UK CLIMATE RISK

UK Climate Risk
Independent Assessment
(CCRA4)

Technical Report

Chapter 8: Land Food and Nature

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8.1 Chapter summary

Land, food and nature encompass our natural environment in all its diversity above and below ground, in freshwater and in the seas surrounding the coastline. This chapter considers the impact of climate change on farmed landscapes, seascapes, as well as natural and semi-natural ecosystems. These systems support biodiversity, interact with agriculture and fisheries, and support the food industry and UK food security. This chapter considers both long term climate change and extreme weather events, which pose risks to land, food and nature systems.

Headlines

- This chapter highlights that More Action, Critical Action and Further Investigation is needed across terrestrial, marine and coastal ecosystems to protect biodiversity in land, coastal and marine, natural and farmed landscapes. Extreme weather events are increasingly threatening the survival of fresh and saltwater environments, key habitats such as peatlands and woodlands, and the productivity of farmed land and seas.
- Risks are already assessed as critical in the present-day, and these are projected to significantly escalate by the middle and end of the century. Major disruption to biodiversity, ecosystem functionality and production yield, quality and viability of crops, livestock and fish is expected.
- Natural carbon stores in the main habitats that can sequester carbon, such as peatlands, saltmarsh and woodlands, are likely to decrease due to climate change. Recent evidence increases confidence that this is also the case for oceans.
- Climate change poses a major and growing threat to UK food security. It can disrupt crop, livestock, and fishery production through extreme weather, drought, and flooding, amplifying other pressures across the food system.
- Climate-driven risks interact with global supply chain dependencies for key inputs, processing, and distribution. This further undermines the stability and resilience of UK food supplies, causing food price inflation which makes a healthy diet less affordable, particularly for vulnerable populations.
- Southern England is particularly at risk from climate change, impacting crops, livestock, and the functional biodiversity needed to support their production.
- Opportunities from climate change for farming ecosystems are minimal. Although some projections indicate that new species of crops could be cultivated in the UK in warmer climates, the recent reality evidenced by increased frequency of extreme weather events means that new crops are just as vulnerable as those currently produced in the UK.
- There are no opportunities for species and ecosystems, since the expansion of any species' ecological niche comes at the cost of others losing their range or habitat. The interconnectedness of the natural world precludes opportunities, as climate change will limit dispersal, contract and fragment habitats, and break down essential interactions among species.
- Evidence gaps exist for the devolved nations, although the picture for the whole of the UK is largely applicable to Scotland, Wales and Northern Ireland. Adaptation strategies developed to date are insufficient to drive the More Action Needed and Critical Action Needed to support land, food and nature.

Extreme weather events are causing damage to natural and farmed ecosystems (N1 – N8). The impacts are exacerbated by poor land and water management and a lack of biodiversity protection. Risks are expected to increase by the end of the century with critical impacts on the integrity of ecosystems.

Climate change risks to terrestrial, marine and coastal ecosystems are major (N1 – N8). Species' survival is threatened now and in the future. Climate change alters the ranges they can occupy and shifts the lifecycles of interacting species. For example, flowering times are becoming earlier, while pollinators are not appearing at the same time. This reduces plant reproduction and food availability for insects, which in turn affects species higher up the food chain. This mismatch in the timing of events is relevant for all ecosystems.

Recent evidence supports an elevated urgency for climate risks to land, food and nature. Evidence has improved for freshwater (N2), marine (N3) and soil (N4) systems. Risks to terrestrial ecosystems (N1), food (N10), fisheries, aquaculture and farming (N6, N7) were already known, but the frequency and severity of extreme weather events, particularly those happening outside of expected seasons, have made the situation more precarious over the past five years.

Extreme weather events have already led to severe losses in crop harvest, heat stress for livestock, and reduction in forage yields (N6). Recent years have seen records for heatwaves in summer in 2022, flooding in 2023, the wettest autumn/winter in 2023/24 and the driest spring/summer in 2025. This has reduced combinable crop yields in each cycle by 20-33% compared to the previous average, plus large-scale field vegetable losses and forage crop yield reductions of up to 60%. Coastal flooding and erosion are projected to reduce the UK land surface classified as 'high quality farmland' from an average of 38% (1961 to 1990) to 11% by 2050.

There are no credible opportunities for agriculture and fisheries (N9) or species and ecosystems (N1) arising from climate change. Although modelling suggest that the UK might be suitable for growing novel crops like soybean, this does not stand up to scrutiny. Novel species may be impacted by the same extreme weather, soil degradation, and loss of pollinators already threatening existing crops. Climate change risks to these interacting elements are severe and therefore new crops are no more viable than existing ones. The reduction of land area suitable for farming (because of climate change) creates further pressures, and displacement of existing crops by new alternatives simply shifts the pressure points in UK's food system. Similarly, shifting species ranges, food chain mismatches, and rising pest and disease risks (N7) eliminate potential benefits for fisheries or wildlife, as incoming species often displace natives, disrupting ecosystems and reducing resilience.

Interactions between species, ecosystems, and food systems, plus factors outside of climate change, lead to increased severity of risk. The natural world operates across borders and is shaped by global trade and environmental change. This means that climate impacts on one ecosystem can trigger cascading effects across others, leading to broader food system shocks. Thus, risks to ecosystems, land and food cannot be understood in isolation.

Climate change related risks disproportionally affect vulnerable populations. Vulnerability is usually associated with the interactions from external hazards, whether that is ecosystem pollution affecting nature (N1 – N8) or poverty affecting human populations (N10). Vulnerable populations, both human and species, are less able to adapt or mitigate the impact of climate change since their ability to respond to external system shocks is already compromised.

Table 8.1: List of risks and urgency scores for Land Food and Nature by country. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI= Critical Investigation. MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action.

ID	Risk		Present	2030	2050	2080	Urgency
N1	Risks to terrestrial and coastal ecosystems	**UK**	+++ (H)	+ (H)	+ (H)	++ (VH)	CI
		England	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	+++ (H)	+ (H)	+ (H)	+ (VH)	CI
		Scotland	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
N2	Risks to freshwater ecosystems	**UK**	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		England	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Scotland	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
N3	Risks to marine ecosystems	**UK**	++ (M)	++ (H)	++ (H)	++ (VH)	MAN
		England	++ (M)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	++ (M)	++ (H)	++ (H)	++ (VH)	MAN
		Scotland	++ (M)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	++ (M)	++ (H)	++ (H)	++ (VH)	MAN
N4	Risks to soil ecosystems	**UK**	+++ (M)	++ (M)	+ (H)	+ (H)	CI
		England	+++ (M)	++ (M)	+ (H)	+ (H)	CI
		Northern Ireland	++ (M)	++ (M)	+ (H)	+ (H)	CI
		Scotland	+++ (M)	++ (M)	+ (H)	+ (H)	CI
		Wales	+++ (M)	++ (M)	+ (H)	+ (H)	CI
N5		**UK**	+++ (H)	+ (H)	+ (H)	++ (VH)	CI
		England	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN

	Risks to natural carbon stores and sequestration	Northern Ireland	+++ (H)	+ (H)	+ (H)	+ (VH)	CI
		Scotland	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
N6	Risks to agriculture	**UK**	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		England	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Scotland	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
N7	Risks to fisheries and aquaculture	**UK**	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		England	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Scotland	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
N8	Risks to forestry	**UK**	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		England	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	++ (L)	++ (L)	++ (L)	++ (M)	SCA
		Scotland	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	++ (M)	++ (M)	++ (M)	++ (H)	MAN
N9	Opportunities for agriculture, fisheries, aquaculture and forestry	**UK**	+ (L)	+ (L)	+ (L)	+ (L)	FI
		England	+ (L)	+ (L)	+ (L)	+ (L)	FI
		Northern Ireland	+ (L)	+ (L)	+ (L)	+ (L)	FI
		Scotland	+ (L)	+ (L)	+ (L)	+ (L)	FI
		Wales	+ (L)	+ (L)	+ (L)	+ (L)	FI
N10	Risks to food security	**UK**	++ (H)	++ (VH)	++ (VH)	+ (VH)	CAN
		England	++ (H)	++ (VH)	++ (VH)	+ (VH)	CAN

	Northern Ireland	++ (H)	++ (VH)	++ (VH)	+ (VH)	CAN
	Scotland	++ (H)	++ (VH)	++ (VH)	+ (VH)	CAN
	Wales	++ (H)	++ (VH)	++ (VH)	+ (VH)	CAN

8.2 Risk to Land Food and Nature

8.2.1 Risk to terrestrial and coastal ecosystems – N1

Climate change is causing and accelerating the decline of the UK's ecosystems (Burns et al., 2023). Rising temperatures, extreme weather, and sea-level rise are damaging habitats, reducing biodiversity, and threatening the provision of ecosystem services. Without stronger adaptation action, widespread ecosystem loss and disruptions are likely to occur within decades.

Headlines

- Climate change is reducing the extent, diversity, and function of terrestrial and coastal ecosystems, with observable shifts in species distributions and sharp declines in the health of key habitats.
- There are no opportunities for ecosystems and species from climate change. Adaptation should focus on reducing risks and helping species adjust through actions like assisted colonisation, improved ecological connectivity, and restoring or creating habitats that allow ecosystems to move and adapt.
- Without effective and systemic adaptation, risks to ecosystem integrity and service provision are projected to increase substantially by the end of the century.
- Ecosystem degradation due to climate change has cascading impacts on agricultural production, particularly through impacts on pollination, soil fertility, and flood regulation.

Table 8.2: Urgency scores for N1 Risks to terrestrial and coastal ecosystems. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

ID	Risk		Present	2030	2050	2080	Urgency
N1	Risks to terrestrial and coastal ecosystems	**UK**	+++ (H)	+ (H)	+ (H)	++ (VH)	CI
		England	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	+++ (H)	+ (H)	+ (H)	+ (VH)	CI
		Scotland	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN

8.2.1.1 Evidence relevant to the entire United Kingdom

Current and future drivers of risk

New research has strengthened our understanding of climate risks to ecosystems. This report builds on the previous Climate Change Risk Assessment Technical Report, CCRA3-IA-TR by assessing new findings. Ecological risks are evaluated at a Across the UK scale, with the level of risk scored as high across the country. This national assessment is essential as impacts on ecosystems occur across wide geographic areas and cannot be captured through isolated local assessments. The level of preparedness is assessed both at UK and nation level.

The UK's terrestrial and coastal ecosystems are affected by hazards such as rising temperatures, droughts, wildfires, sea-level rise, and extreme weather events. These can damage habitats, disrupt species interactions and migration, as well as reduce biodiversity which, weakens food webs and nature's ability to provide ecosystem services like carbon storage, water regulation, and fertile soils (Environment Agency, 2023).

Many habitats and ecosystems are vulnerable to climate change. Upland, freshwater, wetland, and coastal National Nature Reserves are considered among the most vulnerable (Duffield et al., 2021; 2024; Taylor et al., 2022), particularly if they are already degraded (Staddon et al., 2023). The species living in these habitats are potentially vulnerable to climate change, both directly and indirectly because of the impacts of climate change on those habitats (Duffield et al., 2024).

Climate change amplifies existing ecological stressors, particularly where ecosystems have already been fragmented, degraded, or isolated. Land use intensification, urban sprawl, and infrastructure development disrupt natural migration pathways and limit adaptive capacity (Lenoir et al., 2020). Hard coastal defences and poorly planned developments reduce the availability of climate refugia (areas that provide relatively stable environmental conditions, allowing species, ecosystems, or ecological communities to persist during changing climatic periods) and hinder inland movement of ecosystems such as saltmarshes and dune systems (Burden et al., 2020).

Assessment of current magnitude of risk

The UK is under a continued decline in plants and animals due to climate change and other human pressures, which in turn increases vulnerability to climate hazards (Burns et al, 2023). Examples include many species of lichens that have lost habitat due to increasingly dry conditions, along with pollution, and changes in land use, resulting in competition with certain mosses (bryophytes). Lichens are key components of many habitats and contribute to nutrient cycling, provide habitat for various species and, act as bioindicators of air quality (Packeman et al., 2022). Similarly, cold-adapted animal species in Special Protection Sites, such as the merlin (*Falco columbarius*) and golden plover (*Pluvialis apricaria*), are already declining due to warmer temperatures, affecting ecosystem's health (Duffield et al., 2024).

As climate changes, important ecological processes are happening earlier or later in the year. Flowering now occurs on average a month earlier than 30 years ago (Buntgen et al., 2022). Bees become active around a week earlier per every 1 °C rise in temperature (Wyver et al., 2023). Despite their £600 million annual contribution to UK crops, pollinators are in decline due to climate change and other human pressures, which exacerbates risks to food production (Breeze et al., 2021; Murphy et al., 2022).

Plants and animals are shifting their ranges in response to climate change (Quezia et al., 2023). Birds, butterflies, and plants are among the species moving northward, with insects showing the largest range (Montràs-Janer et al, 2024; Olsen et al., 2022; Bybee et al., 2016). In Britain, dragonflies are expanding north more successfully than damselflies, as not all species are equally able to adapt or move (O'Neill et al., 2023). Some plant and animal communities are becoming more alike due to climate and land-use change. This trend, observed in pollinators, birds, butterflies, and plants, reduces ecosystems' ability to adapt to future climate shifts (Vasiliev & Greenwood, 2021). These pressures are leading to warmer-adapted and more uniform species communities over both the short (20 years) and long term (50+ years), despite local increases in species richness. Semi-natural grasslands (e.g., meadows, pastures, heathlands, and open wetlands) show lower rates of biodiversity change and support more distinct communities than all other natural and managed ecosystems. Their contribution to national biodiversity has doubled over time, highlighting their role in maintaining ecological resilience (Montràs-Janer et al., 2024).

Climate change is reducing ecosystems’ resilience by affecting natural processes. In woodlands, warmer temperatures are affecting the seed cycles of beech trees, making regeneration harder (Foest et al., 2024). Dry heaths and blanket bogs face growing wildfire threats due to drier conditions, causing high biodiversity loss (Naszarkowski et al., 2024; Davies et al., 2023a). Combined with poor land management, fires lead to long-term damage of key species like Sphagnum moss, that fails to recover while other native species take over, reducing carbon storage, water regulation and soil retention (Kelly et al., 2023).

Rising sea levels and droughts can degrade coastal ecosystems. Saltmarshes are lost to the sea where their inland movement is blocked by seawalls, dune slacks (low-lying areas within dune systems that are seasonally flooded) have dried by 30% in protected sites (Burden et al., 2020), and coastal birds face population declines due to habitat loss, shifting prey, and extreme weather (Burton et al., 2023; Davies et al., 2023b).

Some invertebrates and seaweeds in rocky shores have been declining since 2002 due to winter warming and storm impacts, such as barnacle losses from shingle scouring in extreme weather. Sea snails and limpets are expanding their ranges, as warmer waters favour warm-adapted species. By 2021, 14 non-native invertebrate and algae species were recorded on Welsh shores (Mieszkowska et al., 2021).

Invasive species are a risk to UK ecosystems as many thrive under climate change. Economic costs of invasive species to the biodiversity conservation sector exceeded £37 million in 2021 without including the potential impacts from climate change (Eschen et al, 2023).

The combined effects of climate change and nature loss could significantly impact the UK economy, potentially resulting in GDP losses equivalent to several years of growth (Ranger et al., 2024). While climate change affects ecosystems directly, degraded ecosystems heighten the risk and severity of acute climate shocks, amplifying their economic consequences. Under acute shock conditions, these combined impacts could reduce UK GDP by up to 8%, with peak losses of around £200 billion. These shocks could persist for several quarters, amounting to the equivalent of 4 to 7 years of lost economic growth (Ranger et al., 2024).

The current magnitude of the risk is therefore assessed as High for all UK nations due to major impacts (approximately 10% or more at national level) to valued habitats and landscapes, and major impact on or loss of species groups.

Assessment of future magnitude of risk

By 2030s, major risks to highly degraded and modified land ecosystems are expected from droughts and fires. The impacts on forests are projected to be highest in the driest parts of the country in the south and east (Yu et al., 2021; Atkinson et al., 2022). Coastal ecosystems will also face high pressures from warming and invasive or spreading native species. Plants, such as ice plant (*Carpobrotus edulis*) and common cord-grass (*Spartina anglica*) might spread coastal cliffs and saltmarshes in the south of the country, respectively. These will then outcompete native species and potentially chang the ecosystem negatively. Combined with rising erosion and flooding hazards, these pressures will reduce coastal resilience and affect nearby communities (Burden et al, 2020).

By the 2050s, UK national nature reserves will likely face significant climate risks, with around 95% exposed to hotter summers, especially in southern England, where temperatures may rise by over 1.5 °C (Brown & Hall, 2022). About half of these areas are expected to experience lower river flows and increased wildfire risk, putting additional stress on wildlife and habitats, particularly when multiple hazards occur simultaneously. Rising temperatures may also reduce earthworm populations in southern reserves, threatening soil health and nutrient cycling (Zeiss et al., 2023). Intensifying droughts will impact wetlands and temperate rainforests, especially in eastern Scotland and in autumn. Although some wetlands are resilient, many lie in drought-prone zones. Temperate rainforests, while less exposed, are more sensitive to drought and face risks to carbon storage, tree reproduction, and plant diversity (Kirkpatrick Baird et al., 2023).

Coastal ecosystems will also face major risks by the 2050s. Around 6 km^2 of Site of Special Scientific Interest (SSSIs) are likely to be threatened by coastal erosion, endangering habitats, biodiversity, and ecosystem services (Environment Agency, 2024). In southern England, wetlands and coastal sites will be highly affected, with over 50% and 75% of site features at risk under central and high emission scenarios, respectively (Parrish et al., 2023). While these figures highlight risks to protected areas, they likely underestimate the full scale of damage, as coastal habitats also lie outside designated sites. At the same time, UK seabirds such as puffins, storm petrels, and Arctic skuas could decline by up to 80% due to warming seas (Davies et al., 2021), while sea-level rise and extreme weather pose additional risks to ground-nesting birds in low-lying coastal zones (Pearce-Higgins et al., 2021).

By the 2080s, in the absence of ambitious adaptation, the UK faces the potential for irreversible loss of ecosystem function and resilience in different landscapes and habitats. Widespread drying, warming, and extreme events could lead to thresholds being crossed, particularly in upland peatlands, temperate rainforests, coastal wetlands, and dry heathlands (Yu et al., 2021; Zani et al., 2020; Ritson et al., 2025, Jenkins et al., 2025). These changes may trigger abrupt regime shifts, undermining the carbon storage, water retention, and biodiversity value of these systems. Under high emissions scenarios, ecosystem collapse (when an ecosystem becomes so damaged that it can no longer support life or natural processes) in vulnerable areas cannot be ruled out, with profound implications for human and non-human life (Jenkins et al., 2024).

In the same period, declining dune water tables and more intense storms will likely reshape coastlines, whilst increase flood vulnerability and reduce habitat (Burden et al., 2020; Dobson et al., 2020). Warmer waters are expected to boost the invasive Pacific oyster (*Crassostrea gigas*) populations, harming native habitats (King et al., 2020).

The future magnitude of the risk is therefore assessed as High for the UK in the 2030s and 2050s due to major impacts (approximately 10% or more at national level) to valued habitats and landscapes. Major impacts on or loss of species groups (approximately 20% or more at national level) increases the magnitude to Very High in the 2080s, in both central and high scenarios.

Level of preparedness for risk

The UK is one of the most nature depleted countries on earth; increasing its exposure to climate impacts (Burns et al., 2023). When ecosystems are degraded and/or lost, the ability to absorb and adapt to climate stressors (e.g., floods, droughts, and heatwaves) is greatly reduced, leaving people, food systems, and economies more vulnerable. While the importance of integrating climate adaptation into conservation policy is increasingly recognised, implementation remains piecemeal, reactive, and under-resourced. Adaptation actions remain limited to protected areas and lack the spatial scale or systemic integration needed to address landscape-wide risks. There is limited uptake of dynamic, forward-looking approaches, including carefully implemented nature-based solutions, adaptive management, connectivity-focused planning, and anticipatory relocation of key habitats or species. Crucially, adaptation remains decoupled from broader agricultural, coastal, and development policy levers that shape ecosystem exposure and vulnerability. Additionally, current sectorial targets for nature protection and restoration do not build in climate risk (CCC, 2023; OEP, 2025).

Assessment on the evidence base and evidence gaps

Over the past 30 years, there has been strong evidence of climate impacts to UK ecosystems. However, key knowledge gaps remain, especially for soil microbial response to compound droughts and other climate hazards, peatland hydrology monitoring, responses of wildlife with limited ranges to increasing temperatures and compounding hazards, climate risks to under-researched coastal habitats, and the effects of interacting climate risks (Bardgett & Caruso, 2020). While the theory of adaptation is well established, there is limited monitoring and assessment of how cost-effective adaptation measures will be and a lack of understanding how much change in landscape connectivity would provide an acceptable level of adaptive capacity for species to move and colonise (Duffield et al., 2024).

Gaps exist in the current understanding of opportunities to species and ecosystems from climate change. More understanding is needed to properly address this and avoid maladaptation.

8.2.1.2 England

Current and future magnitude of risk

This section includes England-specific evidence but should be read with the Across the UK assessment for a full understanding of climate risks affecting this nation.

England's upland, freshwater, wetland, and coastal National Nature Reserves are highly vulnerable to rising temperatures, altered rainfall patterns, and extreme weather, with cold-adapted upland birds already declining in Special Protection Sites (Duffield et al., 2021; 2024). By the 2050s, major climate risks are projected to impact protected land and coastal ecosystems, particularly wetland and coastal SSSIs. Under central and high scenarios increased heat stress, disrupted breeding, invasive species spread, more winter flooding, and summer droughts, will degrade water quality and harm wildlife (Parish et al., 2023). In the Fens, increased flooding, biodiversity loss, and reduced water availability for farming are expected by the 2050s, escalating to projected ecosystem collapse by the 2080s, with sharp declines in pollinators, crop yields, and over half of species threatened by climate change.

Level of preparedness

Climate adaptation policies for England's ecosystems are still limited, with most actions focused on individual species or habitats and lacking integration of climate risks. Small, isolated reserves remain highly vulnerable, highlighting the need for a connected, landscape-scale approach. Implementation is often unclear, and long-term monitoring remains limited (CCC, 2025).

Recent policies on adaptation include current National Adaptation Programme (NAP3), promoting agroforestry, flood management, and soil health. The Local Nature Recovery Strategies are limited to providing guidance for including climate change (Defra, 2023). Environmental Land Management Schemes provide limited farm-level options, while the Landscape Recovery Scheme offers greater potential for large-scale restoration, but its weak focus on adaptation risks its delivery (Defra, 2023). Since 2024, SSSIs include climate risk in assessments, with high-risk sites set to receive Adaptive Delivery Plans from 2025/26. National Nature Reserves are moving towards more flexible management approaches (Duffield et al., 2023).

Evaluation of urgency score

More action needed as the scale and pace of current responses in England are not commensurate with the magnitude or trajectory of climate risk. Although recent strategies such as the Environmental Land Management Schemes and the NAP3 acknowledge climate risks, they fall short on actionable mechanisms, spatial targeting, and outcome monitoring. There is limited evidence of risk reduction or resilience building at ecosystem scale. Given projected climate impacts, and the current state of many degraded ecosystems, more coordinated action is required now to avoid irreversible loss of ecological function and escalating risks to people and economies. The score is given with Medium confidence for future scenarios, reflecting limited evidence on future adaptation but strong expert agreement on the magnitude of climate risks.

Table 8.3: Urgency scores for N1 Risks to terrestrial and coastal ecosystems for England. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

England								
N1 Risks to terrestrial and coastal ecosystems.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.1.3 Northern Ireland

Current and future magnitude of risk

This section includes Northern Ireland-specific evidence but should be read with the Across the UK assessment for a full understanding of climate risks affecting this nation.

Wildfires are severely affecting Northern Ireland's upland peatlands due to rising temperatures, drought, and poor land management. Fires can cause long-term damage to peatlands, with no recovery of vital species like Sphagnum moss, weakening the peatland's ability to store carbon, regulate water, and retain soil (Kelly et al, 2023).

Level of preparedness

Climate adaptation policies for land and coastal ecosystems in Northern Ireland are insufficient (CCC, 2023). The Third Northern Ireland Climate Change Adaptation Programme (2024–2029) (NICCAP3) is being developed by the Department of Agriculture, Environment and Rural Affairs (DAERA). The previous version aimed to strengthen nature's resilience by improving habitats, species, and soils. While over half of its targets showed good progress, there is no evidence of its effectiveness. Sector-specific policies, such as the Northern Ireland Biodiversity Strategy (2021-2030) and the Environmental Improvement Plan (2024), support climate adaptation, but progress and effectiveness remain unclear.

Evaluation of urgency score

Critical Investigation is needed due to High and Very High magnitude of risks based mostly on evidence from the entire UK and few nation-specific studies. Northern Ireland has insufficient policies to maintain or reduce current risks. Reducing risks will require strong resilience-focused planning. The score is given with Low confidence, reflecting little evidence on the magnitude of risks specific to this nation or no evidence on future adaptation but good expert agreement.

Table 8.4: Urgency scores for N1 Risks to terrestrial and coastal ecosystems for Northern Ireland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Northern Ireland								
N1	Risks to terrestrial and coastal ecosystems.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	+ (H)	+ (H)	+ (H)	+ (H)	+ (H)	+ (VH)	+ (VH)
With adaptation	+++ (H)	+ (H)	+ (H)	+ (H)	+ (H)	+ (H)	+ (VH)	+ (VH)
Urgency scores	MAN	CI		CI			FI	
Overall urgency score	CI							

8.2.1.4 Scotland

Current and future magnitude of risk

This section includes Scotland-specific evidence but should be read with the Across the UK assessment for a full understanding of climate risks affecting this nation.

Despite Scotland's wet climate, drought is emerging as a major climate threat. Wildfires are and will continue to affect highly sensitive heathlands and blanket bogs. Fires lead to greater biodiversity loss in dry heaths than in wetter habitats like bogs (Naszarkowski et al., 2024; Davies et al., 2023). Similarly, species of lichens have lost habitat due to increasing drier conditions (Packerman et al., 2022). By the 2050s, more intense droughts will affect wetlands and temperate rainforests (Kirkpatrick Baird et al, 2023).

Level of preparedness

Adaptation policies for Scotland's ecosystems are limited but reflect an emerging vision for resilience (CCC, 2023). Recent strategies promote integrated landscape-scale approaches, yet lack detail, clear implementation plans, and robust monitoring. The Scottish Climate Adaptation Plan (2024–2029) emphasises resilience through well-connected nature networks, supported by the National Planning Framework 4 and the Scottish Biodiversity Strategy to 2045. While these frameworks set a strong strategic direction, most remain high-level, with delivery plans still pending. Nature Networks aim to enhance ecological connectivity, but on-the-ground implementation is still in the early stages. Adaptation goals are increasingly integrated across strategies, but concrete actions remain limited.

Evaluation of urgency score

More Action Needed due to the High and Very High magnitude of the risks and limited responses. While policies in Scotland are focusing on more integrated approaches to address climate risks to terrestrial and coastal ecosystems, there is little evidence of effective adaptation or sufficient non-governmental action to maintain or reduce current risk levels. The score is given with medium confidence, reflecting limited evidence on future adaptation but strong expert agreement.

Table 8.5: Urgency scores for N1 Risks to terrestrial and coastal ecosystems for Scotland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Scotland								
N1	Risks to terrestrial and coastal ecosystems.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.1.5 Wales

Current and future magnitude of risk

This section includes Wales-specific evidence but should be read with the Across the UK assessment for a full understanding of climate risks affecting this nation.

Climate change is reshaping rocky shore ecosystems in Wales, with key invertebrate and seaweed species declining since 2002. Cold-affinity species are most affected, and storm events have caused barnacle losses from shingle scouring in North Wales (Mieszkowska et al., 2021). Barnacle species are shifting ranges and warm-adapted and non-native species are expanding, with 14 new invertebrate and macroalgae species recorded in 2021 (Mieszkowska et al., 2021). No information on future climate-related impacts on terrestrial ecosystems is available specifically for Wales.

Level of preparedness

Adaptation policies for land and coastal ecosystems in Wales remain limited, with key gaps such as the lack of statutory biodiversity targets and an unclear agricultural framework weakening accountability and coherence (CCC, 2023). The 2024 Climate Adaptation Strategy introduces a systems-based approach focused on resilience, nature-based solutions, and ecological connectivity, but implementation is still at an early stage. Peatland and Woodland Strategies are in place, targeting peatland restoration and support for native woodlands, alongside pest and disease monitoring. The proposed Sustainable Farming Scheme may support adaptation but lacks detail, while the 2020 Flood and Coastal Strategy promotes nature-based solutions but relies on voluntary coordination. Overall, while fragmented progress and missing legal commitments limit current policy effectiveness, recent strategies reflect an emerging vision for resilience.

Evaluation of urgency score

More Action Needed due to the High and Very High magnitude of the risks and limited responses. While policies in Wales acknowledge risks to terrestrial and coastal ecosystems, there is little evidence of effective adaptation or sufficient non-governmental action to maintain or reduce current risk levels. Reducing risks will require wider and coherent resilience-focused policies across sectors. The score is given with Medium confidence, reflecting limited evidence on future adaptation but strong expert agreement.

Table 8.6: Urgency scores for N1 Risks to terrestrial and coastal ecosystems for Wales. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Wales								
N1 Risks to terrestrial and coastal ecosystems.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.2 Risk to freshwater ecosystems – N2

This chapter assesses climate change risks to UK freshwater ecosystems, focusing on biodiversity, ecological function, and key services (e.g., water purification, flood regulation, and carbon cycling). Freshwater ecosystems, comprising of open waters, wetlands, and floodplains, supply water for domestic, industrial, and agricultural use, hydropower, and navigation. They also support diverse habitats; regulate carbon, hydrological flows, and pollution; contribute to flood protection; and provide cultural, recreational, and educational services. In 2015, these assets were valued at about £37 billion (ONS, 2015).

UK freshwaters face intense pressure from historic degradation, including drainage for land-use change, river modification, agricultural runoff, sewage discharges, and invasive species. The chemical and ecological condition of rivers is poor, with The Rivers Trust (2024) reporting that no river in England or Northern Ireland is in good overall ecological health.

Climate change, through rising air temperatures, altered precipitation patterns, and more extreme events, may worsen conditions both directly (affecting flows and water temperature) and indirectly (interacting with other stressors). Without urgent action, biodiversity, ecological function, and ecosystem services will decline further. Chalk streams in England, due to their global rarity, are of particular concern.

Headlines

- Freshwater ecosystems are threatened by climate change and other non-climatic stressors (e.g., land-use, pollution and invasive species). These human-driven pressures are also exacerbated by climate change impacts on hydrology, including reduced summer flows, higher temperatures and more intense rainfall events.
- Hydrology-climate-ecology interactions are degrading water quality, habitat availability and ecosystem resilience. More action on immediate and comprehensive climate change adaptation measures is required to avoid irreversible biodiversity and ecosystem service losses.
- Climate-based risks are projected to significantly increase by 2080 under high warming scenarios, causing major disruption to freshwater biodiversity and ecosystem function. This risk is higher where catchments already face multiple non-climatic stressors and where adaptation measures are not fully implemented.
- There is limited evidence on the long-term effectiveness of adaptation strategies at catchment scale, and many future risk assessments still rely heavily only on expert judgment rather than models accounting for multiple stressors.
- Improved long-term monitoring, scenario modelling and evaluation of nature-based interventions are urgently needed.

Table 8.7: Urgency scores for N2 Risks to freshwater ecosystems. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

ID	Risk		Present	2030	2050	2080	Urgency
N2		UK	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN

	Risks to freshwater ecosystems	England	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Scotland	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN

8.2.2.1 Evidence relevant to the entire United Kingdom

Current and future drivers of risk

Freshwater ecosystems face escalating risks driven by environmental, social, and policy pressures. These risks interact through changes in hazard, exposure, and vulnerability and are intensified by climate change (Sinclair et al., 2024; Sarremejane et al., 2024). Long-term degradation has resulted from agricultural intensification, urban growth, land drainage, channel modification, water abstraction, pollution, and invasive species. While improvements have occurred up to 2010 through habitat restoration, better water management, and EU policies such as the Urban Wastewater Treatment Directive (91/271/EEC) and Water Framework Directive (2000/60/EC), progress has since stalled (Qu et al., 2023; Haase et al., 2023).

