Committee on Climate Change

UK 2017 | Climate Change Risk Assessment

UK Climate Change Risk Assessment 2017 Evidence Report

Summary for Northern Ireland

UK Climate Change Risk Assessment 2017 Evidence Report – Summary for Northern Ireland

Contents

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1. Introduction

1.1 Context

Northern Ireland is characterised by unique terrestrial, water and marine landscapes and geology, and a variety of species of national and international importance. With a population of 1.8 million Northern Ireland is the smallest of the UK's devolved administrations. Northern Ireland's economy is mainly driven by its manufacturing and food industry, with exports accounting for more than 25% of Northern Ireland's Gross Domestic Product (GDP). 70% of Northern Ireland's seaborne trade is handled by Belfast Harbour. Small and Medium Enterprises constitute 99.9% of private sector enterprises in Northern Ireland, accounting for 75% of private sector employment and 74% of turnover; higher than the UK average (of 60% and 47% respectively). This differences in geography, and regional economies, as well in the projections of climate change, will mean some risks and opportunities in Northern Ireland differ from elsewhere in the UK.

This document summarises the Northern Ireland-specific evidence included in the UK Climate Change Risk Assessment 2017 (CCRA2) Evidence Report.[1] The CCRA Evidence Report was developed at UK-wide scale involving scientists, government departments and other stakeholders from across the United Kingdom. In some areas the country-specific information is limited and readers should refer to the full Evidence Report for a more detailed analysis of each of the risks and opportunities described here. This document only includes references to sources of information that were not included in the full Evidence Report.

1.2 The CCRA method

In compiling CCRA2 the UK Government asked the Adaptation Sub-Committee of the Committee on Climate Change to consider the following 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 and opportunities identified has been assessed in a three-step urgency scoring process (see Figure NI1 below and Chapter 2 of the Evidence Report):

- What is the current scale of climate-related risk or opportunities, and how much action is already underway?
- What is the potential scale of future risks and opportunities, and to what extent will planned actions or autonomous adaptation address these?
- Would there be benefits from further action being taken in the next five years within each of the four countries of the United Kingdom?

Each assessment is based on the evidence available to the team of authors that worked on each chapter, collated through a call for evidence in early 2014, two rounds of academic peer review, and numerous stakeholder discussions that took place during the process. The available evidence has been supplemented by four research projects commissioned specifically for

[1] www.theccc.org.uk/uk-climate-change-risk-assessment-2017

CCRA2, funded by the Natural Environment Research Council, Defra, and the Environment Agency:

- Future projections of UK flood risk.[2]
- Updated projections of water availability in the UK.[3]
- An aggregate assessment of climate change impacts on the goods and services provided by the UK's natural assets.[4]
- Developing high-end (High++) climate change scenarios.[5]

The Evidence Report uses the concept of urgency to summarise the findings of the analysis and reach conclusions that meet the study's aim. One of four 'urgency categories' has been assigned to each risk or opportunity, to summarise the ASC's advice for the next round of national adaptation programmes. The urgency categories are designed to be mutually exclusive, so that each risk or opportunity falls in to a single urgency category:

- **More action needed.** New, stronger or different Government policies or implementation activity – over and above that already planned – are needed in the next five years to reduce long-term vulnerability to climate change.
- **Research priority.** Research is needed in the next five years to fill significant evidence gaps or reduce the uncertainty in the current level of understanding in order to assess the need for additional action.
- **Sustain current action**. Current and planned levels of future activity are appropriate, but continued implementation of these policies or plans is needed to ensure that the risk is managed in the future. This includes any existing plans to increase or change the current level of activity.
- **Watching brief.** The evidence in these areas should be kept under review, with long-term monitoring of risk levels and adaptation activity so that further action can be taken if necessary.

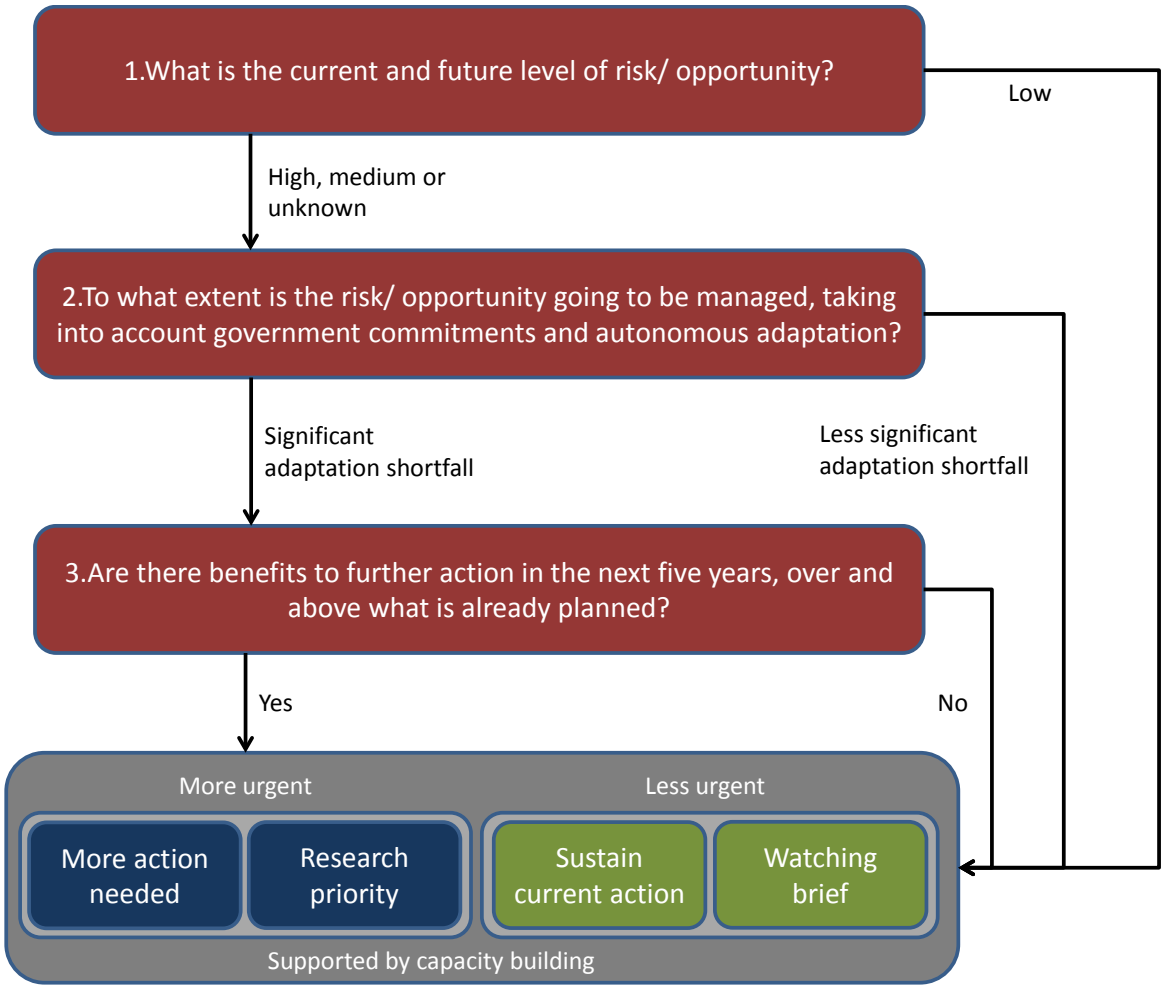
The 'research priority' category is reserved for those areas where in the ASC's judgement, the risks could be significant but further evidence is needed to determine the best course of action. Significant research gaps will also exist elsewhere, and these gaps have been identified within the individual chapters of the Evidence Report. But where other urgency categories have been assigned, it means the existing evidence base is judged to be sufficiently robust to recommend either more action being taken, current levels of action being sustained, or action being kept under review for ('watching brief').

Across all of the risks and opportunities identified, **capacity building** will be important to equip decision makers and practitioners to make timely, well-evidenced and well-resourced decisions.

[2] https://www.theccc.org.uk/publication/sayers-for-the-asc-projections-of-future-flood-risk-in-the-uk/
[3] https://www.theccc.org.uk/publication/climate-change-risk-assessment-ii-updated-projections-for-water-availability-for-the-uk/
[4] https://www.theccc.org.uk/publication/aecom-assessment-of-climate-change-impacts-on-uk-natural-assets/
[5] https://www.theccc.org.uk/publication/met-office-for-the-asc-developing-h-climate-change-scenarios/

In most cases, the urgency score assigned to a risk or opportunity for Northern Ireland will be the same as for the UK as a whole. However, in some areas, either the magnitude of the risk or opportunity, or the level of adaptation being undertaken, will lead to a different urgency category for Northern Ireland. In these cases, the urgency score for England, Scotland and Wales are shown separately.

Figure NI1: Overview of approach for urgency scoring



Source: CCRA Evidence Report, Chapter 2.

1.3 Impact of the vote to leave the European Union

The process of compiling the CCRA Evidence report was complete before the results of the EU Referendum in June 2016 were known. Leaving the European Union is unlikely to change the overall scale of current and future risks from climate change, but in some areas it may affect individual policies and programmes important to address climate-related vulnerabilities.

If such policies and programmes are changed, it will be necessary for UK measures to achieve the same or improved outcomes to avoid an increase in risk. The Adaptation Sub-Committee will consider the impact of the EU Referendum and the Government's response in its next statutory progress report on the UK National Adaptation Programme, to be published in June 2017.

2. Climate change in Northern Ireland

2.1 Observed changes

Annual average temperatures in Northern Ireland are similar to the UK average. Average temperatures over land have warmed in recent decades. The 2005 - 2014 decade was 0.7°C warmer than the 1961-1990 average (see Chapter 1 of the Evidence Report). There are no significant recorded changes in the number of days of air frost in Northern Ireland (Met Office, State of UK Climate 2014).

At the UK level (as no separate data are available for Northern Ireland) the daily maximum and minimum temperature extremes have increased by just over 1°C since the 1950s (Brown et al., 2008), and heavy seasonal and annual rainfall events have also increased (Jones et al., 2013).

Local sea level trends for Northern Ireland alone are difficult to break down. A UK sea level index, computed using data from five stations (Aberdeen, North Shields, Sheerness, Newlyn and Liverpool), provides a UK-scale best estimate of 1.4 ± 0.2 mm/yr for sea level rise since 1901 (Woodworth et al., 2009), corrected for vertical land movement.

2.2 Projected changes

The latest set of projected changes in climate for Northern Ireland comes from the 2009 UK Climate Projections. Under a medium emissions (A1B) scenario, regional summer mean temperatures are projected to increase by between 0.8 – 4°C by the 2050s compared to a 1961-1990 baseline.[6] Downscaled scenarios for nine climate stations across Northern Ireland[7] show temperature increases of between 0.8 and 4.2°C by the end of the century compared with the present day, with night-time temperatures during winter and inland stations showing more pronounced warming.

Regional winter precipitation totals are projected to vary between 0 to +19% for the same scenario.[7] Downscaled scenarios for Northern Ireland[8] show summer precipitation reducing by up to 41% and winter precipitation increasing by 27% by the end of the century.

Table NI1 shows how extreme summer temperatures and winter rainfall are projected to change for Belfast, compared to the other UK capital cities.

[6] http://ukclimateprojections.metoffice.gov.uk/23673?emission=medium

[7] Mullan, D., Fealy, R. & Favis-Mortlock, D. (2012) Developing site-specific future temperature scenarios for Northern Ireland: addressing key issues employing a statistical downscaling approach. International Journal of Climatology. 32, 13, p. 2007-2019

Table NI1. Values of 20-year return period events for daily maximum surface temperature in summer (June-August), and accumulated rainfall over five consecutive days in winter (December-February)

City	Daily summer max temperature (°C)				5-day winter rainfall accumulation (mm)			
	1961-1990 Observed	2041-2060 Low	2041-2060 Central	2041-2060 High	1961-1990 Observed	2041-2060 Low	2041-2060 Central	2041-2060 High
Belfast	25.9	26.5	28.5	30.9	70.3	70.6	76.9	84.6
London	34.4	34.1	37.2	40.6	56.1	57.8	62.5	68.3
Cardiff	31.7	31.9	34.7	38.1	73.6	76.6	79.8	83.6
Edinburgh	23.5	24.8	26.2	27.9	63.4	63.5	70.0	78.4

Source: from Brown et al. (2014), CCRA2 Evidence Report, Chapter 2.
Note: For each national capital, estimated observed values for 1961-1990 are compared with values for the 10th (low), 50th (central) and 90th (high) percentiles of probabilistic projections for 2041-2060 under the A1B emissions scenario. Projections are obtained by applying the UKCP09 methodology to predict future changes in parameters controlling the properties of statistical EVD. The examples provided show cases where the results are robust to plausible variations in the methodology, based on sensitivity tests assessing the degree of consistency between the global and regional modelling components of UKCP09.

The average sea level for Belfast is expected to increase by between 22.8 cm and 37.6 cm by 2090 compared to a 1990 baseline. Higher rates of sea level rise for the UK of up to 1.9 metres by 2100 have been modelled in a plausible high++ scenario, though this is considered highly unlikely to occur this century. However, sea levels are projected to continue to rise beyond 2100 even in lower emission scenarios and several meters of sea level rise within centuries is possible.

2.3 Climate change adaptation in Northern Ireland

The UK Government is required under the 2008 Climate Change Act to publish a UK-wide climate change risk assessment every five years. The Act stipulates that the Government must assess 'the risks for the United Kingdom 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 Northern Ireland Climate Change Adaptation Programme was published in 2014 and set out actions to tackle the risks identified by the first UK Climate Change Risk Assessment in 2012.

The Climate Change Act makes provision for the NI Executive to publish an updated Northern Ireland Climate Change Adaptation Programme as soon as reasonably practicable after the publication of each UK Climate Change Risk Assessment. As such, the CCRA2 Evidence Report will feed into the next Northern Ireland Climate Change Adaptation Programme expected in 2019.

3. Natural environment and natural assets

Northern Ireland's biodiversity is internationally important with some 20,000 species found in its terrestrial, freshwater, coastal and marine habitats. For its size, Northern Ireland is one of the most geologically diverse areas of the planet and this is an important factor in understanding its rich biodiversity. Protection measures, in the form of various types of designation, have been put in place for approximately 7% of Northern Ireland's land and 15% of marine environments through a range of EU and national initiatives. Semi-natural peatlands cover 165,000 hectares and have a high biodiversity value, as well as being important natural carbon stores. Agriculture is one of the cornerstones of the Northern Ireland economy, covering 70% of land area. Woodland makes up 8% of land cover, of which more than half is managed by the Forest Service. Wetlands, including lakes, fens and flooded grassland, cover around 7% of Northern Ireland. There are more than 1,600 lakes ranging in size from small ponds to Lough Neagh, the largest freshwater lake in the UK. Northern Ireland also has a rich and varied marine environment. About 50% of Northern Ireland's biodiversity is in its seas, which support fishing, tourism and renewable energy and are a vital part of the country's cultural heritage.[8]

The Natural Environment and Natural Assets chapter in the Evidence Report is structured according to a natural capital framework. The risks and opportunities from climate change to key 'natural assets' are assessed and these are summarised, along with the urgency scores, in Table NI2.

Climate change poses risks to Northern Ireland's soils, farming, freshwater resources, natural carbon stores, marine ecosystems, wildlife and habitats. More action is needed to build resilience to these risks. More evidence is also needed to fully understand other climate change risks that are likely to be important for Northern Ireland's natural environment, including potential changes in agricultural and forestry productivity and land suitability and impacts on freshwater and marine ecosystems.

Table NI2. Urgency scores for natural environment and natural assets

Risk/opportunity (reference to relevant section(s) of CCRA Evidence Report)	More action needed	Research priority	Sustain current action	Watching brief	Rationale for scoring
Ne1: Risks to species and habitats due to inability to respond to changing climatic conditions (3.2)	UK				More action needed to reduce existing pressures, improve condition of habitats, restore degraded ecosystems, and deliver coherent ecological networks. More action to factor climate change into conservation planning and site management
Ne2: Opportunities from new species colonisations (3.2)	UK				More action needed to deliver coherent ecological networks and to factor changes in species composition into site management.

[8] DOENI, Valuing Nature , A Biodiversity Strategy for Northern Ireland to 2020, https://www.cbd.int/doc/world/gb/gb-nbsap-v3-p3-en.pdf

Table NI2. Urgency scores for natural environment and natural assets

Risk/opportunity (reference to relevant section(s) of CCRA Evidence Report)	More action needed	Research priority	Sustain current action	Watching brief	Rationale for scoring
Ne3: Risks and opportunities from changes in agricultural and forestry productivity and land suitability (3.3)		UK			More research needed on the nature and scale of changing land suitability and its impacts. More research needed into resilient trees and crop varieties or species, and cropping regimes.
Ne4: Risks to soils from increased seasonal aridity and wetness (3.3)	UK				More action needed to reduce existing pressures on soils, increase uptake of soil conservation measures and restore degraded soils.
Ne5: Risks to natural carbon stores and carbon sequestration (3.3)	UK				More action needed to restore degraded carbon stores, particularly peatlands. Ensure climate change impacts on carbon stores are accounted for in the UK GHG inventory.
Ne6: Risks to agriculture and wildlife from drought and flooding s (3.4)	UK				More action needed to reduce pollution and over-abstraction and improve the ecological condition of water bodies Ensure decisions on use of water allow for necessary environmental flows and take account of climate change.
Ne7: Risks to freshwater species from higher water temperatures (3.4)		UK			More evidence needed on scale of risk and effectiveness of adaptation measures.
Ne8: Risks of land management practices exacerbating flood risk (3.3, 3.4)	UK				Deliver wider uptake of natural flood management in high-risk catchments especially where there are likely to be carbon storage, water quality and biodiversity benefits. Review potential for adverse flood risk outcomes from land subsidies.
Ne9: Risks to agriculture, forestry, landscapes and wildlife from pests, pathogens and invasive species (3.7)			UK		Continue to implement surveillance and bio-security measures. Continue current research efforts into the impact of climate change on long-term risks.
Ne10: Risks to agriculture, forestry, wildlife and heritage from change in frequency and/or magnitude of extreme weather and wildfire events (3.3)			UK		Continue to build resilience of ecosystems to drought, flood and fire Continue current efforts to manage and respond to wildfires. Monitor heat stress impacts on livestock. Continue current efforts to manage impacts of high winds on forestry.

Table NI2. Urgency scores for natural environment and natural assets

Risk/opportunity (reference to relevant section(s) of CCRA Evidence Report)	More action needed	Research priority	Sustain current action	Watching brief	Rationale for scoring
Ne11: Risks to aquifers, agricultural land and habitats from salt water intrusion (3.5)			England, Wales	Northern Ireland, Scotland	Continue actions to manage salinity risks to freshwater habitats. Monitor impacts on aquifers to assess whether risks are increasing.
Ne12: Risks to habitats and heritage in the coastal zone from sea-level rise; and loss of natural flood protection (3.5)	UK				More action needed to deliver managed realignment of coastlines and create compensatory habitat. No system is in place in NI to decide which areas must be protected and where realignment or retreat is more appropriate.
Ne13: Risks to and opportunities for marine species, fisheries and marine heritage from ocean acidification and higher water temperatures (3.6)		UK			More research needed to better understand magnitude of risk to marine ecosystems and heritage.
Ne14: Risks and opportunities from changes in landscape character (3.7)				UK	Monitor impacts and ensure climate change is accounted for in future landscape character assessments.

Ne1: Risks to species and habitats due to inability to respond to changing climatic conditions, and Ne2: Opportunities from new species colonisations

Current and future risks/ opportunities

Throughout the UK, terrestrial species appear to be shifting distributions as the climate warms. In Northern Ireland, there is evidence of species moving northwards and to higher ground, with new colonisations from the south, but there have been losses of cold-loving species at the margins of their southern range.

Bioclimatic envelope modelling projections suggest that species associated with cold montane habitats are likely to see continued contraction of their range towards the most northern and high-altitude locations. For example, the range margin of Ireland's only endemic mammal, the Irish hare (*Lepus timidus hibernicus*) is projected to contract north-westward.[9]The scale of actual local extinctions and colonisations in response to changes in climate space will be heavily dependent on the ability of individual species to physically disperse. The rates of colonisation differ markedly between species and depend on whether there is suitable habitat conditions present for a species to thrive. Species will not be able to move to new areas if there is insufficient suitable habitat in good condition available for them to do so. While changes in range are taking place, there are also natural mechanisms that increase the chances of some species surviving in their present locations, at least for more moderate levels of climate change.

[9] Leach, K., Kelly, R., Cameron, A., Montgomery, W.I. & Reid, N. (2015) Response to climate change is related to species traits in the Lagomorpha. PLOS ONE10(4): e0122267.

Some species may be able to survive as a result of genetic adaptation and species which have not shifted their distribution are more likely to have changed phenology, which may also improve their chances of persistence. Species are more likely to persist in some areas than others as the climate warms. These areas, termed '*refugia*', are characterised by locally cool microclimates (such as on northern slopes and at higher altitudes), less intensive land use and a lower rate of temperature increase (for example close to the coast) than elsewhere.

Adaptation

A Northern Ireland Biodiversity Strategy was published by the Northern Ireland Executive in 2002. Its broad goal is to arrest biodiversity decline by 2016. Habitat Action Plans (HAPs) have been published for priority habitats requiring conservation action. Each of these plans detail a range of targets and actions for NI government departments and agencies.

A review of the implementation of the Strategy in 2009 by the Northern Ireland Biodiversity Group concluded that the 2002 Strategy was out of date and needed revision, including accounting for the implications of climate change. Following this review, *Valuing Nature, A Biodiversity Strategy for Northern Ireland to 2020* was published in 2015. The Strategy sets out how Northern Ireland plans to meet its international obligations and local targets to protect biodiversity. It builds upon the first Biodiversity Strategy published in 2002, but follows an ecosystem services approach. Reducing the impact of climate change is one of seven high-level challenges identified by the 2015 strategy. However, there has not been an assessment of the extent to which Northern Ireland's network of habitats have the ecological coherence to be resilient to future climate change, as has been done in England though the Lawton Review.

At the European Union (EU) level, neither the Birds nor the Habitat Directives explicitly account for changing species distributions, habitat composition and migratory patterns driven by climate change. There has therefore been limited consideration to date of the implications of these changes for the management of internationally protected sites in Northern Ireland.

Urgency score

More action needed - Further action is needed now and into the future to improve the condition and extent of ecological networks, adopting the Lawton Review principles of 'bigger, better, joined'. This will create the right conditions for species to be able to autonomously adapt and make the transition as climatic conditions change. Ecological restoration can take many decades for some habitats, meaning that there are long lead-in times for adaptation action.

Enhancing ecological networks is also beneficial for managing a wide range of climate and non-climate risks, i.e. has a range of co-benefits. Key to this is the need to safeguard the continued provision of ecosystem goods and services delivered by species and habitats, such as clean water, carbon storage and flood alleviation.

