of such flows is typically reserved to the UK Government, for example trade agreements, tariffs and border controls, the risks described below have impacts across the UK.

There is little differentiation in how the risks present themselves in England compared to the rest of the UK nations, therefore only a high-level summary of each risk is presented below. For more information on these risks, users should look at the International Dimensions Technical Chapter.

Most of the risks and opportunities arising from international climate change have remained the same, but in some cases their urgency has increased as shown in the table below.

Risk, Opportunity or Risk and Opportunity	Urgency Score CCRA2	Urgency Score CCRA3
ID1. Risks to UK food availability, safety, and quality from climate change overseas	Research priority	More action needed
ID4. Risks to the UK from international violent conflict resulting from climate change overseas	Research priority	More action needed
ID5. Risks to international law and governance from climate change that will impact the UK	Research priority	More action needed

There follows a summary of all climate risks and opportunities related to the implications of climate change from the rest of the world.

ID1. UK food availability, safety, and quality

International Dimensions				
Risk or Opportunity	Receptor	Nature of risk/opportunity	UK Urgency Score	Risk Owner
RISK	ID1. UK food availability, safety, and quality	Decreasing yields from rising temperatures, water scarcity and ocean changes globally	More action needed	DAERA

Summary of risk definition and description

Climate change exacerbates disruptive events impacting on agricultural production and food supply chains (from droughts, agricultural pests and diseases, storms), with increased risks of disruption which will increase the likelihood of risk cascades amplifying the impacts. Increasing risks implies a requirement to develop food systems that are resilient to disruption, rather than focusing on supply chain efficiency, which increases fragility.

The absolute availability of food is not likely to be an issue for the UK as a whole because of climate change up to 2100, but, as the international food system becomes more exposed to climate related hazards, food price spikes may become increasingly likely. This, in turn, changes the accessibility to food, particularly for the poorest in society.

Case Study 6: Fresh produce shortages in 2017

An area of concern is the extent to which the UK relies on fruit and vegetable imports as over 80% of fruit and about 50% of vegetables consumed are imported. The vegetable shortages of early 2017 were the result of climatic shocks to the food system.

Poor growing conditions in key sourcing regions, such as Murcia in southern Spain, resulted in rationing and price increases of up to 25-300% across the UK. Shortages were mostly encountered in lettuce, but also courgette, aubergines, tomatoes, peppers, broccoli, cauliflower, onions, carrots and celery. Multiple drivers of shortages were identified, including flooding in south-east Spain and cold temperatures in Italy. In Spain, the highest rainfall in 30 years reduced the area of arable land to only 30% of the area planted. Italy shifted from exporting over the European winter to importing. Traders imported from the US to fill the shortfall, thus increasing cost, emissions and contaminants associated with the produce.

During the vegetable shortages of 2017, some caterers and restaurants were bulk buying from supermarkets instead of wholesale, in response to the shortages and price spikes. Some supermarkets

appeared to opt for empty shelves rather than paying the higher price. Shortages appeared to be supermarket dependent, with, for example, the Co-op not reporting shortages. This suggests that vulnerability may be the result of a high proportion of imports coming from one region. It also suggests that supply chain management might reduce the future impact of events of this kind. Indeed, some companies have since diversified their growers' networks. For example, Florette have mitigated future risk due to production shortage in southern Spain by moving the grower network of some supply to northern Spain, southern France and northern Africa. Nonetheless, events of this sort continue to occur and interact with UK growing conditions to produce shortages, as in the case of cauliflowers in August 2019.

The socioeconomic and demographic inequalities across the UK result in different exposures and vulnerabilities to the risk of food price spikes. More broadly, environmental hazards exist everywhere and can be related to income, education, employment, age, sex, race/ethnicity and specific locations or settings. In addition to these differences in exposure, inequalities are also caused by social or demographic differences in vulnerability/susceptibility towards certain risks. For example, supermarket shoppers in cities may be exposed to variations in food prices or supply, and they will be differentially vulnerable to price rises, according to their income. Shoppers in rural locations, with access to smaller and more highly dispersed retail outlets, will be exposed to different risks as availability of food will vary more, as well as its price.