The most recent UK Climate Projections (UKCP18) show all UK regions warming, especially in summer, with wetter winters, drier summers, and more frequent and intense summer rainfall events (Met Office, 2022). In England, river temperatures are expected to rise by approximately 0.3 °C per decade from 1981–2005 levels to 2070–2079 under a high emissions scenario (RCP 8.5) (Environment Agency, 2025). This in turn, increases drought risk. Freshwater ecosystems are highly sensitive to such changes, as key processes like oxygenation, nutrient cycling, and hydrological connectivity depend on temperature and flow (Capon et al., 2021; Jane et al., 2021; Woolway et al., 2022). Climate change acts as a threat multiplier, with altered flow regimes degrading habitat stability, warming intensifying water stratification and oxygen loss, and extreme rainfall driving sediment, nutrient, and pollutant runoff. These impacts interact with existing pressures, such as channel modification, drainage, abstraction, habitat fragmentation, pollution, and invasive species, creating complex, compounding risks across the four nations.

Assessment of current magnitude of risk

Current risks to freshwater ecosystems are assessed as High across the UK, including all devolved nations, based on strong empirical evidence of warming waters, declining water quality, and biological disruption (Macadam et al. 2022; Sinclair et al. 2024; Johnson et al., 2024). UK lakes and rivers are warming at an average rate of 0.3 °C per decade in terms of their minimum annual temperature, leading to increased thermal stratification (Woolway et al., 2019). Scottish lakes are warming even faster than the surrounding air (May et al., 2022). River temperatures in England have a similar rate of warming of approximately 0.3 °C per decade from 1981 to 2005 (Environment Agency, 2025).

Warming in lakes and rivers is disrupting fish and invertebrate communities by altering species distributions, reproductive cycles, and food web dynamics. Iconic cold-water species such as the Artic char (*Salvelinus alpinus*) and brown trout (*Salmo trutta*) have declined due to rising temperatures (Jane et al., 2021; Kelly et al., 2020), while non-native invasive species like signal crayfish (*Pacifastacus leniusculus*) and quagga mussels (*Dreissena rostriformis bugensis*) are spreading, outcompeting natives and altering ecosystem function (Valido et al., 2021). Reduced cold-hardening in freshwater invertebrates limits their tolerance to low temperatures (Smith & Lancaster, 2020). Warming can give invasive fish a thermal advantage over natives, increasing feeding rates and disrupting food web energy balance (Muhawenimana et al., 2021; Nudds et al., 2020; Valido et al., 2020; Barneche et al., 2021), although some invasions may be temporary if predation pressure is restored (Gallardo, 2015). Not all invasives rely on thermal advantage. For example, signal crayfish spread fungal plague, to which it is immune, enabling it to outcompete the native white crayfish. Stocking rates also influence Atlantic salmon (Salmo salar) fry and parr production (juvenile life stages), though these life stages are vulnerable to river flow changes (Glover et al., 2020).

More frequent droughts are intensifying pressures from land drainage, channel modification, and abstraction, leading to greater habitat fragmentation and altered river flow regimes. Low flows, particularly during droughts, increase water residence times, which, along with higher temperatures, promote algal blooms (Bowes et al., 2016) and influence aquatic plant and algal responses to eutrophication (O'Hare et al., 2018; Rippey et al., 2025). Reduced flows, drying of perennial reaches, and higher solar radiation raise water temperatures, causing deoxygenation and loss of cool-water safe spaces for species, which impairs fish reproduction and feeding (Kelly & Kelly, 2024; Environment Agency, 2025). Declines in groundwater inputs, especially in chalk and sandstone catchments, further exacerbate warming effects.

Climate-driven shifts in river flow regimes, intense rainfall alternating with droughts, are accelerating changes in the physical features of the surface of the earth. Higher peak flows favour more bank erosion, sediment scouring and sediment loads, and channel incision (Milan & Schwendel, 2021; Li et al., 2021), reducing habitat diversity, limiting refugia, and disrupting connectivity (Death et al., 2015). Intense rainfall increases nutrient runoff from agriculture and urban areas, fuelling eutrophication and harmful algal blooms in rivers and lakes (Bowes et al., 2024; Spears et al., 2022). Runoff also raises dissolved organic carbon in upland lakes, contributing to lakes and rivers becoming increasingly coloured (Arsenault et al., 2023; Ritson et al., 2014), which reduces light penetration and increases treatment costs (Blanchet et al., 2022). Suspended sediments mobilised in storms degrade water quality further by transporting pollutants (Upadhayay et al., 2021).

Biodiversity is declining. Of the 753 terrestrial and freshwater species', abundance has on average fallen by 19% in the UK since 1970 (Burns et al., 2023). This is reducing ecosystems' adaptive capacity, weakening resilience to changes in species seasonal timing, temperature stress, and altered feeding and reproduction (Bonnaffe et al., 2024; Weiskopf et al., 2020). Persistent monitoring gaps in biodiversity and pollution tracking limit evidence-based action, increasing the risk of crossing ecological thresholds (Burdon et al., 2020; de Vries et al., 2021; Polazzo & Rico, 2021).

The current magnitude of risk to freshwater ecosystems is assessed as High for all UK nations due to major impact (approximately 10% or more at national level) to valued habitats and landscapes, major impact (10-15% at national level) to an individual natural capital asset and associated goods and services, and major impact on or loss of species groups.

Assessment of future magnitude of risk

The assessment of the future magnitude of risk to UK freshwater ecosystems has largely relied on expert judgement, either by interpreting projected changes in river flow, temperature, and water quality, or extrapolating findings from lab and field studies that link ecosystem responses to these single explanatory variables often using statistical methods, for example water temperature (Environment Agency, 2025). While more integrated statistical and process-based models accounting for multiple stressors are starting to emerge, they are still in the early stages of adoption in climate impact assessments. Yet it is the assessment of these multiple and interacting stressors that is key (de Vries et al., 2021).

By the 2030s, freshwater biodiversity is expected to face growing pressure due to more frequent droughts, altered flow regimes, and the spread of invasive species, increasing habitat risks and requiring urgent action (Stubbington et al., 2024; Environment Agency, 2025). By the 2050s, under medium to high warming scenarios, these stressors are projected to intensify and could surpass the adaptive capacity of many ecosystems, leading to widespread biodiversity loss and habitat degradation where adaptation is limited (Dudgeon and Strayer, 2024). By the 2080s, risks are expected to reach critical levels under high warming, with some evidence pointing to the potential for severe ecological degradation and species extinctions without significant adaptation measures. For this, the future risk to freshwater ecosystems is assessed as High, rising to Very High by the 2080s.

Future magnitude of risk is scored as High for the 2030s and 2050s rising to Very High by 2080s due to critical impact (approximately 20% or more at national level) to valued habitats and landscapes, critical impact (15% or more at national level) to an individual natural capital asset and associated goods and services, and major impact on or loss of species groups. These scores reflect the direct impacts of climate change on water availability and temperature, alongside multiple existing stressors that already harm ecological function and biodiversity.

Level of preparedness for risk

Actions to address climate change impacts on freshwater ecosystems have had mixed success. Local adaptation measures — such as riparian shading, nutrient management, barrier removal to restore flows, and targeted species conservation — have shown benefits but remain limited in scope and unassessed at scale (Amat-Trigo et al., 2024; Johnson & Wilby, 2015; Feller et al., 2024; Wade et al., 2022). However, even where nutrient controls are implemented, expected reductions in algal growth are not always achieved due to legacy nutrients in sediments (Wade et al., 2022).

Key strategic frameworks like the Environmental Improvement Plan (EIP) 2023, the National Framework for Water Resources 2025, and the Flood and Coastal Erosion Risk Management Strategy (2020) provide important direction but often lack clear, evidence-based objectives and long-term targets beyond 2030 (DEFRA, 2023–2024). The Government's 2023 Integrated Plan for Water presents a vision for integrated water system management, yet its connection to regulatory reforms remains unclear, and it is uncertain how the revised EIP will specifically address freshwater climate risks. Upcoming reforms to the Water Framework Directive (2000/60/EC) and updates to River Basin Management Plans and Water Resources management plans offer key opportunities to embed more robust climate adaptation into freshwater policy. Equivalent strategies are in place across Scotland, Wales and Northern Ireland, for example Scotland's Environment strategy (2020), Wales' Natural resources policy, and Sustainable Water - A Long-Term Water Strategy for Northern Ireland (2015-2040). Each broadly supporting integrated catchment management and climate resilience but have similar challenges around embedding long term adaptation.

No systematic national assessment exists on the combined effects of multiple stressors on UK freshwater ecosystems. While risks are recognised in environmental legislation and action plans across the UK, progress on adaptation is limited, and there is little evidence that non-governmental action will sufficiently address them. Policies, strategies, and plans require clear SMART (Specific, Measurable, Achievable, Relevant and Time-bound) objectives to reduce risks across future climate scenarios.

Assessment of the evidence base and evidence gaps

The evidence base for freshwater risks shows current impacts from multiple interacting stressors, with future projections, mainly for river flows, water temperature, nutrient concentrations, and algal growth. These impacts are largely based on temperature and precipitation scenarios. Significant gaps remain in understanding the large-scale, long-term effectiveness of adaptation, particularly beyond the 2030s, and the composition of future ecosystems is uncertain due to potential shifts in species and communities.

Risk levels remain unchanged for all nations, not because adaptation is ineffective, but due to insufficient evidence to assess its effectiveness at catchment scales. Freshwater ecosystems are shaped by complex interactions, and it is unclear how results from small-scale trials will translate to larger systems or combined measures. A precautionary approach is maintained until robust evidence identifies effective strategies across regions. This gap reflects the early stage of adaptation implementation, making outcome assessment challenging; systematic evaluation is essential (Wilby & Darch, 2025).

8.2.2.2 England

Current and future level of risk

The current level of risk is assessed as High for England, and some details are given in the UK section. In addition, 85% of the worlds' chalk streams are found in England, which are a globally rare ecosystem dependent on stable groundwater regimes. Recent studies have shown that rising temperatures and changing river flow regimes are already impacting chalk stream species, putting them at risk of population decline and local extinction (Stubbington et all, 2024, EA 2025). Interacting pressures combine with climate change to threaten this internationally important habitat. This strengthens the urgency score of More Action Needed and highlights the need for targeted climate adaptation measures.

Rising water temperatures and excessive water extraction risk turning rivers that flow year-round into ones that only flow seasonally or dry up completely, damaging their ecological function (Stubbington et al., 2024; Marsh et al., 2021). Given the vulnerability of chalk streams, under the most extreme warming scenario of the 2080s, the future risk is assessed as Very High.

Level of preparedness

England has limited adaptation policies for freshwater ecosystems (CCC, 2025). While updated River Basin Management Plans (RBMPs) and supporting measures have been published that include actions to address climate risks, the level of implementation is uncertain. The RBMPs incorporate national risk assessments and include principles to improve climate resilience, but their effectiveness depends on future deployment. Natural England's 2022 Nutrient Neutrality guidance aims to reduce water pollution. These nutrient management policies are not only relevant to conventional water quality goals but are also integral to climate adaptation. Reducing nutrient and pollutant loads helps prevent climate-amplified eutrophication, supports oxygen availability during warming events and protects against harmful algal blooms. Yet the effectiveness of these polices has not been assessed.

Evaluation of urgency score

Based on expert judgement, More Action Needed is applied as the magnitude of this risk is High now and in the 2030s and 2050s. Due to the vulnerability of chalk streams, a globally rare ecosystem, the overall risk for England is projected to be Very High by the 2080s under the higher warming scenario. Climate risks to freshwater systems are recognised in some policies, but there is limited evidence of progress or non-governmental action to maintain or reduce the risk levels. Confidence is High for the present due to the strong evidence base for the UK as a whole as well as for England. Confidence is Medium for all periods based on strong expert agreement supported by some model-based projections.

Table 8.8: Urgency scores for N2 Risks to freshwater ecosystems for England. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

England								
N2	Risks to freshwater ecosystems.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.2.3 Northern Ireland

Current and future level of risk

Northern Ireland’s freshwater ecosystems face rising pressures from climate change (Adams, 2022). Warming and stratification in loughs are threatening water quality and ecosystem function through harmful algal blooms, affecting both major river systems and standing waters (e.g., Lough Neagh) (Spears et al., 2022; Rippey et al., 2025). By the 2050s and 2080s, major seasonal and extreme river flow changes are expected, increasing risks to water quality as warmer waters accelerate nutrient release from sediments (Kay et al., 2021; McElarney et al., 2021; Reid et al., 2024). While experts broadly agree on the high threat climate change poses to freshwater biodiversity, evidence remains limited, focusing on individual species or habitats rather than whole systems. There are key gaps in understanding feedback loops and tipping points in Northern Ireland. Current and future risks to Northern Ireland’s freshwaters are assessed as High increasing to Very High in the 2080s. Confidence is rated as Medium for all periods based on strong expert agreement.

Level of preparedness

There are limited policies to ensure resilience of Northern Ireland’s freshwater systems. The Long-Term Water Strategy includes adaptation and water quality goals but lacks accessible monitoring data. The latest RBMPs (2021–2027) do not account for climate change limiting its effectiveness in addressing future risks to freshwater habitats.

Evaluation of urgency score

Based on expert judgement, More Action Needed is applied as the magnitude of this risk is High now and in the 2030s and 2050s, increasing to Very High in the 2080s. Climate risks to freshwater ecosystems are recognised in some policies, but evidence is limited on their progress or non-governmental action to maintain or reduce the risk levels. Confidence is High for the present due to the strong evidence base across the UK. Confidence is Medium for the future, due to less simulations of future scenarios.

Table 8.9: Urgency scores for N2 Risks to freshwater ecosystems for Northern Ireland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Northern Ireland								
N2	Risks to freshwater ecosystems.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
With adaptation	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.2.4 Scotland

Current and future level of risk

Scotland's freshwater ecosystems face rising pressures from climate change, land use, and population growth, altering species distributions and increasing vulnerability, particularly in aquatic insects (Adams, 2022; Macadam et al., 2022). Warming and stratification in lochs threaten water quality and ecosystem function through harmful algal blooms (Spears et al., 2022), while invasive species, unstable river flows, and reduced survival of Atlantic salmon (Salmo salar) compound risks (Natural Resources Scotland, 2024; Soulsby et al., 2024). Droughts cause severe impacts, including mass mortality of freshwater pearl mussels (Cosgrove et al., 2022) and reduced invertebrate diversity (Vander Vorste et al., 2021), with hydropower schemes further disrupting flows (Curley et al., 2021). Given these pressures, risks to Scotland's freshwaters are assessed as High for the present, 2030s and 2050s, increasing to Very High by the 2080s. Medium confidence is given for all periods based on strong expert agreement. Further evidence is given in the UK section that is relevant to Scotland.

Level of preparedness

Scotland has policies for freshwater adaptation such as the Scottish National Adaptation Plan (2024-2029) and the Climate Adaptation Capability Framework. The Scottish Biodiversity Strategy to 2045 and RBMPs could help reduce risks (Soulsby et al., 2024). However, these lack sufficient detail on how targets could be met, and some strategies lack detail on climate adaptation. While government funding supports various nature-based projects through initiatives like the Water Environment Fund, the Nature Restoration Fund, and NatureScot's Biodiversity

Challenge Fund, some adaptive measures (e.g., controlling invasive species) remain ineligible for support. Online resources like the Water Environment Hub aim to help land managers access data and manage water systems sustainably (CCC, 2023).

Evaluation of urgency score

Based on expert judgement, More Action Needed is applied as the magnitude of this risk is High now, and in the 2030s and 2050s, increasing to Very High in the 2080s. Climate risks to freshwater ecosystems are recognised in some policies, but evidence is limited on their progress. Evidence is also limited in respect to non-governmental action to maintain or reduce the risk levels. Confidence is High for the present due to the strong UK evidence base. Confidence is Medium for the future, due to limited simulations of future scenarios.

Table 8.10: Urgency scores for N2 Risks to freshwater ecosystems for Scotland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Scotland								
N2 Risks to freshwater ecosystems.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.2.5 Wales

Current and future level of risk

In Wales, freshwater ecosystem, particularly upland headwater streams, are highly sensitive to climate change. While freshwater biodiversity showed signs of recovery before 2010, this progress has since stalled (Larsen et al., 2024). Rising river temperatures and changing rainfall patterns are driving more frequent algal blooms and increasing nutrient pollution risks (Bowes et al., 2024; Pharaoh et al., 2024).

Level of preparedness

There are partial policies in Wales to support freshwater resilience. Recent efforts include the Natural Resource Wales' (NRW) Climate Adaptation Plan (2023-2027), the State of Natural Resources Report for Wales (2020) and the Glastir monitoring and evaluation programme and its successor, the Environment and Rural Affairs

Monitoring & Modelling Programme (ERAMMP). ERAMMP provides a long-term and integrated national monitoring programme across Wales' rural environment. Its most recent report found that widespread long-term declines appear to have slowed, but more exploration of climate change specific factors is needed (Emmett & ERAMMP, 2025). Sectoral policies like the RBMPs, lack adaptation targets and planning. The scores remain High with adaptation as current policies are not likely to reduce the magnitude of risk.

Evaluation of urgency score

Based on expert judgement, More Action Needed is applied as the magnitude of this risk is high now, and in the 2030s and 2050s, increasing to Very High in 2080s. Climate risks to freshwater ecosystems are recognised in some policies, but evidence is limited on their progress. Evidence is also limited with respect to non-governmental action to maintain or reduce the risk levels. Confidence is High for the present due to the strong evidence base across the UK, and Medium in the future, due to limited simulations of future scenarios.

Table 8.11: Urgency scores for N2 Risks to freshwater ecosystems for Wales. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Wales								
N2 Risks to freshwater ecosystems.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.3 Risk to marine ecosystems – N3

Between 1950 and 2020, global sea surface temperature increased by about 0.11 °C per decade, profoundly affecting marine physiology, oxygen levels, species distributions, trophic interactions and ecosystem services (Venegas et al., Deep-Sea Res. Pt II, 2023). The impact of ongoing global warming poses a major risk to the marine ecosystems around the UK and globally. These risks are strongly interconnected with those facing other ecosystems, productive sectors, food security, public health, and the economy.

Headlines

- Under future climate change scenarios, risks to marine ecosystems are major (High to Very High). Ecosystems and species are already decreasing in numbers and distributions are changing as a result of species looking to stay within their preferred temperature zone. Other environmental factors such as species following their food source are also important.
- Risks are expected to increase by the end of the century with critical impacts on ecosystem integrity.
- Risks to marine ecosystems have cascading risk on fisheries and aquaculture.
- More Action Needed is applied for adaptation actions that reduce risks to the marine ecosystems.

Table 8.12: Urgency scores for N3 Risks to marine ecosystems. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

ID	Risk		Present	2030	2050	2080	Urgency
N3	Risks to marine ecosystems	**UK**	++ (M)	++ (H)	++ (H)	++ (VH)	MAN
		England	++ (M)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	++ (M)	++ (H)	++ (H)	++ (VH)	MAN
		Scotland	++ (M)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	++ (M)	++ (H)	++ (H)	++ (VH)	MAN

8.2.3.1 Evidence relevant to the entire United Kingdom

Introduction

As the atmosphere warms and greenhouse gases increase, the ocean absorbs some of this extra heat and carbon, helping to moderate global climate change. Consequently, sea surface temperatures are rising, impacting bottom sea temperature as well as vertical mixing. Changes in stratification (the formation of water layer that do not mix throughout the water column) due to temperature have an impact on nutrient mixing and primary production, effects that will travel through the whole of the marine food web. Absorption of excess carbon dioxide leads to changes in water alkalinity (pH), with an impact on shell forming organisms. Deoxygenation, timing of spring bloom, storminess, sea-level rise and algal or jellyfish blooms (from temperature change, eutrophication, and change in species diversity) are all potential issues that arise from the impact of climate change on the marine environment.

The last 5 years have produced additional research on the impacts, though a lot of it is at the global to regional level rather than the national level. The research increases our understanding of the impacts and their magnitude. From these we can extract the risk and impact for the UK nations and evaluate the preparedness.

Current and future drivers of risk

Climate change is responsible for significant stress on marine ecosystems through a multitude of mechanisms like warming, change in stratification and currents, acidification, de-oxygenation and species interactions.

Between 1981 and 2021, the increase of mean sea surface temperature (SST) in UK waters was about 1.2 °C, with a marked regional difference with the northern and western parts warming less and the southern North Sea warming faster. At the same time, the number of marine heatwaves (a period during which the sea surface temperature is above the typical average for the location and season) have increased by an average of four events per year (Cornes et al., 2023).

These changes in temperature may affect other important drivers of marine ecosystems like their salinity and the oxygen content, however it can be difficult to distinguish the impact of climate change from the natural variability for these components (Dye et al., 2020; Mahaffey et al., 2023).

UK waters have acidified with an average pH in excess of 0.002 units per year in the period 1990-2015 at the sea surface (Findlay et al., 2025). Coastal observations for the last 15 years in the English Channel and in Scotland suggest that the speed of acidification could be five times higher in these regions than the UK average (Findlay et al., 2025).

These changes in the physical and chemical environment can have significant direct impacts on all organisms living in the marine environment, from the small planktonic organism that are at the base of the marine food web, to the large mammals. Furthermore, many species can also be indirectly affected through changes in habitats that they depend on (e.g. for nursery) or through changes in species that they interact with (e.g. a decrease in food availability, and an increase in presence of predators).

Assessment of current magnitude of risk

Evidence presented below highlights impact on intertidal species, the deep-sea environment, fish and megafauna (from marine mammals to sea birds). There is evidence in changes in plankton composition (the base of the food-web) and poleward migration of marine species to maintain their preferred environmental temperature.

The latest wild bird population assessment for the UK showed a marked decrease in the population of breeding seabirds between 1986 and 2019, with an apparent stabilisation over the last 5 years (DEFRA, 2023). This decline is also reflected by the OSPAR assessment in the recent Quality Status Report where surface feeding seabirds and benthic feeding seabirds were classified with a status of poor. It has been demonstrated that warming has an indirect negative impact on the reproductive success of many species of seabirds because of the reduction in prey availability or a shift in their timing. Direct impacts of climate change on seabirds are less studied but there is evidence that extreme weather (especially wind) and sea conditions affect the survival of seabirds throughout their life cycle, from nest and eggs loss to adult individuals that need to spend more energy to fly and forage under extreme conditions.

An analysis of marine mammals strandings on the UK coast between 1990 and 2018 highlighted a clear increase in the presence of species that are adapted to warm waters in the North. This shift is a direct consequence of the warming registered in the area that makes the northern coasts more suitable for these species. On the contrary, no significant change has been observed in the rest of the UK coast, likely because these warmer regions were already inhabited by the species adapted to warmer waters (Williamson et al., 2021). In addition to the direct effect of temperature, marine mammals are affected by the impacts of climate change on the entire marine food web, starting from the small zooplankton up to key prey species like sandeels (Martin et al., 2023).

The main impact of climate change on fish in UK waters is the increase in the presence of species adapted to warmer water and a decline of those adjusted to colder water. There is an increasing amount of evidence that this is the result of a combination of processes (e.g. productivity, oxygen level, and salinity) and not just associated to the migration of fish as consequence of the warming.

Climate change can affect many physiological processes that determine the success of a species to survive in a specific environment. It has been observed that the reproductive success of Atlantic Cod, a key species of high ecological and economic importance, is significantly disrupted at temperature higher than 9.6 °C (Kjesbu et al., 2022). Furthermore, embryos have been shown to be particularly sensitive to warming, limiting the ability of a species to survive long term in a particular location (Dahlke et al., 2020). Impacts of ocean acidification on fish are varied depending on the species and it is difficult to generalise for the whole community. However, the number of studies showing negative impacts on early development, reproduction and sensory performance has increased in the recent years.

Scores are based on available evidence, which remain scarce at the UK level, or lack the specificity needed to separate between the different devolved governments. Nonetheless, clear intermediate impacts are evident (approximately 5% or more at national level to valued habitats or landscape types), while major impacts are expected, including future potential losses and impacts on species groups, habitat disturbance (approximately 10% or more at national level to valued habitats or landscape types. Risks increase by the 2080s for all nations due to increasing climate hazards and critical impacts (approximately 20% or more at national level to valued habitats or landscape types). Confidence is medium due to limits on evidence availability compared to the complexity of the marine environment, including key uncertainties such as species and food-web interactions and their effects on ecosystem function.

Assessment of future magnitude of risk

Global projections of climate change impacts on marine ecosystems suggest significant long-term declines in global marine animal biomass and unevenly distributed effects on fisheries, particularly in the Arctic and North temperate regions. Using advanced ecosystem models from the Fisheries and Marine Ecosystem Model Intercomparison Project (Fish-MIP), driven by updated climate data from the 6th Coupled Model Intercomparison Project (CMIP6), a greater decline in ocean animal biomass compared to previous projections was found with respect to previous analyses, with the largest losses under high-emissions scenarios (Tittensor et al 2021).

Future warming is likely to continue to shift the geographical distribution of primary and secondary plankton production northwards. This may negatively affect ecosystem services such as oxygen production and ocean carbon storage within 20–50 years (MCCIP, 2020).

Warming sea temperatures in the Northeast Atlantic may further decrease mean plankton community body size, with consequences for fish, marine mammal and seabird populations. Ocean acidification has the potential to negatively affect calcifying organisms of the plankton community and the rate at which they sink and transport carbon to the seabed (MCCIP, 2020).

Rises in sea temperature results in a shift in the food web because of the impact on Plankton. This will also impact fish, with changes in species composition and abundances affecting predator-prey relationships (Schickele et al., 2021). For bottom-dwelling species such as cod, the northern North Sea will remain a somewhat suitable habitat throughout the coming century; a shrinkage of the suitable space is visible in projections. On the other hand, conditions could become favourable for warm-water species such as Mediterranean horse mackerel and bogue as far north as the middle of the Irish and North Seas. This mean that climate impacts at a regional and species level that needs to be considered for fishery management plans (Sailley et al., 2025). This may require changes in the spatial scales at which data are collected, reported and analysed in the coming decades.

Climate change is projected to have mixed impacts on the breeding and non-breeding numbers and distributions of seabird and waterbird species in the UK and Ireland. Recent studies highlight the value of protected area networks in supporting resilience of species as they respond to climate change.

Many UK and Irish seabird populations are at or near the southern limit of their breeding range and/or are highly sensitive to changes in prey availability, limiting their resilience to climate change. Some species may struggle to shift their breeding locations northwards due to low hatching and breeding dispersal rates. Arctic and sub-Arctic breeding waterbirds that winter in the UK and Ireland are amongst the most vulnerable due to climate change impacts in their high-latitude breeding grounds. Direct impacts from changes in severe weather events and sea-level rise may increase for both seabirds and waterbirds in the future.

Risks to marine mammals from disease and thermal stress may increase in the future. Changing environmental conditions may affect when marine mammals breed, particularly those species that build up energy stores beforehand. Species closely tied to their breeding grounds, are more likely to be affected by changes in sea surface temperature as this will impact both habitat availability and the breeding behaviours associated with that habitat. Finally, marine mammals face an increase in the cumulative impacts from climate change (e.g., change in prey availability, pollution, and temperature stress) and other increasing pressures such as marine renewable expansion, shipping, and dredging.

The scoring is based on the evidence indicating impact on ecosystems (e.g., warming, change in production and food available) with the subsequent species distribution shift and change of abundance, informed by expert knowledge of climate change effects on marine ecosystems beyond UK waters. Future risks are High for all scenarios, except for the 2080s which are scored as Very High (critical potential impact with loss of species, decrease in abundance and diversity of species). This is due to how the marine system will be slow in responding to a change in emissions with the differences in the scenarios being more pronounced in the 2080s causing a visible divergence between scenarios then.

Confidence scores are Medium, due to the lack of resolution to specific species and group, supported by strong expert agreement.

Level of preparedness for risk

The UK recognised the importance of the marine environment in its national adaptation policies, but evidence on climate change risks remains limited, whilst adaptation options may be constrained by the vastness and interconnectedness of marine ecosystems. There is an on-going increase in awareness if the risk of climate change to the marine environment, as illustrated by the new Marine Management Organisation (MMO) plan. Most of the focus has been on Marine Protected Areas (MPA), which are critical for enhancing ecosystem resilience by protecting biodiversity and enabling species range shifts. While 60% of MPA had management measures by 2019, only 10% had fully implemented them and biodiversity loss persists. Scotland has taken specific action by implementing fisheries measures in 27 MPA, while Wales and England focus on using MPA to boost ecological resilience. Effective management is hindered by limited data, slow plan implementation, and insufficient reductions in fishing pressures, particularly for protecting benthic habitats. Future effectiveness of

MPA is further threatened by climate-induced habitat shifts, with models predicting substantial changes by 2100. Inclusion of climate change impacts into marine planning is key for efficiency (Queiros et al., 2021).

Assessment on the evidence base and evidence gaps

Recent reviews show that UK decision-making about marine natural capital and ecosystem services has only sparse evidence for how marine habitats regulate water quality and other regulating services. Most studies focus on provisioning (e.g., fisheries) and cultural services (e.g., recreation), rather than on non-use (e.g., value from knowing nature exists) or indirect values. Marine Protected Areas (MPAs), though widely implemented, often lack monitoring that accounts for climate change effects such as warming, acidification, or oxygen loss. There is also little evidence quantifying or managing compound risks (multiple stressors combined) or detecting early tipping points in UK marine ecosystems under climate stress.

8.2.3.2 England

Current and future level of risk

This section includes England-specific evidence but should be read with the UK assessment for a full understanding of climate risks affecting this nation.

The marine environments around England are at risk from warming, decrease in productivity and acidification. These impact cause northward migration of species (either new species moving in or existing species shifting their distribution), this is true for plankton, fish, marine mammals and seabirds. Risks to the UK's marine ecosystems are largely assessed at UK level because marine environments are highly interconnected, and studies available cover shared waters rather than individual nations.

Level of preparedness

England has partial climate change adaptation polices for the marine environment (CCC, 2023). The UK Government introduced new marine monitoring programmes under the 2024 Marine Strategy Part Two update to improve evidence and close indicator gaps for assessing climate adaptation progress. It has also set long- and short-term targets for the marine environment, aiming for 70% of designated MPA features to be in favourable condition by 2042, with 48% by 2028, though many of these features are vulnerable to climate change impacts. Additionally, three new Highly Protected Marine Areas (HPMAs) have been established to restrict damaging activities like fishing and dredging, supporting nature recovery and ecosystem resilience. However, the reduction in the number and size of planned HPMAs could limit progress toward achieving marine restoration and adaptation goals. Additionally, the MPA (Bottom Trawling) Bill, which is yet to be approved, would see an increase in the areas of the sea floor protected from the effect of bottom trawling.

Evaluation of urgency score

More Action Needed is applied due to the High and Very High magnitude of the risks for the future and the limited responses. While policies in England acknowledge climate risks to marine ecosystems, there is little evidence of effective adaptation or sufficient action to maintain or reduce current risk levels. Reducing risks will require wider and coherent resilience-focused policies across sectors. The score is given with Medium confidence, reflecting limited evidence on future adaptation but strong expert agreement.

Table 8.13: Urgency scores for N3 Risks to marine ecosystems for England. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

England								
N3 Risks to marine ecosystems.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (M)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
With adaptation	++ (M)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.3.3 Northern Ireland

Current and future level of risk

This section includes Northen Ireland-specific evidence but should be read with the UK assessment for a full understanding of climate risks affecting this nation.

The marine environment in Northern Ireland is at risk from warming, decrease in productivity and acidification. These impact cause northward migration of species (either new species moving in or existing species shifting their distribution), this is true for plankton, fish, marine mammals and seabirds. Risks to the UK's marine ecosystems are assessed at a UK level because marine environments are highly interconnected, and studies available cover shared waters rather than individual nations.