Ne3: Risks and opportunities from changes in agricultural and forestry productivity and land suitability

Current and future risks/ opportunities

A high proportion of land in Northern Ireland is constrained in terms of its use due to climatic conditions, primarily in the uplands. Increases in temperature and radiation at key times of the year can have benefits for yield of some crops and varieties. Grassland, which is the predominant

land use in Northern Ireland,[10]is sensitive to climate-related factors such as night temperature and changes in evapotranspiration. Grass growth can benefit from warmer conditions, but if conditions are too hot and dry there can be negative implications for productivity. Maize is more tolerant of drier conditions than grass and requires a minimum temperature higher than grass to grow effectively. The area under maize in Northern Ireland increased from 1,400 hectares to 3,500 hectares between 2001 and 2008; but decreased to 1,600 hectares by 2014.[11] This decline might be due to maize being relatively expensive to cultivate.

A projected trend towards warmer, drier summers is projected to increase the risk of heat stress in sensitive crops (e.g. winter wheat) and to cause problems for crops with high water demands (e.g. potatoes). At the same time, warmer, drier summers and increased mean winter temperatures may be beneficial for some crops (e.g. maize, which is sensitive to frost). There may also be increased potential for energy crops (e.g. *miscanthus*) which are currently limited by temperature.

Warmer temperatures will undoubtedly be of benefit for grassland productivity, particularly in marginal upland areas that currently experience difficulties during colder conditions. In winter, the extended growing season may provide opportunities for longer outdoor grazing, but this could be counteracted if increased precipitation increases the risk of damage to swards by poaching from livestock.

There are likely to be increases in tree growth rates in the future, particularly in cooler and wetter areas, because of a lengthened and warmer growing season. For example, Sitka spruce growth rates may increase by up to 2.8 m^3 per hectare per year for each 1°C warming. Models generally suggest positive changes to yield potential in western and northern areas (at least in the short to medium term). The productivity advantage of some conifer species over deciduous species may increase with warmer temperatures and higher CO_2 concentrations.

The warming climate allows for a potential expansion of land used for agriculture and forestry in Northern Ireland. Many areas that are currently marginal for cultivation due to climatic limitations could experience an improvement in land capability.

Adaptation

Autonomous adaptation is likely to occur to take advantage of new opportunities through changes in land use, and in the selection of crop and grass varieties and tree species that are well-adapted to future environments through genetics and adaptive crop breeding.

However, autonomous adaptation will largely happen reactively and is less likely to maximise opportunities at a larger scale. It will be necessary to ensure ready access to the necessary genetic variation through the continuing maintenance of germplasm collections, particularly as investment in genetics and crop breeding has a long lead time between research and large-scale field implementation.

Land use planning is mainly based upon protecting prime agricultural land from development, on the assumption that prime land will remain in current locations into the future. There is also a specific policy aspiration to increase the proportion of woodland cover in Northern Ireland from 8% currently to 12% by 2050.[12]

[10] https://www.daera-ni.gov.uk/sites/default/files/publications/dard/agricultural-census-ni-june-2015.pdf
[11] Annual Agricultural and Horticultural Survey.
[12] http://www.nienvironmentlink.org/cmsfiles/files/Publications/Forestry-Bill-Briefing-Note.pdf

Urgency score

Research priority - There is a need for a realistic assessment of the suitability of current agricultural and forestry systems in Northern Ireland given the projected changes in land capability. This could include reviewing the potential costs and benefits from more widespread production of "novel" crops and tree species, as well as changes in current land uses (e.g. increased cropping or afforestation of marginal land currently used for livestock). Such assessment will provide the early steps to inform better decisions in the near future and reduce the risk of lock-in to unsustainable future pathways.

Ne4: Risks to soils from increased seasonal aridity and wetness

Current and future risks

Land management has to date been a more significant driver of risk to soil health than climate change.

There is minimal data available on soil erosion in Northern Ireland, but estimates range from 0.02 to 1.27 t ha-1 yr-1 for mineral soils, and as much as 10 t ha−1 yr−1 in cultivated arable fields due to the exposure of bare soil. Projected changes in rainfall intensity could cause an increase of the erosion rate in Northern Ireland of up to 7.8 t ha yr-1.[13] . The use of waterlogged soils by heavy machinery or high livestock numbers can also increase erosion risk by causing long-term damage to soil structure. Erosion risk could be further exacerbated by changes in cropping types and cultivation practices, for example the further expansion of high-risk crops such as maize and increased cropping on marginal land, particularly slopes. Northern Ireland studies show that a switch from permanent grasslands to maize cropping can increase erosion rates by over 700%. When land use changes are modelled together with increasing rainfall intensity, results show that erosion rates could be as high as 11 t ha yr-1 by the end of the century.[2]

Wetland habitats, such as peat bogs and fens, are particularly sensitive to changes in soil moisture regime. Widespread historical drainage, afforestation and adverse management have resulted in an estimated 88% of peatlands in Northern Ireland showing signs of degradation in 1990.14 There are no more up to date studies available.

Climate change appears to be a more significant causal factor for the loss of Soil Organic Carbon on peat soils in semi-natural habitats to date than on agricultural soils. Warmer and drier conditions could have adverse implications for the viability of already stressed peatland habitats and their species, particularly bryophytes (mosses and liverworts).

Changes in climate are also expected to affect the abundance and activity of soil microflora (e.g. bacteria, fungi and protozoans), with implications for decomposition of organic matter and hence carbon storage, nutrient cycling and fertility-related ecosystem services.

[13] Mullan, D. (2013) Soil erosion on agricultural land in the north of Ireland: past, present and future potential. Irish Geography. 45, p. 154-171

[14] Cruickshank M. M.& Tomlinson R. W.(1990) Peatland in Northern Ireland: inventory and prospect. Irish Geography, Volume 23, Issue 1, 1990

Adaptation

There is no specific or stand-alone soil strategy or framework in Northern Ireland. The Strategic Planning Policy Statement for Northern Ireland (SPPS[15]), published in September 2015, recognises the importance of peatlands to Northern Ireland for biodiversity, water and carbon storage. There are a number of policy interventions that provide farmers with some incentives to conserve soils, for example the Rural Development Programme 2014-2020. These are primarily based on the Common Agricultural Policy (CAP), as farmers must provide minimum soil cover, take measures to prevent erosion, and maintain soil organic matter levels in order to qualify for the full single farm payment. However, low levels of inspection make it difficult for the soil protection requirements under Pillar 1 to be enforced.

The available data suggests that that the vulnerability of soils in Northern Ireland is increasing. Autonomous responses to the changing climate (e.g. cultivation of steeper slopes; expansion of maize cropping) may increase erosion risks further in the future. Current policy interventions are not sufficient to manage this risk.

Urgency score

More action needed - Further action is needed to improve the condition of degraded soils, restore peat habitats, better protect soils from damaging practices and encourage the wider uptake of soil conservation. Effectiveness of current measures needs to be monitored to assess their effectiveness. This will have a range of co- benefits for managing a wide range of climate and non-climate related risks and avoid lock-in to a pathway where the UK's most fertile and carbon-rich soils are lost at some point in the future. Many soil conservation actions are also cost-effective to implement now especially when accounting for non-market values, such as carbon and water quality. Ecological restoration can also take many decades for peat habitats, meaning that there are long lead-in times for action.

Ne5: Risks to natural carbon stores and carbon sequestration

Current and future risks/ opportunities

Carbon is naturally stored in soils and vegetation, as well as in marine and coastal habitats. Vegetation growth acts to sequester CO_2 from the atmosphere into plant tissues which can then be transferred to soil carbon through litter and humus. Soils can also be a source of CO_2 emissions through decomposition and respiration, which may be accompanied by losses of methane (mainly from wetlands), and nitrous oxide (mainly from artificial fertilisers), both powerful greenhouse gases. Blue carbon' is defined as the carbon stored in coastal and marine habitats and sediments. Typically, blue carbon is thought of as only being coastal, but recent studies suggest that offshore habitats around the UK are also important carbon stores. Rates of carbon sequestration are particularly high in saltmarsh and sand dunes.

The largest terrestrial carbon stocks occur in soils, particularly organic (carbon-rich) soils as exemplified by deep peat. When in a pristine condition, peatlands are usually waterlogged and actively sequester carbon due to retarded decomposition rates and colonisation by peat-forming species, notably Sphagnum. In Northern Ireland, "high levels of soil organic carbon prevail over much of the rough grazing land in comparison to much of the rest of the EU"[1].

[15] http://www.planningni.gov.uk/index/policy/spps.htm

Peatlands occupy around 10% (23,000 km^2) of the UK's land area and store over 3 billion tonnes of carbon, with Northern Ireland holding 7% of the UK peat resource.[16] An estimated 15% (206,400 hectares) of Northern Ireland's land is covered by peaty soils, including most of the uplands.[17]

Northern Ireland has a low woodland cover in comparison to Great Britain average, at 8% compared to 13%.[18] Of the 111,000 hectares, over half (67,000 hectares) are conifers with 45,000 hectares of broadleaved woodland. As a result, only 4% of the 17 $MtCO_2$ sequestered by UK forests in 2013 was from Northern Ireland.

Climate change may have direct impacts on the ability of soils and vegetation to sequester and store carbon. A longer growing season and increased CO_2 concentrations in the atmosphere could increase sequestration rates by trees. There is some evidence of enhanced tree biomass growth in recent decades across Europe, but this may be attributable to non-climate factors (enhanced N deposition; recovery from S deposition; forest management changes).

However, higher temperatures and changes to soil moisture regimes could increase carbon losses due to enhanced soil respiration. There is some evidence that these factors could be contributing to the observed carbon losses from semi-natural peatlands. In vulnerable areas (e.g. drained peatlands), higher temperatures and drier summers would be likely to substantially increase the loss of carbon, with implications for both CO_2 emissions and water quality. Forest policy and standards state a general presumption against new afforestation of peat soils. There is a lack of data on the effect on GHG balance of replanting on existing peat soils. However it is probable that moderate and high productive forests planted on shallower peat soils (< 50cm deep) with limited soil disturbance provides a net C uptake over the forest cycle, because uptake of CO_2 by the forest exceeds emissions from soil decomposition. On deep peats where tree growth is likely to be poor without substantial soil modification and drainage required to achieve good growth, it is likely that the net GHG balance would be negative.[19] Any significant expansion of intensive agricultural production in Northern Ireland in response to changing climatic conditions would also be likely to have negative implications for soil and forest carbon stocks. Future projections of CO_2 emissions and sequestration from soils and forests do not currently account for the direct or indirect implications of climate change.

Adaptation

There are several projects underway in Northern Ireland aimed at achieving peatland restoration. For example, NI Water, RSPB and NIEA undertook a project aiming to protect and restore over 2000 hectares of peatland at Garron Plateau Blanket Bog in the Antrim hills. The Garron Plateau is the largest intact peatland in Northern Ireland and an Area of Special Scientific Interest (ASSI). There is also a policy aspiration to increase the proportion of woodland cover from 8% to 12% by 2050. However, the impacts of climate change are not accounted for in future projections of GHG emissions and removals from soils and forests. The UK Greenhouse Gas (GHG) inventory also currently underestimates GHG emissions from peatlands, although this

[16] http://www.iucn-uk-peatlandprogramme.org/sites/www.iucn-uk-peatlandprogramme.org/files/IUCN%20UK%20Commission%20of%20Inquiry%20on%20Peatlands%20Full%20Report%20spv%20web_1.pdf
[17] https://www.cbd.int/doc/world/gb/gb-nbsap-v3-p3-en.pdf
[18] http://www.forestry.gov.uk/website/forstats2015.nsf/LUContentsTop?openview&RestrictToCategory=1
[19] http://www.forestry.gov.uk/pdf/FCS_forestry_peat_GHG_final_Oct13_2010.pdf/$FILE/FCS_forestry_peat_GHG_final_Oct13_2010.pdf

is in the process of being addressed by the Department of Energy and Climate Change. GHG emissions and removals from coastal and marine ecosystems are not accounted for.

Urgency score

More action needed - Further action is needed to restore degraded peat habitats and create new woodlands in appropriate locations. This will have co- benefits for managing a wide range of climate and non-climate related risks. Restoration can take many decades for peat habitats, meaning that there are long lead-in times for action. Action is also needed to improve the UK GHG Inventory so that all carbon stores are accounted for and to review climate mitigation policy to better account for the potential implications of climate change on carbon stores and emissions.

Ne6: Risks to agriculture and wildlife from drought and flooding

Current and future risks

Freshwater species are highly sensitive to low flows, as the quantity of water in part determines the level of dissolved oxygen available. Low flow conditions can also reduce dilution of pollutants. High flows and their associated sediment loads can cause significant ecological damage, e.g. to fish spawning beds. Water quality can also be adversely impacted during periods of heavy rainfall due to increased transport of diffuse pollutants from land to water and effluent discharge from point sources (e.g. storm overflows). Diffuse pollution from agriculture causes 69% of Significant Water Management Issues (SWMI) in Northern Ireland. Point-source pollution causes 33% of whilst abstraction for other purposes (mostly public water supply) causes a further 9%. About 30% of rivers across the province are currently classified to be in a 'bad' or 'poor' ecological condition, with 18 out of the 21 lakes in Northern Ireland in 'less than good' condition in 2012.[20,21]

Future projections of river flows imply changes across the seasons, with increases in average winter flows and reduced spring and summer flows. As explained in Box NI1, updated projections of future water availability in Northern Ireland show important progress in managing demand, which might offset the reduced supply projected with climate change. Whilst this would suggest that water availability might not be an immediate issue, further analysis is needed.

[20] http://www.nienvironmentlink.org/cmsfiles/Towards-a-Land-Strategy-for-NI_2015-Main-Report.pdf
[21] http://www.nienvironmentlink.org/cmsfiles/policy-hub/files/documentation/Marine/water-facts-and-figures-booklet-2014-final-for-web.pdf

Box NI1: Projections of water availability in Northern Ireland

HR Wallingford et al. (2015) for the ASC carried out an analysis of water availability in Northern Ireland using the best available data at the time, the planning tables from the 2009 Water Resource Management Plan (WRMP). Since 2009, Northern Ireland Water has undertaken a significant amount of work to reduce by 15% the demand on its system, primarily through leakage control. NIW has produced new data that reflects this work for their next WRMP.

HR Wallingford has reanalysed the public water supply projections for Northern Ireland to evaluate what these changes in demand might mean for projected water availability. In the original analysis, four out of the seven Water Resource Zones (WRZs) in Northern Ireland were projected to be in deficit by the 2030s and all WRZs in deficit by the 2080s under the most severe scenario tested. When the new demand data are used in the projections, no WRZs are in deficit in the 2030s, nor in the same scenario in the 2080s, even without any additional adaptation actions being carried out beyond those in the current WRMP.

The re-analysis shows the influence that assumptions on future demand-side measures can have on the supply-demand balance within a WRZ. Whilst the primary reason for Northern Ireland Water's actions was not for long-term climate change resilience, the effect of their work to control leakage has likely had a significant benefit in this regard. The overall message provided by the re-analysis is that there is a projected surplus, in all future scenarios evaluated, in Northern Ireland.

However, caution should be exercised when interpreting these results as new supply-side data were not available for the new analysis. However, given the relatively low projected influence of climate change on Deployable Output across Northern Ireland and the population growth rate, it is unlikely that supply-side values would change enough to significantly alter this overall position.

Source: HR Wallingford et al. (2016) for the ASC.

Projected future changes in water quality remain highly uncertain due to the complex interaction between climate and land use change, which will vary by catchment. Few studies have been undertaken, but some projections show increased risk of algal blooms and suspended solids.

The loss of dissolved organic carbon (DOC) from peat soils into water bodies also has potential long-term implications for water quality. The loss of DOC is controlled by rainfall but is also associated with solar radiation and temperature. A number of studies report increases in DOC concentrations in freshwater sites across the UK, including in Northern Ireland.

Adaptation

The EU Water Framework Directive requires that member states prevent deterioration in all water bodies (rivers, lakes, estuaries, coastal and ground waters) and aim to achieve good ecological status by 2015. WFD objectives and measures are implemented through river basin management plans, which are developed and reviewed on a 6 year planning cycle. Any climate-driven changes in low or high flows could possibly challenge meeting the WFD timeline, and make it harder to ensure that water bodies remain in good ecological condition in the long-term. Beyond the end of the third planning cycle in 2027 there is no clear mechanism for managing the consequences of changes in flow for meeting the WFD targets.

The way land is used and managed can either enhance or reduce high and low flows. Incentivising management practices that increase the natural capacity of soils and vegetation to store water or retard runoff rates requires policy intervention, as the recipients of the benefits

tend to be located downstream[22]. Some policies are in place to incentivise sympathetic management, mainly in the form of agri-environment schemes under Pillar II of the CAP along with some catchment-scale initiatives. However, management practices continue that are likely to be reducing the natural capacity of soils to manage flows, particularly in the uplands.

Urgency score

More action needed - Further action is needed to improve the condition of water bodies and to encourage the wider uptake of management practices that help to reduce the impacts of low and high flows. There is a need for more strategic planning for increased water scarcity in vulnerable locations, including re-evaluation of land use options and if necessary investment in storage infrastructure to maximise use of surplus winter rainfall. This will have range of co-benefits for managing climate and non-climate related risks and avoid lock-in to a pathway where the majority of the Northern Irish water bodies are ecologically degraded in the future. Ecological restoration can also take many decades, meaning that there are long lead-in times for action. Consideration of the implications of relaxing environmental flow requirements for meeting WFD and biodiversity targets is also needed.

Ne7: Risks to freshwater species from higher water temperatures and reduced water quality

Current and future risks

As waters warm, the thermal tolerance of species can be exceeded and warmer waters can have lower dissolved oxygen content. Water temperatures have increased in UK rivers and lakes at similar rates to regional air temperatures since the 1970s or 1980s with an average warming of 0.03^{o}C per year reported between 1990-2006. This temperature change has modified the circulation of some loughs, particularly the process of stratification in which the thermal profile becomes more evident as a series of distinct layers, reducing circulation of water, oxygen and nutrients.

There is some evidence of a response to changes in water temperature, for example with reductions in fish species in some catchments. In one site, spring invertebrate abundances have declined by around 20% for every 1^{o}C rise as species typical of cooler-water conditions have been lost. However, to date, increased temperatures have not directly caused any water bodies to fail to meet good ecological status under the Water Framework Directive. Temperature changes are often masked by other factors, notably changes in water quality.

Future projected temperature increases imply that this risk will increase with further adverse effects on sensitive species. Potential increased temperature on Lough Neagh could benefit increased growth and capture conditions of eels but might negatively affect key cold water species such as pollan[23], with important implications for fisheries that are key for the regional economy. Reductions in flow are also likely to lead to greater increases in river temperatures in summer. Reduced circulation is likely to increase the risk from cyanobacterial blooms and deoxygenation in smaller, shallow lakes. Larger deeper lakes are likely to be more sensitive to

[22] Mulugeta, E., Reid, N., Beori, M., Hutchinson, G. & Longo, A. (2014). Determining the value of peatland in Northern Ireland. Report prepared by the Natural Heritage Research Partnership (NHRP) between Quercus, Queen's University Belfast and the Northern Ireland Environment Agency (NIEA) for the Research and Development Series No. 14.

[23] Freyhof, J. & Kottelat, M. (2008) Coregonus pollan. The IUCN Red List of Threatened Species.

longer periods of stratification reaching greater depths causing deoxygenation and loss of fish assemblages. Continued decline in species adapted to cold conditions (eg. arctic charr) and those with complex life cycles (eg. salmon) may be expected, with potential for invasive fish species such as Common Carp, European Catfish and Roach.

Adaptation

The primary legislative driver for managing the risk of higher water temperatures is the Water Framework Directive. WFD objectives and measures are implemented through river basin management plans, which are developed and reviewed on a 6 year planning cycle. Increasing water temperatures, combined with changes to flow, could possibly make meeting the WFD targets even more challenging.

There have been some efforts to reduce the impacts of higher water temperatures through planting of riparian woodland, which provides localised shading and cooling. This has, however, been opportunistic rather than strategic, with efforts not necessarily targeted at the most sensitive locations. The amount of planting would have to be significantly increased to match the level of risk under medium or high future climate projections. There would be benefits for managing a wide range of climate and non-climate related risks from further riparian tree planting, as long as the right trees are planted in the right places. Widespread riparian planting also have long lead in times. For some species (eg. Arctic fish such as vendace), translocation is being trialled as a last resort option. There is however a lack of evidence on the scale of possible translocation required, as well the potential wider ecological implications.

Urgency score

Research priority - Research is needed to inform the development of a strategic programme of riparian woodland creation targeted to provide cooling for sensitive water bodies of high biodiversity and/or cultural importance (e.g. salmon rivers). Further consideration is also needed into the costs and benefits of a possible cold-water species translocation programme. Such an assessment will provide the early steps to inform better decisions in the near future.

Ne8: Risks of land management practices exacerbating flood risk

Current and future risks/ opportunities

Degraded and compacted soils can exacerbate flood risk by increasing the speed of rainwater run-off and silting up of rivers. Field studies have shown that some land management practices can cause soil compaction, due to the use of machinery or presence of livestock on waterlogged soils, resulting in damage to soil structure, reduced aeration and penetration of plant roots, and the potential for increased erosion due to reduced water infiltration and increased runoff from overland flow. While a number of small-scale studies have found locally occurring increases in soil compaction, there has been no systematic study of the national extent, or severity of, this issue; as a result, it is not currently possible to provide a quantitative assessment of the current state or trend across Northern Ireland or the UK.

Agricultural land accounts for over 75% of Northern Ireland's land area[24], which means that the way in which it is managed can have a profound effect on the wider impacts of flooding. Flood

[24] DAERA data.

walls and embankments routinely protect what would be the natural floodplain from inundation, forcing water downstream into built-up areas where much more significant damage can be caused. Rivers over the course of centuries have been narrowed, deepened and straightened in order to maximise the available land for food production. This speeds the flow of water causing scour to riverside structures and potentially increases the size of flood peaks. Furthermore, there is evidence that some land management practices have a particularly adverse impact on downstream flood risk, including maize cultivation on slopes, over-stocking of livestock and the drainage of blanket bog habitats.

Warmer, wetter winters and drier summers in the future could affect rates of soil weathering and increase soil erosion (as noted in Ne.5 above). This could in turn increase peak flows and hence fluvial and groundwater flood risk. This risk will be exacerbated where soils are degraded and compacted due to land management practices.

Adaptation

As noted in NE5 above, land managers are required to take measures to prevent erosion in order to qualify for the full single farm payment under Pillar 1 of the CAP. However, in practice the low levels of inspection make it difficult for these requirements to be enforced. There is currently no process in place that requires land managers to assess the extent to which their practices may be exacerbating flood risk.