Source: CCRA3 Technical Report International Dimensions Technical Chapter
Image: Tomatoes (Pixabay)

Benefits of further adaptation action in the next five years

- That due consideration be given to a range of aspects within emerging Free Trade Agreements, following the UK's exit from the EU.
- To remove some of the barriers for the private sector to encourage climate change adaptation, as well as ensuring a higher level of resilience along supply chains.
- For a greater focus on adaptive management, research and learning which could also contribute to more resilient food system.
- To address food access inequality, access to fresh produce and informed dietary choices, which will likely have the co-benefit of reducing vulnerability to the risk of decreasing nutritional quality of food produced due to climate change.

ID2. UK food availability and exports

International Dimensions				
Risk or Opportunity	Receptor	Nature of risk/opportunity	UK Urgency Score	Risk Owner
OPPORTUNITY	ID2. UK food availability and exports	Increases in productivity and areas suitable for agriculture overseas	Watching brief	DAERA

Summary of risk definition and description

Global patterns of climate change can alter the comparative advantage of the UK in producing and trading in food. Climate change is one of a number of drivers that has an impact on food production patterns, through changes in productivity and/or changes in the land suitable for producing food.

On balance, the lack of evidence of global yield increases in response to climate change, and difficulties in the use of marginal land and in water management suggest that food production opportunities will not be the norm. There are, however, opportunities associated with other drivers of international food systems, not least the ongoing trend towards plant-based meat substitutes and plant-based diets, which have the potential to both mitigate climate change and result in healthier diets.

Benefits of further adaptation action in the next five years

Ensuring access to a broad range of international markets would capitalise on any opportunities associated with climate impacts overseas. There is no evidence to suggest further actions that would support such opportunities are currently taking place. Access to markets, which was covered in some detail in Chapter 7 of the CCRA2 evidence review, has the co-benefit of providing some resilience to external shocks, be they climate-induced, or sourced elsewhere (e.g. a global health disruption such as COVID-19). Hence there are multiple lines of reasoning that suggest benefits of access to markets.

ID3. Migration to the UK and effects on the UK's interests overseas

International Dimensions				
Risk or Opportunity	Receptor	Nature of risk/opportunity	UK Urgency Score	Risk Owner
RISK & OPPORTUNITY	ID3. Migration to the UK and effects on the UK's interests overseas	Climate-related international human mobility	Watching brief	UK Govt

Summary of risk definition and description

Negative climate change impacts will make some places more difficult to live in and could undermine the development gains overseas in which the UK has invested. One potential adaptation is displacement and migration with affected areas most likely to be in the global south exposed to frequent climate extremes with high dependence on agriculture and weak social support programmes. Unplanned, unsupported and precarious climate migration presents risks to the human rights of the people on the move, as well as their wider social and economic opportunities. Most climate-related migration in the near future will be domestic, within affected countries or regions. Thus, the UK is unlikely to be a major migrant receiving country and there is weak evidence on any security threat associated with migrants. Where migration to the UK does increase due to change, climate will be one of the many drivers of migration, and it will take place along existing flows. However, increased mobility as a result of climate change is likely. Where people are on the move between regions overseas, there are risks to the wellbeing of those individuals and as such the potential to undermine development gains overseas.

Adaptation involves ensuring pathways for regular migration and altering negative perceptions of migration in receiving countries, as well as supporting development, infrastructure, and strong institutions and transparent decision-making.

Benefits of further adaptation action in the next five years

In the context of the Lifetime Skills Guarantee, the UK Prime Minster has highlighted skilled labour shortages that could be filled with migration until filled domestically. Thus, there is an opportunity for the UK to set up procedures to ensure that any increases in migration are beneficial to the nation. There are also likely to be 'win-win' opportunities ensuring that overseas development and humanitarian response empowers local communities such that they are not forced to migrate but have agency in whether, when and where they chose to move.

During the period immediately following the UK's exit from the European Union, there is a window of opportunity to provide pathways for safe and orderly migration to the UK. The UK can maximise on the benefits that any new migrants bring and thus there are benefits to the UK's investment in social mechanisms that allow newcomers to integrate effectively into the job market and local society.