Level of preparedness

Northern Ireland has limited policies and plans (CCC, 2023). MPAs in Northern Ireland have grown to exceed the Government target. A Marine Plan is in advanced stages of development with a planned publication pending for executive approval.

Evaluation of urgency score

More Action Needed is applied due to High and Very High future magnitude of risks and a response that includes climate change in the plans. Northern Ireland has limited policies to maintain or reduce current risks levels. Reducing risks will require strong resilience-focused planning. The score is given with Medium confidence, reflecting little evidence on risks but strong expert agreement.

Table 8.14: Urgency scores for N3 Risks to marine ecosystems for Northern Ireland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Northern Ireland								
N3	Risks to marine ecosystems.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (M)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
With adaptation	++ (M)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.3.4 Scotland

Current and future level of risk

This section includes Scotland-specific evidence but should be read with the UK assessment for a full understanding of climate risks affecting this nation.

The marine environment in Scotland is at risk from warming, decrease in productivity and acidification. These impact cause northward migration of species (either new species moving in or existing species shifting their distribution), this is true for plankton, fish, marine mammals and seabirds. Risks to the UK's marine ecosystems are assessed at UK level because marine environments are highly interconnected, and studies available cover shared waters rather than individual nations.

Level of preparedness

Scotland has partial policies and plans for marine ecosystems adaptation (CCC, 2023). The new Scottish Climate Change Adaptation Plan 2024-2029 recognises climate change as the biggest threat to Scotland's wildlife and habitats with ocean warming and acidification impacting the rate and extent of marine species losses across Scotland.

Scotland is developing its second National Marine Plan (NMP2), due by 2026, which will directly address the climate and nature crises by supporting Scotland's Net Zero by 2045 target and managing growing competition for marine resources. The withdrawal of proposals to designate 10% of Scottish seas as HPMAs will delay enhanced protections, though a new pathway is being developed to align with Scotland's goal of becoming nature positive by 2030.

Efforts are underway to improve marine and coastal habitat monitoring, with NatureScot leading new pilot programmes and a review of the Scottish MPA Monitoring Strategy, but funding and data gaps still limit large-scale climate risk assessment. The Scottish Marine Environmental Enhancement Fund is channelling public and private investment (over £3.3 million since 2021) into projects that restore and enhance marine ecosystems, helping build long-term resilience to climate impacts. Additionally, the first five-year Delivery Plan of the Scottish Biodiversity Strategy is closely aligned with the new Adaptation Plan.

Evaluation of urgency score

More Action Needed is applied due to the future High and Very High magnitude of the risks and limited responses. While policies in Scotland are focusing on more integrated approaches to address climate risks to ecosystems, the marine system is highly interconnected and the lack of effective measure in the other UK nations is likely to have an impact on Scotland. The score is given with Medium confidence, reflecting limited evidence on future adaptation but strong expert agreement.

Table 8.15: Urgency scores for N3 Risks to marine ecosystems for Scotland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Scotland								
N3 Risks to marine ecosystems.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (M)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
With adaptation	++ (M)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.3.5 Wales

Current and future level of risk

This section includes Wales-specific evidence but should be read with the UK assessment for a full understanding of climate risks affecting this nation.

The marine environment of Wales is at risk from warming, decrease in productivity and acidification These impact cause northward migration of species (either new species moving in or existing species shifting their distribution), this is true for plankton, fish, marine mammals and seabirds. Risks to the UK's marine ecosystems are assessed at UK level because marine environments are highly interconnected, and studies available cover shared waters rather than individual nations.

Level of preparedness

Wales has partial policies and plans to support adaptation of marine habitats, with some progress in adaptation planning but limited evidence on their effectiveness (CCC, 2023). Ongoing efforts aim to improve resilience to climate impacts in the future. The MPA Management Steering Group oversees the MPA Network Management Action Plan (2022–2023), which prioritises biodiversity restoration, invasive species control, and improved MPA condition. Though it would benefit from more research into adaptive responses to ocean warming and acidification.

The Welsh National Marine Plan (WNMP, 2019) promotes the sustainable use of Welsh seas by encouraging development that works with natural processes, reduces coastal change risks, and enhances ecosystem and community resilience to climate change. Similarly, The Wales Marine Evidence Strategy (2021–2025), led by the Welsh Government and NRW, sets priorities for collecting evidence on marine ecosystem resilience and improving understanding of climate change impacts on Welsh marine environments.

Evaluation of urgency score

More Action Needed is applied due to the High and Very High magnitude of the risks and partial responses. While some policies in Wales acknowledge risks to marine ecosystems, there is little evidence of effective adaptation or sufficient non-governmental action to maintain or reduce current risk levels. Reducing risks will require wider and coherent resilience-focused policies across sectors. The score is given with Medium confidence, reflecting limited evidence on future adaptation but strong expert agreement.

Table 8.16: Urgency scores for N3 Risks to marine ecosystems for Wales. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Wales								
N3 Risks to marine ecosystems.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (M)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
With adaptation	++ (M)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.4 Risk to soil ecosystems – N4

UK soils are increasingly vulnerable to climate change, with extreme heat, rainfall, and drought driving erosion, carbon loss, pollution, and biodiversity decline that threaten both natural ecosystems and agriculture. Risks are projected to intensify as warming and extreme weather events worsen soil degradation. Major knowledge gaps remain about how multiple climate impacts interact. Adaptation efforts are fragmented, highlighting the need for more action.

Headlines

- Critical Investigation is applied for this risk, as recent evidence confirms that UK soils are increasingly affected by extreme temperatures, rainfall, and drought, leading to erosion, carbon loss, water pollution, reduced soil fertility, and biodiversity loss above and below ground. This negatively impacts natural and agricultural habitats and threatens agricultural production and carbon stores and sequestration.
- Risks are expected to grow as climate change intensifies, with warming, heavier rainfall, and frequent droughts, likely to worsen soil degradation and biodiversity loss. There is strong evidence to support this, but major knowledge gaps remain around how the impacts of climate change may compound as many studies have looked at impacts independently (e.g., drought or temperature).
- Adaptation planning is still in its early stages. There is no coordinated UK response. A national strategy for managing climate risks to soils is urgently needed.
- The urgency remains Critical Investigation. The magnitude of risk is rated as Medium for the present and projected to increase to High by 2050 and 2080.

Table 8.17: Urgency scores for N4 Risks to soil ecosystems. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

ID	Risk		Present	2030	2050	2080	Urgency
N4	Risks to soil ecosystems	**UK**	+++ (M)	++ (M)	+ (H)	+ (H)	CI
		England	+++ (M)	++ (M)	+ (H)	+ (H)	CI
		Northern Ireland	++ (M)	++ (M)	+ (H)	+ (H)	CI
		Scotland	+++ (M)	++ (M)	+ (H)	+ (H)	CI
		Wales	+++ (M)	++ (M)	+ (H)	+ (H)	CI

8.2.4.1 Evidence relevant to the entire United Kingdom

Introduction

Soils are vital to the health of all terrestrial ecosystems. They are essential for food production, water regulation, carbon storage, waste breakdown, and help manage pollution and climate (Guerra et al., 2022). Soils also hold a wide variety of life, including bacteria, fungi, plants, and animals of different sizes. All of which are essential to maintaining soil health and the services it provides (Guerra et al., 2020).

Soils are highly variable in their physicochemical characteristics, and are influenced by many natural and anthropogenic factors, such as land use and management. The UK has over 700 soil types, with many variations within those types. Many soil types are shared throughout the country. Therefore, in face of similar climate hazards, most risks identified here are likely to be applied to all nations. When specific risks are identified for a specific nation, we present them on their respective section below.

The main climate drivers of risk to soils identified are related to temperature and precipitation increases, as well as the severity and frequency of drought and flood events. As for precipitation in the UK, increases have been observed over the last decades, and projections show a high probability of drier summers and wetter winters (Maisey et al., 2019). These projections raise risks of erosion, waterlogging, and soil physical, chemical and biological degradation. These will be explored as we present evidence to justify our magnitude scores.

Risks to soils interact with other climate change risks, negatively impacting natural and agricultural habitats and threatening agricultural production (N6). Nearly 99% of UK agricultural production relies on soil, and climate change is a major threat to farming due to increased erosion, compaction, flooding, drought, and loss of biodiversity and organic matter (Tibbett et al., 2020).

It is important to keep in mind that there is still a lack of large-scale monitoring data, there are also no standardised set of soil health indicators, which complicates further generalisations even though the evidence is compelling at the local level. Knowledge gaps were also identified concerning other climatic risks to soils, such as increases in soil acidification (acid sulphate soils) and soil gleying (waterlogging and lack of oxygen), for which there is little recent evidence within the UK. Therefore, the justification for the magnitude risks in this section will be based on the recent and available academic literature, indicating the specific impacts reported, that may or may not be applied to other areas and soil conditions.

Assessment of current magnitude of risk

Many risks to soils are a product of climatic processes in association with socioeconomical factors, which lead to soil degradation. The main soil degradation processes linked to climate change are related to erosion, flooding, drought, compaction, loss of carbon (C) stocks, pollution, decreases or shifts in microbial communities or soil fauna populations (e.g. earthworms, insects). A review by Tibbett et al. (2020) identified climate change as a major threat to soil biodiversity, along with intensive human exploitation, land use change, soil degradation and plastics. Temperature, moisture shifts, and extreme weather events directly impact soil biodiversity, increasing erosion and salinity. It is worth noting that climatic impacts can also interact. Increases in water content and temperature can affect structure (aggregate stability), which impacts microbial communities and soil erosion, and depends on the existing soil texture (clay/sand content) (Dowdeswell-Downey et al. 2023). Impacts may also compound or generate positive feedbacks, possibly increasing or decreasing their magnitudes.

<u>**Erosion and high precipitation:**</u> According to Benaud et al. (2020), soil erosion in the UK is unsustainable, with 16% of arable records showing excessive soil loss in comparison to the ‘tolerable’ rate of 1 tonne per hectare per year. This was particularly high in Wales and northern England. Like findings for the UK and England, erosion risk maps for Scotland, produced by modelling (RUSLE), project high erosion rates in high-risk areas of 1.51 tonne per

hectare per year for arable soils, and 1.26 tonne for pasture/grasslands (Wiltshire et al., 2024). As high rainfall is projected for winter months (Maisey et al., 2019), erosion is most likely to increase in the future.

The Environment Agency's (EA) State of the Environment (2019) report estimated that, in England and Wales, more than 2 million hectares of soil are at risk of erosion, and approximately 4 million hectares are at risk of compaction. Intensive agriculture led to 40 to 60% of C loss from soils. Compaction and the loss of organic C are serious threats to soil health. They impact agricultural productivity and resilience to climate change. UK soils currently store about 10 billion tonnes of carbon, which is roughly equivalent to 80 years of annual UK greenhouse gas emissions (N5).

Flooding and high precipitation: Flooding is a common consequence of excessive rainfall, especially in short periods of time or after a drought event. This not only impacts soil structure, leading to runoff and erosion, but can cause nutrient loss and water pollution. Khan et al. (2022), observed in controlled conditions that two grassland soils (Devon) showed significant phosphorus (P) loss after flooding, particularly a flash flooding event. Leaching of P from flooded soils not only decreases fertility but will consequently accumulate in bodies of water.

Flooding also affects living organisms in soils (e.g., earthworms) which are important for nutrient cycling, soil structure (aggregation) and water regulation (infiltration); all of which benefit plant growth, including crops. Kiss et al. (2021), sampled earthworm populations of two English fields (Reading; Holm-on-Swale) in pasture and arable systems, and reported a significant decrease in earthworms in frequently flooded soils, which was particularly high in arable soils (a decrease of 59% from non-flooded to flooded arable soils). In heathlands within the UK (southern Britain and northern Scotland), Kowal et al. (2022) reported a negative correlation between precipitation and plant root colonisation by arbuscular mycorrhizal fungi, which are important fungi in soils that support plant nutrient uptake by forming a mutualistic relationship with plants (Plassard et al., 2019). Both temperature and high rainfall are expected to rise in the UK, which can differentially affect microbial communities in soils. Investigating different European forests (including the UK), Sangiorgio at al. (2024), showed that while higher temperatures may boost microbial growth and diversity (species richness), high rainfall decreases it. However, more evidence is needed to better understand the impact of temperature and rainfall on soil microbes.

An often-neglected climate change risk to soils is the possibility of enhancing the concentration or bioavailability of potentially toxic elements (PTEs) due to flooding. It can affect metal availability by altering soil pH and its redox potential due to the lack of oxygen. Ponting et al. (2022) observed that a change in soil conditions due to flooding around the River Loddon (southeast England) decreased the availability of heavy metals such as cadmium and chromium, but increased manganese (Mn), which is concerning, since excess Mn is detrimental to plants and microbes (De Oliveira et al., 2023).

Drought: Agricultural droughts have been increasing in the UK, with examples from 1921 to more recent years in 2018, 2020, and 2025 (Reinsch et al., 2024; Met Office 2025). Dry summers are expected to increase as part of climate change, which may lead to more frequent droughts across the UK (Kay et al., 2022). The most common effects of droughts include decreases in crop yield, vegetation dieback, and decrease in macrofauna and soil microbial diversity, with dry areas becoming more prone to wildfires and soil erosion (Reinsch et al., 2024).

In peatlands, drought can alter fungal diversity and decrease both richness and diversity of bacterial communities (Robinson et al., 2023). However, these results are from peatlands outside of the UK, and more investigations regarding drought effects on microbes within British peatland areas are needed.

An important ecosystem service from soils is the ability to suppress plant diseases and pathogen infections in plants by allowing predation or competition between soil microbes. Doring et al. (2020), showed that higher temperatures (40 °C) and drought conditions (50% less moisture) can decrease soil capacity to supress diseases, which can have major consequences for plant health and yield loss (up to 80% in peas).

When drought is followed by high rainfall, besides the higher risk of surface runoff and erosion, the dry-wet cycle can also negatively impact soil microbes and the functions they provide (Miura et al., 2020; Xu et al., 2024), likely affecting soil and plant health.

Temperature: A field trial (Lancaster) suggested that a 2 °C increase in air temperatures can reduce plant root biomass in grassland soils (Barneze et al., 2024), and such decrease may contribute to lower C sequestration in soils as temperatures rise. Taking into consideration that both drought and higher temperatures can decrease carbon dioxide (CO_2) sequestration by 28-30% (Xenakis et al., 2021), it is crucial that these two factors are addressed simultaneously to generate more robust evidence and more precise models.

By assessing microbes in soils across different regions of the UK and Europe (e.g., arid, cold and temperate), Siles et al. (2023) showed that warming temperatures (daily maximum temperatures in particular) tend to reduce fungal biomass and shift communities in favour of bacteria, which increases CO_2 emissions via soil respiration (Adekanmbi et al., 2022).

Therefore, the current magnitude of risk to soil ecosystems is assessed as Medium due to the moderate impacts, including thousands of hectares of land lost or severely damaged, moderate disturbance of system functionality and intermediate loss of species groups, and loss of £ tens of millions or 0.001% to 0.005% GDP.

Assessment of future magnitude of risk

2030s, central warming scenario: Due to the lack of projections and models for climate impacts on soils in such a near timeframe, the risks for 2030s were considered as Medium, the same as the current risk. The new evidence gathered in the past five years does not suggest a substantial difference in impacts to soils for the 2030s. However, more evidence is needed to increase the confidence in this score.

2050s, central and high warming scenarios: Projections from Panagos et al. (2021) suggest that by 2050, average soil loss rates due to water erosion are expected to increase from 13% to 22.5% in the EU and UK, based on 19 models and three different Representative Concentration Pathways (RCPs). Erosion rate was estimated to increase from 3.07 tonne per hectare per year (in 2016) to 3.46-3.76 tonne per hectare per year (in 2050) depending on the RCP. Future rainfall is expected to intensify soil erosivity by at least 15%.

Kay et al. (2022) used the UKCP18 regional projections (for Dec 1980–Nov 2080 under RCP 8.5 emissions) to investigate soil moisture extremes across the UK and concluded that larger dry areas will be expected in UK soils in the 2050's and for longer periods of time.

2080s, central and high warming scenarios: By the end of the century climate change simulations for Great Britain reveal an increase in heavy precipitation that may lead to widespread soil erosion. Ciampalini et al. (2023) simulated the soil erosion response for two periods (1996–2009 and a 13-year future period at 2100) in a catchment in West Sussex, England. Modelling soil erosion in that area, authors found a general increase in sediment production (off-site erosion) of 43% by the end of the century.

Increased vegetation productivity due to rising temperatures could help reduce soil erosion by up to 33%, however, shifts in land use to arable crops would not provide the same benefits. This could lead to significant increases in erosion, projected to rise to 60% from 2070 to 2099 (Ciampalini et al. 2020). In a warmer future climate, the probability of compound flooding (high sea level as well as heavy precipitation) is also projected to greatly increase, particularly along the west coast of Great Britain in 2070-2099 (Bevacqua et al., 2019).

For the 2050s and 2080s, the magnitude of risk was scored as High due to the possibility of major impacts, including tens of thousands of hectares of land lost or severely damaged, major disturbance of system functionality and major loss of species groups, and loss of £ hundreds of millions or 0.005% to 0.05% GDP.

Level of preparedness for risk

Adaptation policies for soils in the UK are limited and lack a coordinated national approach. While soil health is mentioned in key policies like the NAP3, the emphasis is mainly on improving arable soil health to enhance climate resilience and reduce flood risks. However, actions and soil-specific monitoring are limited, and there is no UK strategy or system in place to track progress or ensure long-term soil adaptation.

Assessment on the evidence base and evidence gaps

The evidence used to write this section was based mostly on peer-reviewed papers published in international scientific journals. Therefore, confidence is higher when data is available for present scenarios, especially when data originates from field trials instead of laboratory experiments, but confidence decreases when considering models and projections for future scenarios (2050s and 2080s). Evidence gaps regarding climate risks impacts on soils includes the effects on soil microbial communities, nutrient cycling, soil acidification (acid sulphate soils) and gleying (waterlogging and lack of oxygen), and the decrease/increase of heavy metals that can be harmful to terrestrial ecosystems.

Research on soil drought and flooding needs to address the multiple impacts on ecosystems, linking soil physical and chemical attributes to biological factors, such as microbial communities, mesofauna, vegetation and their ecosystem services under climate pressures. Most studies are highly local, possibly constrained by time and budgetary reasons, however it is imperative a UK assessment of climate change on soil health, including multiple soil types and conditions that better reflect the variability of soil types and terrestrial communities is conducted.

8.2.4.2 England

Current and future level of risk

The main climate drivers of risk to soils identified in England are related to temperature and precipitation increases, and the severity and frequency of drought and flooding events. Around 16% of arable fields in the UK are losing soil at rates higher than the ‘tolerable’ level of 1 tonne per hectare per year, showing that soil erosion is happening faster than soils can naturally recover (Benaud et al., 2020). The highest erosion rates are found in northern England, where many peat soils are located. These are associated with higher erosion and waterlogging rates, loss of soil carbon, fertility and biological diversity. Recent studies show that soils in northern England are increasingly vulnerable to climate-related stress. Rising temperatures have increased microbial respiration and CO_2 emissions from grassland soils (Adekanmbi et al., 2022). The 2018 drought reduced net CO_2 uptake in spruce forests by 30%, highlighting the impact of extreme weather on soil carbon balance (Xenakis et al., 2021). Drought also weakens soil–plant interactions, as shown by reduced arbuscular mycorrhizal fungi (AMF) hyphal growth and root colonisation even after recovery (Xu et al., 2024). These findings indicate widespread, unsustainable soil loss, supporting a magnitude assessment of “thousands of hectares of land lost”.

Level of preparedness

There are currently limited policies in place to address climate risks to soils in England, with no specific adaptation measures focused on soil conservation. Sectoral policies focusing on soils in England include: the Environmental Improvement Plan (2023) that will map soil health and manage 40% of agricultural soils sustainably by 2028 and the Environmental Land Management (ELM) schemes that is the main tool to improve soil health on farms, covering around 70% of England’s land (Soil Health Report, 2023). A key barrier to progress is the lack of agreed soil health indicators and consistent data, which limits the ability to set clear targets and monitor policy impact. Experts have urged the government to define indicators, but this has not yet occurred (Environmental Audit Committee, 2016; Soil Health Report, 2023).

Evaluation of urgency score

Based on the evidence above for England, and the UK, the urgency score for present day was identified as More Action Needed. This reflects the magnitude of Medium associated with a High confidence level. Specific criteria reflected by the current evidence were the same as for the overall UK, described previously. Due to the expected increase in climate hazards in the future (2050s and 2080s), the magnitude score was identified as High for future scenarios. However, as the evidence is based on projections from a few peer-reviewed publications, the confidence in this score is considered as Low, requiring Critical Investigation and Further Investigation respectively for the 2050s and 2080s. This means that more evidence is urgently needed to fill significant gaps and reduce the uncertainty of these projections and better assess the need for additional action.

Table 8.18: Urgency scores for N4 Risks to soil ecosystems for England. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

England								
N4 Risks to soil ecosystems.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (M)	++ (M)	++ (M)	+ (H)	+ (H)	N/A (N/A)	+ (H)	+ (H)
With adaptation	+++ (M)	++ (M)	++ (M)	+ (H)	+ (H)	N/A (N/A)	+ (H)	+ (H)
Urgency scores	MAN	MAN		CI			FI	
Overall urgency score	CI							

8.2.4.3 Northern Ireland

Current and future level of risk

The main climate drivers of risk to soils identified in Northern Ireland are related to temperature and precipitation increases, and the severity and frequency of drought and flooding events. These hazards can cause major impacts on peat and other soil types in Northern Ireland as these are associated with higher erosion and waterlogging rates, loss of soil carbon, fertility and biological diversity. Evidence suggests widespread, unsustainable soil loss, supporting a magnitude assessment of “thousands of hectares of land lost.”

Please refer to the previous section regarding the whole of the UK, which reports into detail the reasoning and evidence behind this assessment, as there are no studies available on climate risks to soils specific to Northern Ireland.

Level of preparedness

As is the case of England, there are only partial policies and plans addressing soil health in Northern Ireland. Currently, DAERA is considering a UK-level programme of wide monitoring to inform future soils policy development (DAERA, 2025).

Evaluation of urgency score

As with other nations, the risk evaluation for Northern Ireland is based on those found for the UK and classified as Critical Investigation. The level of risk is Medium for the present and 2030s with Medium confidence based on expert agreement and risks in other nations. Confidence is lower for Northern Ireland in the present day with respect to England, based on the lack of studies specific to this nation but supported in strong expert agreement. In the 2050s and 2080s, the level of risk increases to High with Low confidence.

Table 8.19: Urgency scores for N4 Risks to soil ecosystems for Northern Ireland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Northern Ireland								
N4 Risks to soil ecosystems.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (M)	++ (M)	++ (M)	+ (H)	+ (H)	N/A (N/A)	+ (H)	+ (H)
With adaptation	++ (M)	++ (M)	++ (M)	+ (H)	+ (H)	N/A (N/A)	+ (H)	+ (H)
Urgency scores	MAN	MAN		CI			FI	
Overall urgency score	CI							

8.2.4.4 Scotland

Current and future level of risk

The main climate drivers of risk to soils identified in Scotland are related to temperature and precipitation increases, and the severity and frequency of drought and flooding events. These are associated with higher erosion and waterlogging rates, loss of soil carbon, fertility and biological diversity. Under drought, the large peatland areas in Scotland could become a source of CO_2 emissions, although more targeted research is needed. In Scotland, climate change is disrupting soil health and carbon balance through multiple pathways. Higher temperatures and extreme weather are increasing the release of greenhouse gases from soils, with peatlands in the Highlands switching from carbon sinks to carbon sources during drought (Sterk et al., 2022; Medinets et al., 2021). More rainfall is also altering root–fungus relationships that support plant growth (Kowal et al., 2022), while heat and drought reduce soils' natural ability to suppress crop diseases (Döring et al., 2020). Together, these changes weaken soil resilience and increase emissions, threatening both agricultural productivity and ecosystem stability with evidence suggesting medium level of risk for the present based on "thousands of hectares of land lost" and increasing to high magnitude in the future.

Please refer to the previous section regarding the whole of the UK, which reports into detail the reasoning and evidence behind this assessment.

Level of preparedness

Scotland has limited policies on soils and there is limited evidence of adaptation efforts for the future. The Agriculture and Rural Communities (Scotland) Act 2024, under Rural Land Management, supports the physical, chemical, and biological integrity of soils and their carbon storage capacity. A five-year Rural Support Plan is expected, which would provide financial and policy support and be formalised through legislation.

Evaluation of urgency score

As with other nations, the risk evaluation for Scotland is based on those found for the UK and classified as Critical Investigation. The level of risk is Medium for the present and 2030s with High confidence for the present, and Medium confidence for the 2030s based on expert agreement and risks in other nations. In the 2050s and 2080s, the level of risk increases to High with Low confidence. However, due to the larger area of peatland soils in Scotland, more targeted research is called for, as their response to climate impacts may vary between different vegetation covers and in comparison to other ecosystems across the UK.

Table 8.20: Urgency scores for N4 Risks to soil ecosystems for Scotland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Scotland								
N4	Risks to soil ecosystems.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (M)	++ (M)	++ (M)	+ (H)	+ (H)	N/A (N/A)	+ (H)	+ (H)
With adaptation	+++ (M)	++ (M)	++ (M)	+ (H)	+ (H)	N/A (N/A)	+ (H)	+ (H)
Urgency scores	MAN	MAN		CI			FI	
Overall urgency score	CI							

8.2.4.5 Wales

Current and future level of risk

The main climate drivers of risk to soils identified in Wales are related to temperature and precipitation increases, as well as the severity and frequency of drought and flood events. These are associated with higher erosion and waterlogging rates, loss of soil carbon, fertility and biological diversity. In Wales, soils are showing clear signs of stress from climate-related extremes. Dry–wet cycles increase microbial death, disrupting soil health and fertility (Miura et al., 2020). After drought, seasonally wet soils with hedgerows in Conwy released large amounts of carbon back into the atmosphere instead of storing it (Ford et al., 2021). Soil erosion is also a growing problem, with losses in some arable areas far above sustainable levels, the highest rates occurring in Wales, where many vulnerable peat soils are found (Benaud et al., 2020). Evidence suggests widespread, unsustainable soil loss, supporting a Medium magnitude assessment of “thousands of hectares of land lost.”

Please refer to the previous section regarding the whole of the UK, which reports into detail the reasoning and evidence behind this assessment.

Level of preparedness

Although recognised as more advanced than its neighbouring nations in terms of soil protection (Peake and Robb, 2022), Wales lacks a dedicated soil health policy. However, the government is now preparing a Soil Policy Statement which is expected to reduce soil degradation, improve knowledge exchange, and enhance monitoring by fostering collaboration between scientists and policymakers to improve soil health (Sanchez-Garcia et al., 2023).

Evaluation of urgency score

As with other nations, the risk evaluation for Wales is based on those found for the UK and classified as Critical Investigation. The level of risk is Medium for the present and 2030s with High confidence for the present, and Medium confidence for the 2030s based on expert agreement. In the 2050s and 2080s, the level of risk increases to High with Low confidence.

Table 8.21: Urgency scores for N4 Risks to soil ecosystems for Wales. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Wales								
N4	Risks to soil ecosystems.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (M)	++ (M)	++ (M)	+ (H)	+ (H)	N/A (N/A)	+ (H)	+ (H)
With adaptation	+++ (M)	++ (M)	++ (M)	+ (H)	+ (H)	N/A (N/A)	+ (H)	+ (H)
Urgency scores	MAN	MAN		CI			FI	
Overall urgency score	CI							

8.2.5 Risk to natural carbon stores and sequestration – N5

More action is needed to protect and enhance the UK's natural carbon stores. Peatlands, native woodlands and coastal ecosystems are increasingly at risk from climate change, which is exacerbating the harm caused by pollution, fragmentation, and degradation from agriculture and infrastructure. Many are already shifting from net carbon sinks to sources due to warming, drying, wildfires, and degradation. Meanwhile, restoration is not keeping pace with targets and may be less effective in future climates. Improving land use decisions and strengthening protections and monitoring systems is essential to preserve the climate mitigation potential of UK habitats. This section covers both the risks to existing carbon within the UK's ecosystems (carbon stores) and the rate at which new carbon is incorporated into ecosystems (sequestration of carbon).

Headlines

- More action is needed to protect and enhance the UK's natural carbon stores, especially peatlands, biodiverse native woodlands, and coastal ecosystems.
- These habitats are increasingly at risk from climate change, which is exacerbating the harm caused by pollution, fragmentation, and degradation from agriculture and infrastructure. Many are already shifting from net carbon sinks to sources due to warming, drying, wildfires, and degradation.
- Although research into carbon stores and sequestration in marine and terrestrial habitats has increased, little of it directly addresses climate risks.
- Where evidence has improved our understanding is specifically in blue carbon (carbon stored in coastal vegetated habitats and seabed sediments) research, so our confidence in this measure has increased.
- Coastal and marine ecosystems in particular face accelerating risks but are poorly integrated into current policy frameworks.

Table 8.22: Urgency scores for N5 Risks to natural carbon stores and sequestration. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

ID	Risk		Present	2030	2050	2080	Urgency
N5	Risks to natural carbon stores and sequestration	**UK**	+++ (H)	+ (H)	+ (H)	++ (VH)	CI
		England	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	+++ (H)	+ (H)	+ (H)	+ (VH)	CI
		Scotland	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN

8.2.5.1 Evidence relevant to the entire United Kingdom

Current and future drivers of risk

Climate change is a growing pressure on the UK's natural carbon stores, with rising temperatures, wetter winters, and more intense summer rainfall contributing to both widespread flooding, increasing drought and wildfire risk; the latter two pressures being felt particularly in the south and east of the UK (State of the Climate Chapter) (Met Office, 2023; Arnell et al., 2021; Perry et al., 2022). These climatic changes are affecting the functional processes of terrestrial and coastal ecosystems, reducing both their capacity to sequester carbon and the permanence of existing carbon stocks (Environment Agency, 2023). This section focuses on carbon stored in vegetation, soils and sediments, excluding long-term geological carbon cycling processes.

Peatlands are the UK's largest store of soil carbon, but also the highest greenhouse gas (GHG) emissions source from land use, land use change and forestry (LULUCF) (Bennett et al 2025). Peatlands ecosystems in good condition sequester additional carbon as the waterlogged environment hampers aerobic decomposition of dead vegetation, and protects existing stores of carbon within the peat. However, drainage of peatlands for other land uses, including agriculture, forestry and peat extraction lowers the water table and allows the peat to decompose, releasing stored carbon as CO_2. These drained peatlands are also increasingly vulnerable to wildfire, especially in dry years (N1). This can result in substantial carbon losses as the peat burns and diminished future storage capacity (Baker et al., 2025; Naszarkowski et al., 2024).

Woodlands are the key LULUCF net sink in the UK GHG Inventory, though the quantity of carbon sequestered by the forest sector has declined since CCRA3-IA-TR, largely due to the age of the UK's forestry (Bennett et al 2025). However, climate-driven risks such as storms, pests, and reduced tree productivity and regeneration, threaten this function. In woodlands, disturbances that reduce tree health or increase mortality can diminish carbon uptake, depending on how resulting deadwood is managed. Climate risks to woodlands (N1 and N8) may also impact woodland carbon stores.

Grasslands and croplands store carbon primarily in soils, although uptake and loss are generally balanced on mineral soils (low organic matter) in the UK, with grasslands on mineral soils representing a small net sink and croplands on mineral soils representing a small net source in the UK GHG Inventory (Bennett et al 2025). Globally, soils represent around 25% of potential natural climate solutions, with 40% of this potential from protecting existing carbon and 60% from restoring depleted stocks (Bossio et al., 2020).