Incentivising management practices that increase the natural capacity of soils and vegetation to store water or retard runoff rates can be challenging, as the recipients of the benefits tend to be located downstream. Voluntary agri-environment schemes funded under Pillar II of the CAP are important mechanisms for encouraging soil conservation, although reducing flood risk is not a priority objective. There have also been efforts to incentivise land management practices in sensitive catchments in order to improve water quality, such as the Nitrates Action Programme and the Phosphorus (Use in Agriculture) Regulations which have reduced inputs of nutrients to water[25].

There is increased interest in the adoption of Natural Flood Management (NFM) schemes, which maximise the use of natural fluvial and landscape features to reduce flood peaks. As most of these schemes are still in the early stages, the benefits remain to be fully established and are usually specific to the sites in which they are located.

A further challenge facing the wider uptake of NFM measures is that it is not possible to guarantee a specific standard of service for flood protection in the same way as with conventional flood defences. NFM schemes also generally require ongoing maintenance, which is typically not included in capital costs.

Urgency score

More action needed- There is a need to better understand the scale of land management practices that exacerbate downstream flood risk, in order to inform the specific policy interventions required. There is a need to review the potential for adverse flood risk outcomes due to the implementation of CAP policies, particularly under Pillar 1.

Further action is also needed to deliver wider uptake of NFM in catchments where the approach can make a significant contribution to reducing peak flow and subsequent flood risk. NFM

[25] http://www.nienvironmentlink.org/cmsfiles/Towards-a-Land-Strategy-for-NI_2015-Main-Report.pdf

approaches should also be designed to maximise benefits for carbon storage, water quality and biodiversity. The economic case for the wider use of NFM measures as part of the suite of Flood and Coastal Erosion Risk Management practices needs to be strengthened. This could be through undertaking cost benefit analysis comparing the costs of repairing flood damage with the costs and benefits of incentivising changes in land management practices. The non-market benefits from NFM, e.g. in terms of carbon storage or water quality, should also be included in such assessment.

Ne9: Risks to agriculture, forestry, landscapes and wildlife from pests, pathogens and invasive species[26]

Current and future risks

This risk is primarily due to human agency at present and exacerbated by expansion in global trade with climate as a background factor. In addition, lack of natural competition may be an additional factor especially in landscapes of reduced biodiversity. However, each pest and pathogen has its own distinctive characteristics.

There has been a distinctive rise in recorded non-native species in terrestrial, freshwater and marine environments in Northern Ireland. Current cold-spots might become suitable for some invasive aquatic species, causing these species to further spread within Northern Ireland.[27] At least 60 non-native species have become established in the wild in Northern Ireland. Invasive species like rhododendron are presently substantial problems for Northern Irish forestry, affecting ground and understorey flora, and competing for water and nutrient resources and inhibiting natural tree regeneration. Freshwater ecosystems have already been affected. Species such as Asian clams (*Corbicula fluminea*) and Zebra mussel (*Dreissena polymorpha*) have been increasingly observed in recent years. NIEA records show that 8 out of 450 river waterbodies in Northern Ireland have zebra mussels. These are in the Lough Erne system. In addition, 8 out of 21 lakes have High Impact species (Zebra mussels, *Elodea nuttallii*) and a further 4 have low impact species (Azolla, Roach). A warmer climate provides an increased likelihood of pests and diseases that were previously limited by climate (notably cold winters) to persist and disperse. There is an increased risk from expansion of vectors for bluetongue and of airborne spread of Foot and Mouth. Small changes in climatic conditions around critical thresholds may result in dramatic changes in parasitic nematodes in livestock. Insect pests are generally expected to become more abundant due to range expansions and phenological changes, including higher overwinter survival rates. For example, NIEA signals the risk of Asian hornet to Northern Ireland's pollinators and commercial bee hives. Wetter winters may increase the risk of liver fluke, which is vectored by water-sensitive lymneid snails.

Warmer sea temperatures mean that *Crepidula fornicata*, the Slipper Limpet, which predates on the blue mussel, is now surviving in the marine waters in Northern Ireland and presents a threat to aquaculture activities. Other invasive species surviving in marine waters include *Sargassum muticum*, *Didemnum vexillum*, the Carpet Sea Squirt, and the *Styela clava*, the leathery sea squirt. The Northern Ireland State of the Seas Report[28] provides a list of the ten species that could pose the greatest threat. The increase in rain shower intensity presents a threat to shellfish water

[26] This includes risks to aquaculture.
[27] Kelly, R., Leach, K., Harrod, C., Maggs, C., & Reid, N.(2014) Combining global climate and regional landscape models to improve invasion risk models. Diversity and Distributions20(8): 884-894 (Impact Factor = 6.122).DOI: 10.1111/ddi.12194
[28] https://www.daera-ni.gov.uk/sites/default/files/publications/doe/marine-report-state-of-seas-invasive-alien-species-2011.pdf

protected areas (SWPAs) under the Water Framework Directive. Intense, flashy rain conditions increase runoff from fields and storm overflows from sewerage infrastructure, both of which increase pathogens in marine waters and in shellfish flesh.

The colonisation and expansion of non-native species is much harder to predict than range changes in native species. Those species which are already native in continental Europe and colonise naturally, for example through airborne dispersal will typically have co-occurred with many British species. In these cases the risks are likely to be relatively small and easily anticipated. With species colonising from other parts of the world as a result of human travel and trade, the consequences are less certain. Climate change will add to the uncertainty as species which would not previously have been able to survive in the UK start to be able to do so.

Depending on the rate of climate change, introduction and dispersal that is more strongly influenced by climatic factors may become more frequent. For example, a shift towards warmer wetter winters is likely to favour the spread of fungi and related organisms. Species such as rhododendron might increase their elevation range if there are warmer conditions, increasing costs of control, and perhaps also increasing disease spread as rhododendron is a host for *Phytophthora ramorum*.

Adaptation

The threat from invasive species, pests and pathogens is taken very seriously across in the UK. There is a UK-wide policy framework in place to manage this risk based on independent scientific reviews.

- A Tree Health and Plant Biosecurity Expert Taskforce reported in May 2013 and the first UK Chief Plant Health Officer took office in April 2014. A UK Plant Health Risk Register has been produced, along with a Plant Biosecurity Strategy and a Tree Health Management Plan, which addresses the recommendations of the Tree Health and Plant Biosecurity Expert Taskforce.
- Livestock diseases are covered by the EU Animal Health Strategy. The Animal and Plant Health Agency, the Forestry Commission and the Forest Service (DAERA) are responsible for monitoring and responding to pests and disease threats to agriculture and forestry. These organisations have embedded climate change into their planning and surveillance arrangements.
- An 'Invasive Alien Species Strategy for Northern Ireland' was published in May 2013. The overarching aim of the Strategy is to minimise the risk posed, and reduce the negative impacts caused, by invasive alien species in Northern Ireland. There is a wide range of International, European and National policy drivers for the Strategy such as WFD, the Habitats Directive and Marine Strategy Framework Directive and EC Regulation No. 1143/2014 on the prevention and management of the introduction and spread of invasive alien species.

There has been progress in areas specifically aimed at addressing the risks from climate change, particularly through research to better understand the nature of the risks. Actions include the Tree Health and Plant Biosecurity Initiative research programme, research to fill the evidence gap on the effects of climate change on pests and diseases that affect livestock, and for environmental change factors to be considered for each risk in the new UK Plant Health Risk Register.

Urgency score

Sustain current action - Current efforts to reduce risks and monitor impacts should continue. Further research might be needed to understand long term adaptation measures to tackle the combined effects of climate change and tree diseases.

Ne10: Risks to agriculture, forestry, wildlife and heritage from change in frequency and/or magnitude of extreme weather and wildfire events

Current and future risks

Wind damage to forests is a major problem to forestry in UK and across Europe where wind and snow storms cause approximately half of all damage to forests. Storms cause immediate damage (loss of timber stock, costs of clear-up), disruption to markets and processing and can increase subsequent risk of damage from insects, pests and wildfires. Predicting future changes in storm tracks is highly uncertain. However, warmer autumns with consequent later leaf loss, are likely to increase the risk of damage in deciduous species. Wind damage may also increase with higher levels of soil wetness, as waterlogging reduces rooting depth and consequently tree stability.

Approximately 28,000 hectares of best and most versatile (BMV) land is at (at least) 1 in 75 year risk from flooding from all types of flooding. There is no data on the proportion of all agricultural land in Northern Ireland at risk of coastal flooding. Inundation of arable land by salt water can cause significant damage to crops and over time result in soil salinization, with implications for the viability of the land for continued production. The area of best agricultural land at 1 in 75 year risk from all sources of flooding is projected to increase by 27% by the 2080s if global mean temperatures rise by 2^0C, and as high as 110% under a 4^0C temperature rise.

Wildfire represents a sporadic but serious risk to Northern Ireland's natural environment. In particular, increased temperatures and decreased precipitation in summer months in the UK and Ireland may contribute to a higher frequency and intensity of uncontrolled fires.[29] Areas of Special Scientific Interest (ASSIs) were damaged by wildfires in Northern Ireland.[30] These fires resulted in extensive changes to biodiversity at these sites, including declines in key plant species indicative of healthy heathland and blanket bog habitats protected under the EU Habitats Directive.[31]

Furthermore, wildfires can result in losses to commercial enterprises including forestry and agriculture, and may impact on ecosystem services such as carbon sequestration and water storage.[32]

Adaptation

The risk of wind damage is well-understood in UK forestry, particularly for productive conifer plantations in the uplands. The planning of rotation lengths, harvesting areas and thinning

[29] Albertson, K., Aylen, J., Cavan, G. & McMorrow, J. 2011. Climate change and the future occurrence of moorland wildfires in the Peak District of the UK. Climate Research 45: 105-118.
[30] Kelly, R, McFerran, D., Hamill, R., Riddell, G., Montgomery, W. I. & Reid, N. (2014) Quantifying the impact of wildfires in Northern Ireland: Interim Report 2014. Report prepared by the Natural Heritage Research Partnership (NHRP) between Quercus, Queen's University Belfast and the Northern Ireland Environment Agency (NIEA) for the Research and Development Series.
[31] Kelly, R., Boston, E., Montgomery, W.I., & Reid, N. (2016) The role of seed bank in the recovery of temperate heath and blanket bog following wildfires. Applied Vegetation Science, Online early: DOI: 10.1111/avsc.12242
[32] Worrall, F., Clay, G. D., Marrs, R. & Reed, M.S. (2010) Impacts of burning management on peatlands. Report to IUCN UK Peatland Program.

regimes usually take measures to reduce the risk. Further adaptation is not really possible, beyond current risk reduction planning strategies.

Drainage of agricultural land in Northern Ireland falls legislatively under the Drainage (Northern Ireland) Order 1973 which now falls within the remit of the new Department for Infrastructure (DfI). Arterial land drainage (i.e. watercourses designated for maintenance under the Order) is maintained by the Department, although the degree of flood protection to agricultural land is generally low (3-5 year return period). The agricultural land behind designated sea or urban flood defences may be protected to a higher degree because those defences also protect properties and key infrastructure (e.g. land protected by sea defences in the Foyle estuary). Schemes to protect domestic and business properties from flooding are considered depending on their economic viability and their priority in relation to other similar schemes in Northern Ireland.

Wildfire is included in the UK National Risk Register and National Risk Assessment in 2013, meaning it is recognised in the same way as other risks such as flooding and pandemic flu. Improvements in approaches to fire-fighting may have contributed to a reduction in large outbreaks in recent years. The Northern Ireland Fire and Rescue Service provides education on fire risk and prevention to land owners. Emergency planning currently includes preparedness and contingency for wildfire but the full extent of the risk and the identification of vulnerable areas remains unknown. Proactive management strategies to minimize wildfire risk on larger sites are being trialled by the 'Northern Ireland Wildfire Initiative' at the Mourne Mountains ASSI. This work has been conducted in partnership by the Mourne Heritage Trust, Northern Ireland Environment Agency, Northern Ireland Water and Northern Ireland Fire Service. The Forestry Commission 'Building wildfire resilience into forest management planning', endorsed by Forest Service (DAERA), was published in 2014. Together, this should help ensure widespread uptake of management practices that reduce risk, such as the use of fire breaks, surveillance systems and public warnings. However, it is also possible that the conversion to continuous cover management systems in recent decades, with an increase in deadwood and forest floor litter, may be increasing the risk of more intense or extensive fires.

DAERA has identified the potential to undertake research and subsequent development of toolkits relating to wildfire and land management practises, weather prediction, post wildfire management and community engagement, subject to the availability of funding.

Urgency score

Sustain current action - Action is underway that can potentially mange this risk. However there is the need to monitor impacts of extreme weather events, particularly flooding, on agricultural and forestry production, as well as systematically recording fire events. The effectiveness of wildfire education programs and risk reduction strategies should also be monitored. Research would also be needed to investigate highly vulnerable areas, particularly those near to population centres, and localised risk factors, as well as quantifying the recovery rates for biodiversity and ecosystem services following wildfire events in the long term (over 10 years).

Ne12: Risks to habitats and heritage in the coastal zone from sea-level rise; and loss of natural flood protection

Current and future risks

Coastal habitats are extremely valuable for wildlife and also provide a range of vital services, including protection from coastal flooding and storm surges. The coastal protection provided by saltmarsh has been demonstrated by modelling, which suggests that up to 50% of wave energy is attenuated in the first 10 - 20 m of vegetated saltmarsh. An 80m width of saltmarsh has been estimated to reduce the height of seawall defence required from 12m to 3m resulting in capital cost savings of £2,600 - 4,600 per metre of seawall. Some stretches of the Northern Ireland coast are protected by hard engineering structures. An estimation of this has been made for Water Framework Directive purposes and approximately 25% of the Northern Ireland coastline is engineered. Coastal defences can prevent natural adjustment of coastal systems to rising sea levels, including the migration of habitats inland to remain in a similar position within the tidal frame (termed 'coastal squeeze'). The UK National Ecosystem Assessment estimated that coastal margin habitats have declined by 16% across the UK due to development and coastal squeeze over recent decades, but also highlighted that this estimate is poorly quantified.

Coastal habitats have also experienced the direct effects of climate change through changing temperature profiles, as similar to terrestrial and freshwater systems. This has been most evident with rocky inter- and sub-tidal species, where warmer 'southern' species are shifting northwards with colder, 'northern' species are declining around the UK.

The level of existing habitat loss on the coast implies that even under a low scenario for future sea level rise there will be continued loss of habitat without further implementation of adaptation measures that recognise the dynamic processes of the coast. The future magnitude of absolute sea level rise around the UK according to UKCP09 is between 12 and 76cm (1-7.5mm/yr) from 1990-2095, with an extreme H++ scenario suggesting an upper end of 93-190cm (10-19mm/yr) by 2100. Sea level rise will continue beyond 2100 regardless of emissions scenario meaning there is a very long-term commitment to sea level rise.

The UK National Ecosystem Assessment projected coastal margin habitats losses to reach 8% by 2060. However, for higher sea level rise scenarios the potential losses may be significantly greater as the risk then increases of threshold effects due to the decreased buffering role of sediment supply in any adjustments, as for example due to the risk of a breach on a barrier coastline. As the current evidence suggests a continuation of sea level rise, the risk is likely to significantly increase with the possibility of the natural buffering resilience of coastal habitats and landforms being lost. It is also likely that areas that currently have not experienced major loss of habitat will experience it much more in the future. The risk is therefore of crossing a dangerous threshold, as well as becoming increasingly locked in to an unsustainable regime for coastal zone management that entails loss of habitat and the ecosystem services.

Adaptation

In Northern Ireland coastal management is the responsibility of different departments: for example, whilst DAERA is responsible for nature conservation protection and marine licensing, the DfI is responsible for coastal defences adjoining to roads and the proportion coastal flood defences managed by the Rivers Agency.

There is no specific legislation to manage coastal erosion risk in Northern Ireland, such as the Coast Protection Act 1949. As consequence, no government department has systems in place to manage the risk from coastal erosion. Recent winter storms (2013-14) have resulted in requests for new sea defence structures around the coast. There is no system in place to decide which areas must be protected and where realignment is more appropriate. However, the Strategic Planning Policy Statement, 2015, states that no development should take place in areas known to be at risk from coastal erosion.

Urgency score

More action needed - In Northern Ireland there is no system in place for coastal erosion risk management. More effort is needed to allow the dynamic readjustment of coastal landforms and habitats, particularly in terms of increased sediment supply and realignment opportunities. This will have range of co-benefits for managing climate and non-climate related risks and avoid lock-in to a pathway where the long-term viability of coastal habitats and the services they provided. Realignment schemes are complex and often involve multiple actors, meaning that there are long lead-in times for action.

Ne13: Risks to marine species and fisheries from ocean acidification and higher water temperatures

Current and future risk

Extensive modification of maritime ecosystems has been attributed to long-term climate change. Sea temperature records in UK waters continue to show an upward trend, notwithstanding short-term variability.

Ocean uptake of CO_2 has increased surface ocean hydrogen ion concentration by ~30% to date, and decreased surface carbonate ion concentration by ~16%. These effects are expected to greatly intensify in the next 100 years in the absence of global emission reduction measures. Ocean acidification is a global scale threat but impacts will be felt at the local and regional level. It is highly likely that UK coastal waters, ecosystems and habitats will be significantly impacted this century if global CO_2 emissions continue to rise. In the Atlantic, ocean acidification has been occurring more rapidly in the European region than in the Caribbean or central Atlantic. In UK/European shelf seas, both observations and modelling show that CO_2 levels in near-surface seawater can currently vary between 200-450 ppm, contributing to a pH variability of as much as 1.0 (typically 0.3-0.4) over an annual cycle.

Extensive changes in planktonic ecosystem have been observed in terms of plankton production overall, biodiversity and species distribution. Species with warmer-water affinities are moving northward to replace the species but are not numerically abundant or as nutritionally (i.e. less lipid rich) important. Over the last five decades there has been a progressive increase in the presence of warm-water/sub-tropical species into the more temperate areas of the North-East Atlantic and a decline of colder-water species. The seasonal timing of some plankton production has also altered in response to recent climate change. This has consequences for plankton predator species, including fish, whose life cycles are timed in order to make use of seasonal production of particular prey species.

Recent warming has caused some cold-water demersal (bottom-dwelling) fish species to move northwards and into deeper water (e.g. cod, whiting, monkfish), and has caused some warm-water demersal species to become more common or "invade" new areas (e.g. John dory, red

mullet). Centres of distribution have generally shifted by distances ranging from 48 to 403 km. Pelagic (blue-water) fish species are showing particularly marked distributional shifts, with mackerel now extending into Icelandic and Faroe Island waters (with consequences for management), whilst sardines and anchovies are invading Irish and North Sea environments. There is evidence that locations where high catches of cod, haddock, plaice and sole occur, have moved over the past 80- 90 years. Climate change may be a factor but fishing and habitat modification have also had an important effect. In recent years, warm-water species have appeared in greater numbers and their exploitation has become viable. Examples include boarfish, trigger fish, squid, anchovy, red mullet and seabass. In 2012, 937 tonnes of sea bass were landed in the UK and the Channel Islands, compared with 142 tonnes in 1984. International commercial landings, from the north-east Atlantic, of species identified as warm-adapted (e.g. grey gurnard, red mullet, hake) have increased 250% in the last 30 years.

There is strong evidence that warming has influenced the relative timing (phenology) of fish annual migrations and spawning events in European waters, with potentially significant effects on population sizes and juvenile recruitment. Observed declines in salmon are strongly correlated with rising temperatures in oceanic foraging areas, with temperature affecting growth, survival and maturation of salmon at sea.

There is increasing evidence that the overwintering distributions of many coastal wading birds have shifted in recent decades in response to warming. Seabird breeding populations in the UK increased in size over much of the last century, but since 1999 these populations have declined by an average of 7.5%. Climate change is considered to be one of the main drivers of these declines.

Climate impacts are evident in changes in distributions and abundances of various species in Shallow and Shelf Subtidal Habitats. Climate-driven impacts on rocky habitats have been observed at the individual species level, with northern range limits of some warm water species extending northwards and cold water species range limits retreating

Bioclimatic modelling suggests northward shifts for most fish species in the future, at an average rate of 27 km per decade (the current rate is around 20km per decade for common fish in the North Sea). Most seabird species in the UK are at the southern limit of their range. By the end of the 21st century, great skua and Arctic skua may no longer breed in the UK. Many features for which marine protected areas have been designated are potentially vulnerable to climate change, meaning the on-going utility of marine protected areas as a conservation tool could be affected.

Projected changes to water temperature, acidity and primary productivity are likely to have implications for marine fisheries and aquaculture. Overall, the UK is expected to benefit from slightly (i.e. + 1-2% compared to present) higher fishery yields by 2050. However, the Irish Sea may see a reduction in yields by the 2050s. Models suggest that cod stocks in the Celtic and Irish Seas might disappear completely by 2100.

In the short term, climate change is unlikely to have a significant effect on UK-farmed marine fish (aquaculture). Rising water temperatures could cause thermal stress for some farmed cold-water fish species (e.g. cod and Atlantic halibut) and intertidal shellfish. However, increased growth rates for some farmed fish species (e.g. Atlantic salmon) may result from rising water temperatures and new farmed species (e.g. sea bass) may be able to be cultivated. Farmed species may become more susceptible to a wider variety of diseases as temperatures increase.

Any increase in harmful algal and jellyfish blooms may lead to additional fish kills and closure of some shellfish harvesting areas.

Adaptation

Policies for protecting and enhancing the marine environment and biodiversity are in place, primarily the EU Marine Strategy Framework Directive, the UK Marine and Coastal Access Act, 2009 and the Marine (Northern Ireland) Act, 2013.

The MSFD establishes a framework within which Member States are required to "take the necessary measures to achieve or maintain good environmental status" in the marine environment by the year 2020 at the latest. Implementation of the MSFD includes the establishment of a marine monitoring programme similar to that for surface water bodies under the Water Framework Directive. If effective MSFD indicators are put in place, then it should be possible to monitor whether Good Environmental Status is being achieved in the marine waters around Northern Ireland waters. The monitoring programme has been developed to specifically monitor the targets and indicators for GES as outlined in the UK Marine Strategy Part One. The programme of measures, published in 2015 has been developed to ensure progress to Good Environmental Status as measured by the targets and indicators. Implementing the directive is a cyclical process and will be reviewed periodically, to ensure that the targets and indicators set are effective in achieving GES. The MSFD has been written with the explicit knowledge that marine systems are dynamic and it includes adaptation and exception sections which require climate and environmental variability be taken into account.

The impact of climate change is one of the factors considered when setting quotas under the EU Common Fisheries Policy. Quotas can be swapped each year between member states which could be used if distributions of managed stocks shift into new areas, or retreat from traditional ones. The need for more action is subject to the scientific evidence underpinning the quota setting and implementation.