ID4. The UK's international interests and responsibilities

International Dimensions				
Risk or Opportunity	Receptor	Nature of risk/opportunity	UK Urgency Score	Risk Owner
RISK	ID4. The UK's international interests and responsibilities	International violent conflict resulting from climate change overseas	More action needed	UK Govt

Summary of risk definition and description

Recent literature continues debating the role of climate change as a driver of conflict. Nevertheless, there is consensus in the recognition of climate as an amplifier of root causes for conflict, whilst also recognising that a range of other drivers affect the association between climate and conflict. These include, but are not limited to, pre-existing conflict at local and country scales, level of democratisation, post-colonial transformation, economic context and population growth. Overseas conflict can have an indirect impact on the UK through a variety of UK overseas interests, and various aspects such as governance, people (migration), refugees and finance and markets.

Benefits of further adaptation action in the next five years

Based on a study in the US, in the context of risks to US international assistance, 'the impacts of climate change, variability, and extreme events can slow or reverse social and economic progress in developing countries, thus undermining international aid and investments made by the United States and increasing the need for humanitarian assistance and disaster relief.' A similar observation could be made regarding the overseas aid budget of the UK.

For mitigation of water-based conflict, more cooperative behaviour is associated with transboundary agreements when participating countries are governed by treaties with water allocation mechanisms that allow flexibility and specificity. Therefore, there may also be opportunities to reduce current tensions through appropriately deployed international agreements on shared resources including access to water (where rivers run between countries) or new opportunities in areas such as the Arctic.

ID5. Changes to international governance affecting the UK

International Dimensions				
Risk or Opportunity	Receptor	Nature of risk/opportunity	UK Urgency Score	Risk Owner
RISK	ID5. Changes to international governance affecting the UK	Reduced international collective governance due to climate change and responses to it	More action needed	UK Govt

Summary of risk definition and description

Climate impacts overseas have the potential to threaten and weaken international law and governance but quantifying their effects on UK's interests and values is difficult. Risks to international law and governance from climate change include human rights violations, contestation of well-established international rules, risks of sovereign defaults in emerging economies and new legal challenges arising from low carbon policies. Such risks have the potential to threaten the UK's economic, diplomatic and military interests and challenge its foreign policy of strengthening the rule-based international system and promoting human rights.

Benefits of further adaptation action in the next five years

Diplomacy is likely to be the main means of adaptation in relation to this risk. Further engagement with multilateral processes and institutions would have benefits for ensuring that the UK preserves its interests and strengthens its image as a respected multilateral player. This could include engaging constructively with a range of processes and initiatives in the context of climate change, such as by supporting the work of the International Law Commission on sea level rise in relation to international law started in 2019, the work of the UNFCCC on loss and damage and the on-going modernisation of the Energy Charter Treaty. There would also be benefits from producing a clear plan to meet the challenges posed by a shift in UK relationships with traditional allies and changing dynamics at the United Nations, to coordinate its activities with the EU and to build new partnerships with the Commonwealth. Whilst the short-term benefit of these adaptations is small, it rises on longer timescales, commensurate with the increase in risk magnitude. There is a suggestion, therefore, that it would be beneficial to act now to enable adaptation in the future.

ID6. Increased trade for the UK

International Dimensions				
Risk or Opportunity	Receptor	Nature of risk/opportunity	UK Urgency Score	Risk Owner
OPPORTUNITY	ID6. Increased trade for the UK	Arctic ice melt opening up new trading routes	Watching brief	DAERA / UK Govt

Summary of risk definition and description

The opportunities from climate change to extend international trade routes are currently limited to potential benefits from increased access to the Arctic and provision of maritime services. However, associated risks coupled with the small magnitude of opportunity lead to the magnitude of this opportunity to be low at present, but longer term, as warming continues, this rises to high. There is no clear need for current action on this issue, as, firstly, the opportunities relating to sea passages opening are being closely monitored by a range of commercial operators in maritime shipping and ancillary industries. Secondly, the UK Government is involved in International Maritime Organisation activities related to the regulation of potential changes in this opportunity.