Coastal and marine ecosystems represent a large carbon stock and continue to accumulate carbon, both from trapping sediment from outside sources and through sequestration from the atmosphere. These systems face high risks from sea-level rise, warming waters, acidification, reduced oxygen, and extreme weather (CCC, 2022; Gihwala et al., 2024) (N1 and N3). The UK's coastline has been highly modified; up to 68% of England's saltmarshes have hard structures defining their landward boundary (Burden et al., 2024). This decreases the ability of coastal habitats to move and adapt in response to pressures, increasing their vulnerability and exposure. Additional pressures, including dredging and anchoring in seagrass beds, further compound climate-related threats (Turschwell et al., 2021).

Assessment of current magnitude of risk

This section presents the current level of risk to carbon stores and sequestration across the UK's three primary carbon-sequestering habitats, peatlands, woodlands, and blue carbon ecosystems. While also considering other habitats where supporting evidence is available.

<u>**Peatlands**</u>: Potential risks include increased plant growth and decomposition, shifting vegetation, and interactions with nutrient pollution that could affect carbon sequestration (Antala et al., 2022; Comber et al., 2023). Despite current restoration efforts, evidence suggests restored peatlands can sequester carbon but often do not return to full undisturbed functioning (Loisel & Gallego Sala, 2022; Allan et al., 2024; Wilson et al., 2022). Climate-driven wildfire risk is also increasing in blanket bogs and dry heaths, reducing both stored carbon and future sequestration potential (Naszarkowski et al., 2024) (N1). In drained agricultural peatlands, which are

major CO_2 sources (e.g. Evans et al., 2021, Freeman et al., 2022), evidence suggest that rewetting strategies like seasonal flooding or paludiculture (wet agriculture and forestry on peatlands), could reduce carbon emissions.

Woodlands: Ecological complexity in woodlands is declining, reducing resilience (Smart et al., 2024), while sustainable management of woodlands, which is intended to build resilience, is currently in a declining trend further increasing the vulnerability of these habitats to climate change (Forestry Commission, 2025). Increased drought levels are likely to reduce carbon uptake by trees in mature stands and keep clear-fell sites as net carbon sources for longer (Xenakis et al. 2021). The role of wet woodlands in carbon sequestration under a changing climate remains poorly understood (Milner et al., 2024).

Blue Carbon: Blue carbon habitats were previously flagged as significant but uncertain carbon stores. Recent work has estimated the UK seabed sediments organic carbon stock to be 244 Mt, with 4.1 Mt (1.7%) in vegetated habitats like saltmarsh, seagrass, and kelp (Burrows et al., 2024). Saltmarsh accumulation rates vary, with more recently restored marshes potentially sequestering more carbon than natural ones (Mason et al., 2022; Parker et al., 2020). Seagrass sequestration is less understood, but its potential loss also threatens adjacent habitats by reducing wave attenuation (Unsworth et al., 2022; Forrester et al., 2024). Fjords (sea lochs) in Scotland show the highest sediment accumulation, while offshore mud habitats show minimal rates (Burrows et al., 2024). Climate change alters these rates by increasing erosion, changing rainfall and river flow, and causing sea-level rise, which affects how much sediment is deposited or washed away.

Other Habitats: Globally, soils account for 25% of natural climate solution potential (Bossio et al., 2020), with significant benefits from converting arable land to forest or grassland (Eze et al., 2023). However, GHG emissions from intensively managed grasslands may increase under warming, posing a feedback risk (BarnU et al., 2022). National data (e.g., from the Countryside Survey) has yet to show clear climate-driven changes in topsoil carbon (Thomas et al., 2020). Choosing appropriate crop types and locations is essential to maximise climate benefits and minimise trade-offs.

Based on this evidence, expert judgement assessed the current magnitude of risk High for all UK nations due to major impact (approximately 10% or more at national level) to valued habitat or landscape types and tens of thousands land lost or severely damaged.

Assessment of future magnitude of risk

Recent literature on the topic focuses on long-term risks by the 2080s. Globally, CO_2 uptake via photosynthesis may peak around 2050 and decline thereafter under moderate emissions scenarios (Shared Socioeconomic Pathway (SSP) 3-7 and SSP 2 – 4.5), while soils may shift from carbon sinks to carbon sources (Ren et al., 2024; Ruehr et al., 2023). Northern peatlands could remain climate-neutral under a central scenario but become a net CO_2 source under a high scenario (Qiu et al., 2022). Restoration is critical, as bogs will only achieve a cooling effect under rapid rewetting (Wilson et al., 2022). Future projections show that under a high scenario, the bioclimatic envelope that promotes the formation of blanket peat will have shifted north and west to the extent that the majority of England, Wales and southern and eastern Scotland could be unsuitable for continued peat formation and hence carbon sequestration (Ritson et al., 2025). However, it is important to note that restoration of semi-natural peatlands should maximise their resilience and remains an important mechanism to safeguard existing carbon stores (Loisel and Gallego-Sala 2022).

Small changes on forest dynamics with impacts on carbon stocks are predicted by 2030 (Yu et al., 2021). By the 2080s, UK woodlands are projected to experience changes in net primary productivity, which when the effects of increased carbon dioxide concentrations are removed are likely to result in reductions in productivity and carbon sequestration particularly in southeastern England (Yu et al., 2021). However, future wood production may not align with improvements in biodiversity or carbon balance (Biber et al., 2020) (N1).

Coastal carbon stores face similar threats. Saltmarshes currently keep pace with sea-level rise through sediment accretion (Wang et al., 2021), but accelerating sea-level rise (Palmer et al., 2023) may soon exceed their capacity to adapt, risking carbon release (Gore et al., 2024; Masselink and Jones, 2024). Warming may also accelerate carbon loss through increased litter decomposition, and accelerating carbon and nutrient cycling (Tang et al., 2023). Seagrasses are similarly vulnerable to warming and face additional pressures such as dredging and anchoring (Turschwell et al., 2021).

Restoration outcomes remain uncertain, particularly under climate change. Peatlands may become less viable in the UK by the 2080s in a high scenario (Ritson et al., 2025), and there is limited long-term data on restored coastal or peatland sites. However, some evidence suggests more recently restored saltmarshes may sequester carbon more rapidly than natural ones (McMahon et al., 2023; Mossman et al., 2022), meaning that care should be taken when extrapolating from short-term measured sequestration rates.

Based on this evidence, expert judgement assessed the magnitude of risk for the 2030s and 2050s as High for all UK nations due to major impact (approximately 10% or more at national level) to valued habitat or landscape types and tens of thousands land lost or severely damaged, increasing to critical by the 2080s as impacts extend to more than 15% of valued habitat or landscape types and hundreds of thousands hectares lost or damaged.

Level of preparedness for risk Across the UK

Policy focuses on protecting carbon stores has increased in the last five years, though the focus has been on reaching Net Zero, not specifically the risks from climate change. The UK's Net Zero Strategy (HM Government, 2021) and Carbon Budget Delivery Plan (HM Government, 2023) aim to protect and restore peatlands and woodlands through new environmental land management schemes, and support of expert advisory groups. They also now include mention of blue carbon habitats, advising further research and collation of evidence. The UK Blue Carbon Evidence Partnership, launched in 2021, aims to strengthen research and policy on blue carbon, publishing an Evidence Needs Statement in 2023 to address key knowledge gaps (UKBCEP, 2023). In 2024, UK Government launched a Tree Planting Taskforce bringing together ministers from across the four UK nations, along with key forestry delivery partners and arm's-length bodies. The Taskforce will provide oversight and share best practice to improve tree planting across the UK.

Despite the presence of national peatland strategies across all devolved nations and accelerated restoration efforts in recent years, restoration and conservation efforts remain well below targets (IUCN, 2024). A major barrier is the lack of national-scale data on peatland baseline condition and restoration activity.

Large land-owning organisations including the Crown Estate, National Trust, and Wildlife Trusts are taking steps to enhance carbon sequestration through peatland restoration and woodland creation. Challenges remain, including limited funding and the need for more integrated, landscape-scale efforts (National Trust, 2023). The UK Blue Carbon Forum supports cross-sector collaboration to integrate blue carbon into research and policy. Voluntary nature markets are emerging to channel private investment into nature restoration, with carbon credits currently being the most established mechanism. UK's Woodland Carbon Code and Peatland Code are already in place to protect and increase the amount of carbon stored in these habitats. New initiatives such as the UK Farm Soil Carbon Code and Saltmarsh Code are in development.

8.2.5.2 England

Current and future level of risk

Much of the UK evidence, particularly on Blue Carbon habitats, applies to England, where climate change currently poses a high risk to carbon stocks and sequestration. This section should be read alongside the UK assessment. Recent mapping shows that 80% of England's peatlands are dry or degraded (Kratz et al., 2025), and despite increased policy attention, national-scale adaptation is not yet sufficient to reduce future risks. By the

2080s, most English peatlands are projected to fall outside the suitable area for peat formation, making restoration and adaptation essential (Ritson et al., 2025). Woodlands in southern and eastern regions, are also vulnerable to changes in temperature, wind, rainfall, and CO_2 levels (Yu et al., 2021) (N1).

Level of preparedness

Policies on carbon stores are getting more attention in line with Net Zero targets. England has taken several steps to reduce risks to carbon stocks and enhance sequestration, particularly through peatland and woodland initiatives. The England Peatland Action Plan (2021) outlines restoration targets supported by over £50 million in investment, while policy tools like the 2021 ban on burning deep peat and a proposed (but unimplemented) ban on horticultural peat aim to conserve carbon stores (IUCN, 2024; CCC, 2024). Research is also underway to assess the effects of farming adaptations on lowland peat (e.g., paludiculture and seasonal rewetting) following the Lowland Agricultural Peat Task Force's recommendations in 2023. In parallel, woodland strategies are advancing Forestry England's Growing the Future: 2021–26 recognises forests as central to climate mitigation, with goals including 2,000 hectares of new woodland planting focused on resilience and species diversity. As part of this, 1,000 hectares across 16 new woodlands were planted by April 2025 through the Nature for Climate Fund.

Evaluation of urgency score

More Action Needed is applied due to High magnitude of risks in the present day, 2030s and 2050s, increasing to Very High in the 2080s. There are insufficient measures in England to address growing risks to carbon stocks and sequestration. Peatland, saltmarsh, and seagrass habitats continue to degrade, with restoration and protection efforts falling short of the scale required to meet climate goals. Policies such as the Environmental Improvement Plan and peatland restoration funding recognise these risks, but implementation remains slow, spatially fragmented, and lacks comprehensive monitoring. Coastal squeeze and land-use pressures are accelerating risks to carbon stores, and adaptation efforts have yet to show ecosystem-scale benefits. Scores are given with Medium confidence for all future scenarios, reflecting strong agreement on risk magnitude but limited evidence.

Table 8.23: Urgency scores for N5 Risks to natural carbon stores and sequestration for England. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

England								
N5	Risks to natural carbon stores and sequestration.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.5.3 Northern Ireland

Current and future level of risk

Although in the last five years, no specific studies have reported the impacts of climate change on carbon stocks and sequestration in Northern Ireland, risks remain High. Here, peatlands are under climate pressure from warming, droughts and wildfires (N1) which damage peat-forming species like Sphagnum moss and increase peat decomposition (Kelly et al.,2023; DAERA, 2024). Northern Ireland contains a significant amount of degraded peatlands that are currently a net source of emissions (CCC, 2025). These emit large amounts of CO_2 (approximately 170,500 tonnes per year) and are highly vulnerable to drier summers, erosion, and fire risk as the climate warms. Risk scores were given according to UK-wide evidence and based on strong expert agreement.

Level of preparedness

Northern Ireland has a Peatland Strategy (2022–2040) to restore and manage 150,000 hectares of peatland by 2050. It also has a Blue Carbon Action Plan (2025–2030) to monitor and protect coastal habitats, although this remains high-level with no defined timelines. Woodland expansion is supported by the Forests for our Future programme (2020) targeting the creation of 9,000 hectares of woodland by 2030. Additionally, the draft of the Third Northern Ireland Climate Change Adaptation Programme (NICCAP3) is being developed and will further focus on the adaptation of carbon stores.

Evaluation of urgency score

More Action Needed is applied due to high climate risks to carbon stores in Northern Ireland. Restoration programmes are small relative to the extent of degraded peat, and policy measures do not fully address pressures from agriculture, drainage, and wildfire risk. Coastal blue carbon habitats face erosion and sea-level rise, with little targeted adaptation. Scores are given with Low confidence for the all future scenarios due to the limited evidence specific to Northern Ireland, but strong expert agreement on magnitude of risks.

Table 8.24: Urgency scores for N5 Risks to natural carbon stores and sequestration for Northern Ireland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Northern Ireland								
N5	Risks to natural carbon stores and sequestration.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	+ (H)	+ (H)	+ (H)	+ (H)	N/A (N/A)	+ (VH)	+ (VH)
With adaptation	+++ (H)	+ (H)	+ (H)	+ (H)	+ (H)	N/A (N/A)	+ (VH)	+ (VH)
Urgency scores	MAN	CI		CI			FI	

Overall urgency score	CI

8.2.5.4 Scotland

Current and future level of risk

The UK scores are relevant to Scotland, with few Scotland specific reports on the current and future risks of climate change to carbon stocks over the past 5 years. The Flow Country peatlands, one of the largest expanses of blanket bog in Europe, which might under extreme circumstances, fall outside the bioclimatic envelope predicted to support continued peat formation, and hence carbon sequestration by the 2080s (Ritson et al., 2025). The drought risk in Scotland forests is projected to reduce forest productivity and carbon sequestration by 2050 (Locateeli et al., 2021).

Level of preparedness

The Scottish Government's Update to the Climate Change Plan 2018-2032 identifies forestry and peatlands as the two key pillars of its Land Use, Land Use Change and Forestry strategy, aiming to expand both to reduce greenhouse gas emissions. The peatland restoration target is 250,000 hectares by 2030, but progress data is limited. The plan also includes phasing out horticultural peat and restricting development on peatlands. From 2025, burning on deep peat will be banned except under licence (Wildlife Management and Muirburn (Scotland) Act, 2024). Woodland creation targets are 18,000 hectares annually by 2024-2025, but it remains unclear whether these goals are being met. Also, a Blue Carbon Research Programme was launched to support the development of a Blue Carbon Action Plan to address evidence gaps, protect existing carbon sinks, and identify the role of coastal habitats in achieving net zero.

Evaluation of urgency score

More Action Needed is applied as Scotland's carbon stores, particularly in peatlands and coastal habitats, remain highly vulnerable to climate change and land-use pressures. Although national commitments to peatland restoration and blue carbon research are more advanced than in other nations, restoration rates remain far below the level needed to reduce ongoing losses. Pressures from drainage, overgrazing, and storm-driven erosion persist, and there is limited evidence that restoration projects are delivering consistent, long-term carbon benefits at scale. Score are given with Medium confidence for future scenarios, based on strong agreement between experts on future risks.

Table 8.25: Urgency scores for N5 Risks to natural carbon stores and sequestration for Scotland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Scotland				
N5	Risks to natural carbon stores and sequestration.			
	Present	2030	2050	2080

		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.5.5 Wales

Current and future level of risk

Risks to carbon stores in Wales in the present day, 2030s and 2050s are High based on UK wide evidence. Risks are expected to rise to Very High by the end of the century based on projected risks. Sea-level rise threatens intertidal habitats like Atlantic salt meadows in Welsh Special Areas of Conservation, with all key blue carbon indicators assessed as vulnerable (Gihwala et al., 2024). By the 2080s, more than 20% of Welsh peatlands are also projected to fall outside the climatic range suitable for peat formation and carbon sequestration (Ritson et al., 2025). Confidence is Medium for future risks due to more limited evidence but strong expert agreement.

Level of preparedness

The Wales Net Zero Strategy (2021–2025) aims to increase tree cover and safeguarding of soil carbon. Tree planting targets under the Woodland for Wales strategy aim to add 2,000 hectares annually, though progress has been limited—only 640 hectares were planted in 2023–2024. Peatland and blue carbon restoration are also central, led by the National Peatland Action Plan and initiatives to restore seagrass and saltmarsh habitats. However, there are data gaps on whether restoration ensures long-term ecological resilience. The Blue Carbon Forum for Wales has also been established to enhance knowledge-sharing. Despite these initiatives, the Net Zero Strategy acknowledges that approximately 60% of required changes fall under UK government control, limiting Wales’ ability to act alone.

Evaluation of urgency score

More Action Needed is applied due to high risks from climate change on peatlands, saltmarsh, and seagrass degradation from drainage, erosion, and coastal squeeze. Agricultural and development pressures, combined with climate-driven change, are further reducing resilience and long-term habitat store and sequestration ability. Scores are given with Medium confidence for the near term, reflecting strong agreement on risks but more limited evidence for future scenarios.

Table 8.26: Urgency scores for N5 Risks to natural carbon stores and sequestration for Wales. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Wales								
N5	Risks to natural carbon stores and sequestration.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.6 Risk to agriculture – N6

Climate change is already negatively impacting UK agriculture through rising temperatures, changing precipitation patterns, and extreme weather events, with impacts on productivity which are likely to increase. Wet conditions in 2024 reduced areas planted and yields of wheat, resulting in 20% lower production, while the record-breaking temperatures experienced during summer 2022 led to increased premature poultry deaths in housing and transport. Evidence shows risks to key agricultural areas in England and loss of high-quality agricultural land due to drought in Wales. More Action Needed is applied, to adapt farming and food systems to increasing risks including drought, flooding, soil degradation, soil erosion, pests, diseases, and heat stress.

Headlines

- More action is urgently needed across all UK nations to strengthen climate change adaptation in agriculture, as rising temperatures, shifting rainfall, and extreme weather are already reducing productivity and increasing risks to farming systems.
- Severe flooding and extreme heat have already caused major yield losses and livestock deaths, highlighting the sector's growing vulnerability.
- Drought, soil degradation, erosion, pests, and heat stress are escalating threats to agricultural land and production.

Table 8.27: Urgency scores for N6 Risks to agriculture. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

ID	Risk		Present	2030	2050	2080	Urgency
N6	Risks to agriculture	**UK**	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		England	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Scotland	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN

8.2.6.1 Evidence relevant to the entire United Kingdom

Current and future drivers of risk

UK agriculture faces significant risks from rising average temperatures and changing precipitation patterns, including damage due to more frequent extreme weather events (e.g., droughts and floods) and from pests, diseases and invasive species as warmer temperatures allow them to survive and reproduce in areas they could not previously. Several studies have examined the effects that these pressures have on specific agricultural sectors. Shifts towards crop monocultures and high intensity systems may increase the exposure to pests and diseases (Dainese et al., 2019).

Nearly 99% of UK agricultural production relies on soil, and climate change is a major threat to farming due to increased erosion, compaction, flooding, drought, and loss of biodiversity and organic matter (Tibbett et al., 2020). This is one of the greatest threats to agriculture (N4).

Warming temperatures are shifting the timing of life-cycle events of animal-pollinated crops, such as fruit. This exposes them to greater frost damage risk and is causing some species to flower before their main pollinators emerge (Wyver et al., 2023a; Reeves et al., 2022). Populations of insect pollinators, which are crucial to produce many high value horticultural crops, are also in decline (Powney et al., 2019), partly due to climate change. Greater drought stress is affecting agricultural productivity, particularly in England (Harkness et al., 2023). Increasing demand for water (for all uses) may limit availability for agricultural irrigation, with projected increases in crop water demand likely to exceed available local supplies.

Climate risks to agriculture will interact with wider drivers such as political instability, conflict, which has disrupted international trade and supply of agricultural inputs (Cole and Petricova, 2024), population growth, changes in self-sufficiency and trade patterns (Defra, 2024) and biodiversity loss, which could impact pest and disease patterns, and pollinator populations.

Assessment of current magnitude of risk

Agriculture has experienced losses of £1 billion annually due to recent extreme events, but this does not consider important dimensions (e.g. impacts on soils, ecosystem services, impacts on wellbeing and rural economy), and depending on the nature of the event, some crops or systems may benefit while others have experienced production losses. Hence this correlates to a High risk magnitude for the UK as whole in the present-day.

Agriculture is particularly vulnerable to drought and flooding. Drought periods, which occur when there is a lack of rainfall over a long period of time and result in water shortages for people, activities or the environment, now encompass 6-15% of arable crop growth period. Approximately 13% of all agricultural land, including approximately 59% of high-quality grade 1 agricultural land is at risk of flooding from rivers and the sea (EA, 2025). These trends are consistent across the four nations but more severe in England where the majority of UK arable land is based. Analysis of recent (2014-2021) data in England indicates negative impacts of hot and dry weather conditions on crop production that are more pronounced in legumes and oilseeds than cereals (Pfuderer, Redhead & Bishop, in prep). Increased rainfall variation between 2005-2017 was associated with greater variation in farm production and income, while temperature variability had less consistent effects (Harkness et al 2023; EA, 2024).

Climate change has expanded the range of horticultural crop pests such as the Mediterranean fruit fly (*Ceratitis capitata*), a pest of many fruit crops (Szyniszewska et al., 2024), with the greatest pressure likely in southern England due to its warmer climate and proximity to continental Europe. Many high value fruit crops depend on pollination by insects for optimal production. Due to warmer temperatures, some of these crops are now flowering earlier than their key pollinators are emerging (Wyver et al., 2023a; Reeves et al., 2022). Combined with historic declines in pollinator diversity (from all causes: Powney et al., 2019), this highlights a risk of inadequate pollination to these crops.

Intensified droughts and changes in precipitation increase soil erosion, compaction, biodiversity and organic matter loss, all of which interact in positive feedback loops to worsen soil degradation. This causes the potential for widespread yield losses and impacts to food security (N4, N10).

UK farmers are already reporting heat, drought, and flooding (often accompanied by soil erosion and run-off) as major threats to their businesses (Wheeler and Lobley, 2021). Weather conditions in recent years have been some of the most extreme on record and have affected domestic production. There has been an increase heat stress risks during UK wheat flowering, but the risk remains small (<1% chance of at least one day per year) (Arnell et al 2021). Livestock in England are more exposed, with 3.3 days per year of heat stress reducing milk yield, compared to 0.3-1.4 days in the other three nations (Arnell et al 2021). The record-breaking temperatures experienced during summer 2022 reduced poultry production by 2.6% (relative to the 1997-2022 average) and led to increased premature poultry deaths in housing and transport, while wheat production increased by 8% (relative to 2017-2021 average) (Davie et al., 2023). England had its wettest 18-month period on record between October 2022 to March 2024. Fields that were normally destined for livestock grazing were submerged. The 2024 UK wheat harvest was 11.1 million tonnes, a decrease of 20% on 2023 (Cereal and Oilseed Production in the United Kingdom, 2024). Only 20% of the Group 1 (milling wheat) harvested in 2023 met the standards required by the milling industry for bread making.

These events have had significant economic impacts. The 2024 wheat production was valued at £2.2 billion compared to £2.9 billion in 2023 – a £0.7 billion loss (Defra, 2024, 2025). Impacts on other crops were smaller (Defra, 2025), barley production increased by 1.8% to 7.1 million tonnes but value of production was 14% lower at £1.2 billion; oilseed rape production decreased by 32% to around 824 thousand tonnes and value of production declined sharply to £335 million, down 31%; sugar beet production increased by 0.9% to 7.8 million tonnes and value of production fell by 0.7% to £365 million. The value of fruit and vegetable production rose by 4.5% and 2.1%, or £1.1 billion and £2 billion respectively. The total value of cereal production dropped by around £1 billion (ECIU, 2024). In 2022, the poultry production loss equates to £315 million (using data from Defra, 2024 and Davie et al. 2023). Wheat production value was 50% higher in 2022 (£4.1 billion) than 2021 (Defra, 2024); the total value of 2022 cereal production was £2.1 billion greater than 2022, but this was partly due to oilseed price increases.

Based on the evidence, the magnitude scores for the present are High for all nations, due to major (large and frequent) damages to agriculture, and major economic damages (£ hundreds of millions or 0.005%-0.05% GDP) from climate change to agriculture across the UK.

Assessment of future magnitude of risk

Slater et al (2022) examined the effects of future climate change on UK wheat yields and predicted that climate shifts may lead to improved yields in the coming decades. Projected warmer winters could counterbalance increased rainfall during wheat's early growth stages, while warmer and drier conditions later in the season may further support yield growth. However, recent evidence has demonstrated that the increased frequency of unpredictable, extreme weather events poses new challenges for UK farming that render the concept of improved yields unrealistic.

There is generally very limited new evidence available for the short-term impacts of climate change (up to the 2030s) with most projections focusing on 2050s and 2080s. However, shorter term projections indicate that drought hazards will increase across the UK relative to the baseline period by 7-11% (dependent on indicator and nation), while there is a greater risk of heat stress to dairy and wheat production in England than in the other three nations (10 days per year vs 1-4 for dairy, 0.3% chance of wheat heat stress vs 0%) (Arnell & Freeman, 2021). These projections only focus on dairy and wheat and may underestimate increases in extreme events due to the methods used. Evidence from historic (2014-2021) data in England indicates that legume and oilseed (break) crops are generally more susceptible to heat stress than cereals; this could reduce the likelihood of crop diversification in future conditions as the risk of high temperature events increases (Pfuderer, Redhead & Bishop, in prep).

Additional risks, such as the increased occurrence or seasonality of pests and parasites may aggravate climate change impacts on UK production (Wreford and Topp, 2020). A warmer UK climate may provide an ecosystem which is habitable for non-native pests as well as reducing habitats for pollinators and natural enemies of pests (Moss et al., 2021). Measures taken to reduce the above risks, such as the increased application of pesticides, pose additional public health and ecological concerns (Martinez-Megias et al., 2023).

By the 2050s, pathogens are a major future risk to horticulture. Potato blight is projected to increase across the UK, with the worst impacts in Scotland, East England, the Midlands, and Yorkshire & the Humber (Garry et al. 2021). Other new pathogens may have a lower probability of establishing, but significant impacts if they do – for example, the vector-borne pathogen responsible for a lethal grapevine disease which threatens the UK's growing and high value wine industry (Giménez-Romero et al., 2022). Climate-related pressures are also expected to push some insect pollinators out of areas that are suitable for the crops they pollinate (Marshall et al., 2023), and European scale projections indicate that many species will lose range overall, increasing the risks from short-term species loss (Gishbain et al 2024). The timing of top-fruit flowering and pollinator activity may further desynchronise, as they respond differently to warming, leading to production losses (Wyver et al., 2023a).

The projected effects of heat stress to 2050 on arable crops vary; studies focusing on cross-year averages show positive impacts on UK wheat yield (Slater et al., 2022) or that little yield losses will occur in South East England (Senapati et al., 2021). Studies on extreme events show that heat stress during critical flowering stages will increase in frequency and severity (Arnell et al 2021), but the impacts of heat stress may be reduced by faster crop development due to warmer average temperatures (Putelat et al. 2021). Arable crops will also be more threatened by drought in England, with the worst year in 20 causing 20% yield loss in wheat in South East England (Senapati et al 2021).

The projected impacts on livestock are more mixed, but heat stress will likely reduce productivity (Wreford and Top, 2020). Arnell & Freeman (2021) project that heat stress will impact milk yield of cattle on 6-25 days per year in the 2050s, compared to 4 days in the baseline period. Estimates that integrate responses to both temperature and humidity indicate that stress threatening production will occur 3.5 days per year in 2051-2070 for dairy cattle and laying poultry, compared to 0.4 days per year in a 1998-2017 baseline. South West England, the area with the most dairy cattle, is projected to experience 15-30 heat stress days per year by 2070 compared to 0-2 days in the baseline period (under a high emissions scenario, Davie, Garry & Pope, 2021). Coastal flooding and erosion are projected to reduce the UK land surface classified as 'high quality farmland' from an average of 38% (1961 to 1990) to 11% by 2050 (Defra, 2021).

Analysis of the long term (up to 2080's) risks indicate that under the low scenario (SSP 2.6), severe drought will occur 16% of the time in England compared to 7-8% in Wales, Scotland and Northern Ireland (Arnell & Freeman, 2021). In England there is a 0.5% chance of heat stress in wheat (and a 3% range from 10-90th percentiles) compared to 0% in the other 3 nations, and 15 days with dairy heat stress in England vs 6, 2 and 2 days for Wales, Scotland and Northern Ireland respectively (Arnell & Freeman, 2021). Dairy cattle in the Southwest may experience a nearly 1000% rise in heat stress events (Garry et al. 2021), affecting animal welfare and milk production. Uncertainty in projections is greater for the 2080s compared to other time periods. By 2070, the frequency of potato blight is expected to rise by 70% in East Scotland and 20-30% in areas such as East England and Yorkshire, impacting potato yields (Garry et al. 2021). Seasonal shifts could reduce grass quality and lead to hay and silage shortages. Increased CO_2 levels may alter plant chemistry in a way that leads to a decrease in the nutritional composition of plants (Ziska, 2022).

Magnitude scores for the 2030s and 2050s remain High as large and frequent damage is projected for the sector, increasing to Very High by the 2080s, because the sector is vulnerable to climate-related hazards such as extreme heat, drought, and flooding which result in very large and frequent damage to agricultural production and hundreds of thousands of hectares severely damaged.

Level of preparedness for risk

The UK still lacks a targeted strategy and associated targets for ensuring agriculture remains productive as the climate changes. Indicators to track the exposure and vulnerability of the sector to climate change remain limited. New agricultural policies have been announced, but it remains to be seen how these will impact the climate resilience of agriculture (CCC progress report, 2025). The UK government is supporting climate adaptation in agriculture through the Environmental Land Management schemes (ELMs) which are currently fully operational in England. These initiatives promote climate resilience through a mix of environmental restoration, lower-intensity agricultural practices and more significant system transformations (e.g. agroforestry). Measures to promote resilience in farming may imply trade-offs, for example resilient crop varieties will perform better than conventional ones during stress conditions but yield lower than current varieties during normal conditions (Davie et al., 2023). The NAP3 also outlines funding for climate-resilient crop and livestock breeds, and improved on-farm water storage and a £30 million commitment to breeding research. Additionally, DEFRA's Genetic Improvement Networks are promoting research to develop crop varieties with better yield, resilience, and disease resistance for UK farming.

Despite these incentives, many farmers are largely motivated by short-term financial stability, do not perceive climate adaptation as a priority and view the risks as too uncertain or too far in the future (Wheeler and Lobley, 2021). These farmers are often unaware of the full range of adaptation options or their relative cost-effectiveness and similarly, the costs and potential interference with farm activities are a major barrier for the uptake of agroforestry practices (Felton et al., 2023).There is a lack of awareness of resilience-building activities, and associated need for educational and outreach activities such as educational schemes to support farmer-to-farmer mentoring, on-farm living labs (Hood et al., 2025), and nature-friendly or more diverse farming practices. Recent work assessing quick wins (measures that are effective, low cost and easy to implement) in farming adaptation could support their more effective uptake (Foulkes et al., 2023a, b).

Assessment on the evidence base and evidence gaps

Although there have been some notable advances in understanding of climate risks to agriculture, significant data gaps remain. The evidence of climate impacts on agriculture, and many of the models used to make these predictions focus heavily on the impacts on arable farming, often due to limited publicly available data on the distribution of non-arable crops and livestock. Most studies have focused on either heat or drought stress in isolation but the two often have compounding, multiplicative effects on productivity. Other climate related long-term pressures and their interactions (e.g., water logging), shocks (e.g., severe winds), elevated CO_2, and pollution are under-explored, as are the impacts on pests and diseases of livestock. Data on crop management (including economic data), protection and physiology is focused at the field scale (Corcoran et al., 2023) limiting capacity to make generalisations and wider-scale assessments of impacts on farm businesses and the food system. Finally, although the contribution of biodiversity has been increasingly recognised, we lack good monitoring data to estimate baseline populations, model status and trends under climate change, and robustly measure the impacts on agriculture or how this might change in the future (e.g., immigrant species replacing lost native pollinators in crops).

There is also limited evidence on climate impacts on agriculture that is specific to each of the devolved nations. Each nation has different major livestocks and crops that make above average contributions to their economies, so significant climate impacts on these products will be of national significance (e.g., dairy cows in Northern Ireland; blackcurrants, barley, oats and potatoes in Scotland; lamb in Wales and wheat in England).