A number of trends suggest that the resilience of marine environment is improving. The area of marine protected sites has increased substantially in recent years. There has also been a sustained reduction in hazardous pollution levels since 1990 and the proportion of fish stocks being harvested sustainably has increased since 2000. Statutory marine plans are in place or in the process of being produced. DAERA is the Marine Plan authority and will publish the first draft Marine Plan for consultation in 2016. This Plan will contain sections and policies on whether and how public authorities consider coastal processes and land sea interactions during the decision making process. This plan reflects the current policy arrangements and do not consider measures to address potential gaps. Key organisations in the sector have also recently reported under the Adaptation Reporting Power, including the Marine Management Organisation and Seafish, the commercial fishing trade body.

It is difficult to judge whether there is currently a significant adaptation shortfall in this area, as mechanisms generally exist in the relevant legislation to enable climate change impacts to be addressed (for example through periodic reviews). The scale of risk faced in the future may mean that current interventions are unlikely to be sufficient. This is particularly the case with ocean acidification, which has the potential to have catastrophic impacts on marine ecosystems in UK coastal waters. However, it is not completely clear if any additional or alternative action is needed for adaptation beyond measures to improve resilience.

Urgency score

Research priority - Despite the substantial research in this field, there is a need to better understand whether adaptation requires any additional or alternative actions to be taken. More research is also needed to improve the understanding of the social and economic implications of climate change for the UK fishing industry.

Other risks

Other risks analysed within the natural environment and natural assets chapter of the Evidence Report and considered to fall in to the 'watching brief' category for Northern Ireland include:

Ne11: Risks to aquifers and habitats from salt water intrusion. Future risk to aquifers is expected to slowly increase with sea level rise and associated tidal surges. However, the relatively slow transitional time of saline intrusion of aquifers (even with higher rates of sea level rise) provides time to adapt.

Ne14: Risks and opportunities from changes in landscape character. Landscape character has changed in Northern Ireland over the last few decades. Climate change has been a contributing factor, both directly through its effects on land cover and indirectly by influencing some land uses over others in specific locations. Changes in land cover and land use will undoubtedly continue to occur into the future and the magnitude of climate change (and responses to it) will be a key factor in influencing this change.

4. Infrastructure

Infrastructure provides vital services to the economy and wellbeing of communities in Northern Ireland. The Northern Irish transport network is important from international perspective, being located in the North Sea-Mediterranean transport corridor. Belfast Harbour is a key node in this corridor, handling around 70% of Northern Ireland's and 20% of Ireland's seaborne trade.[33]

The Infrastructure chapter in the CCRA Evidence Report is structured by sector. The risks and opportunities from climate change to sectors are assessed and these are summarised, along with the urgency scores, in Table NI3.

Infrastructure in Northern Ireland is exposed to range of climate hazards. Impacts on some assets have the potential to cascade on to others as part of interdependent networks. Flooding poses the greatest long-term risk to infrastructure performance from climate change, but the growing risks from heat, water scarcity and slope instability caused by severe weather could be significant.

Table NI3. Urgency scores for infrastructure

Risk/opportunity (reference to relevant section(s) of CCRA Evidence Report)	More action needed	Research priority	Sustain current action	Watching brief	Rationale for scoring
In1: Risks of cascading failures from interdependent infrastructure networks (4.4 to 4.9)	UK				More action to enhance arrangements for information sharing in order to improve understanding of critical risks arising from interdependencies.
In2: Risks to infrastructure services from river, surface water and groundwater flooding (4.4 to 4.9)	UK				More action needed to manage increasing risk to existing assets and networks and ensure increased risk is accounted for in design and location of new infrastructure.
In3: Risks to infrastructure services from coastal flooding and erosion (4.4 to 4.9)	England, Wales	Northern Ireland, Scotland			In NI there is no system in place to decide which areas must be protected and where realignment or retreat is more appropriate. More research is needed to understand whether current coastal policies are realistic in context of climate change.
In4: Risks of sewer flooding due to heavy rainfall (4.5)	UK				More action needed to deliver sustainable drainage systems, upgrade sewers where appropriate and tackle drivers of increasing surface runoff (e.g. impermeable surfacing in urban areas).
In5: Risks to bridges and pipelines from high river flows and bank erosion (4.5, 4.7, 4.8)		UK			More research needed on implications of projected changes in river flows on future risk of scour/erosion.
In6: Risks to transport networks from slope and embankment failure (4.7)	UK				More action needed to locate and remediate embankments and cuttings at risk of failure.

[33] https://www.belfast-harbour.co.uk/port

Table NI3. Urgency scores for infrastructure

Risk/opportunity (reference to relevant section(s) of CCRA Evidence Report)	More action needed	Research priority	Sustain current action	Watching brief	Rationale for scoring
In7: Risks to hydroelectric generation from low or high river flows (4.8)				UK	Monitor impacts and be ready to adapt operations given observed impacts.
In8: Risks to subterranean and surface infrastructure from subsidence (4.5, 4.6, 4.7, 4.8)				UK	Monitor changes in temperature and rainfall patterns to update assessments of subsidence risk.
In9: Risks to public water supplies from drought and low river flows (4.5)	England, Wales		Scotland, Northern Ireland		Keep current efforts to reduce risk through long-term water resource planning under review.
In10: Risks to electricity generation from drought and low river flows (4.8)				UK	Continue to monitor risks including as a result of deploying carbon capture and storage. Ensure appropriate siting of new infrastructure and use of cooling technologies.
In11: Risks to energy, transport and digital infrastructure from high winds and lightning (4.6, 4.7, 4.8)		UK			More research needed on the implications of increased vegetation growth rates on future risks of damage from falling trees in storms.
In12: Risks to offshore infrastructure from storms and high waves (4.7, 4.8)		England, Scotland		Wales, Northern Ireland	Monitor risks to deployment of any new offshore infrastructure.
In13: Risks to transport, digital and energy infrastructure from extreme heat (4.6, 4.7, 4.8)			UK		Continue current actions to reduce risks, maintenance and renewals of infrastructure networks.
In14: Potential benefits to water, transport, digital and energy infrastructure from reduced extreme cold events (4.5, 4.6, 4.7, 4.8)			UK		Continue current actions to reduce risks, including cold-weather planning and response.

In1: Risks of cascading failures from interdependent infrastructure networks

Current and future risks

Infrastructure networks do not operate in isolation, with services in particular reliant on power, fuel supplies, and ICT. Transport links including local roads are important for logistics and to allow staff to travel to work. Failures caused by interdependencies are not systematically recorded.

Outputs from various research projects are beginning to quantify the scale of interdependency risks at the UK level, but the scale of the risk remains largely unknown.

Adaptation

The importance of interdependencies between networks is recognised and the Cabinet Office has begun focusing on cross sector vulnerabilities as part of their annual resilience review. Individual sectors are also reviewing their dependency on other networks, in particular their

reliance on power, ICT, and critical road and rail links. However, as yet there is no systematic national assessment of interdependency risk or a comprehensive plan to address it.

Urgency score

More action needed - common standards of resilience would help with investment planning, and help emergency planners better understand the potential for service disruption arising from assets in their area. A good example of a common standard is ETR138, the 'resilience to flooding' adopted within the electricity transmission and distribution sector. Enhanced arrangements for information sharing on critical risks of interdependence are also required. This will help to create the right institutional conditions for adaption in the next five years and in the long-term.

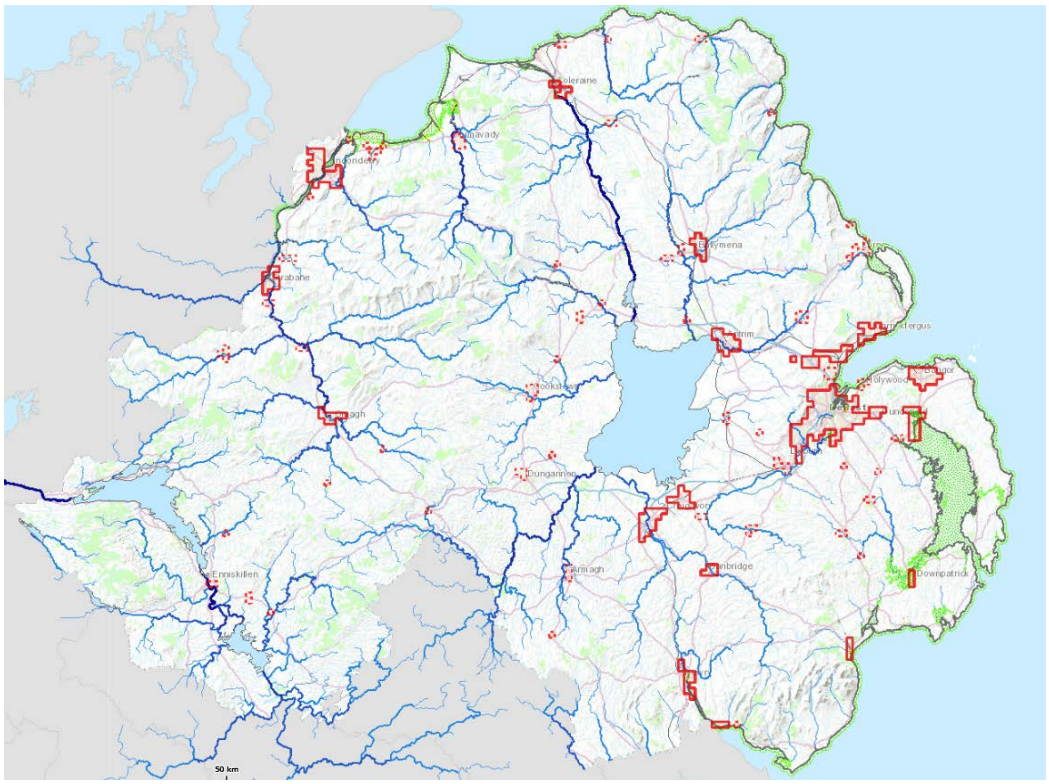
In2: Risks to infrastructure services from river, surface water and groundwater flooding

Current and future risks

Infrastructure across all sectors is exposed to coastal, river, surface water and groundwater flooding. Flooding already accounts for significant losses in infrastructure services, with outages caused by flooding tending to last longer than other weather-related hazards (during extreme events, for several days and in some cases weeks). Surface water flooding is considered to account for half of all flood events in Northern Ireland.[34] The flooding in 2007 had widespread impacts, and in the following year flooding affected the water treatment works at Foffanny (County Down) whilst transport in Belfast was severely disrupted when a new underpass flooded.

[34] https://www.infrastructure-ni.gov.uk/publications/flood-risk-management-plans

Figure NI2: Flood risk areas in Northern Ireland, showing Significant Flood Risk Areas (red blocked areas) and the tidal floodplain (0.5%AEP, darker green shaded areas)



Source: Flood maps NI https://www.infrastructure-ni.gov.uk/articles/what-flood-maps-ni

Assets and networks across all infrastructure sectors are already exposed to river and surface water flooding, with some located in areas that are exposed to a significant level of risk (defined as a 1 in 75 or greater annual chance) (Table NI4).

Table NI4. Infrastructure assets and networks in Northern Ireland located in areas at 1:75 or greater annual chance of flooding from rivers and/or surface water (present day)[35]

Receptor	River	Surface water
Clean and wastewater sites	15	8
Electricity generation sites	0	0
Major electricity transmission and distribution substations [36]	1	1
Strategic road network (km)	515	3,255
Rail network (km)	120	565
Rail stations	0	1
Mobile phone masts	49	72
Active landfill sites	0	0

Table NI4 reports the results from the UK level assessment carried out for the CCRA. Data from NI Electricity Networks and NI Rivers Agency (Table NI5) shows that all the three main transmission station in Northern Ireland are located in areas at flood risk higher than 1 in 200.

Table NI5. Electricity and distribution substations located in areas at 1:100 or greater annual chance of flooding from river and 1:200 or greater annual chance of surface water flooding (present day)[37]

Type of substation	1:100 river	1:200 surface water
Transmission - Grid	1	5
Transmission - Main	2	3
Primary distribution	6	6

The risk of river and surface water flooding is expected to rise, as patterns of rainfall become more intense. Modelling for CCRA2 finds that the continuation and delivery of current levels of adaptation could manage the increase in risk for some assets, but for most exposure is projected to increase significantly (Table NI6).

[35] 1:100 for fluvial flooding and 1:200 for coastal and pluvial flooding is the industry standard for electricity networks as set out in ENA ETR138. The 1:75 return period is used in the CCRA to consistently identify areas of high flood risk across the United Kingdom for all the receptors studied (i.e. buildings, people, infrastructure networks, agricultural land).

[36] The analysis for CCRA2 only assesses risk to substations that serve 5,000 customers or greater.

[37] See above Footnote.

Table NI6. Projected change in number/length of infrastructure assets and networks in Northern Ireland located in areas exposed to a 1:75 or greater annual chance of flooding from rivers and/or surface water under a 4ºC rise in global mean temperature by the end of the century.

Receptor	River	Surface water
Clean and wastewater sites	+62%	-100%
Electricity transmission and distribution substations	+53%	-100%
Strategic road network	+180%	+85%
Rail network	+164%	+78%
Rail stations	No change	
Mobile phone masts	+151%	+30%

Note: Assumes no additional adaptation beyond current plans.

Adaptation

The Department for Infrastructure is responsible for flood risk management in Northern Ireland. Draft Flood Risk Management Plans for 2015 to 2021, produced by the DfI Rivers Agency to meet the requirements of the EU Flood Directive, were subject to consultation in the first six months of 2015. Final Plans were completed and published in December 2015 and are available on-line.[38] It is not clear from the draft FRMPs whether planned flood alleviation activity in the next six years is consistent with offsetting the increases in flood risk that can be expected over the long-term. The plans take into account current risk as well as climate change for a medium probability scenario for 2030, as included in the updated flood maps.[39].

There is no published account of what has been achieved by efforts in recent years to improve the resilience of infrastructure systems in Northern Ireland to flood risk. Most sectors do not report on the resilience of their assets, networks and services. This is particularly the case with the non-regulated sectors (i.e. ports and digital networks) and for local infrastructure, especially minor road networks and highways. Few sectors systematically describe the disruption that has been caused by flooding, and the actions that have been taken as a result. For example, Northern Ireland Water's objectives for 2015-2021 include investing in their key water and wastewater treatment works and other critical sites to improve flood resilience, and developing a programme which continues to work towards separating storm water from the sewerage system[40]. NI Water reports that two projects have been initiated, one of which relates to resilience of Water Treatment Works.

Following the recommendations of the PEDU Review of the Response to Flooding in June 2012, much work has been done by Rivers Agency (now part of the Department for Infrastructure) and its stakeholders to improve the resilience of communities and key infrastructure to flooding.

[38] https://www.infrastructure-ni.gov.uk/publications/flood-risk-management-plans
[39] https://www.infrastructure-ni.gov.uk/articles/what-flood-maps-ni
[40] http://www.niwater.com/sitefiles/resources/pdf/reports/pc15/pc15companystrategyweb.pdf

Under the Floods Directive implementation umbrella, a Critical Infrastructure Group was set up to inform providers of key infrastructure and utilities about flood risks to their systems and premises and for them to consider how best to adapt their infrastructure to be resilient to flooding, now and in future.

However, to truly assess vulnerability to flooding there needs to be consideration of the resilience of systems as well as of the assets that combine to create systems. Networks may be resilient even if individual assets fail, if services can be provided by alternative means. Recognising this, the Cabinet Office has set a benchmark that "as a minimum essential services provided by Critical National Infrastructure (CNI) in the UK should not be disrupted by a flood event with an annual likelihood of 1 in 200 (0.5%)". It is not clear how this benchmark has been interpreted by each sector, and whether this minimum standard of flood resilience is now in place. It is therefore uncertain whether this risk is being managed either autonomously or through Government policy.

Urgency score

More action needed - There is a need for the development of consistent indicators of network resilience to flood risk across all critical national infrastructure sectors and networks. This will help to create the right institutional conditions for adaptation in the next five years and in the long-term. Consistent indicators of resilience will allow for improvements to be measured over time, so enabling better decisions in the near future, especially in relation to longer-term major risks, i.e. to build early interventions within an iterative adaptive management framework.

In3: Risks to infrastructure services from coastal flooding and erosion

Current and future risks

Northern Ireland has some infrastructure assets and networks located in coastal areas, with stretches of railway (especially in the north and west) and roads next to the shoreline (Table NI7). There are five commercial ports in Northern Ireland, at Belfast, Larne, Londonderry, Warrenpoint and Coleraine. Other than Larne (owned by P&O), these are public trust ports managed by DfI.

Table NI7. Infrastructure assets and networks in Northern Ireland located in areas at 1:75[41] or greater annual chance of flooding from the sea (present day)	
Receptor	**Number/length**
Clean and wastewater sites	1
Electricity generation sites	0
Major electricity transmission and distribution substations	0
Strategic road network (km)	191
Rail network (km)	44
Rail stations	2
Mobile phone masts	33
Active landfill sites	0

Table NI7 reports data for major assets at high risk based on a UK level assessment carried out for the CCRA. NI Electricity Networks and NI Rivers Agency data show that three main transmission substation and three primary distribution substations are located in areas at 1:200 or greater annual chance of flooding from the sea (Table NI8).

Table NI8. Electricity transmission and distribution substations located in areas at 1:200 or greater annual chance of flooding from the sea (present day).	
Type of substation	**Number**
Transmission - Grid	0
Transmission - Main	3
Primary distribution	3

Approximately 20% of the Northern Ireland coastline is currently experiencing coastal erosion, a natural process that can be exacerbated by heavy or prolonged rainfall and coastal storms. Erosion can have significant impacts on transport networks. The rate of coastal erosion in Northern Ireland is generally low relative to other parts of the UK. However, some stretches of road and rail are in exposed coastal areas.

No government department in Northern Ireland has systems in place to manage the risk from coastal erosion. Recent winter storms (2013-14) have resulted in requests for new sea defence structures and for the repair of existing infrastructure around the coast. Further work is needed to assess the risk to coastal infrastructure to future-proof sustainable decision making.

[41] See above footnote.

Sea levels have already risen by around 15cm around the UK coast (slightly less in Northern Ireland due to ongoing post-glacial land movement). This century, in Northern Ireland, between 20cm and less than 40cm of sea level rise is expected. Modelling for CCRA2 suggests the number of assets and length of existing infrastructure networks located in areas exposed to a high risk of flooding from the sea is projected to increase with climate change (Table NI9).

Table NI9. Projected change in number/length of infrastructure assets and networks in Northern Ireland located in areas exposed to a 1:75 or greater annual chance of flooding from the sea under a 4°C rise in global mean temperature by the end of the century.

Receptor	% change
Clean and wastewater sites	No change
Electricity generation sites	No change
Electricity transmission and distribution assets	No change
Strategic road network	+28%
Rail network	+13%
Rail stations	+5%
Mobile phone masts	+142%
Active landfill sites	No change

Note: Assumes no additional adaptation beyond current plans.

Adaptation

No single Department in NI has the responsibility for coastal erosion risk management. The Northern Ireland Executive's policy on coastal protection is determined by what is commonly known as the "Bateman Formula". Under this long-standing "Formula", central Government departments have a responsibility to construct, maintain and repair the coastal defences in their possession. For example, the Department for Infrastructure's Rivers Agency has powers to maintain sea defences that have been designated for the purpose of protection against flooding (but not coastal erosion) by the sea. Dfl's Transport NI has responsibility for coastal defences that protect the public road and railway network.

DAERA is the marine licensing authority for deposits in the marine area below the mean high water spring tide, and also has responsibility for marine and coastal conservation. In addition, DAERA is the Marine Plan authority. The first draft Marine Plan will be published for consultation in 2016. The draft Marine Plan will contain sections and policies on whether and how public authorities consider of coastal processes and land sea interactions during the decision making process, reflecting the current arrangements. Potential gaps are not addressed.

Coastal Flood Plans are being developed by Emergency Preparedness Groups in NI which include actions to be taken by key infrastructure providers during flood emergency situation. Whilst there is no national assessment on whether port operators in Northern Ireland have

considered the impacts of climate change, specific examples are provided from Belfast Harbour. Climate change impacts on coastal flood risk are considered in the harbour's flood risk assessment and the flood risk management plan. The 'Harbour Resilience' Group considers potential impacts from climate change. The harbour's authority (Belfast Harbour) has adopted enhanced floor and quay levels for new projects based on life expectancy of projects (30, 50 and >90 years), including climate change. Climate change is incorporated into the harbour's Business Continuity Planning process, Warning and Informing system, planning and operational controls for adverse weather and storm surges. Belfast Harbour has also participated to the development of the Belfast Coastal Flood Plan.

Urgency score

Research priority - There is a need to assess whether current policies to manage coastal flooding are realistic in the context of climate change and national/local value for money and affordability constraints, and to identify infrastructure assets at risk if holding current defence lines is economically unrealistic. There is also the need to assess impacts from coastal erosion on coastal infrastructure to develop appropriate risk management strategies. This is needed to avoid lock-in to a particular pathway over the next few decades and will help to create the right conditions to adapt later where changes will long-lead in times are likely to be required, such as the relocation or rerouting of infrastructure networks inland.

In4: Risks of sewer flooding due to heavy rainfall

Current and future risks

Widespread flooding in 2007 damaged 55,000 properties across the UK, with the majority of damage blamed on drains and sewers being overwhelmed by heavy rain. The floods highlighted that traditional piped sewer systems cannot readily be adapted to deal with increased rainfall, particularly in densely urban areas.

The risk of sewer flooding is being exacerbated by front gardens in urban areas being increasingly paved over. Only 4% of all UK residential paving sales were of permeable design in 2013. Almost all the surfaces being used are likely to be impermeable, such as concrete block paving and asphalt. Without additional action being taken, it is estimated that a combination of climate change, population growth and continued urban infill development will increase the likelihood of sewer flooding by around 50% over the next few decades.

Adaptation

The Water and Sewerage Services Act (Northern Ireland) 2016 introduces new restrictions to the right to connect surface water sewers to the public sewer network. The 2016 Act sets out further grounds for refusal of a connection on the basis that there is suitable alternative means of dealing with the surface water or that such means could reasonably be provided. It makes clear that suitable alternatives include sustainable drainage systems. The Northern Ireland's Strategic Planning Policy Statement (SPPS), published in September 2015, also promotes and encourages developers to use SUDS and also indicates that council's should continue to promote the use of SUDS through their Local Development Plans. Northern Ireland Water is expected to develop a Drainage Strategy to inform its business planning and future delivery, so that it can manage flood risk and pollution incidents in a changing climate.

Urgency score

More action needed - Although the new Act provides the basis to increase the uptake of sustainable urban drainage systems (SuDS) there is the need for policies to enable widespread retrofitting of SuDS schemes into existing built-up areas in order to relieve pressure on the public sewer system. The impact of the new legislation on increasing the uptake of SuDS would also need to be monitored. As well as directly reducing vulnerability to sewer and surface water flooding, this will also have benefits for managing a range of non-climate related risks, including improvements to water quality, biodiversity and amenity. SuDS are in most cases also cost-effective to implement now.

In5: Risks to bridges and pipelines from high river flows and bank erosion

Current and future risks

High and fast river flows can cause localised riverbank erosion, undermining structures such as bridges and exposing buried cabling and pipework. Bridges carry services (gas, telecoms, power) as well as people and road/rail traffic. Loss of bridges can therefore have multiple impacts.