Benefits of further adaptation action in the next five years

There is some projected analysis which indicates that opportunities from climate change, including arctic ice melt, on international trade routes could be large, including from the economic effects of trade that is facilitated by a reduction in transport distance between suppliers and consumers. The effect on UK GDP was estimated to be equivalent to an annual increase of 0.24%. There are also potential tourism opportunities that increased access to the Arctic allows, and associated port development in locations that facilitate these trade and tourism opportunities. While these would need to be seen against potentially very large negative impacts from an ice free Arctic for other reasons, they do indicate potential economic benefits. There is an issue whether these benefits will be fully realised by non-Government adaptation alone and it is possible that higher benefits would be achieved for the UK through some enabling actions from Government, which would have likely low costs.

ID7. International trade routes

International Dimensions				
Risk or Opportunity	Receptor	Nature of risk/opportunity	UK Urgency Score	Risk Owner
RISK	ID7. International trade routes	Climate hazards affecting supply chains	More action needed	DAERA / UK Govt

Summary of risk definition and description

Climate-related disruption to non-food supply chains may occur in production facilities, for example floods affecting factories or mines, but perhaps is more likely to impact on supply-chain logistics, which can be interrupted in multiple ways. COVID-19, for example, disrupted supply chains through the closure of centralised processing facilities, the interruption of transport flows due to grounding of vehicles, lack of labour and delays at borders. With globalised supply chains characterised by 'just-in-time' delivery, high efficiency but low redundancy, they can be fragile and lack resilience to disruptions. Given the projected and observed increase in disruptive events, this risk may become more potent in future.

Benefits of further adaptation action in the next five years

Given that shocks are likely to increase in future, as climate hazards from extreme events increase, there is benefit from a focus on building further resilience. However, resilience would typically arise from four main properties: building in redundancy (e.g. stocks), diversity (of sourcing, or substitutability), creating modularity or distributed rather than centralised networks, and creating greater flexibility/adaptability. All of these properties have typically been removed to increase efficiency and the leanness of supply chains. Thus, there is a trade-off between fragility (and lower prices) and resilience (and higher prices). As risks increase, the trade-off tips towards resilience providing better returns on average. Resilience as a 'design feature' may become a greater focus for investment during post COVID-19 recovery.

ID8. Economic loss to the UK

International Dimensions				
Risk or Opportunity	Receptor	Nature of risk/opportunity	UK Urgency Score	Risk Owner
RISK	ID8. Economic loss to the UK	Climate driven resource governance pressures and financial exposure	Sustain current action	Dept of Finance

Summary of risk definition and description

A significant way that international climate risks impact the UK is through finance. This is separate from the physical impacts within the UK that climate change may have on insurance and investments (risk B4). There may be significant financial exposure to extreme weather (including wildfires), and impacts in other countries especially through the insurance markets and investments. London operates a global insurance market with products covering both direct climate change events such as agriculture insurance as well as indirect impacts such as business interruption. Investment risks are clear where domestic owned assets are exposed to extreme weather events in other regions or supply chains are disrupted. This could have a significant impact on all types of asset classes and potentially put further stress on UK pension funds.

Benefits of further adaptation action in the next five years

Whilst banking and insurance sectors have responded effectively to current extreme weather events, the increase in magnitude and frequency means the likelihood of 'unhedgeable risk' is higher, straining the insurance sector. Given that financial risks are still not integrated within firm operating models or in financial markets, there are still significant systematic risks. Whilst companies have started adopting the Task Force on Climate-related Financial Disclosures (TCFD) recommendations, identifying climate risks is only the first step. TCFD's most recent status update report acknowledges that there needs to be a better understanding of how disclosing climate-related financial information is changing corporate strategies on adaptation, and how investors are using the disclosed information to inform their decisions.