8.2.6.2 England

Current and future level of risk

This section includes England-specific evidence but should be read with the UK assessment for a full understanding of climate risks affecting this nation.

In England, present risks to agriculture are already significant, with major economic losses due to climate impacts. The total value of cereal production fell by around £1 billion (ECIU, 2024), and wheat production dropped from £2.9 billion in 2023 to £2.2 billion in 2024 (Defra, 2024, 2025). Other crops were variably affected

— barley values declined by 14%, oilseed rape production fell 32%, and sugar beet value dropped 0.7%, while fruit and vegetables saw modest increases (Defra, 2025). Poultry losses reached £315 million (Defra, 2024; Davie et al., 2023). Future risks remain high however, droughts in South East England could cause 20% wheat yield losses in one-in-twenty years (Senapati et al., 2021), and heat stress during flowering is expected to intensify (Arnell et al., 2021). By the 2080s, wheat heat stress probability may reach 0.5% (Arnell & Freeman, 2021). For livestock, dairy cattle in South West England could face 15–30 heat-stress days annually by 2070 (Davie, Garry & Pope, 2021) and up to a 1000% increase in heat-stress events (Garry et al., 2021), while coastal erosion may reduce high-quality farmland from 38% to 11% by 2050 (Defra, 2021).

The Fens is the UK's largest coastal lowland, containing around half of the UK's Grade 1 agricultural land and is therefore strategically important to food production. Increases in flood risk by the 2080s, with limited adaptation, is projected to be approximately 7 times the present-day value. Furthermore, droughts are projected to worsen under future climate change. At 2 °C, which could occur by the 2050s, the number of months in severe drought in a 30-year period is projected to be 34.3. By the 2080s, yields of major crops are projected to plateau or decrease. Given the high proportions of total agricultural production currently supplied by the Fens, this is likely to have a major impact by mid-century, and critical impact by the 2080s on UK domestic food production (Jenkins et al., 2024).

Level of preparedness for risk

England has several policy actions that can influence agricultural adaptation to climate change. In 2020, the Path to Sustainable farming (DEFRA, 2020) outlined a transition plan from 2021-2024, which aims to reduce reliance on subsidies and promote ELMs. The EIP) (DEFRA, 2023) proposed delivering a headline environmental goal to sustainably use natural resources. Farm-specific commitments within the Plan include supporting farmers to create or restore 30,000 miles of hedgerows a year by 2037 and 45,000 miles of hedgerows a year by 2050, returning hedgerow lengths in England to 10% above the 1984 peak (360,000 miles). Hedgerows and trees are a major source of nesting, shelter and forage resources for functional biodiversity such as pollinators and natural predators of pests, can reduce the risks of erosion and flooding, and can provide shelter for crops and wildlife (Staley et al., 2023). The EIP also includes an initial £10 million investment to enhance on-farm water storage capabilities, including the construction of reservoirs and irrigation infrastructure. This is part of a broader strategy to increase on-farm water storage by 66% by 2050, helping farmers maintain productivity during periods of drought and low water availability. The Carbon Budget Delivery Plan (DESNZ, 2023) set out the objective to increase silvoarable agroforestry (crops grown simultaneously with a long-term tree crop) from <1% to 10% arable land by 2050, which would likely increase food production (Staton et al., 2022) and resilience to climate change (Lawson et al., 2019). This farming system also offers many environmental benefits over arable farming, including promoting biodiversity (Kletty et al., 2023) and soil health (Beule et al., 2023).

Evaluation of urgency score

More Action Needed is required as climate change already poses a High risk to agriculture, which is expected to become Very High by 2080. This is due to the sector's vulnerability to climate-related hazards such as extreme heat, drought, and flooding which are projected to increase into the future. Although some policies acknowledge these threats, there is limited evidence of effective action being taken to reduce them. Confidence in the current risk assessment is High due to strong evidence across England, but this confidence declines for the 2030s, 2050s, and 2080s to Medium, emphasising the need to strengthen the evidence base.

Table 8.28: Urgency scores for N6 Risks to agriculture for England. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

England								
N6 Risks to agriculture.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.6.3 Northern Ireland

Current and future level of risk

This section includes Northern Ireland-specific evidence but should be read with the UK assessment for a full understanding of climate risks affecting this nation.

No risk data are available for the present day specific to Northern Ireland, but future projections suggest that severe droughts may occur 7–8% of the time by the 2080s, over the same time dairy cattle could experience around 2 heat-stress days per year (Arnell & Freeman, 2021), suggesting localised impacts on livestock productivity.

Level of preparedness for risk

Northern Ireland is still operating under its Second Climate Change Adaptation Programme (2019-2024). This recognises the need for adaptation to climate change and introduces new systems to protect productivity, use resources efficiently, and improve resilience to risks, shocks and long-term variability. Any transformation of Northern Ireland agricultural systems will need to be done without depleting the natural resource base. However, the actions are focused on assessing and improving national and international food systems. Changes in policy have occurred since Brexit. The primary policy is the Agriculture Act 2020, which replaced the EU Common Agricultural Policy and continues public funding for environmentally friendly management. Because this act was passed during a period where the Northern Ireland Assembly was not in session, there is no set timeline for developing the country's own legislation on agriculture.

Evaluation of urgency score

In Northern Ireland, agricultural climate risk is currently assessed as High and in the 2030s and the 2050s increasing to Very High by the end of the century. This is due to major and critical impacts, respectively and due to the sector's vulnerability to climate-related hazards such as extreme heat, drought, and flooding which are projected to increase into the future. Existing policies recognise the need for adaptation, but their effectiveness is unclear, and region-specific evidence remains limited. Medium confidence is given for all periods, reflecting strong expert agreement equated with some anecdotal evidence of impacts but limited robust data for this nation.

Table 8.29: Urgency scores for N6 Risks to agriculture for Northern Ireland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Northern Ireland								
N6	Risks to agriculture.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
With adaptation	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.6.4 Scotland

Current and future level of risk

This section includes Scotland-specific evidence but should be read with the UK assessment for a full understanding of climate risks affecting this nation.

Risks particularly relevant to Scotland include potato blight, liver fluke and flooding. Scotland is a major grower of seed potatoes (potatoes grown to produce more potatoes), accounting for 75% of the planted area in Britain. Historically, the cool, wet climate has kept potato viruses at bay, as these conditions are not favourable for the aphids that transmit them. Climate change is likely to increase aphid incidence in Scotland as the environment becomes more suited to them (Energy and Climate Intelligence Unit, 2024), where risks from blight are projected to increase by 70% in East Scotland by 2070 (Garry et al., 2021). The economic damage of liver fluke in Scotland is expected to increase 2-fold on dairy farms and 6-fold on beef farms due to the impacts of climate change. These will disproportionately affect smaller farms. The number of vulnerable dairy and beef farms is projected to increase by 20% and 27% respectively (Shrestha et al., 2020). Scotland saw extreme flooding in October 2023, leading to the loss of millions of pounds worth of unharvested vegetables (Carruth, 2023).

Level of preparedness for risk

Following significant revisions to land policy via the Agricultural Bill, Land Reform Bill and the new Scottish Climate Change Adaptation Programme, Scotland will shift half of its agricultural funding to be contingent on delivering climate and nature including adaptation through support programmes such as The Whole Farm Plan, which will provide funding for key adaptation actions on farms via the Agri-Environment Climate Scheme (e.g., the creation of irrigation lagoons which can reduce water scarcity risks) and The Water Scarcity Plan which will refine the monitoring of water scarcity used to trigger voluntary and regulatory actions. The Scottish Government has also approved a £50 million annual Strategic Research Programme, to support research on important Scottish crops. To establish varieties which can manage a combination of environmental stresses explore the development of novel crops and cropping systems for increased agricultural adaptability. Livestock research will support the development of feeding and breeding strategies for climate adaptable and resilient livestock as discussed in the Scottish National Adaptation Plan (2024 – 2029), but it is too early to assess whether this has been effective in doing so.

Evaluation of urgency score

The current risk to Scottish agriculture is High and will continue into the 2030s and the 2050s, with High confidence. The risk is expected to increase to Very High by the 2080s, reflecting the sectors' vulnerability to increasing climate threats. Confidence score is Medium for the future, based on strong expert agreement but limited robust data. There are policies and adaptation plans in place, but it is too soon to assess their effectiveness in reducing climate risks to agriculture. Therefore, More Action Needed is recommended.

Table 8.30: Urgency scores for N6 Risks to agriculture for Scotland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Scotland								
N6	Risks to agriculture.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.6.5 Wales

Current and future level of risk

This section includes Wales-specific evidence but should be read with the UK assessment for a full understanding of climate risks affecting this nation.

Nearly 90% of land in Wales is used for farming. Extreme weather events impacted Welsh agriculture during 2018, 2020 and again in 2023 (Farmlytics, 2024). These weather extremes are affecting farms through reduced grass growth (for feeding animals), restricted crop growth, livestock deaths, water shortages and storm damage to agricultural infrastructure. In 2018, the impact of drought and floods on crops and grass growth meant farmers had to bring in additional livestock feed at an estimated cost of £151 million. High lamb mortality (estimated at a lost value of £23.8 million) also occurred, with reduced value of the ruminant livestock sector by 9% of the total Welsh agricultural output. Reduced crop yields cost up to £4 million. In 2023, Wales saw one of the driest periods on record followed by the third-wettest July in over 100 years. The 2022-2023 drought caused feed costs to rise by £265 million.

Specific evidence for Wales indicates a contraction in the quality of agricultural land grade (a measure of the overall quality of land for agricultural production based on soil and water characteristics). The total area of high-quality Grade 1 agricultural land is predicted to decrease by 50% in the 2050s and by 65-82% in the 2080s, relative to the present day, affecting more than 27,000 hectares. By contrast, the total area of poor Grade 4 land is predicted to decrease under all emission scenarios, before substantially increasing by the 2080s (returning to the baseline under low and medium emission scenarios and greatly exceeding the baseline under the high emission scenario), this encompasses up to 40% of the total land area of Wales (Keay and Hannam 2020). This will greatly reduce the productivity of Welsh agriculture.

Level of preparedness for risk

No new specific policies were identified for Wales, with little reference to agriculture in the NRW Climate Change Adaptation Plan (2023-2027).

Evaluation of urgency score

In Wales, climate risk is currently High, with major annual damages caused by extreme climate conditions. Limited policies exist in the NRW Climate Change Adaptation Plan (2023-2027), and specific adaptation measures are unclear. This High risk is projected to persist through the 2030s and 2050s with increasing drought hazards but Medium confidence due to gaps in regional data. By the 2080s, risks rise to Very High, with increasing climate-hazards causing potential critical losses in agriculture. However, confidence score is Medium reflecting strong expert agreement but less certainty in future risks. Overall, More Action Needed is applied to address growing climate threats to Welsh agriculture.

Table 8.31: Urgency scores for N6 Risks to agriculture for Wales. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Wales								
N6	Risks to agriculture.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (N/A)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.7 Risk to Fishery and Aquaculture – N7

Climate change is already disrupting UK fisheries and aquaculture through shifting species, marine heatwaves, and rising disease risks, with impacts expected to intensify by the 2080s, threatening food security and livelihoods. More action is needed to reduce risks.

Headlines

- Climate change poses risks to fishery and aquaculture through decline in species for wild catch (species are already decreasing in numbers with changing distribution), change in environment suitability for aquaculture, risk from marine heatwave, and increase risk of disease and pest.
- Risks are expected to increase by the end of the century.
- Risks to fishery and aquaculture have cascading risk on economy, food supply and health of the public (ease of access to sea food as part of a healthy and balanced diet).
- More action is needed for adaptation actions include climate change impact and plan beyond the management of fish stock to reduce risks.

Table 8.32: Urgency scores for N7 Risks to fisheries and aquaculture. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

ID	Risk		Present	2030	2050	2080	Urgency
N7	Risks to fisheries and aquaculture	**UK**	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		England	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Scotland	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	+++ (H)	++ (H)	++ (H)	++ (VH)	MAN

8.2.7.1 Evidence relevant to the entire United Kingdom

Introduction

The latest FAO Review of the State of the World Marine Fishery Resources (Sharma et al., 2025) highlights how catch in the Northeast Atlantic have been decreasing for the past 30 years, from an estimated 10.4 million tonnes per year in the 1980s to 8.7 million tonnes per year in the 2010s. At present, 25% of the fish caught are unsustainably fished. Considering that climate change is an additional stressor it is important to account for the state of fisheries when looking at climate adaptation. Aquaculture is put at risk from increase in temperature and ocean acidification, plus warmer winters are likely to increase the impact of pest and pathogens (e.g., gill disease in salmon) (MCCIP, 2020).

Over the past five years, new research has strengthened our understanding of climate risks to fisheries and aquaculture. This report builds on CCRA3-IA-TR by assessing new findings. Risks are evaluated at a UK scale, with the level of risk scored as High across the country. Therefore, the assessment of risk associated with each nation is not distinct enough to justify isolated local assessments. In contrast, the level of preparedness is assessed individually for each UK nation, as most plans are policies are nation specific.

Current and future drivers of risk

Marine risk to fishery and aquaculture is mainly driven by increase in average sea surface temperature as well as the frequency (35% more heatwaves are projected to happen compared to the long-term average) and the intensity of heatwaves. Ocean acidification is also impacting growth and survival of larvae (fish and shellfish). Changes in ocean temperature and stratification (the creation of separate layer within the water column depending on temperature and salinity) which is important for the timing of the onset of the plankton spring bloom, causing a mismatch between predator and prey, in addition to changing dominant species at the bottom of the food web (e.g., lipid rich plankton being replaced by lipid poor plankton). Changes in the composition of the species available to catch could impact fishery yields, if adaptation measures are not taken to ensure proper gear and quota.

Warmer waters will increase the risk from pest and disease especially for aquaculture, and harmful algal bloom might cause periods of time during which shellfish cannot be sold.

While fisheries are a small fraction of the economy and the risk could be considered small from an economical viewpoint, it is important as many livelihoods depend on it. Plus, fishery and aquaculture cannot be separated from the marine environment meaning that the risks to the marine environment (N3) are having a direct effect on risks to fishery and aquaculture (N7). There are downstream effects on economy (jobs and market linked to fishery and aquaculture), health (access to seafood as part of the diet), and culture (traditional seafood dishes that may not be available or need to adapt to different food).

International risks exist in the agreement for management of resources (fish and shellfish) within shared bodies of water like the North Sea and the English Channel; when setting quotas, changes in catch by UK fleets and changes in the export market for fish caught in UK water.

Assessment of current magnitude of risk

<u>Fisheries:</u> In the North Sea impacts include reduced catches of cod and other cold-water species during marine heatwaves, increased abundance of warm-water species such as European seabass and red mullet, and shifts in spawning times and locations for key commercial species (Wakelin et al., 2021).

Recent increases in fish species richness in the North Sea (1991-2019) may be driven by temperature changes due to climate change, rather than the concurrent reduction in fishing mortality (Jones et al., 2023). While some species might benefit from it, this is not the case for all species and changes in the composition of the fish available will need changes in gear for catch as well as new management measures.

<u>Aquaculture</u>: In the UK, climate change is already impacting the aquaculture sector, and the response has been limited. In the UK, there have been no major changes to the types or locations of species farmed in aquaculture in response to climate change or to try and mitigate effects. At salmon farms, a strong link between milder winter temperatures, disease and increased fish mortality has been identified. In Scotland, some shellfish areas have experienced poor spat settlement (end of the free swimming larval stage into the adult stage that is sedentary and often fixed to its substrate) and mortality, but the link to climate change is not fully established (Murray et al., 2022).

Invasive Non-Native Species (INNS) and aquaculture: Marine INNS include tunicates (a group of marine invertebrates that can live fixed to rocks or marine structure) as well as species that are free floating. They can form colonies that will compete with aquaculture species for food. The main invasive species are the carpet sea squirt (*Didemnum vexillum)* and leathery sea squirt (*Styela clava),* which are spreading, although this may not be climate-change related. These INNS have the potential to smother and outcompete cultured shellfish species as well as incurring additional husbandry and product-processing costs. The carpet sea squirt has been found on aquaculture sites and in an oyster hatchery in England (MarLin, 2025), and more recently on sites in Scotland. The introduction of the Pacific Oyster (*C. Gigas*) (N2) is directly related to anthropogenic activity with temperatures above 16 °C supporting their establishment and possibly leading to them outcompeting native oysters (Wood et al., 2021).

As a result of warming waters, populations of the Pacific oyster which were originally considered unable to reproduce at UK seawater temperatures, have successfully bred in many areas (King et al., 2021). The Pacific blue mussel (*Mytilus trossulus)* is a native UK nuisance species for the aquaculture of the blue mussel *(M. edulis)* as its flesh quality is inferior and its weaker shell is prone to harvesting and storm damage. Recent research suggests that environmental effects may influence shell strength more than previously thought (Michalek et al., 2021), but further research is needed to confirm if climate change has affected this.

Growth and metabolism of farmed species: Finfish and shellfish are 'cold blooded' organisms and so growth rates are strongly influenced by water temperature (Elliott and Elliott, 2010). Though growth is also associated with other factors such as food utilisation and health of the farmed species. For salmon, increased metabolism at warmer temperatures leads to increased food requirements. Feed composition has changed considerably in recent years and ongoing research to develop sustainable diets that are optimal for salmon (Albrektsen et al., 2022) including feeds that are appropriate for higher water temperatures and heatwaves (Mock et al., 2021). Higher temperatures were one of the factors that Ashton (2020) linked to oyster mortality events in Lough Foyle, which lies between Northern Ireland and the Republic of Ireland.

Fish and shellfish health: Farmed animal health is critical to aquaculture sustainability both directly and through impacts on wild animals. Disease is a major cause of losses in aquaculture, although this is part of a complex interaction with other factors (Oliveria et al., 2021). Climate change impacts on disease (Woo et al., 2020) could affect aquaculture. A strong link between increased mortality in salmon farms with milder winter temperatures has been identified (Moriarty et al., 2020; Casas et al., 2021). Gill health challenges have increased in recent years (Borelage et al., 2020), due to new pathogens. For example, the emergence of Amoebic Gill Disease (AGD) is associated with high salinities and temperatures in regions where it is established (Sokołowska and Nowak, 2020) and environmental stressors are associated with complex gill disorders. AGD likely emerged in Scotland and Norway following a particularly warm summer in 2006 and thereafter outbreaks follow mild winters. Other pathogens also respond to changing environments, notably sea lice populations grow faster and are more difficult to control in warmer waters (Fast and Davlin, 2020).

Assessment of future magnitude of risk

Fisheries: At the UK scale we can expect a potential reduction in fisheries catch of 92,000 tonnes by mid-century, reaching 240,000 tonnes by the end of the century (compared to a 2023 catch recorded at 700,000 tonnes per year which was worth around £1 billion (CCC, 2019)).

Changes in temperature, productivity and to a lesser extent salinity can lead to shifts in the distribution of commercially important fish and shellfish. With climate projections showing a 15-20% decrease in cold-water species biomass (southern UK waters) and a potential increase of 5-10% of warm-water species biomass (northern UK waters) by mid-century (Townhill et al., 203). There is additional modelling evidence on the impact of climate change on species distribution with the northward shift of many fish species, ranging from 20 to 100s of km depending on the climate scenario (Sailley et al., 2025). The habitat suitability and latitudinal shifts for 49 species were projected for two futures (2030–2050; 2050–2070) for waters around the UK (Townhill et al., 2023). Of the species examined, around half were projected to have consistently more suitable habitat in the future, including European seabass, sardine, and anchovy.

Conversely, UK waters could become less suitable for species including Atlantic cod and saithe. Results show that the general trends in habitat suitability and abundance are robust across models and climate scenarios (Townhill et al., 2023, Sailley et al., 2025). Change in distribution will impact time at sea and distance travelled for fishing vessels and their crew. This could combine with an increase in storm-intensity and negatively affect fishing operations. Additionally, there is the potential for changes in spawning times for key commercial species, shifting 1-2 weeks earlier by mid-century, meaning they might not by matched in time with their prey and recruitment will fall.

At the European to global scale, climate change is projected to impact marine ecosystems and fisheries in European Atlantic shelf areas by the end of the century. Projections indicate that total biomass and catch for the whole Atlantic European seas would decrease due to changes in temperature by 11.5% and 10.0%, respectively, by 2090−2099 (relative to 2013−2017) under a high emissions scenario. The projected decrease in catch is 310,000 or 240,000 tonnes by 2090−2099 under high or central scenarios, respectively (du Pontavice et al., 2023). Some areas, such as the Celtic Sea (the body of water between England and Ireland), would be more affected than others, while the climate impact on the seabed organism's biomass and catches would be more pronounced, especially toward the higher trophic levels.

Potential socio-economic repercussions come from the interactions of multiple fleets fishing multiple species with various gears, as either target or bycatch, as well as bycatch regulations through a landing obligation, and interacting effects of climate change affecting fisheries yield and profits. These are a challenge for seabed mixed fisheries of the North Sea.

Climate change, combined with bycatch regulations and fluctuating fuel and fish prices, poses major challenges for North Sea mixed fisheries. Projections show that climate-driven declines in fish recruitment, particularly for cod, saithe, and whiting, could significantly reduce yields and profits in the short term, especially under strict landing obligations. While relaxing quotas within sustainable limits may buffer initial losses, this would lower profits in the longer term (Kühn et al., 2023).

The impacts of climate change on fisheries are further evidenced by global projections of higher trophic levels biomass (FishMIP project, 2025). The North Atlantic Ocean might face a mixture of responses in terms of exploitable fish biomass by mid-century, with more spatially variable outcomes under the high emissions scenario than under a low emissions scenario. The most extreme losses are projected for the Northwest Atlantic, with mean ensemble losses of 12% by mid-century and 35% by the end of the century under the high emissions scenario. Under a low emissions scenario, 71% of these end-of-century losses are averted. A similar situation is shown across all Atlantic FAO regions under the high emissions scenario (albeit with high levels of inter-model variability), particularly for the Southeast, Eastern Central, and Northeast Atlantic, which currently sees the bulk of fisheries catches (Blanchard & Novaglio, 2024).

Aquaculture: Projected decrease in ocean pH (increasing acidity) by the end of the century will negatively impact shellfish aquaculture. Ocean acidification may reduce shellfish spat settlement, although it is unlikely to affect finfish farming. Temperatures are expected to remain suitable for salmon growth until the end of the century (Murray et al., 2022), however, Northern Ireland and the southwest of Scotland may experience seasonal declines due to warming leading to a rise in outbreaks including sea lice, fish diseases and shellfish pathogens, with subsequent increased mortality. Finally, more frequent and intense heatwave events will increase mortality in the future, highlighting the need for adaptive management.

Jellyfish are a challenge to marine fish aquaculture, impacting fish health through gill tissue damage, impaired function, and secondary disease. Shifting plankton distributions, driven by climate change, overfishing, and aquaculture practices, exacerbate this issue. Shifting jellyfish populations can potentially impact the UK's aquaculture production of 156,220 tonnes of Atlantic salmon (*Salmo salar*), rainbow trout, and Atlantic halibut, along with the production of other countries (Clinton et al., 2021).

The magnitude scores are scored High across the UK, for the present and future scenarios, increasing to Very High by 2080s. The scoring is based on the evidence above indicating major impacts on existing stock and loss of fisheries catch. This also includes the increase in risk from parasite, disease and INNS, resulting in large and frequent damage to fisheries and aquaculture. Magnitude increases to Very High by the 2080s due to critical species loss, and stress from changing environment on the species targeted by fishery and aquaculture and very large and frequent damage. While the fishery and aquaculture industry is a small fraction of the UK economy, the losses to it are substantial without any climate mitigation, with links to the economy, job security, health, and culture. It is also tightly linked to ecosystems risk (N3) which means the impact will be beyond the loss of wild catch and aquaculture production.

Confidence in the scores is Medium based on strong expert agreement combined with the lack of evidence on the interacting risks such as temperature stress and parasite, or survival of juvenile stages.

Level of preparedness for risk

The UK has partial climate adaptation policies for fisheries and aquaculture, as adaptation remains inconsistently applied. Fisheries Management Plans (FMPs) include commitments to sustainable fisheries, yet climate risks are often overlooked, and publication delays persist beyond 2024. Ongoing work, such as the 2024 Climate Adaptation Plan for the Wild Capture Seafood Industry and Marine Management Organisation (MMO) trials on fishery diversification in southwest England, seeks to address shifting species distributions. However, current management approaches remain fragmented, and focusing adaptation at the national level is risky, as marine ecosystems, species movements, and threats such as invasive species and disease transcend political boundaries (CCC, 2025).

Assessment on the evidence base and evidence gaps

While there is increasing evidence on climate change impacts on fisheries and aquaculture, there is still a lack of evidence on interacting risks, such as temperature stress and parasite, or survival of juvenile stages. There is also a lack of robust and detailed pest/pathogen data, especially for aquaculture species beyond shellfish. Modelled projections for climate impacts on fisheries and aquaculture often depend on laboratory or coarse modelling rather than real-world field data, limiting confidence in future risk estimates. Additionally, understanding is limited in how industry-level adaptive capacity can be built systematically.

8.2.7.2 England

Current and future level of risk

This section includes England-specific evidence but should be read with the UK assessment for a full understanding of climate risks affecting this nation.

Little evidence on climate risks to fisheries and aquaculture specific to England has been published in the last five years. Most of the studies available describe risks to fisheries in the North Sea, Western Europe or UK waters. Two pieces of evidence are specific to England. First, the reduction in catches of cold water fish species in the North Sea, and second a recent study on the invasive carpet sea squirt and its impact on aquaculture sites and in an oyster hatchery (MarLin, 2025).

Level of preparedness

England has partial policies and plans for climate adaptation of fisheries and aquaculture (CCC, 2023). However, they lack consideration of climate impacts under different warming scenarios and they lack monitoring and evaluation.

Important progress has been made by Seafish with the Climate Change Adaptation Plan, that provides an updated plan for the wild capture seafood industry will outline how the sector can respond to climate risks and opportunities under future climate scenarios. The Joint Fisheries Statement (2020) was the first statement by the four UK administrations that recognised the need for sustainable fisheries management and climate adaptation but lacks detail on how policies will be implemented. The Fisheries and Seafood Scheme & UK Seafood Fund provide financial support to strengthen long-term sustainability and environmental performance, though neither specifically funds climate resilience projects. The Annual Sustainability Assessments evaluate fisheries negotiations to help address cross-boundary climate risks by promoting international collaboration. Lastly, the FMPs will guide sustainable fisheries management and should explicitly address climate risk mitigation, though publication timelines remain unclear.

Evaluation of urgency score

More Action Needed is applied due to the High and Very High magnitude of the risks and the limited responses. While some policies are in place in England there is a lack of or little evidence of effective adaptation or sufficient non-governmental action to maintain or reduce current risk levels. Reducing risks will require wider and coherent resilience-focused policies across sectors. The score is given with Medium confidence, reflecting limited evidence on future adaptation but strong expert agreement.

Table 8.33: Urgency scores for N7 Risks to fisheries and aquaculture for England. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

England								
N7	Risks to fisheries and aquaculture.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
With adaptation	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.7.3 Northern Ireland

Current and future level of risk

This section includes Northern Ireland-specific evidence but should be read with the UK assessment for a full understanding of climate risks affecting this nation.

Climate change is already affecting fisheries and aquaculture in Northern Ireland. Higher temperatures caused oyster mortality events in Lough Foyle Ashton in 2020. Although temperatures are expected to remain suitable for salmon growth until the end of the century (Murray et al., 2022), Northern Ireland may experience seasonal declines due to a rise in outbreaks including sea lice, fish diseases and shellfish pathogens, with subsequent increased mortality linked to warming.

Level of preparedness

There are insufficient policies and plans in Northern Ireland. No localised plans exist on climate-resilient fisheries and aquaculture, but there is coordinated input into the Joint Fisheries Statement under the Fisheries Act (CCC, 2023).

Evaluation of urgency score

More Action Needed is applied due to High and Very High magnitude of risks and response not including climate change in the long term. The score is given with Medium confidence, reflecting the strong evidence of risk at the UK level and the expert agreement.

Table 8.34: Urgency scores for N7 Risks to fisheries and aquaculture for Northern Ireland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Northern Ireland								
N7 Risks to fisheries and aquaculture.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
With adaptation	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.7.4 Scotland

Current and future level of risk

This section includes Scotland-specific evidence but should be read with the UK assessment for a full understanding of climate risks affecting this nation.

In Scotland, some shellfish areas have experienced poor spat settlement (end of the free-swimming larval stage into the adult stage that is sedentary and often fixed to its substrate) and mortality, but the link to climate change is not fully established (Murray et al., 2022).

Invasive species, such as the carpet sea squirt has been found on aquaculture sites and in an oyster hatchery in Scotland (Wood et al., 2021). As a result of warming waters, populations of the Pacific oyster (originally considered unable to reproduce at UK seawater temperatures) have successfully bred in many areas (King et al., 2021), including Scotland.

Climate change is already affecting fish health. For example, the emergence of Amoebic Gill Disease (AGD) is associated with high salinities and temperatures in regions where it is established (Sokołowska and Nowak, 2020) and environmental stressors are associated with complex gill disorders. AGD likely emerged in Scotland since 2006 and thereafter outbreaks follow mild winters. Although temperatures are expected to remain suitable for salmon growth until the end of the century (Murray et al., 2022), the southwest of Scotland may experience seasonal declines due to a rise in outbreaks of sea lice, fish diseases and shellfish pathogens, with subsequent increased mortality linked to warming.

Level of preparedness

The new Climate Change Adaptation plan has a strong focus on climate resilient fisheries and aquaculture. The Scottish Government is implementing several policies and programs under the Fisheries Act 2020 to enhance this sectors' sustainability and adaptability. In collaboration with UK administrations, the Scottish government is developing 22 FMPs aimed at maintaining fish stock health. By 2026, technical measures will be in place to reduce fish discarding and bycatch of sensitive species.

In aquaculture, the Farmed Fish Health Framework supports the sector in addressing climate challenges. The Vision for Sustainable Aquaculture to 2045 sets ambitious goals for a net-zero and resilient sector, emphasising environmental protection. Climate resilience plans for aquaculture, developed with stakeholders by 2029, will tackle warming seas and increased storm frequency. Additionally, the Aquaculture Innovation Centre and Sustainable Aquaculture Forum foster collaboration to address climate impacts on fish health.

The Joint Fisheries Statement (2022) recognises the need for sustainable fisheries and adaptation to climate change but provides limited detail on implementation. The Blue Economy Vision (2022), Sustainable Aquaculture Vision (2023), and Wild Salmon Strategy (2022) all highlight resilience to climate impacts, yet none include SMART targets to track progress. The forthcoming second National Marine Plan aims to address climate risks within broader marine management objectives, while the Farmed Fish Health Framework (2022–2023) has begun to tackle climate impacts on aquaculture species. However, the Fisheries Management Strategy 2020–2030 Delivery Plan remains focused on productivity and Net Zero goals, missing key opportunities to embed adaptation. Although Scotland is building an evidence base on climate impacts to fish populations, a coordinated strategy with measurable adaptation targets and monitoring is still needed to ensure long-term resilience of its fisheries and aquaculture sectors.

Evaluation of urgency score

More Action Needed is applied due to the High and Very High magnitude of the risks and limited responses. While policies in Scotland are focusing on more integrated approaches to address climate risks to fisheries and aquaculture, they lack SMART objectives and there is still little evidence of effective adaptation or sufficient non-governmental action to maintain or reduce current risk levels. The score is given with Medium confidence, reflecting limited evidence on future adaptation but strong expert agreement.

Table 8.35: Urgency scores for N7 Risks to fisheries and aquaculture for Scotland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Scotland								
N7	Risks to fisheries and aquaculture.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.7.5 Wales

Current and future level of risk

This section includes Wales-specific evidence but should be read with the UK assessment for a full understanding of climate risks affecting this nation.