Across the UK, bridge scour on average causes one bridge failure per year. There has not been any national-level modelling of how risk may increase in the future for Northern Ireland.

There are some significant uncertainties on the structural integrity of road and rail bridges, many of which were built over a century ago. It is also not known at a national level which bridges are used for gas pipelines/electricity cables, although service providers have this mapped at the local level.

Adaptation

TransportNI reports that scour has not been regarded to be a significant risk to bridges in NI in the past. However, the Phase 1 assessment of scour risk required by BD 97/12 (current design manual outlining requirements for scour assessment) was deemed uncertain due to reasons including the lack of detailed knowledge of foundations. The Phase 2 assessment was not considered to be justified given the cost and the historical risk. TransportNI have a regime of bridge inspection, which assesses and places priority on any scour observed. This assessment does not include climate change impacts. TransportNI reported a general lack of funds for maintenance of drainage systems and structures.

Urgency score

Research priority - more research is needed to quantify climate change impacts to bridge scour risk and the amount of adaptation underway, including impacts of current maintaining regime.

In6: Risks to transport networks from slope and embankment failure

Current and future risks

Older, less well compacted earthworks such as those supporting the rail network are deteriorating at a faster rate than newer earthworks built to more modern construction standards. Northern Ireland Railways Co. Ltd (NIR) operates 342 km of track and shares a cross border service to Dublin with Irish Rail. By 2002, NIR had noted a significant increase in

embankment and cuttings instability and failures. In June 2012 an embankment failure in County Antrim led to a train with 150 passengers on board being suspended over a large hole for 12 minutes. The failure was caused by heavy rainfall the previous night.

The public road network in Northern Ireland is around 25,000km long, with some 1,200km of trunk roads linking major towns. An increasing risk of slope instability has been identified by the Roads Service. A study by Queen's University Belfast was commissioned by the Roads Service following a major landslide. The study recommended similar slopes be inspected and remedial works carried out if the risk of landslide is high.

Modelling shows that across low to high emissions scenarios soil moisture fluctuations will lead to increased risk of shrink-swell related failures. At the UK level, the issue is expected to be most acute in the high plasticity soils of south-east England but may also cause problems in Northern Ireland given the long lengths of road and railway often located in steep valleys. Failures of natural and engineered slopes that affected the road and rail networks in the winters of 2012/2013 and 2013/2014 demonstrate their vulnerability to the type of intense rainfall events that are expected to occur more frequently in the future.

Adaptation

In their investigation of the Country Antrim near-miss in 2012, the Rail Accident Investigation Board found that NI Railways had not worked with the Rivers Agency to assess flood risks to their assets, and had no procedures in place to deal with flooding or heavy rainfall, despite having previously identified slope stability to be a potential issue.

TNI and NIR recognised the need for further research in this area and supported an ongoing EPSRC project at QUB valued at £1.9m on the assessment of infrastructure slopes and the long term effect of climate change (iSMART EPSRC). TNI and NIR also are stakeholders in a NERC sponsored research programme using inSAR to remotely assess infrastructure slopes. This work is driven by a shared understanding that given current climate predictions infrastructure slopes are likely to fail more frequently.

TNI and NIR are currently funding two PhD programmes, carried out in partnership with Queen's University Belfast, to investigate the impact of climate on their infrastructure slopes. A 26m high cutting on the A1 near Loughbriclkand has been instrumented for over 7 years and the response of the soil to changing weather conditions recorded. Initial results indicate that this system has the potential to reduce the risk of slope failure by significantly slowing the rate of progressive failure. A similar slope of the rail network at Craigmore was also heavily instrumented and monitored over an extended period of time, funded by NIR. Both these sites have helped inform TNI on the likely impact of climate change on their geotechnical infrastructure. TNI also developed (with Queen University Belfast) a risk assessment methodology for infrastructure slopes based on both terrestrial and remotely sensed data, taking into account some aspects of climate[42]. This approach could be further adapted to take into account climate change. The PhD programmes will be completed in 2017, and Transport NI will consider whether to develop an action plan based on the findings of these projects.

[42] Spatial and temporal analyses using terrestrial LiDAR for monitoring of landslides to determine key slope instability thresholds: Examples from Northern Ireland and Canada. Bell, Andrew; McKinley, Jennifer; Hughes, David; Hendry, Michael; Macciotta, R. 2014, 6th Canadian Geohazards Conference, Kingston ON, 15-18 June.

TransportNI is also carrying out a programme of works to reduce the impact of instances of geotechnical instability on the road network, including the construction of retaining walls and the installation of rock-fall fences and netting systems. Transport NI reported on the risks from lack of maintenance of the drainage system.

Urgency score

More action needed - further action is required to ensure that the outcomes from the ongoing research projects are used to manage this risk, and that projected increases in heavy rainfall events are factored into long-term renewal programmes for earthworks and embankment renewals. This will reduce vulnerability now, and is likely to be cost-effective to implement given that the risk is increasing with further asset deterioration combining with heavier and more frequent rainfall events.

In9: Risks to public water supplies from drought and low river flows

Current and future risks

Accurate projections of future water supply-demand balance for Northern Ireland are not available (see Box Ni1), but available data suggests a relatively low projected influence of climate change on Deployable Output across Northern Ireland.

Adaptation

Water companies have been actively involved in climate change adaptation and long-term planning since the 1990s. Since 2009, Northern Ireland Water has reduced demand on its system by 15% (see Box Ni1). This shows that demand-side measures play a key role in ensuring future water availability. Whilst the primary reason for Northern Ireland Water's actions was not for long-term climate change resilience, the effect of their actions has had a significant benefit in this regard. Despite the limitation of these results (see box NI1), this evidence suggest that demand-side measures might be appropriated to manage this risk.

Urgency score

Sustain Current Action - planned levels of future activity are appropriate, but continued implementation of these plans is needed to ensure that the risk is managed in the future. This will require monitoring the delivery of the commitments and outcomes in the current water company business plans and beyond this, ensuring the options in Water Resources Management Plans (WRMPs) are effective in managing the risk of future supply/demand deficits. In the next round of WRMPs from 2019, there may be a case to look further ahead (i.e. 50 years), integrate drought planning with the WRMP process, and stress test both WRMPs and Drought Plans with a wider range of climate change (particularly low flow and drought) scenarios. The WRMPs should start considering the feasibility of implementing further adaptation options that may be needed in the second half of this century, and consider the lead times that would be necessary to take such action. NI Water is currently preparing its next Water Resource Management Plan combined with its drought plan, i.e. the Water Resource and Supply Resilience Plan (WRSR Plan).

In11: Risks to energy, transport and digital infrastructure from high winds and lightning

Current and future risk

High winds are a significant cause of disruption to electricity networks, causing 20% of all customer disruption between 1995 and 2011 in the UK. Across the UK, over 2 million customers suffered power cuts in the winter storms of 2014/15, of which 16,000 were without power for more than 48 hours. The majority of damage and disruption to the network from high winds is due to trees and branches falling onto power lines. Tree-related faults on the UK's electricity distribution network significantly increased between 1990 and 2006. The observed increase in the duration of the growing season, which has gained ten days in Northern Europe since the 1960s, is likely to be contributing to this trend. Lightning strikes were responsible for 8% of total disruption to electricity distribution networks between 1995 and 2011.

High winds also cause interruptions of transport services. In December 2015, Storm Frank caused several cancellations of flights from George Best Belfast City Airport, whilst in February 2016 Storm Henry caused cancellations of train and ferry services. As with electricity networks, the majority of damage to the rail network is caused by trees or substantial branches being blown on to railway tracks, blocking services, causing damage to trains and bringing down cabling. Other third party items, including garden sheds and polythene sheeting, also cause disruption.

Between a 4% to 36% increase in the numbers of faults due to lightning by the 2080s is projected (for low and high climate scenario respectively) for the UK electricity transmission and distribution network. There is no statistically significant change in impacts caused by wind or gales, and a decrease in faults due to snow, sleet and blizzard (-70% to -90%) based on the current relationships between weather and faults.

Longer growing seasons are likely to result in further increases in vegetation growth rates which may, in the absence of additional management, increase the number of tree-related faults and disruption to electricity and rail networks. No projections exist for future storm or lightning damage to rail services.

Adaptation

There is no evidence available relating to adaptation plans by either Northern Ireland Electricity or for NI Railways to manage future risks from high winds or lightning .

Northern Ireland Electricity Networks (NIE Networks) is subject to separate regulatory requirements, overseen by the Northern Ireland Authority for Utility Regulation. ETR132 obligations were defined in the Electricity Safety, Quality and Continuity Regulations (Northern Ireland) 2012 and the obligations on NIE Networks will take effect from 2017. In the interim NIE is working to meet these in addition to normal ongoing activity to mitigate the impacts of storm damage. Data on effectiveness of these activities as compliance measures have only recently commenced.

There is limited modelling of the potential impacts of future increases in the length of the growing season for tree-related faults. It is also not clear whether sufficient action is being taken to improve resilience to the projected increase in faults to the electricity distribution network caused by lightning strikes.

Urgency score

Research priority - There is a need for further modelling of the risk of increased tree-related faults due to increased vegetation growth rates. This will help to create the right conditions to adapt later if it becomes apparent that additional interventions are likely to be required to manage the change in risk.

In13: Risks to transport, digital and energy infrastructure from extreme heat

Current and future risks

Rail and electricity transmission and distribution networks are the sectors most vulnerable to impacts during periods of high temperatures. Hot weather has the potential to cause train service cancellations and speed restrictions, and require de-rating of overhead power lines. High temperatures can also affect what maintenance can be performed, for example making tensioning rail track difficult due to thermal expansion or by new road tarmac drying too quickly. Met Office analysis of historical fault data on electricity transmission and distribution networks found that solar heat faults are currently a relatively low risk compared with other weather-related causes of faults in Northern Ireland.

Average summer temperatures in Northern Ireland are expected to increase by 0.8 – 4^{o}C by the 2080s (medium emissions, p10 and p90 values). More extreme temperatures are projected to result in a threefold increase in the number of days where track maintenance cannot be carried out. Overhead power cables also sag in hot weather, increasing the frequency of trains being disconnected to their power line ('dewirement'). The exposure of staff working outdoors to heat stress may also increase.

Adaptation

The de-rating of power lines during hot weather is a standard operational procedure in Northern Ireland, which is activated when necessary and has no short or long-term consequences. Assets and equipment used in electricity networks conform to international standards and are proven in countries with analogous climates to that expected later this century. Electricity DNOs are already taking steps, such as to change their specification for poles carrying overhead lines to be 50cm to 1 metre taller to allow for increased sagging in hot weather without breaching ground clearance safety levels.

The Design Manual for Roads and Bridges, produced by the UK Highway Authorities including the Department for Regional Development (now DfI) in Northern Ireland, takes account of climate change and aims to further improve the resilience of the road network. Adaptation in the rail sector is more difficult, due to the extent of exposure and the costs of upgrading track and lineside equipment. However, data specific to Northern Ireland are not available, and Translink NI Railways have not produced a climate change adaptation plan.

Urgency score

Research priority - research is needed to establish to scale of the long-term adaptation challenge in the rail and electricity sectors to high temperatures, and to prioritise areas for cost-effective investment. This will help to create the right conditions to adapt later, especially if measures are required that have long lead times.

In14: Potential benefits to water, transport, digital and energy infrastructure from reduced extreme cold events

Current and future risks

Cold weather (including snow and ice) is a major cause of disruption to transport services, and electricity transmission and distribution. For example, the ice storm in 2010 caused 100,000 houses to lose power, whilst the electricity line from Magherafelt to Derry was severely affected by ice accretion in December 2011. Cold weather has also caused problems with water supply services in the past (see PB14).

The average number of extreme cold days is likely to diminish over the course of the century. Cold winters will still be possible, but are expected to become increasingly unlikely. There may be opportunities arising from fewer snow and ice days reducing winter disruption and maintenance costs.

However, an extreme H++ scenario involving slowdown of the gulf stream and low solar activity would reduce average winter temperatures from to around -5oC, with daily temperatures falling to -18oC. This scenario is unlikely this century but is physically plausible and cannot be ruled out.

Adaptation

Autonomous adaption to the decreasing incidence of severe cold weather days can be expected.

Urgency score

Sustain Current Action - Planned levels of future activity are appropriate, but continued implementation is needed to ensure that the risk is managed in the future.

Other risks

Other risks considered as part of the infrastructure chapter but considered to fall in to the 'watching brief':

In7: Risks to hydroelectric generation from low or high river flows. Hydroelectric generation stations are relatively few in Northern Ireland are all are less than 1MW, the largest being Sion Mills Hydro (780kW) in County Tyrone. Hydropower output may be reduced (particularly in summer) and increased in winter (representing an opportunity) and is vulnerable to both extreme flooding and drought. Excess water levels may need to be sluiced from reservoirs, leading to environmental damage downstream. Impacts of increased or reduced hydropower generation can be managed using normal operation procedures on the national grid.

In8: Risks to subterranean and surface infrastructure from subsidence. Falling and rising moisture levels - particularly in clay-rich soils - causes shrink-swell subsidence, the most damaging geohazard in Britain today (£300 million annual costs, BGS 2014). Subsidence has a strong regional pattern, with London and the east of England the most susceptible areas in the UK. However, incidents tend to be isolated and localised; meaning incident response and recovery is likely to be the most cost-effective means of managing the risk by operators.

In10: Risks to electricity generation from drought and low river flows. Power stations are a significant user of water, both freshwater from inland sources and tidal and coastal waters,

although most of the abstracted water is returned to the environment. Power stations in Northern Ireland can generate about 10GW of energy, about 14% of the overall UK major non-wind generation capacity (DUKES July 2015). Most of the power stations are fossil fuel (coal or gas) on coastal or estuary sites, meaning there should be no shortage of cooling water available. There are currently no plans to install water-intensive carbon capture and storage facilities in Northern Ireland, with CCS infrastructure more viable on the east coast on England and Scotland near to storage sites in the North Sea.

In12: Risks to offshore infrastructure from storms and high waves. The majority of offshore infrastructure in the UK is in the North Sea, so this is not currently a high priority risk for Northern Ireland. However, if there is an increase in offshore infrastructure in the future then this risk would need to be assessed.

5. People and the built environment

Improving health and wellbeing is a core principle of the Strategic Planning Policy Statement (SPPS) for Northern Ireland '*Planning for Sustainable Development*', published in 2015. Climate change poses risks to wellbeing, communities, homes, people and the healthcare system.

The CCRA Evidence Report suggests that there are potential health benefits from warmer winters in Northern Ireland, but more action is needed to manage current risks to people from cold temperatures through addressing fuel poverty. There are several risks that might be important for Northern Ireland but there is not enough evidence to assess to what extent adaptation action is already underway to manage the risks. Such areas include risks to communities from flooding and sea level rise, extreme weather impacts on the healthcare system, risks to building fabric from moisture, risks to culturally valued buildings, and risks to health from overheating buildings, poor air quality and pathogens. For these risks, more research in Northern Ireland is urgently needed.

Table NI10. Urgency scores for people and the built environment

Risk/opportunity (reference to relevant section(s) of CCRA Evidence Report)	More action needed	Research priority	Sustain current action	Watching brief	Rationale
PB1: Risks to health and wellbeing from high temperatures (5.2.2, 5.3.2, 5.5.3)	England	Northern Ireland, Scotland, Wales			There are around 2,000 heat-related deaths per year across the UK. The risk to health is likely to increase in the future as temperatures rise, but there is a lack of evidence on the scale of the risk in buildings in Northern Ireland. Future mortality projections are small but not trivial. Policies do not exist at present to adapt homes or other buildings to higher temperatures.
PB2: Risks to passengers from high temperatures on public transport (5.3.9)		Wales	England	Northern Ireland, Scotland	There is a lack of evidence to suggest that further action is needed in Northern Ireland in the next 5 years.
PB3: Opportunities for increased outdoor activities from higher temperatures (5.2.3)				UK	Leisure and other activities are likely to be taken up autonomously by people as the climate warms.
PB4: Potential benefits to health and wellbeing from reduced cold (5.3.3, 5.5.4)	UK				Currently there are between 35,800 and 49,700 cold-related deaths per year across the UK. Climate change alone is projected to reduce the health risks from cold, but the number of cold-related deaths is projected to decline only slightly due to the effects of a growing, ageing population increasing the number of vulnerable people at risk. Further measures need to be taken in the next 5 years to tackle large numbers of cold homes and reduce cold effects on health, even with climate warming.

Table NI10. Urgency scores for people and the built environment					
PB5: Risks to people, communities and buildings from flooding (5.2.5, 5.3.4, 5.5.1)	England	Northern Ireland, Scotland, Wales			It is not known at present how future spending plans in Northern Ireland compare to the level of risk. Research conducted for the CCRA suggests that increases in flood risk cannot be avoided in a 4 degree world even under the most ambitious adaptation scenarios considered.
PB6: Risks to the viability of coastal communities from sea level rise (5.2.6, 5.2.7)		UK			Research is needed to better characterise the impacts from sea level rise on coastal communities, thresholds for viability, and what steps should be taken to engage and support affected communities.
PB7: Risks to building fabric from moisture, wind and driving rain (5.3.4, 5.3.6, 5.3.7)		UK			More research is needed to better determine the future level of risk and what adaptation further steps might be appropriate.
PB8: Risks to culturally valued structures and the wider historic environment (5.3.8)		UK			Climate-related hazards damage historic structures and sites now, but there is lack of information on the scale of current and future risk, including for historic urban green spaces and gardens as well as structures.
PB9: Risks to health and social care delivery (5.4)	England	Northern Ireland, Scotland, Wales			There is a lack of evidence regarding how the level of action within the health and social care sector in Northern Ireland relates to the level of risk.
PB10: Risks to health from changes in air quality (5.2.2, 5.3.5, 5.5.5)		UK			More research is needed to understand the influence of climate change on ground level ozone and other outdoor air pollutants (especially particulates), and how climate and other factors (behaviour) affect indoor air quality.
PB11: Risks to health from vector-borne pathogens (5.5.2)		UK			Further work is needed to improve the monitoring and surveillance of vector species and related infectious disease, and to assess the extent to which current efforts are focussed on those infections that pose the biggest long-term risks.
PB12: Risk of food borne disease cases/outbreaks (5.5.6)				UK	Regulations in place to monitor and control food-related hazards should be kept under review.
PB13: Risks to health from poor water quality (5.5.6)			UK		Current policies and mechanisms to assess and manage risks to water quality in the public water supply should continue to be implemented.
PB14: Risk of household water supply interruptions (5.2.4)			UK		Policies are in place to safeguard the continuity of public water supplies during droughts and from burst pipes in cold weather. These risks should be kept under review to make sure long-term risks continue to be appropriately managed.

PB1: Risks to health and wellbeing from high temperatures

Current and future risks

High temperatures have a negative effect on human health and wellbeing. There is a robust relationship regarding the effect of temperature extremes on acute mortality. High temperatures are also associated with an increase in hospital admissions for respiratory causes, and there is some evidence suggesting an increase in GP consultations. At the UK level, there are around 2,000 heat-related deaths per year (high magnitude, high confidence). In Northern Ireland, there are currently estimated to be around 0.9 excess deaths per 100,000 population per year (which with a population of 1.85 million equates to 16.7 excess deaths per year). Indoor exposure to heat is likely to drive much of the current risk as people spend roughly 90% of their time indoors. However, there is a lack of evidence on current temperature trends in all types of buildings in Northern Ireland.

The frequency of exceedance of overheating thresholds is projected to increase in the future. Heatwave events such as the 1976 or 2003 heatwaves in the UK are likely to become the norm between 2030 and 2050. The intensity of heat waves in Europe is projected to increase in the future by between 1.4◦C and 7.5◦C for a rise in global mean temperature of 2◦C. Uncertainties remain in the magnitude of the increased intensity because of sensitivity to the modelling of the physics associated with vegetation and drying of the soil. The Northern Ireland population aged over 75 is also projected to increase from 7% of the total population in 2015 to 19% of the total population by 2085. Heat-related mortality in the 2050s is estimated to increase to between 1.5 to 6.1 per 100,000, based on the UKCP09 medium emissions scenario. This would equate to about 30 - 100 premature deaths per year, not considering population growth. Taking into account population growth whilst modelling the future impacts, this figure would be higher (medium magnitude, medium confidence).

Adaptation

It is plausible that some degree of autonomous physiological adaptation will take place in response to gradual increases in mean temperature. However, it is less likely that this will occur in response to higher extreme temperatures, particularly if overall temperature variability increases, as people are less able to adapt to sudden increases in temperature over a short period of time. There is some evidence that people lack awareness of the risks to health from high indoor temperatures, and thus they are less likely to take measures to protect themselves.

Uptake of air conditioning in housing is currently low in the UK (3% of homes). Although uptake may increase autonomously in the future, relying on air conditioning to deal with the risk would be a maladaptive solution as it expels waste heat into the environment – thereby enhancing the urban heat island effect – and can increase carbon emissions if powered from non-renewable electricity sources. There are no policy levers to control overheating through passive cooling or other means in existing homes in Northern Ireland.

Guidance and awareness raising policies for heatwaves are in force across the UK. Northern Ireland does not produce a heatwave plan, but responding to heatwaves is covered under the national emergency planning system. The effectiveness of current plans has not been tested to date, though the risk in Northern Ireland is currently low.

Urgency score

Research priority - There is a lack of evidence on the total level of risk and the benefits of acting on overheating risks for all types of buildings in Northern Ireland. More research is also required to better understand the size of the risk in different types of buildings, how people react in hot weather and the effectiveness of measures to encourage the public to protect themselves. Expert workshops[43] also identified capacity building on climate change risks as a priority among health practitioners.

PB4: Potential benefits to health and wellbeing from reduced cold

Current and future risk/ opportunities

Cold-related mortality is significant, with the estimated number of cold-related deaths between 35,800 and 49,700 deaths per year across the UK. In Northern Ireland, there are estimated to be around 40 - 60 excess deaths per 100,000 population per year (which with a population of 1.85 million equates to between 740 – 1,110 excess deaths per year) (high magnitude, low confidence). Poor quality housing (cold homes) is a major determinant of the burden of cold related mortality and morbidity. In 2011 in Northern Ireland, 42% of households were classed as fuel poor. This is partly due to a high percentage of off gas grid households (who therefore use alternative, more expensive fuels to heat their homes).

Higher temperatures from climate change will reduce the risk of cold-related deaths but this will be offset to a large extent by the increase in the older population. One study estimates that that total number of deaths will only decline by around 2% from a baseline of 41,000 deaths across the UK, by the 2050s (medium emissions scenario, includes population growth). The same study projects a reduction in cold-related mortality in Northern Ireland in the 2050s to between 29 – 43.5 per 100,000, based on the UKCP09 medium emissions scenario. Assuming no growth in population, this would equate to about 540 – 800 deaths per year (high magnitude, low confidence). This risk therefore still has a high magnitude in the future (low confidence).