ID9. Introduction of infectious diseases to the UK from abroad

International Dimensions				
Risk or Opportunity	Receptor	Nature of risk/opportunity	UK Urgency Score	Risk Owner
RISK	ID9. Introduction of infectious diseases to the UK from abroad	Increase in vector borne diseases due to climate change	More action needed	Dept of Health

Summary of risk definition and description

There are two factors that determine climate-induced vector borne disease risk. These are emergent favourability of overseas climate, and prevalence. The risk is high where the vector has been introduced recently and become endemic. There are several examples where UK visitors to popular parts of western Europe now bring the risk of exposure to diseases that until recently were only found in the tropics. The UK climate is also relevant, since it may change enough to allow local transmission of these diseases by vectors which transmit the infection human to human or to a further host from that initially overseas infected person (risk H8).

Of the infectious diseases with known climate drivers, the most likely to impact the UK are those transmitted by animal vectors, such as mosquitoes, midges and ticks, when considering disease of human and domesticated and wild animals (case study 15). In some cases, birds are the possible introducer of the pathogen but the local climatic conditions must allow the transmission of that pathogen by the vectors and to date this has been observed in the UK more for insects than other animals.

Case Study 7: Risks to the UK from competent vectors

The spread of dengue from nine countries a few decades ago, to being endemic for almost half the world's population today, is highly relevant to ongoing climate-induced risks as people continue to travel and return from these countries. The changes in the distribution of dengue are possibly in part driven by climate change, urbanisation and the ability of mosquitoes to thrive within polluted waters of rapidly expanding urban areas, mostly in the tropics and sub-tropics.

The locally acquired cases of dengue in Spain and France due to Aedes albopictus reported in September 2019, Italy's first dengue outbreak in August 2020 and the 2017 local outbreak of chikungunya virus in Italy have shown how vulnerable

mainland Europe, frequently visited by UK travellers, is to the introduction of what were seen previously as tropical diseases.

Further areas of concern include the spread of other diseases in the UK. For example, Culex modestus, a competent vector of West Nile virus, has recently found to be well established in the marshland sites of the Thames Estuary and could spread to a wider area. The discovery of the virus that causes tick born encephalitis was found in two places the UK for the first time in 2019. There has also been a more regular introduction and detection of Aedes albopictus in Kent.

Source: CCRA3 Technical Report International Dimensions Technical Chapter
Image: Mosquito (Pixabay)

Benefits of further adaptation action in the next five years

Actions to promote adaptation to emerging diseases include:

- More real-time monitoring of air travel routes, transmission pathways of movement of people and goods.
- Communicate outdoor risks if a vector-borne disease is introduced.
- Improve training and awareness of primary health care practitioners.
- Raise the levels of surveillance programmes and some random screening (for example, part of blood donation screening for antibodies).
- Improvement of public and professional level information, transmission pathway IT/information.

There would also be benefits from increased surveillance of wildlife, people or other imports (e.g. used tyres, the trade of which can aid the spread of mosquitos) coming into the UK, which comes with increased costs. However, if newly arrived infected vectors or animals in combination with more favourable UK climate leads to local transmission, the cost of the impacts may be a lot more. COVID-19 has provided a good example of the scale of impact costs and how this can cascade into other sectors. Therefore, it shows that investments in surveillance can pay off to avoid high impact situations.

ID10. Risk multiplication to the UK

International Dimensions				
Risk or Opportunity	Receptor	Nature of risk/opportunity	UK Urgency Score	Risk Owner
RISK	ID10. Risk multiplication to the UK	Interactions and cascades of named risks across systems and geographies	More action needed	FCDO

Summary of risk definition and description

There is the potential for hazards to create cascading risks that cross geographies and sectors through infection. COVID-19 is an example, where the emergence of the disease may have an attributable component from climate change, but the spread of the disease and attempts to mitigate it have created disruptions in demand, in trade through supply-chain disruptions from changes in labour availability, through people movement and broader economic impacts. This variety of impacts affecting multiple sectors and all countries are an exemplar of 'systemic risks' arising from highly inter-connected sectors and economies. Therefore, the interconnectedness of risks such as those outlined in this section so far suggests it would be beneficial to have a more joined-up assessment of the overall risk of international climate change to the UK, which is more than just a sum of each individual risk.