Level of preparedness

Wales has insufficient policies and plans for climate resilient commercial fisheries and aquaculture (CCC, 2023). Marine ecosystems around Wales, particularly in the Irish Sea and Celtic Sea, are among the most overexploited in the Northeast Atlantic, with fisheries largely targeting non-quota species. Effective management of Welsh marine ecosystems requires understanding the fishing industry and its interactions with the environment, but major knowledge gaps remain because fisheries mainly target non-quota species, making sustainable management more challenging.

The Welsh National Marine Plan (WNMP) provides a 20-year framework for sustainable fisheries and aquaculture, recognising climate risks and the need for stronger evidence but lacking specific adaptation actions. The Welsh Marine and Fisheries Scheme (2022) allocates £3 million to support adaptation, research, and resilience in the sector, while the Joint Fisheries Statement (JFS) acknowledges climate risks but fails to outline concrete measures for industry adaptation. The revised Welsh Seafood Strategy aims for 30% sustainable growth in the seafood industry by 2025, aligned with the Well-being of Future Generations Act, yet lacks clarity on actions for climate resilience. Additionally, the Great Britain INNS Strategy 2023–2030 includes marine environments and promotes the "Check, Clean, Dry" campaign to prevent invasive species spread, a key aspect of building ecological resilience under changing climate. Policies and plans are insufficient to ensure fisheries and aquaculture remain resilient to climate change. Most fish stocks have limited protections due to them not being subject to fishing quota requirements (CCC, 2023).

Evaluation of urgency score

More Action Needed is applied due to the High and Very High magnitude of the risks and limited responses. While policies in Wales acknowledge risks to fisheries and aquaculture there is little evidence of effective adaptation. The score is given with Medium confidence, reflecting limited evidence on future adaptation but strong expert agreement.

Table 8.36: Urgency scores for N7 Risks to fisheries and aquaculture for Wales. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Wales								
N7 Risks to fisheries and aquaculture.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
With adaptation	+++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.8 Risk to forestry – N8

Climate change is already affecting UK forestry through rising temperatures, shifting rainfall patterns, and more frequent extreme weather. Risks are High now increasing to Very High by 2080 in England and Scotland, threatening timber production, carbon sequestration, biodiversity, and the wider ecosystem services forests provide.

Headlines

- Climate change is directly impacting UK forests and the forestry industry. Wind damage is, and is expected to remain, the leading cause of environmental forest loss, interacting with other climate-related disturbances and compounding risks.
- Tree pests and diseases, increasingly driven by climate change, may spread more widely and affect large areas of productive forest over time.
- There are significant knowledge gaps on compound risks and the extent of adaptation measures being applied in productive forests, though lessons can be drawn from international experience.
- New evidence suggests reduced potential for tree growth and timber quality despite warmer conditions and higher CO_2 levels, increasing vulnerability to damage at younger ages.
- Strategic action plans and new guidance across the UK are beginning to support more informed forest resilience and adaptation.

Table 8.37: Urgency scores for N8 Risks to forestry. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

ID	Risk		Present	2030	2050	2080	Urgency
N8	Risks to forestry	**UK**	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		England	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Northern Ireland	++ (L)	++ (L)	++ (L)	++ (M)	SCA
		Scotland	++ (H)	++ (H)	++ (H)	++ (VH)	MAN
		Wales	++ (M)	++ (M)	++ (M)	++ (H)	MAN

8.2.8.1 Evidence relevant to the entire United Kingdom

Current and future drivers of risk

Climate change increases the frequency, range and intensity of risks directly impacting UK forests, reducing their natural capital and associated ecosystem services. This, in turn, negatively affects mitigation and adaptation efforts. The exposure and vulnerability of forests to climate change is driven by environmental and socio-economic, factors. The range of forest types, combined with geographical and environmental factors, plus the long timescales for the growth of a forest stand (a contiguous area of trees with similar species, age, size, and arrangement) increases the potential exposure to multiple risks, which increases the complexity required to assess, understand and manage overall risk.

A temperature increase of approximately 1 °C since pre-industrial times (Met Office, 2023), changes in extreme temperatures, precipitation patterns and soil water availability and sea-level rise are well documented and have direct and indirect risks to forests and their natural capital value. Reduced frost and snow days, increased storm frequency, windspeeds and wildfire present the main risks to forest and to woodland.

Recent expert assessment has highlighted the increased risk of partial or total collapse of forest ecosystems within the next 50 years due to wind, fire and bark beetles (Tew et al., 2023) and whilst the impact of wind, fire and beetle attack is often exacerbated by certain management approaches (Pataccca et al., 2023), changes to forest management (in the absence of disturbance) are usually considered on decadal timescales and have therefore a degree of lock in to the current trajectory. Further, the threat from compound risks (i.e., interaction between risk factors) has increased since the CCRA3-IA-TR, particularly interactions between storms, pest and disease (Atkinson et al., 2025).

Current evidence indicates that the effect of changes in atmospheric CO_2 to increase tree growth is likely to be variable and increases in growth are likely to be constrained. For example, accelerated growth of Sitka spruce under climate change is likely to increase the risk of wind snap during storm events. Similarly, damage occurring in early growth stages from drought events reduce net carbon uptake in a mature Sitka stand (Xenakis et al., 2021). Modelling by Yu et al. (2021) suggest reduced timber productivity and carbon storage particularly in southeast England being the region most affected by weather variability. However, they also suggest there may be more CO_2-stimulated increase in leaf area index and net primary productivity in cooler, wetter, central and northern areas.

There are strong synergies between forest and woodland creation for carbon sequestration and storage (N5), however, the potential for optimal mitigation benefit is at risk from climate change in the absence of adaptation or presence of maladaptation. Active forest management planning is therefore critical to ensure climate change risks to forests at stand level (or appropriate scale) are fully assessed at that action to adapt through the implementation of adaptation measures are undertaken where required. Woodland and natural processes cannot keep pace with the current changes in climate without intervention, particularly given rising temperatures, shifts in precipitation and frequent extreme weather, which are increasing the spread and impact of tree health threats from pest and diseases.

Assessment of current magnitude of risk

The current magnitude of risk is evaluated in relation to climate driven threats to forestry (wind, pest, disease, drought, wildfire, flood and frost risk) and risk combinations. The assessment is at UK level and applies across the devolved nations. Reporting across risk factors and measures to mitigate these risks varies by forest type, altitude and geography which, to draw out in a meaningful way is beyond the scope of the assessment.

<u>Wind:</u> Wind is the most important recent forest disturbance agents. The UK has severe wind climate, which presents a challenge to the forestry sector. Expected changes to atmospheric circulation are likely to lead to a shift in storm tracks and increased wind speed in future. Recent storm damage has severely impacted large areas of forest (Box 2.8.1). The cumulative effect of storms of different severity results in annual timber losses with associated impacts including financial loss, damage to infrastructure, fatalities and extensive consequences on natural capital (Patacca et al., 2022).

Increased storm frequency and extreme wind speeds under climate change are expected to increase forest storm damage and site factors influence vulnerability to wind hazard (State of the Climate Chapter). Increasing temperature and changes to the growing season are likely impacting tree growth and form, leading to higher vulnerability to wind damage. Further, they are likely contributing to reducing the age at which trees become vulnerable to wind damage (Ward, 2025). In oak (an important species for socio-economic, environmental and cultural reasons) the scale of damage increases with greater storm magnitude (Halstead et al., 2024). Whilst the changing climate will continue to alter the nature of storm damage, appropriate silvicultural (practice of controlling the growth) and adaptation strategies, including contingency planning, can reduce the impact on the sector and society. An advanced decision support tool "ForestGALES" (Locatelli et al., 2022) offers industry-standard wind risk modelling to support assessments of wind damage risk to forests and of treefall on infrastructure (e.g. Gardiner et al., 2024).

Box 2.8.1. UK storm damage to forestry

UK winter storms 'Arwen' and 'Barra' (2021) caused extensive damage and losses to forested areas with significant ecological and cultural impact. Forestry and Land Scotland reported Arwen affected around 4,000 hectares of Scottish forests and resulted in around 1 million m³ of fallen trees (roughly one third of what they would harvest nationally in a given year). It also led to hundreds of miles of trails closed (Grey et al., 2021; Sinclair at al., 2022). Welsh forests were particularly affected during the 2024/25 storms Bert, Darragh and Éowyn which led to an 3,327 ha of windblown area (Forest Research, 2025). In Ireland, Storm Éowyn (2025) caused unprecedented damage and while official data are not yet available, reports indicate wind damage to hundreds of hectares. The damage from Éowyn has been further compounded by the impact of the previous storm (Darragh) and Herminia that followed, causing damage to centuries old trees of local significance.

<u>Forest pests:</u> Climate change is altering the impact and distribution of forest pests worldwide, acting directly upon the insects and indirectly through changes to the health and resistance of their host trees. Warmer temperatures enable some insects to produce more generations each year, whilst more frequent drought events impact tree defences through water-stress and poor growth, increasing their risk of attack by pests (Inward, 2023). UK conditions are likely to become more suitable for a wider range of non-native forest pests with potential for devastating consequences to UK forest productivity. In recent years, extensive climate-mediated outbreaks of the eight-toothed spruce bark beetle (*Ips typographus)* have devastated large areas of Norway spruce (NS) forest across continental Europe (Hlásny et al., 2021). Although frequently intercepted at ports, only in 2018 was the first breeding population of this regulated pest found in Britain (Kent), with NS being killed locally (Blake et al., 2024). Since 2021 however, incursions of the eight-toothed spruce bark beetle have been detected in southeast England. The enormous European populations, synchronised dispersal events, and southerly winds combined to assist beetles to disperse naturally across the English Channel and colonise weakened and wind-thrown NS trees (Inward et al., 2024). Although subject to extensive eradication efforts, there are concerns that the beetle may fully establish and spread, notably threatening Britain's extensive Sitka spruce forests which comprise 54% of planted conifers (Forest Research, 2023).

<u>Forest pathogens:</u> There is evidence of increased impacts and risks to UK forests from pathogen threats. Increased winter rainfall, milder winters, warmer summers and droughts are all associated with increased activity of *Phytophthora* species (Frederickson-Matika, 2022). An example is *Phytophthora ramorum,* which is responsible for the sudden larch death epidemic (Webber et al., 2010) and affects a large range of other broadleaf, conifer and shrub species. For these reasons there is a continuing programme of surveillance and statutory management, with disease levels in some areas of Scotland now designated as beyond local control (Scottish Forestry, 2022). Newly detected species to the UK also pose a risk, such as *Phytophthora pluvialis*, found widely in Wales, Scotland and England where it has caused stand-level decline of western hemlock in the warmer, wetter south-west (Perez-Sierra et al., 2022) but also is affecting larch (Perez-Sierra et al., 2024) and

Douglas fir. Other increasing threats to Douglas fir include Swiss needle cast caused by a fungal pathogen and infection is favoured by increased humidity and rainfall in early summer (Blake and Perez-Sierra, 2020).

A major fungal threat to pine driven by climatic factors is *Diplodia sapinea*, which is present in the UK and likely to emerge as a damaging pathogen given the prevalence of pines as principal forestry species. This fungus is now causing mortality in northern Europe and severe episodes are strongly associated with climate change and damage caused by hail and drought (Brodde et al., 2023; Wingfield et al., 2025). Whilst for broadleaf species, repeated acute episodes of drought are acting as an important predisposition factor contributing to Chronic and Acute Oak Declines (Denman et al., 2022).

Drought: Drier summers and more frequent droughts projected under UKCP18 will increase risks to UK forests, particularly in southern and central England and on shallow, free-draining soils (Forest Research, 2022a). Forest on brownfield can also be more vulnerable, as can tree species and combinations with poor drought tolerance, sites with high ground vegetation competition or a lack of mixed planting as some species can 'lift' water from deeper soils (Forest Research, 2022a). Increased temperatures as well as dry springs and summers are likely to cause reductions in growth even in key productive areas, as exemplified by the 30% reduction in net carbon uptake, in a mature Sitka spruce forest during 2018 drought (Xenakis et al., 2021), while the 2022 drought and heatwave severely affected over 60% of newly planted trees on the worst-hit sites (Atkinson et al., 2023). Heat and drought also reduce seed viability in common beech (*Fagus sylvatica*), threatening regeneration and altering forest dynamics, especially in southeast England where broadleaf cover is highest (77%, 1.3 million hectares) (Forest Research, 2024; Foest et al., 2024).

Wildfire: Wildfire risk is increasing across the UK (Arnell et al., 2021) with the most pronounced increase likely in the south and east, although wetter areas are also at risk, exemplified by extensive fires in April 2025 including areas of Galloway Forest Park, Scotland. The proportion of summer days with high and very high fire risk has increased (Thompson et al., 2025). However, multiple factors increase fire risk including outbreaks of disease, wind damage and areas with new planting and substantial ground fuels. As most fires are presently surface fires, older stands are less vulnerable than younger stands, but this is likely to change with an increasing occurrence of crown fires if there is more dead material and understorey vegetation. Risks are also increased in stands which are unmanaged or have little silvicultural diversification and stands in more urban locations (Forest Research, 2022a; Schultz, 2025). Decreasing summer rainfall will increase wildfire risk. Crawford et al., (2025) found cumulative rainfall (in the preceding 20-25 days) strongly influenced ground litter moisture and flammability in pine, spruce and birch stands. Fire weather is more likely to occur now than in the past and there is concern about the future impact of extreme fire weather and wind driven fires (Rodrigues et al., 2023; Thompson et al., 2025) the increasing occurrence of which could lead to higher risks rapidly reaching adaptation limits (Giannaros and Papavasileiou, 2023). It is critical to mitigate wildfire risk, reflecting UKFS Guidance Building wildfire resilience into forest management planning (2014) and act (Post Note 717, 2024; Little et al., 2025).

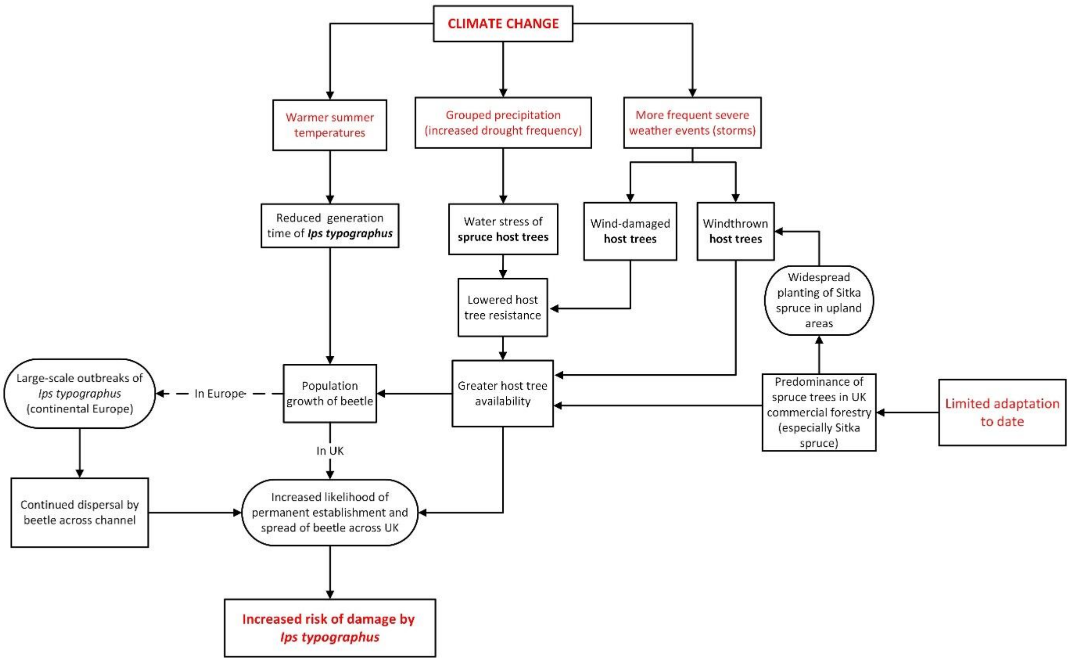
Flood: The frequency of floods is expected to increase. Forests and riparian woodland can contribute substantially to reducing downstream flood risk (PN636, 2021). However, many of these benefits are dependent on healthy woodlands and the trees themselves may be damaged by an increase in soil wetness. Soil waterlogging restricts the supply of oxygen to tree roots and for some species, prevents normal function. Longer lasting flood conditions typically have more impact on tree growth and survival and for flood-intolerant species, flooding and prolonged waterlogging can damage trees and reduce growth. Flooding can and lead to soil compaction, restrict rooting depth and make trees more vulnerable to disease (e.g. *Phytophthoras*) and increase vulnerability to secondary impacts such as windthrow. Care in species choice, soil management and drainage, design, placement and management can mitigate these effects and help to secure benefits for reducing downstream flood risk. However, forest operations need to carefully managed (FR, 2022). New Practice Guidance is available Designing and Managing Woodlands and Forests to Reduce Flood Risk (Forest Research, 2022) and material in the Working with Natural Processes Evidence Directory (EA, 2025).

Frost Risk: Late spring frosts are a risk to forestry as they can damage newly emerged leaves and shoots, young growth and young trees. This can affect the growth rate and the form of the trees, and subsequent timber quality. However, the frequency of ground frosts has declined as the most recent decade, 2014–2023 has had over 7 fewer days of ground frosts per year than the 1991–2020 average and 23 fewer days than 1961–1990 (Kendon et al., 2023; Kendon et al., 2024). While this should reduce the risk of damage, the trend towards reduced hardening time in the winter and earlier bud burst in woody species because of warmer springs and might counteract this, but the impact will vary depending on the tree species. Atucha-Zamkova et al. (2021) assess that although budburst of Sitka spruce is likely to occur earlier under climate change, the number of post-bud-burst frosts is unlikely to change to the extent that it has consequences for commercial forestry. However, given studies outside the UK suggest models likely underestimate risk of frost occurrence (Svystun et al., 2021), a better understanding of frost risk across a wider palette of tree species is increasingly important to inform forest management adaptation through tree species diversification (e.g., using a wider range of tree species in commercial forestry).

Compound and other risks: Projecting changing risk to forestry is a multidisciplinary research endeavour with a high degree of complexity (noted above) and future research is required to better understand compound and cascade risks across different scales in relation to chronic (accumulative) and acute (failure) components, such as in relation to wind (Quine, Gardiner and Moore, 2021), pest (Inward et al., 2024) and drought risk (described above). Compound risks are presented in relation to factors contributing to potentially devastating beetle damage (Box 2.8.2). The changes in temperature, precipitation and the growth season, noted in earlier sections, are affecting tree growth and masting- large number of seeds all at once in certain years (e.g., Hacket-Pain, 2025), vigour, and resilience to damage from windstorms (Ward, 2025). These reduce the age at which trees become vulnerable to damage, with impacts of delivery of ecosystem services such as carbon sequestration. Projecting changes in the life cycles of plants and animals (Kendon et al., 2023) across the UK raise concerns around mismatches in different aspects of the natural world (Büntgen et al 2022) and interrelationships e.g., the earlier flowering in Hazel and 4 days longer leaf on season for some woody species, with associated ecological risks (N5). Models need advancement to better understand long term implications, studies outside the UK suggest current models likely underestimate the local risk of frost occurrence (Svystun et al., 2021).

Box. 2.8.2. Compound risk factors

Our understanding of risk is increasingly focused on compound factors. Whilst this is broadly understood by forest scientists, the UK evidence base is underdeveloped in quantifying and managing these more complex risks. Taking *I. typographus* as example, the figure below illustrates how climatic and ecological factors interact with tree species selection and management to increase the risk of forest damage.



Level of preparedness for risk

Future climate risk to forestry in the UK is set to remain High and in the absence of adaptation, would worsen in the coming decades. However, UK Commitments through the Environment Act (2021), Net Zero Strategy (2021) and particularly the fifth edition of the UK Forestry Standard (2023), strengthen requirements for enhanced resilience and implementation of adaptation measures through UK Forestry Standards (UKFS) requirements, underpinning grants, regulations, certification and management of the nation’s forests. Overall, there appears to have been a shift towards increasing forestry sector awareness of changing environmental risk associated with climate change across England, Scotland and Wales. There is no strong evidence at this stage to suggest this awareness is being acted upon. However, given that forest management planning is typically updated after a decade, we would expect the actions embodied in government advice (in England, Scotland and Wales), published since the last assessment and strategic advice towards increasing resilience, to start to be better reflected in practice shortly and therefore picked up for future assessments, i.e. CCRA5 onwards. The actions in place since the last assessment include:

- New action plans supporting more informed action to increase resilience and evidence of adaptation support across the UK (e.g., Forestry Commissions Fourth Round of the Climate Adaptation Reporting Power, 2025, Scotland's Forestry Strategy Implementation Plan 2022-2025, Scottish Forestry Route map to Resilience (2025), Timber Strategy for Wales.

- Preliminary identification of alternative tree species to broaden the palette of options for commercial forestry, given the risks to what is a small number of important commercial forest species dominating current UK forestry (Reynolds et al., 2021; Edwards et al., 2025).

- Improved guidance, tools and case studies available to inform decision making in relation to climate change risks to forests (e.g. Forest Research's practitioner focused Climate Change Hub, ForestGales and Ecological Site Classification tool).

- New evidence strengthens recommended adaptation actions to reduce risk associated with large scale disturbances such as pathogens in pursuit of sustainable forest management, including for example diversifying planted forests to reduce the risks associated with insect pests and pathogens (Field et al., 2025).

Box 2.8.1. UK storm damage to forestry

UK winter storms 'Arwen' and 'Barra' (2021) caused extensive damage and losses to forested areas with significant ecological and cultural impact. Forestry and Land Scotland reported Arwen affected around 4,000 hectares of Scottish forests and resulted in around 1 million m^3 of fallen trees (roughly one third of what they would harvest nationally in a given year). It also led to hundreds of miles of trails closed (Grey et al., 2021; Sinclair at al., 2022). Welsh forests were particularly affected during the 2024-2025 storms Bert, Darragh and Éowyn which led to an 3,327 hectares of windblown area (Forest Research, 2025). In Ireland, Storm Éowyn (2025) caused unprecedented damage and while official data are not yet available, reports indicate wind damage to hundreds of hectares. The damage from Éowyn has been further compounded by the impact of the previous storm (Darragh) and Herminia that followed, causing damage to centuries old trees of local significance.

Assessment on the evidence base and evidence gaps

- The UK evidence base around compound risks need to be developed to quantify, understand, better manage and prepare for complex risks.
- An advanced understanding across all risks and opportunities to forests and relative potential for different adaptation measures to mitigate these is variable. The evidence base needs to be lifted to a more consistent standard across multiple risks.
- Experts agree more work is required to understand local risk of frost occurrence in a UK context and better understand longitudinal differences which could be considered adaptive measures to local conditions (Gafenco et al., 2022).
- There are opportunities for collaboration with an expanded range of organisations and to better align with national civil response co-ordination for extreme events, building on work by the Climate Security National Foresight Group.

8.2.8.2 England

Current and future level of risk

England has 1,338,000 hectares of woodland (Forest Research, 2024), predominantly Broadleaves (1,033k hectares). The risk to this area of forest and woodland from the changing climate is unevenly distributed across forest types and areas across southern England are particularly vulnerable to drought, pest, pathogen and wildfire risk. However, factors such as management (particularly undermanagement), stand age and geography have an influence on vulnerability, with areas of young broadleaf planting, particular tree species and certain free draining soil types, all increasing vulnerability.

The magnitude of risk for England is High for the present and future periods due to major impact to valued habitat or landscape types (approximately 10% or more at national level) and/or tens of thousands of hectares land lost or severely damaged; increasing to Very High by the 2080s due to critical impact to valued habitat or landscape types (approximately 20% or more at national level) and/or hundreds of thousands of hectares land lost or severely damaged.

Level of preparedness

The England Trees Action Plan (2021-2024), Forestry Commission Commitment to adaptation Thriving for the Future (2023-2028) and the UK Forestry Standard (2023), strengthen requirements for enhanced resilience and implementation of adaptation measures. However, there is no evidence identified to assess the extent to which measures to assess risks, implement adaptation measures and increase resilience across this area are being applied.

Evaluation of urgency score

Due to the High projected magnitude from multiple risks to forestry, an underdeveloped understanding of compound risk and potential for exposure across the lifetime of a forest, the risks have been scored More Action Needed. The need to assess and adapt to risk is well progressed and recognised in the NAPs for England, specifically the Forestry Commission Adaptation Reporting Power: Fourth round report (2024) and significant progress to advance understanding of adaptation measures, provide guidance and support adaptation implementation is apparent. However, evidence of uptake for forests in private ownership (beyond uptake on the public forest estate or post disturbance planning) remains absent. This score is given with Medium confidence, reflecting expert consensus (Atkinson et al., 2025) and evidence gap concerning effectiveness of adaptation measures.

Table 8.38: Urgency scores for N8 Risks to forestry for England. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

England								
N8 Risks to forestry.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
With adaptation	++ (H)	++ (H)	++ (H)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)

	Present	2030 Central	2030 High	2050 Central	2050 High	2080 Low	2080 Central	2080 High
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.8.3 Northern Ireland

Current and future level of risk

Forests in Northern Ireland cover 118,000 hectares (Forest Research, 2024), they are vulnerable to wind, drought, pest and disease risk and have low species diversity. Pests, pathogens, and invasive species continue to pose a significant threat to productivity, and increased biosecurity is required.

The magnitude is low for the present, 2030s and 2050s, as forestry in Northern Ireland represent a small proportion of productive forestry in the UK. Minor impacts (approximately 1% or more at national level) to valued habitat or landscape types and/or hundreds of hectares of land lost or severely damaged are expected. Due to increasing climate hazards, the score increases to medium by 2080.

Level of preparedness

Policies in Northern Ireland are limited (CCC, 2023). There is a new catalogue of Pests and Pathogens of Trees (2021), but main policies are at UK level and guidance from the UK Forestry Standard is applied consistently by the Forest Service in Northern Ireland.

Evaluation of urgency score

Sustain Current Action is required to increase resilience given the legacy of extensive spruce monocultures and focus on production objectives. This score is given with Medium confidence supported by strong expert agreement.

Table 8.39: Urgency scores for N8 Risks to forestry for Northern Ireland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Northern Ireland								
N8	Risks to forestry.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (L)	++ (L)	++ (L)	++ (L)	++ (L)	N/A (N/A)	++ (M)	++ (N/A)
With adaptation	++ (L)	++ (L)	++ (L)	++ (L)	++ (L)	N/A (N/A)	++ (M)	++ (M)

Urgency scores	SCA	SCA		SCA			SCA	
Overall urgency score	SCA							

8.2.8.4 Scotland

Current and future level of risk

Scotland has 1,511,000 hectares of woodland (Forest Research, 2024), predominantly conifers (1,070,000 hectares) (Forest Research, 2024). The risk to forest and woodland from climate change is unevenly distributed across forest types and areas. Areas of low species diversification are particularly vulnerable to wind, pest, pathogen and wildfire risks. Forests in east, central, and south Scotland are likely to see direct effects of severe droughts (Locatelli et al., 2021). Multiple factors including management, stand age and geography have an influence on vulnerability, with elevation and certain soil types increasing vulnerability. Due to lock-in to the current trajectory associated with current forest areas in the current rotation, given rotation lengths, stands remain vulnerable to climate change risks until its viable to introduce adaptation measures which will increase resilience, the majority of these measures are introduced following disturbance or felling and therefore given the low species diversification and heightened wind and pest risk.

Drought risk to forests in Scotland (Locatelli et al., 2021) indicates high confidence that east, central, and south Scotland are likely to see direct effects of severe droughts primarily on forest productivity and carbon sequestration. This would reduce timber quality and drought periods are expected to limit the anticipated increase in forest productivity that is likely to be caused by warmer temperatures and atmospheric CO_2 concentration increase. Evidence of the duration of adverse impacts to forests following drought events remains a significant evidence gap. However, future exposure to prolonged or repeat periods of drought stress could cause increased mortality (Low confidence). Key forestry tree species including Scots pine, Douglas fir, and Sitka spruce are vulnerable and can be heavily impacted by severe droughts, with higher mortality in Sitka spruce than Douglas fir. More work exploring the drought sensitivity of different species and provenances and developing better planting material could help with reducing drought risk in the future. While efforts are being made to diversify tree species (Scottish Forestry, 2025), Sitka spruce remains the most important commercial species and it is vulnerable to drought (Davies et al., 2020). Forests planted on sites which experience prolonged seasonal waterlogging are also at increased risk during summer droughts due to limited rooting depth (Atkinson, 2022).

The magnitude of risk for Scotland is high for the present and future periods due to major impact to valued habitat or landscape types (approximately 10% or more at national level) and/or tens of thousands of hectares land lost or severely damaged; increasing to very high by the 2080s due to critical impact to valued habitat or landscape types (approximately 20% or more at national level) and/or hundreds of thousands of hectares land lost or severely damaged.

Level of preparedness

There is no evidence identified to assess the extent to which measures to assess risks and increase resilience are being implemented across this area. However, new action plans supporting more informed action to increase resilience and evidence of adaptation support across the UK (e.g., Scotland's Forestry Strategy Implementation Plan 2022-2025, Scottish Forestry Route map to Resilience 2025).

Evaluation of urgency score

Due to the High projected magnitude from multiple risks, an underdeveloped understanding of compound risk, dominance of few tree species, new evidence concerning vulnerability to drought and the potential for exposure to extreme events and beetle infestation, combined with current lock in, More Action Needed is recommended. Whilst new strategic direction to increase resilience reflects significant progress, coupled with the need for adaptation being recognised in the NAPs for Scotland, evidence of uptake of measures is absent. This score is given with Medium confidence, reflecting expert consensus (Atkinson et al., 2025) and evidence gap of effectiveness of adaptation measures to compound risk.

Table 8.40: Urgency scores for N8 Risks to forestry for Scotland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Scotland								
N8 Risks to forestry.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (H)	++ (H)	++ (VH)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
With adaptation	++ (H)	++ (H)	++ (VH)	++ (H)	++ (H)	N/A (N/A)	++ (VH)	++ (VH)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.8.5 Wales

Current and future level of risk

Extreme events are expected to lower resilience and increase risk from pest and pathogen damage, with areas of low species diversification more vulnerable to pest, disease and fire. Woodland covers 358,400 hectares (16.9%) of Wales (ERRAMP, 2025) and due to the range of climate change impacts and low diversity of softwood, there is a Medium projected magnitude, with intermediate impacts (approximately 5% or more at national level) to valued habitat or landscape types and/or thousands of hectares of land lost or severely damaged. Magnitude increases to High by the 2080s.

Level of preparedness

The State of the Natural Resources Report (SoNaRR, 2020) identified significant risks, including alteration of species ranges and potential for extinctions, as changing temperatures and precipitation disrupt natural distribution.

Evaluation of urgency score

More Action Needed is applied. Whilst progress has been made in the launch of the Welsh Plant Health Surveillance Network (2022), unprecedented storm damage to productive forests and evidence of uptake of measures to manage pest, disease and wind risk is absent. This score is given with Medium confidence, reflecting expert consensus.

Table 8.41: Urgency scores for N8 Risks to forestry for Wales. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Wales								
N8 Risks to forestry.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (M)	++ (M)	++ (M)	++ (M)	++ (M)	N/A (N/A)	++ (H)	++ (H)
With adaptation	++ (M)	++ (M)	++ (M)	++ (M)	++ (M)	N/A (N/A)	++ (H)	++ (H)
Urgency scores	MAN	MAN		MAN			MAN	
Overall urgency score	MAN							

8.2.9 Opportunities for agriculture, forestry, fisheries and aquaculture – N9

While climate change may create new or expanded opportunities in agriculture, forestry, and fisheries, these are highly contingent on broader environmental, socioeconomic, and policy conditions. Potential opportunities remain speculative, poorly quantified, and highly vulnerable to climate hazards. Realising opportunities will require careful management of trade-offs, alignment with environmental goals, and adaptation strategies that enhance resilience without exacerbating inequality or ecological degradation.