Adaptation

The risks to health from cold are projected to decline somewhat over time as winters warm, but cold will still be the largest weather-related driver or mortality in the 2050s without additional action. It is important that policies are further developed and implemented to address fuel poverty without increasing the risk of overheating. The current level of risk of cold-related mortality across the UK remains high compared to other NW European countries. Fuel poverty levels are used as a proxy indicator for exposure to cold, and have seen little change over the last decade.

In Northern Ireland**,** NICE has issued guidance on measures to reduce cold impacts on health. Initiatives such as the Warm Homes Scheme and energy efficiency grants have been in place and helped several thousand households. A cold weather payment scheme has been set up to help households afford the cost of heating. However, there is as yet no evidence on how this scheme and the other initiatives have helped to reduce vulnerability.

[43] www.climatenorthernireland.org.uk

Urgency score

More action needed - Further work is needed to understand the effects of current policies in Northern Ireland to reduce fuel poverty; and to put in place steps to ensure that further insulation of the housing stock does not increase overheating risk in the summer.

PB5: Risks to people, communities and buildings from flooding

Current and future risks

Flooding is a threat to life. Studies from other populations have shown that significant mortality events are mostly associated with flash flooding. There is no precise estimate of flood mortality for the UK, as the definition of a flood death can vary. Mortality associated with flooding can include related car accidents, and other accidents, e.g. from persons falling into fast flowing water. The wider social impacts of flooding are not well quantified but include lack of access to services and loss of school and work days. All income groups are at risk of adverse consequences. Large systematic reviews of epidemiological evidences suggest that flooding has adverse effects on mental health and wellbeing. The main epidemiological evidence relates to common mental disorders (i.e. anxiety and depression) and measurable post-traumatic stress syndrome. There are a wide range of values given for the number of people affected after a flood event.

According to Sayers and partners (2015) for the ASC, there are currently 56,000 residential properties at any degree of risk from flooding across Northern Ireland (4% of all properties), of which 23,000 (2%) are at 1:75 or greater risk. This equates to 56,000 people living in areas at 1:75 or greater risk (low magnitude, medium confidence). Current expected annual damage to residential properties is estimated to be £8.1 million (low magnitude, medium confidence).

By the 2050s the projected number of people at 1:75 or greater risk rises to 67,000 under a 2 degree scenario and 76,000 for a 4 degree scenario, assuming a continuation of the current level of adaptation and not including population growth. For the 2080s, the projections suggest 73,000 people at 1:75 or greater risk under a 2 degree scenario and 98,000 people under a 4 degree scenario (low magnitude, medium confidence).

Expected annual damage to residential properties is projected to rise by between 33 - 62% in the 2050s and 60 - 150% in the 2080s depending on climate scenario (medium magnitude, medium confidence).

Adaptation

It is reported that spending on capital works by DARD Rivers Agency (now part of the Dept. for Infrastructure) to provide new or improved river flood defences is of the order of £8million per annum.

Northern Ireland Water is also spending a total of almost £20million from 2015/2016 – 2020/2021 to upgrading their sewerage systems to alleviate out-of-sewer flooding at properties across Northern Ireland. It is not known what effects this investment has had on the number of properties in areas at risk of flooding.

Northern Ireland's Strategic Planning Policy Statement was published in September 2015. The SPPS provides a strategic planning policy framework for the reformed two-tier planning system which became operational on 1 April 2015. The policy applies to the whole of Northern Ireland.

Its provisions must be taken into account by Councils in the preparation of Local Development Plans and all decisions on individual planning applications and appeals. The aim of the SPPS in relation to flood risk is to prevent future development that may be at risk from flooding or that may increase the risk of flooding elsewhere. It is considered that the current uptake of Property Level Protection (PLP) in Northern Ireland is low. There are no firm data available on this but it is known that a small number of homeowners at risk have arranged their own installations. To tackle this, a 'Homeowner Flood Protection Grant Scheme' was launched by DARD (now DfI) Rivers Agency in January 2016 and is currently being implemented. This will provide grant assistance to facilitate the fitting of Individual Property Protection measures to homes that meet the eligibility criteria. Consideration is being given to extending this scheme to non-domestic properties.

Northern Ireland is the only part of UK without a flood forecast/alert service. The Rivers Agency is a government responder to flood emergencies, providing advice to fellow drainage agencies and other responders on the potential flood impacts associated with heavy rainfall weather conditions. In the case of the coast, the Agency liaises with the UK Coastal Monitoring and Forecasting Service (UKCMF) regarding the likelihood of tidal surges and will inform fellow responders should there be potential tidal conditions which could lead to serious coastal flooding. Incidents are handled at a local level by the individual emergency services, district councils, Health and Social Care bodies and other locally based organisations, without an overarching coordination group.

Urgency score

Research priority - More evidence is needed to assess precisely how the current level of action relates to the level of risk in Northern Ireland. Some further actions that could help to understand the effects of current action on risk include:

- Reviewing future plans for flood defence spending and considering how the Government should balance future flood defence investment against other measures such as property-level and community-level flood protection measures.
- Improving the rate of retrofitting of sustainable urban drainage systems/designing urban areas to better manage local flood risks, and monitoring the uptake of SuDS in new development.
- Better understanding of and accounting for the actual change in flood risk from new development on the floodplain.
- Capacity building at the community level.

PB6: Risks to the viability of coastal communities from sea level rise

Current and future risks

Monitoring and understanding sea-level rise at the local level is difficult as the actual level of sea-level rise at any one place depends on a wide range of factors including gravitational variation across the Earth and a number of oceanographic factors. The current level of risk to the viability of coastal communities from sea level rise alone (not including ongoing coastal erosion) is thought to be low (low magnitude, high confidence), but the future risk is uncertain and could be significant.

Adaptation

No single government department has systems in place to manage the risk from coastal erosion. Hence, shoreline management plans or other policies that assess and plan for changes to coastal communities have not been developed for Northern Ireland. However, the Strategic Planning Policy Statement, 2015, states that no development should take place in areas known to be at risk from coastal erosion. This will be reflected in the local development plans being drafted by the local councils.

Engagement with communities at known flood risk is a key element of flood warning and informing activities in Northern Ireland and an initial pilot project has been completed. In order to ensure that the 'Informing' aspect of this initiative is delivered effectively, a standardised, regional strategy has been developed. This involves input from a wide range of public and voluntary sector organisations and, to this end, a Regional Community Resilience Group (RCRG) has been formed. This Group is co-chaired by Local Government and Rivers Agency.

Work has included:

- identification of communities, using pre- agreed criteria, to be initially engaged in relation to flood warning and informing;
- preparation of standard community resilience plans and household pack templates; and
- sharing of weather warning and river level information, assistance in relation to Individual Property Protection initiatives, and education in relation to flood risk in their area.

Urgency score

Research priority - There is a need to assess the need for long-term plans – in addition to shoreline management plan and community engagement schemes - for coastal communities that are at risk of being lost as a result of sea level rise.

PB7: Risks to building fabric from moisture, wind and driving rain

Current and future risks

Building fabric can be damaged following a flood through damp, mould and the deposition of salts and sediments as a result of flooding.

Moist atmospheric conditions can also affect the fabric of buildings. During warmer spring and autumn weather, the moisture removal capacity of outdoor air may be reduced, meaning additional ventilation may be required to adequately remove moisture produced inside a building. Reverse condensation, or interstitial condensation, may occur in spring and autumn seasons, when damp walls are heated by solar radiation to the extent that moisture can migrate towards the cooler interior of the building where it may lead to interstitial condensation.

In many locations across the UK, particularly in coastal areas, buildings may be exposed to driving rain. The installation of full-fill cavity wall insulation in locations with wind-driven rain can lead to damp, as the insulation retains water that penetrates the façade, and can bridge moisture into the inner walls. There have been no population-wide studies that link the prevalence of mould in buildings to flooding or other climate risks. There are no projections of damage caused by damp/mould, driving rain and wind in the future (unknown magnitude, low confidence).

Approximately 90,000 houses across Northern Ireland are constructed from red brick, a porous material which allows the ingress and egress of moisture in the building. These properties are often upgraded by installing insulation internally. Work completed on two case study properties in Northern Ireland found high relative humidity levels in the insulation and cavity which over prolonged periods would have detrimental impact on the building fabric.[44] Increased winter wetness would add to these existing issues with a potential to decay and damage structural timber members in such buildings.

Adaptation

Research suggests that damp, mould, wind and driving rain might be an issue for the Northern Irish building stock. However, the overall level of risk, as well as the current and future level of adaptation is unknown.

Urgency score

Research priority - Further research is needed to better understand the degree of risk at regional level and whether additional action is needed, in particular, to understand the following:

- The degree of current and future risk of different types of buildings or buildings in different areas to driving rain, mould, and damp.
- What adaptations are taking place at a national level, and how widespread these are.

PB8: Risks to culturally valued structures and the wider historic environment

Current and future risks

Climate change is likely to affect culturally-valued buildings and their immediate surroundings, such as parks and gardens, from the effects of extreme events (flooding, erosion or land instability, wind storms) and longer-term, chronic damage to a building fabric (see also NE14 for risks to archaeological sites and heritage).

Although some strategic planning, risk assessment work, case and scoping studies have been conducted, and there is some understanding of how climate change might affect historic building materials, there is little or no quantitative information on the level of current and future risk for the UK's historic buildings and grounds, including in Northern Ireland. Many listed buildings are in private hands and there are is no national-level assessment of what risks these buildings face from climate change (unknown magnitude, low confidence).

Adaptation

Although the risks to historic buildings and gardens are not quantified at the national scale, there are plenty of case study examples that show that there are impacts from extreme weather now, and these are likely to increase in the future (see Chapter 5 of the Evidence Report for examples). Work is in progress to better understand risks and adaptation options including weather proofing and additional flood protection. In general however, an overarching plan and appropriate adaptation actions are not yet in place.

[44] Campbell, N. et al. (2013) Heat and Moisture Transport in Buildings with Retrofitted Insulation: Computer Modelling and Case Studies Paper presented at the SB13 Conference, Dubai.

Urgency score

Research priority - Measures should be put in place in Northern Ireland to better quantify the current and future risks to the historic built environment from climate change, and assess appropriate measures to put in place.

PB9: Risks to health and social care delivery

Current and future risks

Floods, storms, snow, cold weather and hot weather/ heatwaves affect health system infrastructure and service delivery through effects on staff, buildings and equipment.

Currently, according to research conducted to support the CCRA, no hospitals in Northern Ireland are located in areas at 1:200 or higher flood risk. There are 19 emergency service stations (8.6% of all emergency service stations), 37 GP surgeries (10.5%) and 16 care homes (7.4%) that are located in areas at 1:200 or higher flood risk (low magnitude, low confidence).

Cold weather can also affect healthcare infrastructure and increase demand on health services. For example, in 2010/11, the cold winter in Northern Ireland reportedly led to the following (correspondence from DoH):

- Ventilation systems in hospitals were damaged by frost. This affected theatre and other ventilation systems, though with little impact on patient care.
- Water cooling equipment for one hospital was frozen and unable to produce isotopes for the PET/CT scanner. However, contingency plans were triggered to order isotopes from Dublin.
- A number of other reported problems with MRI cooling systems were reported.
- A number of facilities lost water supplies because of both burst pipes within the Trust Estates and loss of supplies from NI Water due to operational restrictions caused by frozen supplies and/or burst pipes. Contingency measures were required to ensure service delivery was maintained including the provision of bottled drinking water.

Heatwaves can also cause problems with the functionality of hospitals as well as the thermal comfort of patients and staff. Research indicates that that older designs are at less risk of overheating than more modern buildings. In general, the risk of heat-related mortality is larger in care homes than in the general population. Qualitative studies suggest that problems may occur associated with poorly adapted equipment, structural design and care practices, though there is no evidence at present on overheating risks in healthcare infrastructure in Northern Ireland.

Future projections indicate an increase in number of GP surgeries, care homes, emergency service stations and hospitals in the flood risk zone. Under a 4 degree scenario in the 2050s, the number of assets in Northern Ireland located in areas at 1:200 or greater risk of flooding increases to 23-24 for emergency service stations, 40 for GP surgeries and 18-19 for care homes, with no hospitals at risk (medium magnitude, low confidence). Future projections of risk are not available for other hazards.

Adaptation

In Northern Ireland, the Health and Social Care Trusts' Business Continuity Management plans are designed to deal with the potential impacts on health and social care assets from severe weather. DoH (DHSSPS prior to May 2016) also provide guidance for caring for patients during heatwave events. It is not known at present how these policies affect the overall level of risk. The DoH current capital investment programme includes updating existing building stock with new facilities that are designed for improved thermal comfort.

Across the UK as a whole, there is some evidence of inconsistencies in terms of planning for extreme weather in the health and social care sector. For example:

- It has been observed that the continuing trend towards greater levels of personalisation, devolution and fragmentation of health and social care are creating a more complex web of responsibilities for preparedness and response to climate related risks.
- The risks of healthcare professionals being unable to reach to patients may also change in the future as home-based care becomes more common. Impacts from extreme weather on transport networks may become more important.
- Problems of organisational management and communication between different groups of health and social care personal may make response to severe weather events less efficient. Although individual service providers may be familiar with severe weather plans and protocols, problems of communication between personnel in different parts of the health and social care system can present a difficulty in implementing severe weather plans efficiently.

Urgency score

Research Priority - More evidence is needed to assess how current plans in Northern Ireland relate to the current and future level of risk. The potential for cost-effective adaptation to overheating in healthcare facilities is thought to be high, but the risk in Northern Ireland is currently unknown. Plans might also be needed that consider how a greater reliance on home-based care may alter the risks to patients and healthcare delivery from extreme weather.

PB10: Risks to health from changes in air quality

Current and future risks

Determinants of outdoor air quality include levels of ground-level O_3, NOx, particulates (PM10, PM2.5), and aeroallergens (mould and pollen). At present, between 6 and 9 million people across the UK suffer from chronic respiratory conditions (asthma and chronic obstructive pulmonary disease) that make them especially vulnerable to air pollution (high magnitude, high confidence). The increased proportion of diesel-fuelled traffic in the UK, and the failure of Euro emission standards for diesel cars to deliver the expected emission reductions of nitrogen oxides, have resulted in difficulties meeting EU air quality limit values for nitrogen dioxide (NO2), prompting infraction proceedings by the European Commission against the UK.

Climate-sensitive air pollutants include ground level ozone and aeroallergens such as pollen. There is sufficient evidence that short-term exposure to ground-level ozone increases mortality, respiratory hospital admissions and, acknowledging more uncertainty, cardiovascular hospital admissions. The effects of weather and climate variability have been studied for pollen, but not

for all species. Higher temperatures, the presence of high concentrations of carbon dioxide, different patterns of rainfall and humidity may be associated with extended growing seasons.

Some thunderstorms have also been associated with increased hospital admittances for asthma exacerbations ("thunderstorm asthma").

Although higher ambient temperature can lead to increased ozone concentrations, studies have concluded that future changes in emissions are a more important driver of future ozone concentrations than changes in the climate. Higher temperatures may trigger regional feedbacks during stagnation episodes (still weather) that will increase peak ground level ozone, but these effects are not as important a driver of future concentrations as future emissions. Average ozone levels over Europe are expected to decrease generally in future in conjunction with lower emissions of ozone pre-cursors; except in one scenario where high methane emissions offset this increase. In polluted areas with high nitrogen oxide levels, warming is likely to trigger feedbacks in local chemistry and emissions, increasing levels of ozone. Recent studies have suggested that the occurrence and persistence of future atmospheric stagnation events in mid-latitudes which influence air pollution levels may increase due to climate change, but these effects are very uncertain.

The impacts of climate change on future pollen-related illnesses include changes to length of pollen season, pollen abundance, and changes in allergenicity. There is a very complex relationship between pollen abundance and seasonality and climate factors, and this also varies by pollen species. Projections of future changes in thunderstorm activity are very uncertain.

The overall impact from climate change on air quality is uncertain, so it is not possible to determine the magnitude of the future risk (unknown magnitude, low confidence).

Adaptation

The need for action to reduce the impacts of climate change alone on air pollution is unclear. There is an obvious need to put in place measures to reduce the effects of emissions on air pollution. Current policies are not currently sufficient to control current air quality levels to within EU guided limits, but the justification for further action in the future due to climate change is uncertain.

Urgency score

Research priority - Research is needed to assess how changes to climate other than increasing temperatures, such as changing wind patterns and blocking episodes, could impact on air pollution levels in Northern Ireland. Long-term data on the number of children and adults living with chronic respiratory conditions in Northern Ireland would also be valuable.

PB11: Risks to health from vector-borne pathogens

Current and future risks

It has not been possible to find evidence specific to Northern Ireland for this risk, which relates to changes in the incidence of Lyme disease (the only vector-borne disease established in UK), and the introduction of new vector-borne diseases (such as West Nile Virus disease, dengue, malaria, Chikungunya, Zika and other arboviruses).

Climate extremes are known to have major effects on host-pathogen interactions in a variety of ecosystems. The 1976 heat-wave, and 1976-197716-month UK drought, led to reduced river flows, ground and surface water. Disease impacts were detectable in animals (including livestock, wildlife and fish) and plants in terrestrial, freshwater and marine ecosystems. Tick species that transmit Lyme Disease are currently distributed throughout the UK, including Northern Ireland. The *Ixodes ricinus* ticks are mostly encountered in the countryside, but are also present in urban parks.

Quantitative predictions of the impact of climate change are uncertain, but it is likely that the range, activity and vector potential of many ticks and mosquitoes will increase across the UK through the century. Higher temperatures in the future will increase the suitability of the UK's climate for invasive mosquito species, facilitating invasion by new species that can transmit diseases in the long term. It is not possible to quantify the likelihood of the introduction of new diseases. Modelling has been done on the capacity of mosquito vectors and tick vectors (*Hyalomma marginatum)* to move north in Europe, indicating that the UK is unlikely to become habitable for *Aedes albopictus* before mid-century. The risk of introduction of malaria is thought to remain low. Projections for the 2080s, under a variety of emission scenarios, only indicate a small risk of malaria transmission in the UK. Lyme disease may shift in altitude and incidence in the UK in response to climate change. However, future trends in agriculture, land use, wild animal populations and tourism will play as large or a larger role as climate in determining future patterns of the disease. The future magnitude of impact is uncertain, but as the current magnitude is thought to be high and the published evidence suggests that the risk will increase, expert judgement is that the future risk will also be high magnitude. This risk has low confidence.

Adaptation

Surveillance and monitoring activities are underway in all four UK countries. 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 how effective these programmes are at controlling emerging vectors and the extent to which the programmes are able to prioritise funding for surveillance of vectors and pathogens that pose the biggest risk from climate change.

Urgency score

Research priority - There are likely to be benefits from improved monitoring and surveillance of emerging infections. Better understanding is needed of the eco-epidemiological drivers that determine the distribution of the UK's existing arthropod vectors and the pathogens that they might carry at finer spatial scales than is possible from current studies. Better ongoing surveillance for the importation of exotic arthropod vectors and pathogens would also be beneficial. Field-based research should be conducted to understand the impact of environmental change and climate change adaptation strategies on disease vectors.

PB13: Risks to health from poor water quality

Current risk and future risks

There is limited evidence regarding the association between gastro-intestinal pathogens and rainfall. In the UK outbreaks of cryptosporidiosis have been linked to heavy rainfall affecting

public drinking water supplies. There has been an expansion of the geographical ranges of some harmful warmer water phytoplankton species into higher latitudes. The transmission of marine pathogens (through food) is also sensitive to higher sea surface temperatures. Evidence is very limited for the UK, although there is evidence from the Baltic Sea. The current level of magnitude of the risk is unknown, and it therefore has low confidence.

There is evidence that the increase in rain shower intensity presents a threat to bathing water quality, measured under the EU Bathing Water Directive monitoring. Each year, DAERA Marine and Fisheries Division assesses the results of Northern Ireland's Bathing Water monitoring against the microbiological requirements of Bathing Water Directive. Intense, flashy rain conditions can increase runoff from fields and storm overflows from sewerage infrastructure, both of which can increase pathogens in marine waters and present a risk to bathers.

Evidence related to the impact of future climate change on gastro-intestinal pathogens in drinking water is also limited. Increasing sea temperatures around the UK may result in an increase in marine *vibrio* infections. However, the public health implications of this are not clear, including whether it would lead to a detectable increase in human disease. The level of magnitude is unknown and this risk therefore has low confidence.

Adaptation

Policies are in place to deal with future issues arising from risks to water quality for domestic use The Water and Sewerage Services (Northern Ireland) Order 2006 provided for the appointment of the Drinking Water Inspectorate as independent regulator of drinking water quality in Northern Ireland. The Drinking Water Inspectorate monitors the quality of public drinking water to ensure that it is safe and meets the standards required by law. In addition to this, Northern Ireland Water has the following:

- A Drinking Water Safety Plan (DWSP) approach to managing water quality. Cryptosporidium risks are included in the risk assessment process.
- WTWs are all full chemical treatment processes with treatment barriers to remove Cryptosporidium in the raw water supplies. All treatment plants are monitored online 24/7 for turbidity at various stages through the treatment process.
- A programme of cryptosporidium sampling as agreed with the Drinking Water & Health Liaison Group (DW&HLG). This is a group made up from representation from the Chief Environmental Health Officer, DoH, Public Health Agency, Drinking Water Inspectorate (NI) and Councils to advise on public health issues associated with both public and private drinking water supplies.
- Weekly reporting of all cryptosporidium cases in the community from the Public Health Agency.

CEFAS have also developed an early warning and forecasting tool for vibrio, a bacteria found in sea water and transmitted to people through sea water or infected shellfish.

Urgency score

Sustain current action - There is insufficient evidence to suggest that further action over and above what is already happening is needed in the next 5 years. However, research might be needed understand whether the current policy framework is resilience manage the risk to bathing water quality from increased rainfall patterns.

PB14: Risk of household water supply interruptions

Current and future risks

The UK has experienced repeated periods of low precipitation. Some of these have lasted longer than anything experienced recently (e.g.mid 1880s to early 1900s). The most severe and widespread drought conditions in the UK in relatively recent times were those peaking in 1976 where nationally rainfall was 59% of the 1981 – 2010 average. There was also a period of low rainfall beginning in 1995 which put public water supplies at risk in some areas. The most obvious community-level manifestation of drought consists of periodic hosepipe bans. Less frequently there are restrictions on the industrial and agricultural use of water that temporarily effect employment. Even more rarely there are restrictions on domestic supplies that can affect health and wellbeing, but standpipes have not been used in response to a UK drought since 1976. A range of health issues arise when tankers, standpipes and/or bowsers are used. The current magnitude of risk annually is unknown and this risk therefore has low confidence. There is also an unknown risk to households connected to private water supplies. Water supply interruptions can also be caused by flooding and cold weather. Over the winter of 2010/11, 450,000 customers in Northern Ireland experienced supply problems due to pipe bursts caused by freeze-thaw conditions. These events are quite rare so it is difficult to provide an estimate of magnitude that is akin to an annual average.