Benefits of further adaptation action in the next five years

While definitions vary, much of the theoretical literature emphasises transformational adaptation and there is often a focus on changes in governance as well as underlying causes of risk or vulnerability. However, there is very little economic evidence on the costs and benefits of transformational adaptation, reflecting that there is very little evidence on what transformational adaptation looks like in practice. This is an area where further research would be beneficial.

9. Next Steps

The CCRA3 Technical Report assesses the current and future risks to the UK from climate change. It does not recommend the specific adaptation actions that are needed to reduce risk or take advantage of opportunities in the future. The report identifies specific areas where further action is felt to be needed most urgently, based on the available evidence, and it discusses the benefits of taking further action. But an economic appraisal of different actions is out of scope of this assessment.

The task for the UK Government and devolved administrations, following the publication of this third CCRA Assessment, will be to weigh up the costs and benefits of different options and set objectives and actions in the next national adaptation programmes, from 2023 onwards (see page 4). The cycle will then enter a new stage from 2027, when the fourth CCRA will be published (see figure 18).

Further outputs can be read alongside this summary, including a series of 17 briefings that summarise the risks to key sectors (these being Agriculture and Food, Business, Cultural heritage, Energy, Flooding and coastal change, Freshwater habitats, Health and social care, High temperatures, Housing, Land use/land use change and forestry, Marine and coastal environment, Telecoms and ICT, Terrestrial biodiversity, Transport, Water availability, Wildfire and Young people).

Other outputs include the Climate Change Committee's statutory advice to Government on the CCRA, in the form of a separate CCRA3 Advice Report, drawing on the evidence presented in the Technical Report. There are also summaries for the other UK nations and other resources, all of which are available on the UK Climate Risk website.

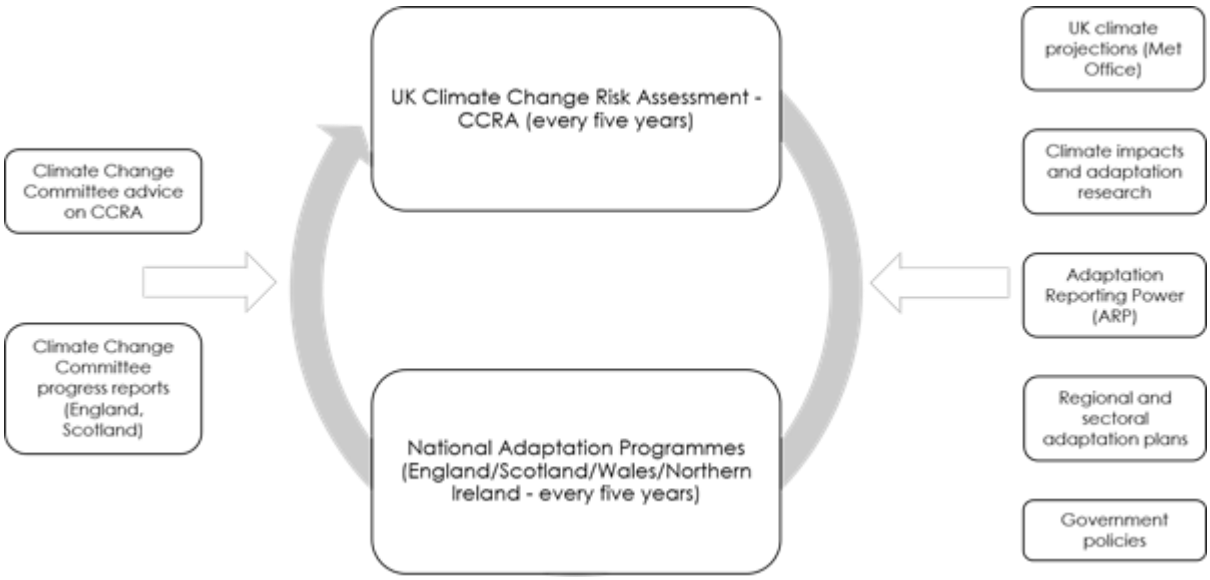


Figure 18: Summary of the UK adaptation policy cycle (taken from CCRA Technical Report Introduction).

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