- Climate models suggest that rising temperatures may allow new crop varieties and fish species to become viable in the UK. However, increasing extreme weather events are likely to limit or erase these opportunities, with evidence showing climate change often reduces yields relative to pre-2020 levels.
- Realising potential gains requires addressing ecosystem risks, future uncertainties, and socioeconomic challenges. New crops face the same threat from extreme weather events as current crops, plus new crops are not adapted to our soils, pests, pathogens and many of them require pollination to produce seeds or fruits (N6). Overall food security (N10) will not be improved by simply swapping one crop with another as there is insufficient land to grow additional crops.
- Further investigation is needed to understand the environmental and economic implications for UK agriculture, forestry, and fisheries.

Table 8.42: Urgency scores for N9 Opportunities for agriculture, fisheries, aquaculture and forestry. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

ID	Risk		Present	2030	2050	2080	Urgency
N9	Opportunities for agriculture, fisheries, aquaculture and forestry	**UK**	+ (L)	+ (L)	+ (L)	+ (L)	FI
		England	+ (L)	+ (L)	+ (L)	+ (L)	FI
		Northern Ireland	+ (L)	+ (L)	+ (L)	+ (L)	FI
		Scotland	+ (L)	+ (L)	+ (L)	+ (L)	FI
		Wales	+ (L)	+ (L)	+ (L)	+ (L)	FI

8.2.9.1 Evidence relevant to the entire United Kingdom

Current and future drivers of opportunity

Warmer temperatures are reducing the suitability of some crops and species currently used in UK agriculture, forestry, and fisheries and are projected to further affect these in the future. However, they may also, in theory, create opportunities to introduce or relocate new crop varieties and fish or aquaculture species to areas with more favourable climatic conditions.

Despite potential opportunities, climate risks to agriculture, forestry, and fisheries remain high because of the current and predicted escalation of the magnitude and frequency of extreme weather events such as flooding, heatwave, drought (N6, N7, N8). We are already seeing extreme weather events in countries where crops potentially new to the UK are presently grown having severe impacts on yields (Hu et al., 2025). Sustaining productivity of new or relocated species under long-term climate change is a major challenge. Related risks must be carefully evaluated to avoid increasing vulnerability or causing unintended harm to ecosystems.

Opportunities are also constrained by trade-offs of new crops against the available agricultural area. Many new crops are pollinator dependent (e.g., soft fruit, orchard crops or legume crops) and therefore the impact of climate change on the distribution and sustainability of these ecosystem services should be considered. Even for wind pollinated crops, such as cereals, the maintenance of habitats that can support natural enemies of pests of these crops is important, and climate change is likely to put additional pressure on these habitats and the ecosystem services they provide.

Crucially, potential opportunities depend on the health of the underlying ecosystems (e.g., soil health, water quality, pollination), which are increasingly degraded by climate change and other human pressures. Continued ecological decline may therefore undermine the feasibility of realising these opportunities. Some sector-specific examples (e.g., tuna fishery expansion, viticulture, and others described in the sections below) may bring short term gains but carry long-term vulnerabilities that require further investigation.

Assessment of current and future magnitude of opportunities

Observed trends, projections, and speculative assessments suggest potential opportunities from climate change for UK agriculture, forestry, and fisheries. Observed trends in vineyard expansion show active vineyards rising from 700 in 2018 to 1,030 in 2023, and wineries from 160 to 221 (WineGB, 2024). The commercial area under vines tripled in the last decade. While it is unclear whether this growth is driven by climate or markets, conditions are becoming more favourable for grape cultivation. However, yields remain variable, with hot, dry years like 2018 producing good harvests and cooler, wetter years like 2020 reducing output (ADAS, 2025), highlighting vulnerability to climate extremes. Along with climate-related risks to vineyards, increased costs and fiscal pressures in the UK have been a constrain for the wine industry (Finacial Times, 2024).

Warming UK seas are supporting the spread of commercially valuable species while negatively impacting others (see sections N3 and N7). Trends show rising mackerel and bluefin tuna populations (MMO, 2024). Mackerel became the UK fleet’s top catch after its Northeast Atlantic range tripled between 2007 and 2016 (Garrett et al., 2024). Projections show further increases in habitat suitability by 2050, but international quota disputes may arise as these species shift across borders.

Some crops could benefit from warming, but challenges remain. Soybean, though projected to become viable across most of England and south Wales by 2050 (Coleman et al., 2021), faces low yield potential, drought risk, and lacks domestic infrastructure. Adoption would require significant investment, and concerns remain about water demands (Jenkins et al., 2024), pest vulnerability, and pollinator dependence (Redhead et al., 2025). Soy yields can increase by 40% with insect pollination (Chacoff et al., 2024). In Cornwall, over 3,000 hectares may become suitable for agriculture by 2050, potentially supporting novel crops like blue lupin, hemp, and sunflower (Gardner et al., 2021). These are highly pollinator-dependent. Thus, the viability of novel crops depends not just on temperature (N6), but also on ecosystem health and pollination services (DEFRA, 2022; Redhead et al., 2025).

Rising temperatures could expand biofuel crops like miscanthus. This biomass crop, now covering approximately 8,500 hectares, could support energy production and farm resilience without displacing food crops, though drought remains a key constraint (Hodgson et al., 2024).

Forestry trials suggest range expansion for seven tree species under climate change. Some examples of this include the Holm oak, Incense cedar, Oriental beech, and Weymouth pine. These offer potential for timber and carbon storage (Reynolds et al., 2021), but productivity is threatened by drought, fire, and pests (N8).

Assessment on the evidence base and evidence gaps

It is important to highlight that while climate change may offer opportunities in agriculture, forestry, and fisheries, these sectors are also highly vulnerable to its impacts. Trials of new crops and species face major risks from extreme events and seasonal variability, especially since they are not bred for UK soils or conditions. UK wine production remains highly dependent on weather patterns, limiting its reliability despite vineyard expansion (ADAS, 2025). In forestry, productivity gains from rising CO_2 and temperature are constrained by water scarcity, shifting rainfall, nutrient limitations, and increased pests and diseases. Even resilient species as Sitka spruce require careful management under drought (Davis et al., 2020). Furthermore, the ecosystem services supporting opportunities, fertile soils, pollinators, and water resources, are at risk from climate change (Kuo et al., 2025).

Opportunities are also constrained by wider environmental, social, and economic factors. Studies highlight risks from market volatility, farming traditions, high costs, low profitability, and limited data on crop management, pests, and financial returns (Gardner et al., 2021b; Felton et al., 2023; Brannan et al., 2023; Sakrabani et al., 2023; Craft & Pitt, 2024).

In marine systems, warming seas bring new species that threaten native biodiversity and increase disease and pest risks. Shifting species distributions can cause conflicts, overfishing and effect quotas (Garret et al., 2024).

Given these limitations, opportunities remain low. Confidence in this score is also Low due to a lack of detailed studies. As such, the assessment is only available at the UK level.

Level of preparedness for opportunities

Preparedness for climate-related opportunities in the UK remains low. Current efforts are largely research focused. DEFRA is investing £30 million through the Farming Innovation Programme to improve climate resilience in breeds and investigate novel crops, while the Forestry Commission is exploring new forestry species (Reynolds et al., 2021). The Marine Management Organisation (MMO) is evaluating the potential for a sustainable bluefin tuna fishery. The UK has a quota allocation of 66.15 tonnes of bluefin tuna in 2025, from this, 45 tonnes will be used for commercial fishery. MMO aim to issue licence authorisations for 15 commercial vessels with three tonnes of quota per vessel in English and Scottish waters (MMO, 2025).

However, critical gaps exist beyond research. Governance remains fragmented, with contradictions between policies promoting food security or export growth and those aiming to protect the environment, potentially increasing ecosystem vulnerability. There is limited planning for how farmers and fishers will transition, and no clear frameworks to manage risks such as stranded assets or maladaptation. Regulatory and market uncertainty, especially around fisheries quotas and novel crop viability, also requires attention.

8.2.9.2 England

Current and future magnitude of risk

Projections suggest that soybean cultivation could be viable in parts of England by 2050s and 2080s under different climate scenarios. In Cornwall, over 3,000 hectares of land may become suitable for agriculture, potentially enabling the growth of novel crops such as blue lupin, hemp, and sunflower (Gardner et al., 2021). However, opportunities are low and face major constraints from increasing climate risks, extreme weather events, and broader environmental and socioeconomic challenges. Thus, opportunities for England are scored as Low. For further detail, see the UK section.

Level of preparedness

Preparedness for opportunities in England remains low. The government is supporting research in potential crops and fisheries, including a £30 million DEFRA investment into climate-resilient breeding and novel crops. Forestry Commission is exploring suitable forestry species (Reynolds et al., 2021). In 2024, MMO ran a second commercial trial of blue fin tuna and launched a new recreational fishery in southwest England, though results are not yet available (MMO, 2024). In 2025, MMO aim to give 15 licence authorisations to fish for 45 tonnes of eastern Atlantic bluefin tuna in English and Scottish waters (MMO, 2025).

Evaluation of urgency score

The urgency score reflects the need for Further Investigation due to the Low magnitude of climate-related opportunities. While some projections and trends exist for England as described above, these remain speculative and are based largely on temperature models, overlooking critical factors like extreme weather, environmental stressors, and socioeconomic challenges. Confidence is Low, as there is no evidence of socioeconomic benefits from novel crops or fisheries. There is strong expert agreement that climate change offers limited opportunities for agriculture, forestry, and fisheries.

Table 8.43: Urgency scores for N9 Opportunities for agriculture, fisheries, aquaculture and forestry for England. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

England								
N9	Opportunities for agriculture, fisheries, aquaculture and forestry.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)
With adaptation	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)
Urgency scores	FI	FI		WB			WB	
Overall urgency score	FI							

8.2.9.3 Northern Ireland

Current and future magnitude of risk

Evidence on climate-related opportunities specific to Northern Ireland remains limited, as most studies focus on Great Britain. However, the UK assessments suggest potential changes for the region's agriculture and fisheries under warmer conditions. Rising temperatures may enable the integration of bioenergy crops such as miscanthus into arable rotations, supporting diversification and farm resilience, though drought risk remains a key constraint (Hodgson et al., 2024). In marine systems, warming seas are linked to increasing populations of commercially valuable species such as mackerel and bluefin tuna, whose ranges expanded significantly across the Northeast Atlantic between 2007 and 2016 (MMO, 2024; Garrett et al., 2024). However, further research is needed to understand local feasibility and associated risks from extreme weather events, and broader environmental and socioeconomic challenges. Thus, opportunities for Northern Ireland are scored as Low. For further detail, see the UK section.

Level of preparedness

There is no information on actions to address opportunities from climate change in Northern Ireland. Refer to the UK section for relevant country-level actions on this matter.

Evaluation of urgency score

The urgency score shows the need for Further Investigation, given the Low magnitude of climate-related opportunities. As no specific information is available for Northern Ireland, the score is based on the UK evidence. Opportunities remain largely speculative, relying on observed trends and modelled projections, often focusing only on temperature and overlooking other variables/factors, as extreme weather, environmental pressures, and socioeconomic challenges. Confidence is Low due to the absence of evidence for real socioeconomic benefits from novel crops or fisheries.

Table 8.44: Urgency scores for N9 Opportunities for agriculture, fisheries, aquaculture and forestry for Northern Ireland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Northern Ireland								
N9	Opportunities for agriculture, fisheries, aquaculture and forestry.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)
With adaptation	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)
Urgency scores	FI	FI		WB			WB	
Overall urgency score	FI							

8.2.9.4 Scotland

Current and future magnitude of risk

Warming seas are supporting northward shifts in commercially valuable fish species, with mackerel and bluefin tuna populations increasing in UK waters; the Northeast Atlantic mackerel range tripled between 2007 and 2016, shifting northward by around 400 kilometres and becoming the UK fleet's top catch (MMO, 2024; Garrett et al., 2024). On land, rising temperatures may enable range expansion of several tree species across Great Britain, including Holm oak, Incense cedar, Oriental beech, and Weymouth pine, offering potential for timber and carbon storage (Reynolds et al., 2021). Bioenergy crops such as miscanthus could also be integrated into Scottish arable systems under warmer conditions, though drought remains a limiting factor (Hodgson et al., 2024). No opportunities for vineyard expansion have been identified in Scotland. However, opportunities are low and face major constraints from increasing climate risks, extreme weather events, and broader environmental and socioeconomic challenges. Thus, opportunities for Scotland are scored as Low. For further detail, see the UK section.

Level of preparedness

By 2027, Scotland's Rural and Environment Science and Analytical Services investment in climate change, will include research on climate-resilient crop varieties, novel cropping systems, and livestock feeding and breeding strategies. In 2025, MMO aim to give 15 licence authorisations to fish for 45 tonnes of eastern Atlantic bluefin tuna in English and Scottish waters this year (MMO, 2025). For more details on preparedness for opportunities, see the UK section.

Evaluation of urgency score

The urgency score reflects the need for Further Investigation, given the Low magnitude of climate-related opportunities. As no specific information is available for Scotland, the magnitude score is based on the UK evidence. Opportunities remain largely speculative, relying on observed trends and temperature models that often overlook key variables/factors as extreme weather, environmental pressures, and socioeconomic challenges. Confidence is Low due to the absence of evidence for socioeconomic benefits from novel crops or fisheries.

Table 8.45: Urgency scores for N9 Opportunities for agriculture, fisheries, aquaculture and forestry for Scotland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Scotland								
N9	Opportunities for agriculture, fisheries, aquaculture and forestry.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)
With adaptation	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)
Urgency scores	FI	FI		WB			WB	
Overall urgency score	FI							

8.2.9.5 Wales

Current and future magnitude of risk

The total commercial vineyard area in Wales and England more than doubled between 2011 and 2021, from 1,384 to 3,661 hectares, reflecting increasingly favourable growing conditions for grape cultivation, although the relative influence of climate versus economic factors remains uncertain (ADAS, 2023). Rising temperatures may also support the range expansion of several tree species across Great Britain, offering potential for timber production and carbon storage (Reynolds et al., 2021). Bioenergy crops such as miscanthus could be integrated into arable rotations under warmer conditions, though drought remains a constraint (Hodgson et al., 2024). In Welsh waters, warming seas are contributing to the northward expansion of valuable fish species such as mackerel and bluefin tuna, whose ranges have increased significantly across the Northeast Atlantic (MMO, 2024; Garrett et al., 2024). However, opportunities are low and face major constraints from increasing climate risks, extreme weather events, and broader environmental and socioeconomic challenges. Thus, opportunities for Wales are scored as Low. For further detail, see the UK section.

Level of preparedness

There is no information on actions to address opportunities from climate change in Wales. Refer to the UK section for relevant country level actions on this matter.

Evaluation of urgency score

The urgency score reflects the need for Further Investigation, given the Low magnitude of opportunities. As no specific information is available for Wales, the score is based on the UK evidence. Opportunities remain largely speculative, relying on observed trends and temperature models that often overlook other variables and factors like extreme weather, environmental pressures, and socioeconomic challenges. Confidence is Low, due to the absence of evidence for real socioeconomic benefits from novel crops or fisheries.

Table 8.46: Urgency scores for N9 Opportunities for agriculture, fisheries, aquaculture and forestry for Wales. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Wales								
N9 Opportunities for agriculture, fisheries, aquaculture and forestry.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)
With adaptation	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)	+ (L)
Urgency scores	FI	FI		WB			WB	
Overall urgency score	FI							

8.2.10 Risk to food security – N10

Climate change impacts food security, defined as “When all people at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”. Food security is part of national security and climate change will cause both chronic and acute crises. Chronic changes in food security caused by multiple drivers (e.g., poverty, conflict, trade patterns) including climate change will alter the availability and quality of food consumed in the UK, and impact on population health through calorie and nutritional deficiencies - and will most markedly impact the poorest in society.

Assessment of this risk is focused on the impacts of climate change across the food system. It includes production, both of food produced in the UK and food imported from overseas which is consumed in the UK, food manufacturing, and considers population groups who are most likely to be affected. Most foods we consume are multi-ingredient and require processing and packaging, plus storage and transport. This chapter primarily considers the raw materials (e.g., crops, meat, fish, dairy) which are often ingredients in the more complex, multi-ingredient foods consumed in the UK, and then in turn require processing, packaging, storage and transport. This is a complex risk which intersects with risks from climate change to agriculture, marine, soil, ecology, transport and health. It has a strong international dimension since the UK imports over half the food we consume, and food security is likely to be further challenged by geopolitical and economic shocks, impacting our ability to be resilient to the impacts of climate change. For these reasons the urgency is scored as Critical Action Needed.

Headlines

- Critical Action Needed is applied because climate change poses a systemic threat to UK food security, affecting domestic production, global supply chains, and population access to affordable, nutritious food. Climate-induced threats to the food system cause food to become more expensive, exacerbating the cost-of-living crisis. This in turn leads to an increase in food insecurity. Food price rises have been linked to recent climate shocks, including in the UK, and are predicted to cause 30-50% of food price inflation by 2035 (ECIU 2023; Kotz et al., 2023, 2024, 2025).
- Climate risk cascades through a globally dependent system. The UK imports over half its food and depends heavily on internationally sourced ingredients, inputs, and packaging materials. Long-term changes in average climate and extreme events will change the suitability of sourcing regions for producing different food products, potentially with both positive or negative impacts depending on the region and product. Food production disruptions in climate-vulnerable countries, whether due to extreme weather, water scarcity, or ecological degradation, can rapidly destabilise UK food supply, processing, and prices.
- Compounding risks and tipping points are important. Climate-induced disruptions are likely to intersect with geopolitical, economic, and energy shocks, amplifying systemic risks. Potential tipping points (Bacon et al. 2025), such as AMOC collapse, agricultural regime shifts or shifting dietary patterns, could fundamentally alter how the UK food system currently operates, but evidence on their impacts is limited.

Table 8.47: Urgency scores for N10 Risks to food security. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

ID	Risk		Present	2030	2050	2080	Urgency
N10	Risks to food security	**UK**	++ (H)	++ (VH)	++ (VH)	+ (VH)	CAN
		England	++ (H)	++ (VH)	++ (VH)	+ (VH)	CAN
		Northern Ireland	++ (H)	++ (VH)	++ (VH)	+ (VH)	CAN
		Scotland	++ (H)	++ (VH)	++ (VH)	+ (VH)	CAN
		Wales	++ (H)	++ (VH)	++ (VH)	+ (VH)	CAN

8.2.10.1 Evidence relevant to the entire United Kingdom

Current and future drivers of risk

Due to the international nature of the UK food system, factors affecting UK food security are applicable across all devolved nations. The term 'food system' includes all supply chains and value chains, as well as impacts on the population and environment. The UK Food Security Report (2024) reports on five themes (Global Food Availability, UK Food Supply Sources, Food Supply Chain Resilience, Food Security at Household Level, and Food Safety and Consumer Confidence), within which the six dimensions of food security are considered (availability, access, utilisation of food, stability, sustainability and agency). All of these aspects are potentially impacted by climate to some degree, whether directly or indirectly.

Climate change affects the food system directly (e.g., impacts of heat stress on livestock welfare and productivity) and indirectly (e.g., changing pest and disease patterns impacting crop productivity). These impacts will be compounded by other factors which affect the movement of ingredients, inputs (e.g., fertilizer, treatments to ensure livestock and plant health, packaging, water, fuel) and food through supply chains (Figure N10.1), some of which will also be impacted by climate change. Even if the direct impact of climate change is relatively small or localised, it can therefore cascade into much bigger and more disruptive responses across the food system (Redman and Benton, 2025). Kotz et al. (2025) calculated that food price inflation would increase in Europe by 30-50% by 2035 due to climate change, when disentangling the climate change element of food price inflation from other contributing factors. For the UK, even the most optimistic emissions scenario causes climate change to inflate food prices by 1% per year, meaning that UK consumers need to spend an extra £944.3 million in the first year, which is then compounded as global warming continues to occur. This cost will be more difficult to bear for the least well-off groups in society (the poorest 20%), who already need to spend 45% of their household income to eat a healthy diet (Food Foundation, 2025). For this reason, current risk is High, future risks under any scenario are Very High and urgency is scored as Critical Action Needed. Confidence is scored as Medium since there are relatively few studies which attempt to isolate the impact of climate change on food security relative to other contributing factors; however, there is substantive evidence that extreme weather events caused by climate change in continuous years from 2022-2025 are already impacting food production and supply chains to the extent that some foods and feeds have not been available in the UK at times when they would have expected to have been available to consumers.

The 2025 Food Strategy and 2024 UK Food Security Report recognise that climate change is increasingly having an impact on the ability of the UK and countries supplying the UK to grow certain types of food and on fish stocks, potentially weakening the resilience of supply chains in the UK and overseas.

Climate change impacts on agriculture affects both the production of animal feed and fuel, and food production. Whilst there is a lack of direct evidence on climate impacts on household-level food security, vulnerability has been increasing (e.g., a 51% increase in food bank use over the last five years[*1*] and 10% of UK households classified as food insecure in 2023-2024[*2*]). These mostly non-climate vulnerabilities are projected to worsen across all regions, with the most severe consequences borne by marginalised and low-income groups. People experiencing diet-related health challenges (e.g., Type 2 diabetes, cardiovascular disease, neurodegenerative

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[1] https://www.trussell.org.uk/news-and-research/latest-stats/end-of-year-stats

[2] Family Resources Survey updated 27 March 2025, Dept for Work and Pensions

disease), people experiencing poverty, marginalised groups and people with a range of protected characteristics will therefore be more vulnerable to the impacts of climate change on food security (H5).

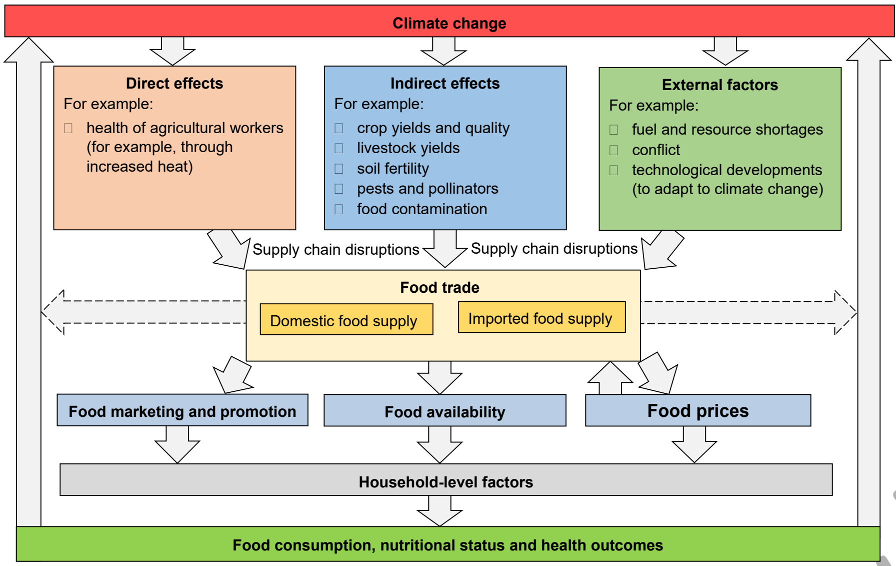

Figure N10.1. Simplified framework of climate change impacts on the UK food system. Reproduced from HECC report 2023.

The UK produces 62% of the food (United Kingdom Food Security Report 2024, Department for Environment Food and Rural Affairs, 2024) consumed in the UK (as a measure of self-sufficiency) but most of the food produced in the UK is consumed as an ingredient within a product that requires multiple other, often imported, ingredients for food manufacturing. There are trade-offs between food security and self-sufficiency in a changing climate. For example, maximising UK self-sufficiency could potentially increase UK exposure to local climate risk risks (e.g., if these increase markedly within the UK), in the absence of robust trading arrangements with partner countries. Producing food ingredients in the UK requires imports such as seeds, fertilisers, pesticides, packing materials and energy. Disruptions to the supply chains that provide these components from climate-change and other factors may halt manufacturing of the food(s) that depend on it, reducing UK food security (Redman and Benton, 2025).

Climate change will increase the likelihood of extreme weather events in the UK and in international sourcing regions, and when these hazards occur at atypical or sensitive times of year, they will increase the vulnerability of UK domestic food production and imports. Global food production is projected to decrease with increasing global mean temperature (Challinor et al., 2014). Recent economic analysis that modelled climate impacts on global crop production, considering projected adaptation and behaviour change (Hultgren et al. 2025) found that adaptation and income growth could alleviate a significant proportion of projected global losses, but substantial residual losses remain for all staples except rice. Areas where agricultural production is currently concentrated are wealthy, but poorly adapted, meaning that most of global calorie production is at risk, in turn increasing the risk of food insecurity in developed countries. Somewhat counter-intuitively, poorer regions, where yields are already low, are more likely to adopt climate adaptation measures, and consequently their yields could be preserved. Locally, climate change is still likely to have severe effects in the poorest regions, but the impact on global food security will be less dramatic as relatively few calories depend on these areas.

Hazards impacting food production, both domestically and overseas include hail, frost, snow, heatwave, flooding and very wet conditions, soil erosion, and high winds. Climate impacts on food security are driven both by these acute events, and by chronic changes such as changes in average winter or summer temperatures. Most of the evidence for this risk is at UK-level and the individual home nations will experience similar current and future drivers of risk; current and future magnitude of risk; and levels of preparedness of risk. However, there are regional differences – for example, heat risks to crops, livestock and cold stores will be greatest in the south of the UK where temperature increases are strongest.

Food security is a key component of national security and central government planning is key for ensuring its robustness (Lang et al., 2025). Strategies to increase UK resilience to food supply interruptions include stockpiling, increased diversity of the supply base and multiple trading routes for the same or similar products. Climate impacts on the food system will occur in the context of wider shocks and drivers, not all of which are directly impacted by climate change. These include production failures of ingredients in the UK or overseas, changes in trading policies and patterns, civil unrest preventing production, logistics or trade, fuel shortages, border closures and blocked transport routes. How the UK population reacts to these shocks also impacts food security; behaviours such as hoarding or shifting dietary patterns (as seen during the Covid-19 pandemic) impact demand. British Gas and The Red Cross routinely advise citizens to stockpile three days' worth of drinking water and food when snow is forecast, placing sudden demands on supply chains. UK retail operates a model of fixed price year-long or season long deals with its suppliers, unlike the EU which operates a short-term model based on supply and demand. The fixed price model works well when input prices, inflation and interest rates are stable. However, volatility, such as that induced by extreme weather events, makes this challenging to operate. UK produce growers frequently planted more fresh produce than they anticipated would be needed by the retailers with whom they had contracts, which provided some resilience, but rising input costs have made these contingencies much rarer. Spiking gas prices in 2022 caused UK growers to abandon planting salad crops into glasshouses over the 2022-2023 winter. Usually, the winter-grown protected crop would have enabled growers to meet their retail contracts from UK grown produce from February, but instead they were reliant on continued production in Spain and North Africa. However, unseasonal cold temperatures, snow and flooding disrupted production in these locations and disrupted UK supply chains, leading to empty UK supermarket shelves. Many growers chose to sell into European markets, where prices rose in response to reduced supply, instead of honouring the fixed price UK contracts (Futter, 2024).

Changes in market demand and consumer behaviour in the UK will impact vulnerability to climate change. For example, shifts towards plant-based diets mean that alternative foods will have to be substituted into the diet, and these often have international supply chains and ingredients which are derived from regions highly vulnerable to climate change and which may already be water insecure and/or deficient in soil quality (Lang et al., 2025).

Assessment of current magnitude of risk

The current risk magnitude is assessed as High. Significant impacts on production alone (N6) have been experienced in recent years, nearing £1 billion (which correlates to High/Very High risk). However, there are other food security-related supply chain activities (and overseas production) and outcomes which are more challenging to quantify but are likely to have experienced significant impacts. For example, food price rises and impacts on health and public services. Confidence is Medium due to the considerable unquantified elements.

Food security is assessed as the capacity of the UK to ensure an adequate supply of food for the population as part of national security and is an important policy area for planning resilience and preparedness strategies.

The UK Food Security Review (UKFSR, 2024) highlighted the interconnected nature of risks, with geopolitical and climate events in the last three years increasing prices of inputs to food production (e.g., energy and fertiliser) and the cost of food. Food inflation in the UK reached its highest point in 45 years. The UKFSR concludes "The impacts of climate change, biodiversity loss and water insecurity both at home and abroad remain pressing risks to food security. They drive volatility in the present and put sustainability and resilience of food production at risk over the longer term. These risks are also now interacting with heightened geopolitical tensions." Falloon et al. (2022) summarised the key risks to UK food system activities from climate change and weather extremes (Figure N10.2).

<u>UK agriculture produces ingredients, most of which rely on imported inputs:</u> The UK imports approximately 40% of the food consumed in the UK (UKFSR, 2024) but this is much higher for some sectors (e.g., 84% of fruit consumed is imported). However, the UK is 75% in the food that can be grown in the country. These figures focus on calorie supply, and do not consider that most citizens are dependent on imported food in raw and processed forms and that domestic food production relies on imported seeds, fertiliser, pesticides etc. UK food system resilience is therefore dependent on the ability of other countries to achieve climate resilient production, processing and manufacturing industries. Self-sufficiency and food security do not have a direct relationship (Redman and Benton, 2025).

Food prices and availability are key determinants of food security in a system dependent on the "Just-in-Time" supply model that prioritizes freshness and efficiency but is highly sensitive to disruptions (Kotz et al., 2025). Processed foods that are produced in one country (with ingredients typically obtained from several countries), are often exported to another country for processing and packaging and then imported into the UK for consumption. Some foods are also UK-produced, exported for processing, and then re-imported. A recent report by the Food Standards Agency and Oxford University (Hasnain, 2024) showed that climate change is already impacting the UK food system, with the most significant effects on food production due to extreme temperatures, flooding, drought, and soil erosion. This highlighted how disruptions extend across the supply chain, impacting distribution, storage, processing, and retail, and contributing to price volatility. Climate shocks can therefore impact the system at any stage of the supply chain and can be experienced domestically or globally (Lang, 2021).

Extreme weather events are already impacting UK food systems with implications for trade (to ensure supply resilience), including heat, drought and flooding impacts on production (N6) and heat impacts on cold stores and retail refrigeration (Davie et al., 2023). Increased ergot (a fungus which produces toxins that are harmful to human and animal health if they enter the food chain) contamination due to wet and mild conditions and 20% lower wheat production in 2024 increased UK wheat imports to 2.6 Mt to meet demand (AHDB Cereal Quality Survey, 2024).

<u>Extreme weather events are already impacting overseas production of food consumed in the UK:</u> Domestic supply of fruits, vegetables, legumes and fish is insufficient, so the UK relies on imports for these foods (Wheeler and Goudie, 2020). Around 18% of the UK's fruits and vegetables come from nations at high- and moderate-risk to climate change (e.g., India, South Africa and Brazil) making the UK's supply of foods associated with healthy diets susceptible to climate-related disruptions. Europe is a significant source of imports for most food groups, while significant amounts of fruit, nuts and seeds were also imported from Africa and the Western Pacific. Smallholder agricultural systems and rainfed production systems, predominantly found in Africa, Asia and South America, are most vulnerable to climate shocks (Frankel Davis et al., 2020) so imports from these regions will be at particular risk in future. Extreme weather simultaneously affecting multiple regions which supply food to the UK could disrupt supply chains, limit availability and raise prices of fresh produce, with potential health implications for the UK population (Scheelbeek et al., 2020).

Yields of crops that are predominantly grown in the South and East of Europe have already been impacted by climate hazards. Orange production reached its lowest level in nearly a decade following adverse weather conditions in Spain (European Commission, 2022). Carbon Brief (Dwyer, 2025) mapped 100 cases of crops being destroyed by heat, drought, floods and other climate extremes in 2023-2024. Flooding and cold temperatures during winter 2022-2023 in Morocco disrupted tomato harvests (Fresen, 2023). Many UK supermarkets introduced purchase restrictions and the cost of a kilogram of tomatoes rose by 41% from January 2020 to January 2023 (ONS, 2023). Food price rises have been linked to recent climate shocks, including in the UK (ECIU 2023; Kotz et al. 2023, 2025). The risk of a future event that would substantially affect the ability of UK consumers to buy enough food is unknown, but climate change will likely play an increasing part in any events where multiple risks converge. Production of foods important for UK diets in climate vulnerable supply regions is predicted to decline, potentially resulting in supply shortfalls and/or price rises (Symons, 2023) and risks to UK food and nutritional security (Symons, 2023).