The future risks to health from droughts are amongst the most difficult to estimate because the science of estimating prolonged and extensive low rainfall patterns is insufficiently advanced. As temperatures rise this may dry the ground and create conditions in which droughts become more likely. Analysis of H++ scenarios for the CCRA looking at the upper end of the impacts that might be expected suggests that 6 month droughts in summer might be more frequent with rainfall deficits of up to 60% of current averages. Medium term multi-annual droughts of up to 18 month duration may become more common. Longer term droughts, similar to those in the historical record, remain possible (unknown magnitude, low confidence). The probability of cold events that cause problems with water supply is likely to decline in the long-term as winters become warmer.

Adaptation

Water utility companies are mandated to account for drought in their water resources management plans. When droughts occur, emergency powers can be used to restrict water supplies and advice is issued to reduce consumption (e.g. hosepipe bans, requests to water gardens with water that has already been used). Plans to avoid health and wellbeing impacts ensure that vulnerable individuals who need access to plentiful water are not adversely affected (e.g. dialysis patients or those with high laundry requirements). However, a community's ability to cope with severe droughts where standpipes need to be used is not well-researched in the UK as it is such a rare event.

Following the 2010/11 incident, Northern Ireland Water took various steps to improve security of supply and communication with customers on pipe bursts. Its future distributional input estimates, which include the amount of water lost to leakage, have decreased from 583.91Ml/d to 564.47Ml/d over the last 3 years

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Urgency score

Sustain current action - Policy levers are in place to deal with the public health implications to security of water supplies from droughts and cold weather. Continued testing and implementation of measures to maintain security of supply remains important to allow for adaptation if the risk increases in the future.

Other risks

Other risks considered as part of the people and built environment chapter but considered to fall in the 'watching brief' category are:

PB2: Risks to passengers from high temperatures on public transport. Higher temperatures have been cited as a risk to the effective functioning of urban transport networks because of risks to commuter comfort and health. In Northern Ireland, the current and future magnitude of this risk on an annual basis is unknown and it therefore has low confidence. This risk is classed as sustain current action at the UK level, but given the uncertainty and potentially low magnitude of overheating risks in Northern Ireland this risk has been classed as watching brief.

PB3: Opportunities for increased outdoor activities from higher temperatures. Climate change is increasingly recognised as a factor that may influence the recreational use of outdoor environments. Despite awareness of the pervasive effects of climate change, its effects on outdoor recreation have only recently been studied in detail. Climate change would have differing impacts depending on the activity. For example, the number of people partaking in certain outdoor recreational activities-such as boating, golfing and beach recreation is estimated, under medium emissions scenarios, to increase by 14 to 36% in the near-term. A study in Switzerland also projected a significant increase in the use of outdoor swimming pools, with increases of > 30% expected for August and September in the future. For Northern Ireland and the UK more widely however, the current and future magnitude of benefit is unknown and this benefit therefore has low confidence. Autonomous adaptation to take advantage of any benefits is thought to be plausible, though there is little evidence to support this assumption made by the authors. This opportunity could also be counterbalanced by a potential for increased UV exposure leading to possible increases in skin cancers. This concern is reflected in the Skin Cancer Prevention Strategy and Action Plan 2011-2021.[45]

PB12: Risk of food borne disease cases/outbreaks. The future level of risk is currently projected to be low, and therefore it is thought unlikely that there would be a significant adaptation shortfall. The relatively high level of regulation regarding food safety from farm to fork provides the UK with a high level of capacity to adapt climate change. As climate change moves the climate into unknown territory this could make current regulations and food monitoring inadequate to deal with future threats, such as emerging disease. Thus, activities such as horizon scanning and ongoing monitoring are needed. Early warning systems or food risk detection systems may also play an important role in mitigating and adapting to climate change induced food threats.

[45] http://www.dhsspsni.gov.uk/hp_microsoft_word_-_sub_1082_2011b_final_draft_-_skin_cancer_prevention_strategy.pdf

6. Business and industry

Flooding and extreme weather events which damage assets and disrupt business operations pose the greatest climate change risks to businesses in Northern Ireland now and in the future. This could be compounded by a lack of adaptive capacity. New regulations or other government intervention made necessary by climate change also poses an indirect risk to businesses.

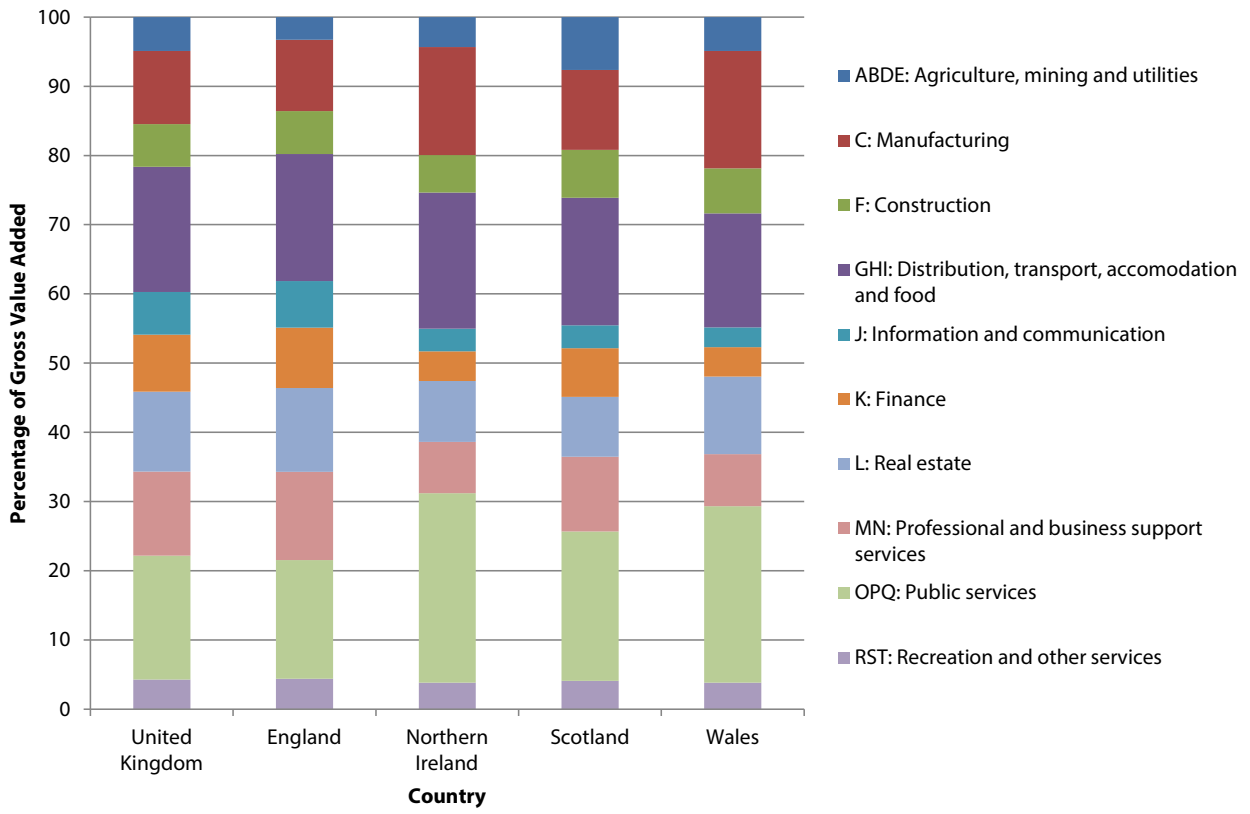
Government has a role in enabling, facilitating and supporting private sector adaptation through policies, regulation and other supportive measures such as information sharing and raising awareness. Resilient infrastructure, in particular power, fuel supplies and ICT, is crucial in enabling businesses to minimise disruptions to their operations from climate hazards.

Table NI11. Urgency scores for business and industry

Risk/opportunity (reference to relevant section(s) of CCRA Evidence Report)	More action needed	Research priority	Sustain current action	Watching brief	Rationale for scoring
Bu1: Risks to business sites from flooding (6.2.2, 6.2.3)	England	Northern Ireland, Scotland, Wales			More research is needed in Northern Ireland to understand uptake of flood protection measures by businesses and how spending plans on defences and other measures may or may not protect individual businesses.
Bu2: Risks to business from loss of coastal locations and infrastructure (6.2.2, 6.2.3)		UK			More research needed on costs and benefits of adaptation options for different coastal areas.
Bu3: Risks to business operations from water scarcity (6.2.4, 6.2.5). NB: Also see related risk In9.			UK		Sustain current actions to create more flexible abstraction regimes and promote water efficiency among businesses.
Bu4: Risks to business from reduced access to capital (6.3)				UK	Monitor and research action by regulators, banks and insurance firms, and information disclosures by UK companies.
Bu5: Risks to business from reduced employee productivity, due to infrastructure disruption and higher temperatures in working environments (6.4.2, 6.4.3, 6.4.4, 6.4.5)		UK			More research needed on disruption to ICT, power and transport infrastructure which prevents workers accessing premises or working remotely, and on impacts of higher temperatures on employee safety and productivity.
Bu6: Risks to business from disruption to supply chains and distribution networks (6.5) NB: Please see related international risks It1 and It3.			UK		Sustain and monitor the uptake of existing guidance which helps businesses improve the resilience of supply chains and distribution networks, particularly at the international level.
Bu7: Risks and opportunities for business from changes in demand for goods and services (6.6)				UK	Monitor sales of adaptation goods and services within the UK, and by UK companies.

To understand the contribution of different sectors to the Northern Irish economy, the Figure NI3 compares the distribution of GVA among sectors by UK country for 2014. The relative contributions can differ. For example, the relative contribution of manufacturing is higher in Northern Ireland (17%) than other UK regions; whilst the relative contribution to GVA of the finance sector is lower (4%). Public services make up a higher proportion of Northern Ireland's GVA (27%) than for the UK as a whole (18%).

Figure NI3. Distribution of Gross Value Added among sectors by UK country, 2014



Source: ONS (2015).

Table NI12 compares the distribution of workforce jobs in the UK and Northern Ireland in 2015. Like for Gross Value Added, there are differences in the proportion of workforce jobs accounted for by different industry sectors. For example, Agriculture, Forestry and Fishing, Manufacturing account for approximately 30,000 workforce jobs or 4% of the total in Northern Ireland, whereas it accounts for 450,000 or 1% of the total in the UK. 270,000 or 32% of workforce jobs in Northern Ireland are in Wholesale and Retail Trade; Repair Of Vehicles and Human Health and Social Work Activities. In the UK these two industry sectors account for 9 million or 27% of workforce jobs.

Table NI12. Percentage of workforce jobs by industry section, 2015		
Industry	**United Kingdom (%)**	**Northern Ireland (%)**
A : Agriculture, Forestry And Fishing	1.2	3.5
B : Mining And Quarrying	0.2	0.2
C : Manufacturing	7.8	10.0
D : Electricity, Gas, Steam And Air Conditioning	0.4	0.4
E : Water Supply; Sewerage, Waste Management	0.6	0.6
F : Construction	6.6	6.5
G : Wholesale And Retail Trade; Repair Of Vehicles	14.7	16.6
H : Transportation And Storage	4.6	3.8
I : Accommodation And Food Service Activities	6.7	6.1
J : Information And Communication	4.0	2.5
K : Financial And Insurance Activities	3.4	2.5
L : Real Estate Activities	1.6	0.8
M : Professional, Scientific And Technical Activities	8.7	4.5
N : Administrative And Support Service Activities	8.4	6.4
O : Public Administration And Defence	4.4	6.6
P : Education	8.7	8.8
Q : Human Health And Social Work Activities	12.4	15.7
R : Arts, Entertainment And Recreation	2.9	2.1
S : Other Service Activities	2.6	2.4
T : Activities Of Households As Employers;...	0.2	0.0
Total (%)	100.0	100.0
Total (Thousands)	33,783	849

Source: ONS (2016d) accessed through NOMIS.
Note: Data are seasonally adjusted. Workforce jobs are the sum of: employee jobs, self-employment jobs, HM Armed Forces and government-supported trainees. The number of people with jobs is not the same as the number of jobs. This is because a person can have more than one job. Industry sections are classified according to the Standard Industrial Classification (SIC) 2007.

The proportion of private sector enterprises accounted for by Small and Medium Enterprises (SMEs) is similar in Northern Ireland compared to the UK as a whole. 99.9% of private sector enterprises in Northern Ireland are SMEs, with the vast majority of these having fewer than 10 employees. SMEs in Northern Ireland account for 75% of private sector employment and 74% of turnover, more than for the UK as a whole (60% and 47% respectively).

Table NI13. UK and Northern Ireland private sectors

Size of business	UK			Northern Ireland		
	Businesses	Employment (thousands)	Turnover (£, millions)	Businesses	Employment (thousands)	Turnover (£, millions)
Micro	5,146,400 (95.5%)	8,461 (32.7%)	672,815 (18.1%)	110,700 (94.7%)	199 (38.5%)	15,976 (28.0%)
Small	203,525 (3.8%)	3,968 (15.3%)	543,058 (14.6%)	5,200 (4.5%)	104 (20.1%)	13,732 (24.1%)
Medium	32,560 (0.6%)	3,183 (12.3%)	537,996 (14.5%)	885 (0.8%)	85 (16.4%)	12,566 (22.0%)
Large	6,965 (0.1%)	10,260 (39.7%)	1,956,409 (52.7%)	135 (0.1%)	129 (25.0%)	14,834 (26.0%)
Total	5,389,450 (100%)	25,871 (100%)	3,710,278 (100%)	116,920 (100%)	517 (100%)	57,107 (100%)

Source: BIS (2015a).
Note: Size of business is determined by the number of employees. Definitions are: Micro (0 to 9 employees), Small (10 to 49 employees), Medium (50 to 249 employees) and Large (More than 250 employees).

Bu1: Risks to business sites from flooding

Current and future risks

Flooding poses a significant risk to business sites in Northern Ireland, both in terms of damage to assets and in preventing employees from being able to access work premises.

Present day estimates suggest approximately 15,000 non-residential properties in Northern Ireland are at risk of flooding (1 in 1000 year or less). Of these, 7,000 are at risk of significant (1 in 75 annual chance or greater) flooding. The direct impacts of flooding result in expected annual damages to non-residential properties of £19 million.

By the 2050s the number of non-residential properties in Northern Ireland at risk of significant flooding is projected to increase between 37% and 58%. Expected annual damages are projected to increase between 36% and 62%, equivalent to a £7 million to £12 million increase. [Scenario: 2°C or 4°C , not including population growth and assuming the continuation of current levels of adaptation]

By the 2080s the number of non-residential properties in Northern Ireland at risk of significant flooding is projected to increase between 45% and 92%. Expected annual damages are projected to increase between 63% and 140%, equivalent to a £12 million to £27 million increase. [Scenario: 2°C or 4°C, not including population growth and assuming the continuation of current levels of adaptation]

Adaptation

Sustainable Water - A Long-Term Water Strategy for Northern Ireland (2015-2040), published in March 2016, contains a long-term vision to manage flood risk and drainage in a sustainable manner, which will help to address the future risks from climate change. The Strategy also includes the following aims relevant to the vulnerability of business site locations:

- ensure a sustainable water sector to support the Regional Development Strategy 2035;
- Sustainable Drainage Systems (SuDS) are the preferred option for managing surface water in new developments;
- Sustainable Catchment Management;
- a holistic integrated approach to rural and urban drainage provision;
- improve Flood Resistance and Resilience in High Flood Risk Areas including extending the Homeowner Flood Protection Scheme to non-domestic properties;
- provide effective, efficient flood emergency information and communication systems; and
- provide information and warnings regarding extreme weather events.

The Water and Sewerage Services Act (Northern Ireland) 2016 introduces new restrictions to the right to connect surface water sewers to the public sewer network. The 2016 Act sets out further grounds for refusal of a connection on the basis that there is suitable alternative means of dealing with the surface water or that such means could reasonably be provided. It makes clear that suitable alternatives include sustainable drainage systems.

Research for the UK (which included some respondents from Northern Ireland) suggested that the proportion of private sector organisations saying they have a business continuity management (BCM) plan in place increased from 42% to 58% between 2008 and 2013. Other research suggests that in general the smaller the business, the less chance there is that they have a plan in place. Around four-fifths of surveyed businesses have reported benefits from having a BCM plan in place.

Urgency score

Research priority - More research is needed to understand future spending plans and the uptake and impact of flood protection measures in Northern Ireland, and ensure that businesses have the right incentives, information and tools to adapt to increasing flood risk. Around four-fifths of UK businesses with continuity plans in place report that the benefits of having one exceed the costs of producing one, suggesting they are cost-effective to implement. However, the uptake of such plans remains low, particularly among SMEs.

Bu2: Risks to business from loss of coastal locations and infrastructure

Current and future risk

Coastal flooding, erosion, sea level rise and tidal and storm surges can lead to the loss of coastal business locations. Coastal flooding is estimated to contribute 8 per cent of total expected annual damages to the Northern Ireland, including both residential and non-residential properties.

Monitoring and understanding the effects of sea-level rise on risk at the local level is difficult as the actual level of sea-level rise at any one place depends on a wide range of factors including gravitational variation across the Earth and a number of oceanographic factors. The current level of risk to the viability of coastal communities and their businesses in Northern Ireland from sea level rise is thought to be low (low magnitude, high confidence), but the future risk is uncertain and could be significant (see also risk PB6). Reliance on maritime logistics and infrastructure can mean that certain sectors, for example, chemical manufacturing, oil and gas and tourism are more exposed to coastal climate change impacts. How much these sectors in Northern Ireland are at risk from permanent coastal climate change has not been quantified to date.

In the future, damages from coastal flooding in Northern Ireland could increase by around 60% by the 2080s from a baseline of £2.2 million present day. (High Magnitude, Low Confidence).

Adaptation

No system is in place in Northern Ireland to decide which areas must be protected and where realignment or retreat is more appropriate. Shoreline management plans or other policies that assess and plan for changes to coastal locations have therefore not been developed.

Many industrial facilities already have active risk management procedures and a level of existing protection, so autonomous adaptation is likely for these operators. However, smaller businesses, for example those involved in coastal tourism, may be less aware of the risk or able to protect themselves and will therefore be more exposed.

Government commitments and autonomous adaptation discussed under step 2 for Bu1(risks to business sites from flooding) are also relevant here.

Urgency score

Research priority - The possible realignment or retreat of coast protection structures due to increasing erosion and flood risks will have an impact on businesses located in the affected areas. Research is required to understand the costs and benefits of different adaptation responses to loss of coastal locations for business, and therefore provide the early steps for cost-effective adaptation.

Bu3: Risks to business operations from water scarcity

Current and future risks

Water is used by industry for cooling and heating, washing products, dissolving chemicals, suppressing dust, and also as a direct input to products. Without sufficient water, production in many businesses could be reduced or have to be stopped temporarily. Estimates suggest that abstractions for general industrial purposes in Northern Ireland account for approximately 6 million m^3 per day. Food and drink and mining quarrying are relatively large abstractors of water within Northern Ireland.

We are unable to assess current or future water availability in Northern Ireland as explained in Box NI1.

Adaptation

The Northern Ireland Environment Agency (NIEA) Abstraction and Impoundment Licensing (AIL) team monitor and control water bodies in Northern Ireland. Industries that abstract over 10 cubic metres per day of surface, coastal or groundwater will be required to notify the NIEA, while Abstractions of over 20 cubic metres per day require a licence. The NIEA and AIL undertake periodic reviews of licences and can review licences at any time and can make modifications.

Sustainable Water - A Long-Term Water Strategy for Northern Ireland (2015-2040), published in March 2016, includes an action to "manage and review abstraction licences to ensure sustainable water resources are available to meet society's needs without compromising the environment. This will factor in the cost of future abstraction reductions (e.g. new treatment works or trunk main)".

Northern Ireland Water encourages and provides advice to businesses on how they can reduce how much water they use.

Evidence from the Federation House Commitment (FHC) shows a decrease in water intensity in the food and drink manufacturing sector. The Water use excluding that used in product at FHC sites fell by 16% between 2007 and 2013; and water intensity, measured in m3 per tonne of product, fell by 22% over the same period. 2% of FHC signatories' sites were in Northern Ireland.

Urgency score

Sustain current action - Sustained effort will be needed to ensure that the abstraction regime is sufficiently flexible and that businesses are able to build on their existing progress in becoming more water efficient.

Bu5: Risks to business from reduced worker productivity, due to infrastructure disruption and higher temperatures in working environments

Current and future risk

Infrastructure disruption

There is no Northern Ireland-specific evidence available for this risk. According to a UK survey by the Chartered Management Institute et al. (2013), staff being unable to come into the office either due to travel disruption (63% of respondents) or school closures/child care costs (46%) were the most common impacts of extreme weather on surveyed organisations, followed by external meetings or business trips being cancelled (43%). The most common measures taken by surveyed organisations in response to extreme weather were to allow staff to work remotely (53%), to prioritise resources on key projects (34%) and to postpone work until the weather improved (29%).

Baglee et al. (2012) assessed that major ICT disruption due to climate change is considered to be relatively low for large businesses. Risks for smaller companies could be greater, particularly if they are located in relatively remote areas where they may be dependent on single electricity and telecommunications connections. Many homeworkers depend on ICT infrastructure to allow them to work remotely. Of people in work between January and March 2014, 4.2 million or 13.9% were homeworkers, two-thirds of whom were self-employed. Homeworking was most

prevalent within the agriculture and construction industries. It is not known what proportion of those classified as homeworkers would be affected by weather-related disruptions to ICT infrastructure.

Projections of future impacts of infrastructure losses on business productivity are not available.

Higher temperatures

There is no Northern Ireland-specific evidence available for this risk. In general, when temperatures exceed certain thresholds in the workplace for a long enough period of time, the productivity of workers has been observed to fall. There is uncertainty regarding the amount of productivity loss and on the annual average impact across the UK. The 2003 European heatwave is estimated to have resulted in a loss in manufacturing output in the UK of £400 - £500 million (2003 prices), but it is unclear how much of this impact was due to reduction in worker productivity.

Workers engaged in heavy outdoor manual labour, particularly in the agriculture, construction and heavy industry sectors, and depending on the sport, professional athletes, are likely to be at the greatest risk of heat stress. Employees working in offices built in the 1960s and 1970s could also be at risk of thermal discomfort. These types of building typically have poor ventilation systems and are often high-rise properties with single glazed windows that maximise solar gain.

Modelling in UK CCRA 2012 suggested the future impacts on productivity could be large. Upper bound results suggested that the cost of loss in productivity due to building temperature could increase from a baseline of £770 million in 2010 to between £850 million and £1.6 billion in the 2020s; between £1.1 billion and £5.3 billion in the 2050s and between £1.2 billion and £15.2 billion in the 2080s.

Adaptation

Research for the UK (which included some respondents from Northern Ireland) suggested that the proportion of private sector organisations saying they have a business continuity plan in place increased from 42% to 58% between 2008 and 2013. Evidence suggests that organisations often activate business continuity plans only after they have been impacted by an extreme weather event. Extreme weather was the most commonly cited reason for activating a BCM plan, cited by 69% of managers surveyed with BCM plans in their organisation. In congruence with this, the most commonly cited reasons for not implementing a BCM were "We rarely get significant levels of disruption in our business", "We deal with disruption as and when it happens" and "Not a priority," respectively cited by 45, 43 and 37% of surveyed managers without a BCM in their organisation. Therefore, BCM plans may increase in future as organisations become more likely to experience extreme weather events.

While not necessarily linked to disruption from extreme weather events, increasing numbers of businesses have been offering workers the option of teleworking. The Confederation of British Industry (2011) reports that "Five years ago, just 13% of firms offered teleworking for employees in at least certain roles some of the time, but now nearly six in ten (59%) do so. This increase has been made possible by improved technology, allowing people to work more effectively away from the workplace.

Businesses have an obligation under the health and safety at work regulations to ensure workplaces are adequately ventilated and temperatures during working hours are reasonable. To support businesses in meeting this requirement, the Health and Safety Executive has

published workplace temperature guidance. However, there are no standard upper limits of acceptable working temperatures, so it is up to individual companies to determine what is reasonable. The Chartered Institution of Building Services Engineers (CIBSE) organised an overheating task force. This was in response to the challenge of building comfortable, low-energy buildings. For example, increasing indoor winter temperatures can lead to lightweight, highly insulated buildings that respond poorly in the summer. One of the task force's outputs was a technical memorandum to inform designers, developers and others responsible for defining the indoor environment in buildings about predicting overheating.

Little is understood about the impacts of heat on productivity and how this varies among occupations. Therefore there is little assurance that workplace temperature guidance and building standards are sufficiently accounting for this risk.

Urgency score

Research priority - There is a need for further research to better understand key interdependencies between business and infrastructure, the types of employment at greatest risk, and the effectiveness of planned or autonomous adaptation. Research will provide the early steps to understanding these interdependencies, and in the case of higher temperatures, adapting workplace temperature guidance and building standards. For example, how building temperatures can be kept in a tolerable range for thermal stress or thermal discomfort reflecting the building's use.

Bu6: Risks to business from disruption to supply chains and distribution networks

Current and future risks

There is a lack of Northern-Ireland specific evidence for this risk. The impacts of extreme weather events vary by type and among businesses, depending how diversified their supply chains and transportation routes are. Regional trade statistics indicate the value of Northern Ireland's exports increased from £8.6 billion in 2005 to £12.2 billion by 2015. Over the same time period the value of Northern Ireland's imports increased from £6.4 billion to £7.1billion. At the UK level, the Business Continuity Institute's Supply Chain Resilience Report for 2015 found that adverse weather was third most cited reason for supply chain disruption over the previous 12 months, with 50% of surveyed businesses reporting it. Studies have found that share prices can fall by between 7% and 30% on average following failures in the supply chain, relative to benchmark companies.

One of the key current and future climate risks for supply chains and distribution networks is extreme weather causing damage and disruption to domestic transport infrastructure (roads, rail, ports and airports). For the businesses concerned, this is likely to result in unfulfilled orders, breach of delivery contracts, loss of revenue and damage to reputation. Flooding in particular can have long-lasting impacts on transport networks and cause widespread disruption.

Food, clothes and electronic equipment are important UK consumption goods which appear to be at comparatively high risk from international supply chain interruptions. The largest climate risks to supply chains appear to be in the earlier stages of product manufacture. These tiers of the supply chain are less likely to be understood and managed by UK businesses. A larger proportion of value in the earlier stages of production is generated in countries that are at a moderate or higher risk from climate change. Evidence suggests that disruptions in the earlier

stages of supply chain are common. A recent survey by the Business Continuity Institute (BCI) found that 42% of supply chain disruptions originated below the first tier of immediate suppliers.

Climate change is expected to increase the risk of weather-related disruptions, particularly for supply chains that involve more vulnerable countries, particularly in South and South East Asia, along with Sub-Saharan Africa. Domestically, the effects of climate change on UK transport infrastructure are significant; the length of railway line located in areas exposed to flooding more frequently than 1:75 years (on average) increases in the 2080s by 53% and 160%; the length of major roads by 41% and 120%; the number of railway stations by 10% and 28%. [Scenario: 2°C or 4°C, not including population growth and assuming the continuation of current levels of adaptation]

Adaptation

Many large companies are considering the risks from climate change to their supply chains and distribution networks and collaborating with their suppliers. This can have wider positive effects and increases the resilience of smaller businesses in their supply chains.

A lot of guidance for businesses on managing their supply chains and distribution networks already exists. However, there is a lack of evaluation to provide sufficient assurance that this guidance is effective and affecting business decisions on the ground. Findings from the Chartered Institute of Purchasing and Supply (CIPS) suggest that many British firms do not fully understand supply chain complexity and that "inadequately trained supply chain professionals" amount to a skills gap.

Guidance and research tends to be high-level and generic. There is a gap therefore, in assessing risks to specific sectors, key areas and vulnerable pinch-points, both for domestic and international supply chain interruptions. Little is known about how the resilience of UK infrastructure affects business' ability to create resilient supply chains and distribution networks.

Urgency score

Sustain current action - International elements of UK businesses' distribution and supply chains are already impacted, and expected to be more at risk as they may take place in countries deemed highly vulnerable to climate change and less able to adapt. Despite the range of surveys and case studies, data are mostly limited to those reported by larger multi-national companies and it is difficult to evaluate the impact and effectiveness of existing adaptation measures, and existing guidance and tools. Therefore it is important to sustain action in this area to continue increasing understanding and enabling businesses with guidance and tools which are proven to be effective.

Other risks

Other risks considered as part of the business and industry chapter but considered to fall in the 'watching brief' category for Northern Ireland are:

Bu4: Risks to business from reduced access to capital. We do not have any evidence that is specific to Northern Ireland for this risk. Future outputs from the finance and insurance sectors, including research, need to be carefully monitored to ensure that both banking and insurance sectors are acknowledging and adapting to future climate change. The state of information

disclosures and how smaller businesses' access to capital and insurance also needs to be monitored to consider if future intervention may be necessary.

Bu7: Risks and opportunities for businesses from changes in demand for goods and services. We do not have any evidence that is specific to Northern Ireland for this risk. Identifying market opportunities and managing risks are core business activities– unless prevented by regulation or hampered by low adaptive capacity, it is expected that companies will respond to growing risks and opportunities. There is a risk that businesses will be unable to overcome adaptive capacity constraints, and therefore ongoing monitoring is important. Small businesses are generally likely to have lower adaptive capacity so would be the least likely to take adaptation action.

7. International dimensions

Climate change will impact upon on water security, agricultural production and economic resources around the world. These impacts can in turn exacerbate risks from conflict, migration, and humanitarian crises abroad, with implications for the UK. The main risks arising for the UK from climate change overseas are through impacts on the food system, economic interests abroad, and increased demand for humanitarian aid.

Some of the policy areas relevant to these risks, such as international development and defence, are reserved (shown with a * below). Other areas, such as food supply and safety policies are devolved to Northern Ireland. In any case, cooperation within the UK, as well as with other countries, is key to managing these risks.

Table NI14. International dimensions of risk

Risk/opportunity (reference to relevant section(s) of CCRA Evidence Report)	More action needed	Research priority	Sustain current action	Watching brief	Rationale for score
It1: Risks from weather-related shocks to international food production and trade (7.2)	UK				At the present, there is no co-ordinated national approach to ensure the resilience of the UK food system. Coordinated approaches require broad participation across policy, industry and research.
It2: Imported food safety risks (7.2)		UK*			There is a gap in surveillance systems to monitor food safety at source and through complex international supply chains.
It3: Risks and opportunities from long-term, climate-related changes in global food production (7.2)		UK			The UK may increase its comparative advantage in specific areas of agricultural production in the future. Trends in global agricultural production and consumption need further monitoring and assessment.
It4: Risks to the UK from climate-related international human displacements (7.3)	UK*				A more proactive strategy to work in partnership with other countries is needed to provide rapid legal and basic assistance to migrants and to build long-term resilience in exposed regions. Otherwise overseas development efforts will increasingly be diverted to provide humanitarian (i.e. emergency) aid.
It5: Risks to the UK from international violent conflict (7.4)		UK*			Further evidence is needed to understand the appropriate balance between long-term development aid (resilience building, disaster risk reduction, state stability) and responsive interventions (peace-keeping, humanitarian aid).
It6: Risks to international law and governance (7.4)		UK*			There is a lack of systematic monitoring and strategic planning to address the potential for breakdown in foreign national and international governance and inter-state rivalry, caused by shortages in resources that are sensitive to climate change.
It7: Opportunities from changes in international trade routes (7.4)				UK*	Potential changes in trade routes are already being assessed and the issue should continue to be monitored.

It1: Risks from weather-related shocks to international food production and trade

Current and future risks

Food security encompasses availability, price and access to a healthy diet. The key issue surrounding food security in Northern Ireland, as for the rest of the UK, is not an absence of food, but issues related to price and trade. Food price spikes affect affordability and access to nutritious food for lower income households, and the farming sector through feed prices. The issues of food price volatility are already high on policy agendas following, for example, global food price surges in 2008 and 2010. Of the 20 years from the end of 1992 to 2012, eight showed a globally significant major production loss associated with one or more extreme weather events (high magnitude, medium confidence). Changing patterns of weather, especially extreme weather, are likely to increasingly impact on global food production. The increasing global interconnectedness of food systems via trade increases the susceptibility of the food system to propagation and amplification of weather-related production shocks via price volatility. It is very difficult to quantify these effects due to the myriad of influencing factors, but as the risks are of medium magnitude now, without additional action they are projected to be high in the future. The profile of international trade will amplify underlying climate risks, since trade represents only a small part of total production, and major trade is restricted to a small number of large producing countries. This is also relevant to business in Northern Ireland, as the agri-food sector sells over 70% of its produce in external markets. Thus events in the global market could potentially impact on local sectors.

Adaptation

Domestic food production and manufacturing are devolved policy areas while overarching goals on UK-wide food security are reserved. As such, the resilience of the food system in Northern Ireland also depends on UK-wide policies. As discussed in Chapter 7 of the Evidence Report, the UK Government does not have an explicit policy on addressing the resilience of the food system that encompasses both international and domestic production. The UK Government monitors volatility of food prices, but it is unclear how these data are used for strategic, forward planning. Relying of market forces alone to manage price volatility works under "normal" conditions, but unprecedented events affecting a country abroad, coupled with over-compensatory market responses from other countries, can amplify shocks that propagate globally. Climate change is likely to increase the occurrence of these 'unprecedented' events, and the market is not likely to bear the costs of adapting without an immediate impact on prices.

These adaptation shortfalls at the UK level also impact Northern Ireland. In recognition of the importance of the agri-food industry to the NI economy the last Programme for Government (and Economic Strategy) created an Agri-Food Strategy Board (AFSB) in 2012. The AFSB published its report (Going for Growth) in 2013 and the NI Executive published its Response in October 2014. This strategy is mostly focused on domestic production. The strategy partially overcomes the shortfall of excessive reliance on the market by including an explicit recognition of the role of Government, calling for greater government intervention in areas such as the identification of best practice for efficient production in relevant sectors and the development of strategic regional land management policies to determine the most productive use of land, through the development of a Sustainable Land Management Strategy. The strategy also recognises the potential benefits of linking food security and health.

Urgency score

More action needed - There is no food security strategy at Northern Ireland or UK level that links domestic and international food production and imports. There also are multiple benefits to the economy from improved management of knowledge to tackle the systemic vulnerability of the food system (e.g. resilient to climate and non-climate shocks), and from improving the functioning of international trade and markets (trade possibilities, building in-country sustainability of production, with long term benefits). Many of these benefits require international co-ordination with EU countries and the WTO.

It2: Imported food safety risks

Current and future risks

Food quality and safety can be directly affected by disease, toxicity and substitution if prices rise following a production shock. There is a lack of evidence specific to Northern Ireland for this risk. At the UK level, climate change impacts could amplify existing quality and safety issues within supply chains. Risks include environmental contamination associated with increased flooding, increased pesticide use in response to new and emerging pests or diseases, and transmission of disease and toxicity through food.

Foodborne pathogens, such as salmonella, and their associated diseases are more prevalent in higher ambient temperatures. While these risks are global, the interaction with supply chains represents an increasing level of imported risk to the UK. The risks in a 4ºC world are significantly greater than those in a 2ºC world.

Mycotoxin risks are likely to increase with temperature and water stress during growth of major cereal crops. Approximately a quarter of the global annual maize crop is contaminated and the toxins have been detected in cereal-based foods. These risks are often managed by temporary import restrictions, disrupting international trade and cereal availability.

There is insufficient evidence to assign magnitude categories to the level of current and future risk for imported salmonella and mycotoxin (unknown magnitude, low confidence). Other disease outbreaks within the food chain have caused significant damages in the past. For example, the direct cost of the 2001 outbreak of foot and mouth disease in the UK was $1.6 billion in compensation to farmers (source: Lloyd's); the return period of an outbreak of foot and mouth disease is estimated to be about 1:15 years.

Adaptation

Actions being undertaken in Northern Ireland to help managing this risk include active participation in the Defra Veterinary Risk Group (VRG), which monitors world-wide disease risks that may have implications for the United Kingdom. Northern Ireland operates portal controls to manage access, post-movement quarantine and disease testing, active and passive animal health surveillance. DAERA also engages farmers, Private Veterinary Practitioners (PVP), the Ulster farmers Union and other industry to build capacity among stakeholders. The Department also has active (as required by legislation) and passive (samples submitted by PVPs) systems to monitor emerging disease or the occurrence of any notifiable disease threat. NI has Contingency Plans to deal with the event of heightened risk or outbreak. The Department of Agriculture has an Animal and Public Health Information System, consisting of an informatics animal traceability system which will be further strengthened with the adoption of electronic identification tagging.

A collaboration of businesses (Food Fortress) has been established by the animal feed industry in conjunction with the Institute for Global Food Security at Queen's University Belfast. This collaboration aims to improving the safety and security of the Food Chain. It now covers 100% of the feed produced by NI's commercial compounders.

Both government and industry fund research on food safety. For example, the Agri-Food Quest Competence Centre, a membership-based, industry-led Innovation Centre, provides a platform for companies to pursue research projects in areas such as packaging, shelf-life, waste minimisation and food security.

Urgency score

Research priority - Identifying elements of supply chains at risk allows targeting to close loopholes in food safety and provide consumer assurance. Other interventions include increased surveillance and prediction, coordinated mechanisms for obtaining rapid expert advice, and maintenance of strategic food stocks. These actions might be carried out by the industry, but the potential risk would justify at least an impact assessment of different options.

It3: Risks and opportunities from long-term, climate-related changes in global food production

Current and future risk

Average, long-term changes in the climate will alter global agricultural systems, affecting production, trade and the sustainability of agriculture in every global region. This will alter the comparative advantage and signals to UK food markets and food production, resulting in a number of risks, depending on the still uncertain trajectories of agriculture in different world regions.

Within Europe, overall yields under a 'business as usual' projection (3.5 degrees of global warming compared to pre-industrial) have been projected to decrease by around 10% by the 2080s. This change is not evenly distributed, however, with Southern Europe experiencing 20% decreases.

Adaptation

As for the rest of the UK, Northern Ireland agriculture could gain a comparative advantage in specific products, relative to the other regions of Europe, notably due to projected yield decline in southern European countries due to water scarcity and high temperatures. At the same time, a strategic approach might be needed to manage potential risks arising from any intensification of Northern Ireland's agriculture. Increased production could have consequences for longer-term soil productivity, landscape and biodiversity, for example. Both the risks and opportunities are potentially high magnitude (low confidence), but quantifications are very scenario-dependent.

Urgency score

Research priority- (at UK level for global trend, at Northern Ireland level for domestic trends). Northern Ireland may have an increased comparative advantage in specific areas of agricultural production in the future. However, this depends on trends in global agricultural production that need further monitoring and assessment; and on the future sustainability of agriculture in Northern Ireland, especially in terms of water and soil resources. Any action that manages

demand at domestic level (e.g. reducing food waste, changing diets) has multiple benefits of reducing the risk of both unsustainable practices and reliance on imports. Many of these actions have clear co-benefits for health, long-term food security and climate change mitigation.

Given high levels of uncertainty concerning long-term comparative advantage and the implications for domestic production and sustainability, there are significant benefits to managing the UK farm sector for systemic resilience to climate change. Resilience is beneficial for avoiding land use and technological lock in.

Other risks

Other risks, although they are listed as urgent, are the responsibility of the UK Government rather than the Northern Ireland Executive. These are described in the Urgency Scoring Tables for Chapter 7 of the Evidence Report. These risks are therefore not reported in detail here but are summarised below.

It4: Risks to the UK from climate-related international human displacements. There is limited evidence that migration movements have been primarily caused by climate change, but widespread evidence that climate change may act as a compounding factor for migration. More action is needed with other EU member states to ensure the policy framework on migration incorporates and anticipates climate change impacts on existing migration flows. For the UK, national and EU level restrictions on regular migration authorised by law and policy is unlikely to reduce flows of international migrants linked to income and wealth inequalities and to effects of conflict or persecution either within or between states, with the risk of people smuggling and trafficking. Therefore continued and further action is needed at the UK and international levels to enhance long term stability and sustainable development overseas. This has multiple benefits: for receiving countries, economies and people, from which the UK economy and trade is also likely to benefit; as well as helping to manage the other risks discussed in this section.

It5: Risks to the UK from international violent conflict. Climate change will likely increase the demand for humanitarian assistance, conflict intervention and peacekeeping. Co-ordination with other countries on building resilience and development in conflict prone countries would bring benefits associated with displacement risks as well as conflict risks. This risk is a research priority, as further evidence is needed to understand the appropriate balance between long-term development aid (resilience building, disaster risk reduction, state stability) and reactive interventions (peace-keeping, humanitarian aid).

It6: Risks to international law and governance. There is a lack of systematic monitoring of the trends and strategic planning to address potential breakdowns in other countries' and international governance, and the threats posed by inter-state rivalry, due to shortages in resources sensitive to climate change. This risk is therefore a research priority at the UK level.

It7: Opportunities from changes in international trade routes. The opening up of Arctic trade routes presents an opportunity for increased trade. However, potential changes in trade routes are already being assessed and the issue should continue to be monitored.

8. Cross-cutting issues

The previous sections summarise the key climate change risks and opportunities for Northern Ireland, based on the urgency of further action to manage these risks now and in the future.

This concluding section builds on the evidence presented in Chapter 8 of the Evidence Report and summarises some of the wider issues that are common to each of the previous sections. These issues are important to consider in order to fully understand the risks from climate change and when developing appropriate adaptation responses.

Interactions among risks

Interactions among risks are important to consider when developing cross-cutting adaptation strategies. CCRA2 does not try to identify the most important interactions among risks, rather it provides a framework to assess these interactions. This framework consists of grouping the CCRA risks based on the impacts that they have on six societal objectives relating to natural capital, water security, food security, wellbeing, economic prosperity and global security.

For example, food security in Northern Ireland is likely to be impacted by increasing constraints to agricultural production from a combination of increased soil erosion (Ne3); the continued loss of soil carbon from intensive agricultural practices (Ne4); and sea level rise (Ne11).

Wellbeing in Northern Ireland can be affected by risks from flooding, for example through impacts on people's physical and mental health and life expectancy, as well as people's living conditions and disposable income, through direct economic damages to properties (PB5). Flooding also impacts on jobs and income through, for example, employers closing business, being forced to change employment conditions, or leaving an area due to unacceptable flood risks (Bu1).

Distributional impacts

The evidence suggests that the effects of climate change on people will be strongly influenced by their social, economic and cultural environment. Low income households are particularly susceptible to climate change impacts, though they might also benefit the most from the positive implications of climate change. Northern Ireland has the highest proportion of properties at risk of flooding that are in deprived areas (27%).This suggests that the distributional impacts of flood damage might be particularly important to consider. However, there has been no recent study assessing the spatial distribution of social vulnerability in Northern Ireland.

Characteristics of businesses can also make local economies more vulnerable: small and medium-sized enterprises (SMEs) are less likely to recover from extreme weather impacts and have a lower adaptive capacity (see Chapter 6). Many SMEs in Northern Ireland have extremely low levels of awareness of climate risk and are poorly resourced to respond. This could be an issue for the economy in Northern Ireland as the country has the highest proportion of SMEs (99.9%) of all UK regions, of which 95% employ fewer than 10 people.

Institutional frameworks for adaptation

There is evidence that the institutional framework for adaptation in the UK has the potential to deliver cross- cutting adaptation action. However, there are obstacles to realise this potential, including: unclear or unmeasurable adaptation policy goals across multiple, correlated risks; a

large number of partners involved in delivering adaptation; the limited alignment between related policy goals (e.g. flood risk management with housing and planning policies); and capacity (including resource) gaps, particularly at the local level.

Adaptive capacity and research gaps

Addressing risks require the capacity to look at them systemically, as well as the knowledge, information, tools and resources to do so. The main research gaps identified by the CCRA for Northern Ireland include:

- Data on the condition of peatlands.
- Possible future land-use changes, impacts on soil conditions and understanding resilient varieties/species and cropping regimes.
- Understanding the scale of the risk to freshwater species from higher water temperatures, and effectiveness of adaptation measures.
- Understanding risks to marine ecosystems.
- Spread of non-native species in terrestrial, freshwater and marine environments in Northern Ireland.
- Evidence to support strategies on riparian woodland creation to provide cooling for sensitive water bodies of high biodiversity and/or cultural importance (e.g. salmon rivers). Further consideration is also needed into the costs and benefits of a possible cold-water species translocation programme
- Wildfire statistics for Northern Ireland.
- Data on the number of bridges at scour risk in the future, and the amount of adaptation underway nationally.
- Understanding the future risk from overheating of buildings.
- Data on the extent of new developments on floodplains.
- Data on uptake of SUDS for new and existing developments.
- Understanding the impact of current and future flood defence spending plans on residual risks.
- Understanding the costs and benefits of adaptation options for different coastal areas, including an assessment of risks for coastal communities exposed to sea level rise.
- Quantitative information on current and future risks for historic buildings and their surroundings, including historic urban greenspaces and gardens.
- Data on current and future risks from wind-driven rain, mould, and damp for different types of buildings in different areas of Northern Ireland (including historic buildings); and on what adaptations are taking place at a national level, and how widespread these are.
- Data on air pollution.

- Disease vector monitoring, and surveillance and research on those diseases posing the biggest risk in the changing climate.
- Understanding impacts of disruption to ICT, power and transport infrastructure which prevents workers accessing premises or working remotely, and the impacts of higher temperatures for employee safety and productivity.

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