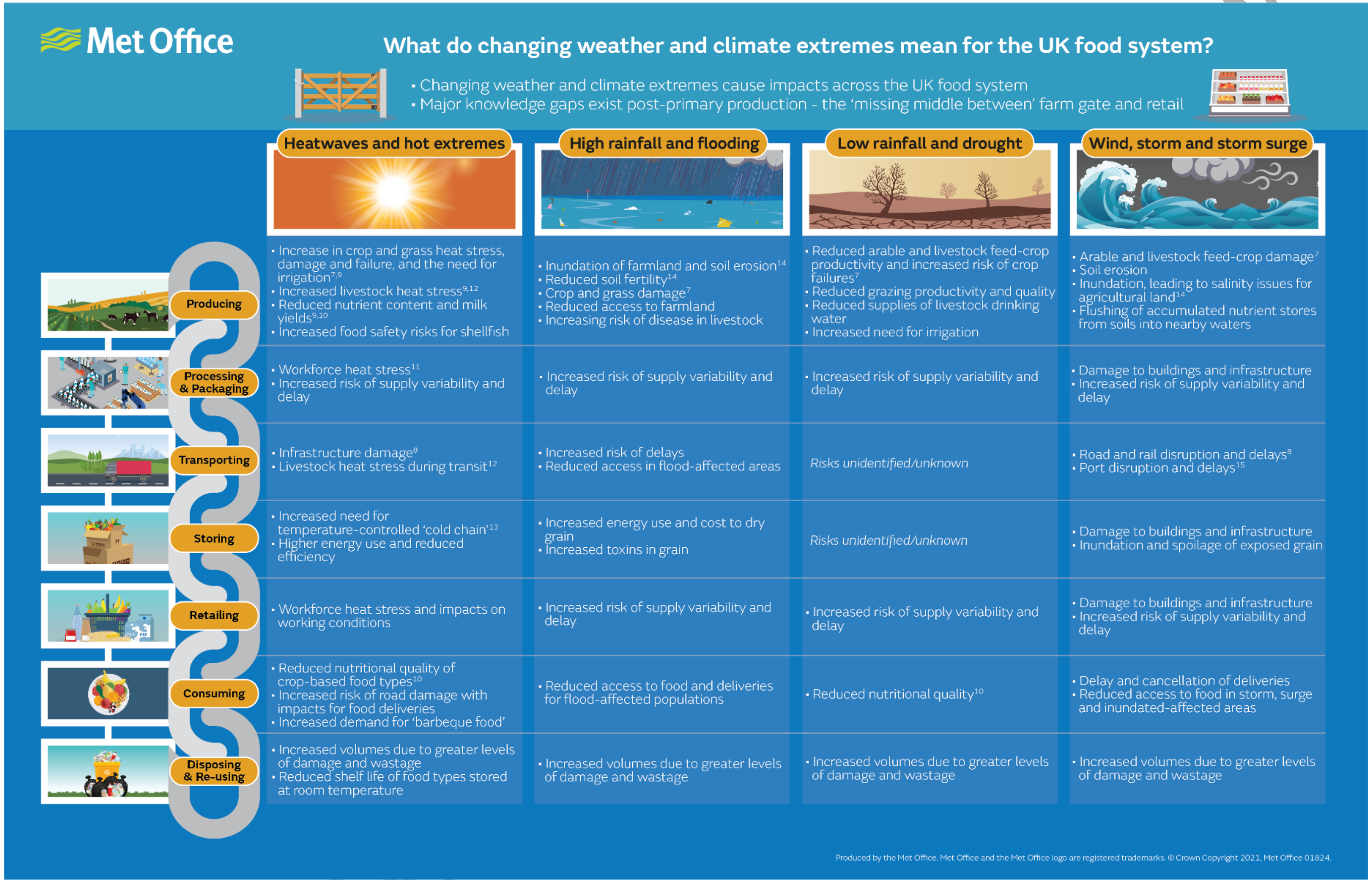

Figure N10.2. Key risks to UK food system activities from climate change and weather extremes (from Falloon et al 2022).

Climate change exacerbates other pressures on the UK food system: The combination of rising energy prices (which increased the cost of food production), manufacturing, and transport, and climate shocks (Lloyd et al., 2022) has resulted in major food price rises and these are forecast to continue, impacting less affluent consumers the most. Recent global events have exposed the vulnerability of the UK to price shocks, such as the Ukraine war (Lawrence, 2022) and COVID-19 (Rivington et al., 2021). The UK food system will continue to be vulnerable to both domestic and international climate risks while it sources ingredients and inputs from overseas. Climate, specifically extreme weather events in the UK and overseas locations which supply food to the UK, is responsible for approximately one third of UK food price increases recently (ECIU, 2023), set against a rise in national level food bills (2021-2023) of £17 billion.

Assessment of future magnitude of risk

Given the assessment of High risks for the present day, and projected increases in future risks under all scenarios as discussed below, the magnitude score for both the UK and the devolved nations is Very High. Future (2060s) food price inflation in Europe attributed only to climate change could range from 1.1-1.8% (Kotz et al. 2024). In 2024, 28.6 million UK households had an average spend on food and non-alcoholic drink of £63.5 per week (or £94.4 billion nationally); taking the lower estimate of 1% climate inflation implies an extra national food spend of just under £1 billion annually. In combination with the risks to UK (N6) and overseas production, and other unquantified but important aspects, this correlated to Very High. Confidence is Medium due to the considerable unquantified elements.

There is insufficient evidence to separate the impact of climate change on England. Evidence used to assess climate impacts at UK level (Scheelbeek and Green 2023; Lang et al., 2025; Falloon et al., 2022; Davie et al., 2022) does not make a distinction between home nations. However, heat stress impacts on livestock (Arnell and Freeman, 2021; Davie et al., 2021) will be greatest in the south and southeast of England; potato blight may increase most in the west of the England, but the large potato growing areas in the east will be more exposed (Garry et al., 2021). Key future climate risks to Scottish agriculture, which is a major producer of UK seed potatoes, including increases in potato blight risk, liver fluke impacts on dairy and beef, and from flooding (N6). Wales-specific aspects climate risks, including the impacts of recent extreme events on agriculture (on livestock feed availability, crop yields and lamb mortality), and on future land quality. These have consequences for food security in Wales and across the UK where much of its produce is consumed.

<u>2030s, central warming scenario:</u>

Drier and warmer days and nights could improve domestic wheat yields (Arnell and Freeman, 2021), while warmer winters could reduce winter livestock feed costs (Wreford and Topp, 2020). Globally, the 'emergence' of climate impacts could occur earlier than previous modelling has suggested, with effects on maize yields occurring as soon as 2032 (Jägermeyr et al., 2021). There is little direct evidence on wider food supply chain impacts or outcomes on this timescale.

<u>2050s, central and high warming scenarios:</u>

The UK currently relies (UK Food Security Report 2024) on imports of wheat for 15% of flour milling supply (predominantly from Canada and Germany), entirely on imports for rice supply (mainly from India and Pakistan), and on Brazil for over half of soybean imports for animal feed. Global mean yields are projected to decrease for maize and increase for wheat and rice (Jägermeyr et al., 2021), with significant regional variations. Maize yields could decrease in North America, Asia, West Africa and Southern Europe but increase in Northern Europe. Wheat yields are projected to increase in many regions but decrease in the Southern USA, Mexico and parts of southern Asia and South America. Rice yield declines are projected over Central Asia and declines in South Asia, northeastern China, West Africa and South America. Soybean yield changes are more uncertain across model projections, with potential increases over higher latitudes, China, Eurasia and parts of South America and southern Africa and decreases for the USA, parts of Brazil and Southeast Asia. The impact of these regional production patterns on UK food security is unclear.

The Health Effects of Climate Change (HECC) report (2023) predicted a reduction in the domestic supply of animal-based products and a concomitant increase in cereal production by 2050. Despite increasing projected demand from consumers, UK production of other plant-based foods is projected to decline (Figure N10.3).

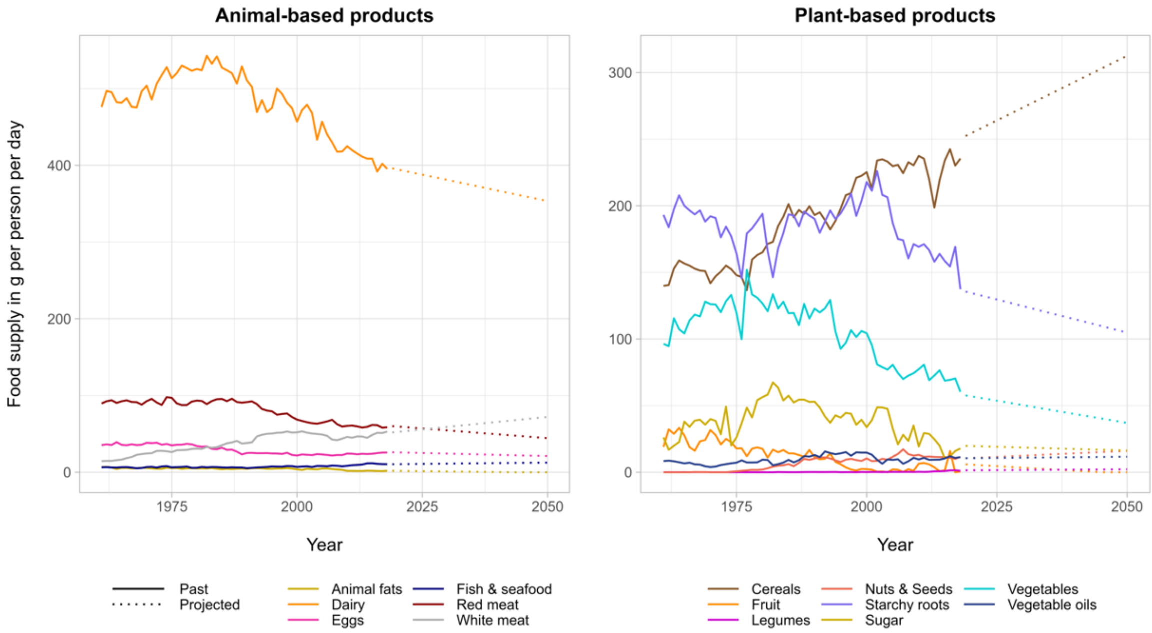

Figure N10.3. Past and projected domestic supply of animal-based and plant-based foods in the UK. Reproduced from the HECC report (2023).

The food categories produced in the UK do not align well with the Eatwell Guide, so if there is a major shift towards healthier diets, the UK will be even more reliant on imports (Scheelbeek et al., 2020). Total fruit and vegetable supply will need to double for UK citizens to meet Eatwell Guide recommendations (HECC report, 2023). By 2050, supply of fruit, vegetables and legumes falls short of what would be needed to meet UK dietary recommendations, but this is greatest for vegetables with a projected shortfall of 2.2 million tonnes due to reduced yields. If climate change reduces the availability of fruit and vegetables, for example through increasing climate extremes during critical production periods (Cottrell et al., 2024) this could result in increased consumption of foods high in saturated fat, sugar and salt, further worsening diets and associated ill-health (Scheelbeek et al., 2020) (H5).

Fish is a key part of a healthy diet, yet presently under-consumed in the UK compared to the Eatwell Guide recommendations. Most fish consumed in the UK is imported and most fish landed on UK shores is exported. In 2022 the UK imported over 1 million tonnes of seafood with the top five countries we import from being – by volume – China, Norway, Iceland, Netherland, and Vietnam (seafish.org). The imports from China and Vietnam will be impacted by climate change as tropical and subtropical fish move to cooler waters. Catch in Asian countries is projected to decrease by 20-30% under a high emission scenario, and 10-20% under a low emission scenario; countries in cooler waters like Norway or Iceland could experience catch reductions around 10% (Blanchard and Novaglio, 2024), despite the potential from warmer water species migrating into these countries. As with the changes in regional crop production patterns, the impacts of these changes in catch on UK food security remains unclear.

Gage et al. (2024) estimated that 37% (or 2.4Mt) of fruit and vegetable produce is lost between production and sale. A combination of climate change impacts, regulatory restrictions on pesticide use, and increased pressure to reduce energy inputs during pre- and post-harvest handling is likely to increase these losses in the short-term.

Level of preparedness for risk

Ensuring resilience to climate change and avoiding food insecurity requires both preventative and reactive strategies that help the food system resist, absorb or recover from stresses or shocks. These measures include both adaptation and re-orientation so that the UK food system continues to support UK citizens to eat an affordable, nutritious and culturally appropriate diet. Food system 'lock-ins' such as the just-in-time supply chain and long-term fixed pricing may hamper the adaptation needed to provide resilience to climate change (Dornelles, 2020).

The 2024 UK Food Security Report highlighted the vulnerability of UK food security to climate change and the need for climate resilient food production and manufacturing, which is also a core element of the emerging Food Strategy. The Joseph Rowntree Foundation (JRF)'s cost-of-living tracker estimated that 7.3 million low-income households (the bottom 40%) went without essentials and 5.7 million experienced food insecurity (Johnson-Hunter and Earwaker, 2023). Lang et al. (2025) highlighted the lack of resilience in the UK to a climate-induced food emergency.

The UK government published a food strategy for England in July 2025, which considered the whole UK food system. The strategy recognises the impacts of climate change and sets out a vision for a more environmentally sustainable, climate-resilient UK food system, but currently there is not a clear delivery plan in place. The devolved nations have also published their own strategies as described in the specific sections below.

Assessment on the evidence base and evidence gaps

Evidence for this risk is drawn from peer reviewed papers, reports and analyses commissioned by government (e.g., the National Preparedness Commission report 2025, UK Food Security Report 2021 and 2024, Health Effects of Climate Change report 2023, UK Food Security and What it means for the Farming Community report 2025, UK Food Strategy 2025). There is excellent agreement on the severity and urgency of action needed to provide food security in the face of climate change in the UK and elsewhere.

The evidence base is consistent in the message that food security is already being affected by climate change, particularly the impact of extreme weather events across the food system, giving High confidence in the scorings.

Very few publications consider the devolved nations separately, but UK food production is highly regional and the infrastructure associated with manufacturing, logistics and retail is nationally distributed. The devolved nations for the most part do not need separate consideration, since supply chains operate across the UK, and migration patterns of pests, disease, pollinator and fish populations do not respect national borders. However, each nation also has distinct agricultural production systems (N6).

The evidence base is focused on production, rather than the complexities of manufacturing multi-ingredient foods in a typical UK shopping basket. The impact of climate change on food manufacturing is likely to be under-represented. Domestic production depends on imported inputs and global trade. Further Evidence Needed means taking a systems approach, to understand the implications of climate change under a range of different pathways of UK food self-sufficiency, sourcing diversification and trade relationships and considering the multi-ingredient, multi-input nature of food consumed in the UK. Overall, the direction of change is clear, towards increased disruption of the UK food system by extreme weather events, compounded by geopolitical volatility and an underlying lack of systemic food system resilience.

8.2.10.2 England

Current and future level of risk

The southeast of England is more frequently and severely exposed to heat shocks. People living in areas of high deprivation are disproportionately affected since they cannot afford the energy costs of running fridges and freezers, which increase during hot weather.

The Foods Standards Agency (FSA) Consumer Insights Tracker[3] 2023 highlighted that 12% of consumers already demonstrate risky behaviours in food preparation and storage due to cost-of-living pressures, which will be exacerbated by extreme temperatures. Climate change is one of several compound, interacting factors that negatively impact food security. In England, 12% of the urban population lived in the most deprived areas (10% of the Index of Multiple Deprivation (IMD)). Intersectionality was also associated with increased risk of food insecurity. The Family Resources Survey (2023)[4] showed that food insecurity was highest in households where the head of the household was Black, African, Caribbean and Black British (19%), Arab (16%), Pakistani (14%) and Bangladeshi (14%) and lowest where the head of the household was White (6%) or Indian (4%). Households in these more vulnerable and intersectional groups are at greater risk of climate change as they are least able to afford the increased price of food predicted to occur under all warming scenarios (Kotz et al., 2025). Food price inflation is likely to impact culturally appropriate foods more, since they often have more bespoke or longer supply chains (e.g., Halal, certain vegetables and fruits) and frequently rely on produce imported from climate-vulnerable parts of the world, including small-island nations at risk of flooding (Mirabaev et al., 2023). England is home to the most multicultural and diverse communities in the UK, and also is point of entry for most culturally appropriate (and other) foods entering the UK. Please also read the UK section above as most of the evidence on climate impacts to food security that applies to this devolved nation.

Level of preparedness for risk

Defra published the beginning of a National Food Strategy for England, with consideration for the wider UK food system, in July 2025, that is intended to continuously evolve. Defra have received strong encouragement from advisors to ensure that incentives to maintain robust ecosystem services do not have the perverse effect of reducing UK food production. NAP3 actions (HM Government, 2023) on food committed to continue measurement, through the three-yearly UK Food Security Review, incorporating climate scenarios into trade models by 2025, and planning and communication with industry stakeholders, but no new committed actions.

Evaluation of urgency score

Based on the available evidence, the urgency is assessed as More Action Needed at present due to the High magnitude of climate risks to food security. By the 2050s, Critical Action is required under all warming scenarios, as risks are projected to reach Very High magnitude with critical impacts on food security. For the 2080s, risks

[3] https://www.food.gov.uk/research/consumer-interests-aka-wider-consumer-interests/consumer-insights-tracker

[4] https://www.gov.uk/government/statistics/family-resources-survey-financial-year-2023-to-2024/family-resources-survey-financial-year-2023-to-2024

remain Very High but confidence is Low, so Further Investigation is needed. Confidence is Medium from the present to 2050s, reflecting good-quality but limited evidence and strong expert agreement, and confidence is Low for the 2080s, given the scarcity of evidence, particularly for individual UK nations.

Table 8.48: Urgency scores for N10 Risks to food security for England. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

England								
N10	Risks to food security.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (H)	++ (VH)	++ (VH)	++ (VH)	++ (VH)	+ (VH)	+ (VH)	+ (VH)
With adaptation	++ (H)	++ (VH)	++ (VH)	++ (VH)	++ (VH)	+ (VH)	+ (VH)	+ (VH)
Urgency scores	MAN	CAN		CAN			FI	
Overall urgency score	CAN							

8.2.10.3 Northern Ireland

Current and future level of risk

In 2022-2023, Trussell Trust Food banks in Northern Ireland distributed 29% more food parcels than in the previous year. More than double the proportion of food bank users in Northern Ireland experienced some form of physical or mental disability compared to the national average, indicating that food insecurity was disproportionately impacting these population groups (Trussell Trust, 2023). The high proportion of vulnerable citizens in Northern Ireland suggests that a similar proportion of the population will be unable to cope with the projected increase in food prices caused by global warming and extreme weather events (Kotz et al., 2024). The island nature of Northern Ireland also makes it vulnerable to climate change impacts on trade routes since it relies on imports from mainland UK and Europe for many foods essential for a healthy diet, although it is a net exporter of potatoes, barley, wheat and meat. Please also read the UK section above as most of the evidence also applies to this devolved nation.

Level of preparedness for risk

The Northern Ireland Food Strategy Framework (November 2024) out the shared long-term direction of travel for food policy. It takes a systems approach to achieving food security for all citizens with climate resilience at the core of Strategic Priority Two (building an environmentally sustainable and resilient agri-food supply chain). The proposal emphasises developing shorter supply chains with fewer links, therefore potentially increasing food security through reducing the number of vulnerable points which can be impacted by climate events. Reducing food waste is a key target since households in Northern Ireland have the highest rate of food waste in the UK according to the Waste and Resources Action Programme (WRAP). The reduction in food waste will support food security, if it enables food to be distributed more efficiently and before it reaches end-of-life and/or if it removes the pressure of 'false demand' driven by shoppers who purchase food that they never consume. Northern Ireland's Framework takes a skills-based approach, with the College of Agriculture Food and Rural Enterprise (CAFRE) using knowledge transfer and education programmes to target decarbonisation in the agrifood sector, focusing on improving productivity, environmental sustainability, resilience and supply chain integration. If successful, this will mitigate the impacts of climate change and equip the population to manage its own food security more effectively.

Evaluation of urgency score

The high proportion of vulnerable citizens in Northern Ireland indicates that many will struggle to cope with rising food prices driven by global warming and extreme weather (Kotz et al., 2024). Northern Ireland's island geography heightens its exposure to climate-related disruptions in trade, as it depends heavily on food imports from the UK and Europe, despite being a net exporter of potatoes, barley, wheat, and meat. Given that food security includes both nutrition and calorie sufficiency, this vulnerability supports an urgency rating of More Action Needed at present and Critical Action for the future. Confidence is Medium for these periods due to good-quality but limited evidence and strong expert agreement, and Low for the 2080s, reflecting Very High projected risks but fewer studies focused specifically on Northern Ireland.

Table 8.49: Urgency scores for N10 Risks to food security for Northern Ireland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Northern Ireland								
N10	Risks to food security.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (H)	++ (VH)	++ (VH)	++ (VH)	++ (VH)	+ (VH)	+ (VH)	+ (VH)
With adaptation	++ (H)	++ (VH)	++ (VH)	++ (VH)	++ (VH)	+ (VH)	+ (VH)	+ (VH)
Urgency scores	MAN	CAN		CAN			FI	
Overall urgency score	CAN							

8.2.10.4 Scotland

Current and future level of risk

Food security (from climate change and other causes) is getting worse in Scotland (Deakin et al., 2023) with 14% reporting worries about running out of food. This is the highest level recorded since the survey began in 2017 and is particularly prevalent among younger adults and those in the most deprived areas, where populations will be least likely to cope with food price inflation caused by climate change (Kotz et al., 2024). Scotland has high food self-sufficiency in cereals, potatoes, lamb, beef, dairy, and eggs, but not in foods essential for a healthy diet, such as vegetables and fruit. It is therefore vulnerable to both production and supply chain impacts of climate change through extreme weather events. Please also read the UK section above as most of the evidence also applies to this devolved nation.

Level of preparedness for risk

Scotland published its first National Good Food Nation Plan in January 2024. This established the Scottish Food Commission – a new public body which would be accountable for the Plan. It made domestic commitments to reduce per capita food waste by 33% by 2025; double the amount of organically farmed land by end of 2026; and international commitments to address biodiversity loss, in line with the Global Biodiversity Framework of the UN Convention on Biodiversity. The inclusion of biodiversity highlights the links between protecting nature and food security, with key Scottish-grown crops such as raspberries, strawberries and orchard fruits, and emerging legume forage crops such as clover and lucerne, being pollinator-dependent (Cole, 2025). Scottish government published Vision for Agriculture in March 2022, which outlines the intention to make Scotland a global leader in sustainable and regenerative agriculture. To enable the delivery of the Vision for Agriculture, the Agriculture and Rural Communities Bill was introduced (2023) to enable delivery of the vision and became an Act in July 2024. This provides Scotland with a future framework that will support farmers and crofters to meet more of the country's food needs sustainably, work with nature and assist in efforts to meet climate change targets. This will alleviate rural food insecurity and enable some reduction of the risks to Agriculture (N6), in turn supporting reduction of this risk.

Evaluation of urgency score

Scotland is largely self-sufficient in cereals, potatoes, lamb, beef, dairy, and eggs, but depends heavily on imports of fruit and vegetables, making it vulnerable to both domestic production losses and international supply chain disruptions caused by extreme weather and climate change. This vulnerability, along with population exposure to food price inflation, supports an urgency rating of More Action Needed at present and Critical Action for the 2030s and 2050s, reflecting the Very High magnitude of climate-related risks to food security. These scores are assigned with Medium confidence, based on good-quality but limited evidence and strong expert consensus. Further Investigation is required for the 2080s, when risks remain Very High but confidence is Low due to the scarcity of long-term, nation-specific studies on food security impacts.

Table 8.50: Urgency scores for N10 Risks to food security for Scotland. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Scotland								
N10	Risks to food security.							
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High

No adaptation	++ (H)	++ (VH)	++ (VH)	++ (VH)	++ (VH)	+ (VH)	+ (VH)	+ (VH)
With adaptation	++ (H)	++ (VH)	++ (VH)	++ (VH)	++ (VH)	+ (VH)	+ (VH)	+ (VH)
Urgency scores	MAN	CAN		CAN			FI	
Overall urgency score	CAN							

8.2.10.5 Wales

Current and future level risk

Extreme weather events are already impacting on Welsh food production and economic productivity associated with the agrifood sector. Around 20% of adults in Wales (or their households) experienced food insecurity in the 12 months to mid-2022, equating to an estimated 753,000 people (IPSOS and Trussell Trust, 2023). This means that one fifth of the population is likely to be unable to cope with increased food price inflation caused by global warming and increased frequency of extreme weather events (Kotz et al., 2023). Only 0.1% of farmed land in Wales is used for fruit and vegetable production and the country is estimated to be under 60% self-sufficient in food, down from about 75% three decades ago. Imported food is therefore essential for a healthy diet in the current Welsh food system, making the country vulnerable to climate change impacts on supply chains as well as in production systems supplying food to its citizens. Please also read the UK section above as most of the evidence also applies to this devolved nation.

Level of preparedness for risk

Wales Community Food Strategy (CFS: 2024) encourages the production and supply of locally-sourced food in Wales. The aim is to develop resilience and build climate change mitigation into the food system, and to reduce the environmental footprint of the food system. Welsh-produced food can help reduce the UK's overall dependence on imports since much of the produce from Wales is distributed throughout the country and beyond.

Evaluation of urgency score

Wales, as all the other nations, is vulnerable to climate-related food insecurity due to its low food self-sufficiency, dependence on imports, and the current high proportion of food-insecure households, all of which make it especially exposed to extreme weather and rising global food prices. The urgency is scored as More Action Needed at present, reflecting the High magnitude of current risks, and Critical Action for the 2030s and 2050s under all warming scenarios, due to the Very High magnitude of risk. Confidence is Medium for these periods, based on good-quality but limited evidence and strong expert agreement. Further Investigation is needed for the 2080s, when risks remain Very High but confidence is Low due to limited long-term, nation-specific evidence on food security.

Table 8.51: Urgency scores for N10 Risks to food security for Wales. Key to the magnitude scores: very light purple (L) = Low, light purple (M) = Medium, purple (H) = High, dark purple (VH) = Very High. Key to the confidence scores: + = Low, ++ = Medium, +++ High. Where urgency scores are represented by: CAN = Critical Action Needed, CI = Critical Investigation, MAN = More Action Needed, FI = Further Investigation, SCA = Sustain Current Action, WB = Watching Brief. Details of how the urgency scores are calculated is provided in the Methods Chapter. Where insufficient evidence is available to provide urgency scores at an individual country level, a single score is provided at the UK level in a merged box.

Wales								
N10 Risks to food security.								
	Present	2030		2050		2080		
		Central	High	Central	High	Low	Central	High
No adaptation	++ (H)	++ (VH)	++ (VH)	++ (VH)	++ (VH)	+ (VH)	+ (VH)	+ (VH)
With adaptation	++ (H)	++ (VH)	++ (VH)	++ (VH)	++ (VH)	+ (VH)	+ (VH)	+ (VH)
Urgency scores	MAN	CAN		CAN			FI	
Overall urgency score	CAN							

8.3 International Risks

World events over the past four years highlight the need for systems-wide risk assessment and adaptation. Food shortages have occurred in the UK with increased frequency and, whilst UK emissions have fallen, the global trend is still rising (https://www.iea.org/reports/global-energy-review-2025/co2-emissions). Food system shocks (e.g., geopolitical conflict or disease pandemics) affect food production, trade routes, energy supplies and prices, IT and communications, economies and wellbeing. The international dimensions of UK climate risks therefore need to consider interactions across geographical borders, other sectors of industry and society, and transmission pathways.

The present Government came into power in July 2024 and are still forming their approaches to climate action and food security. Food system disruptions could be in imported food supplies, agricultural inputs or packaging, and arise directly from climate impacts on production processes or indirectly from transport infrastructure interruptions. Markets will be subject to both short- and long-term shocks, depending on the acute or chronic nature of disruptions (e.g. extreme weather or gradual warming). Changing weather patterns over the next 15 years could create significant structural change in the UK food system through changing trade, prices and adaptation within the UK agricultural sector (Redman and Benton, 2025).

Exit from the EU changed the trading landscape for the UK. Climate hazards in countries that supply the UK with food are compounded by rising costs of production inputs, labour, energy required for production, manufacturing, controlled temperature storage and logistical transport. These compound effects inflate food and drink prices; as of the first quarter of 2025, food and drink prices have risen by 39.2% when compared with 2015 in the UK (Clark, 2025). Low-income households are most at risk of obesity, malnutrition, and associated diet-related diseases. The overall costs of poor diets exceed £268 billion in the UK, far greater than the entire NHS annual budget (Jackson, 2024). Therefore, strategies to tackle inequality in physical and economic access to healthy, sustainable diets will need to consider the impacts of climate change on the nutritional quality, availability and sustainability of food to all population groups in the UK. People living in areas of deprivation are already contending with complex interacting challenges around health, transport, housing quality, infrastructure and food in their daily lives; all of which are vulnerable to climate change and will therefore be felt most acutely by these populations.

If food production in the UK and in equivalent products overseas are simultaneously impacted by extreme weather events, the lack of resilience in the 'just-in-time' supply chain will be exposed and potentially affect meeting UK population demand for food. Lang et al. (2025) argued for transition to a 'just-in-case' food system to increased UK preparedness and resilience to climate hazards, particularly in the context of the challenges from interactions between climate and other types of risks. However, trade-offs of a 'just-in-case' food system could include greater needs for local storage and distribution routes increasing costs and food prices, and greater local exposure to climate hazards (e.g., if the region was to experience continued extreme events).

Although international risks to food security will decrease if the proportion of UK-produced food consumed in the UK is increased, this could create vulnerability through cascading risks. For example, through combinations of increased energy demand (for controlled temperature production, food manufacturing, transport and storage); spikes in consumer demand (due to extreme weather events); and production shocks from climate extremes. Increasing domestic food production would likely increase agricultural intensification, in contrast with trends towards more regenerative, diverse and low emission agriculture, designed to create resilience to climate change and move the UK towards Net Zero.

The trend towards plant-based diets in high income countries is counterbalanced by a steep increase in meat consumption globally, itself driven by changing dietary patterns of countries with expanding economies and populations. Global meat production has risen from 315 – 363 million tonnes from 2013 – 2023, with Asia emerging as the predominant region in terms of meat production (Ritchie et al., 2023). There is a lack of evidence on how dietary changes interact with climate resilience.

There is robust evidence with high confidence that global food production will decrease with increasing global mean temperature (Challinor et al., 2014). Recent economic analysis modelled production of major crops in response to climate change, considering projected adaptation and behaviour change (Hultgren et al., 2025). Adaptation and income growth could alleviate 23% of projected global losses in 2050, and 34% at the end of the century. This is set against projected production losses of 6% and 12%, respectively (moderate-emissions scenario), but substantial residual losses remain for all staples except rice. Areas where agricultural production is currently concentrated are wealthy, but poorly adapted, meaning that most of global calorie production is at risk – in turn increasing the risk of food insecurity in developed countries. Somewhat counter-intuitively, poorer regions, where yields are already low, are more likely to adopt climate adaptation measures, and consequently their yields could be preserved. Locally, climate change is still likely to have severe effects in the poorest regions, but the impact on global food security will be less dramatic as relatively few calories depend on these areas.

8.4 Connections between risks

Ecosystems are interconnected across terrestrial, freshwater, marine, coastal, and soil systems, and these links are crucial for both biodiversity and human wellbeing. The functioning of one ecosystem often depends on another, forming a complex web that supports essential services such as climate regulation, carbon storage, soil fertility, and clean water. Ecosystem services sustain key sectors including agriculture, forestry, fisheries, and aquaculture, which in turn depend on healthy natural systems for productivity and resilience. As climate change intensifies, risks to one ecosystem interact across others, amplifying threats to food security, water quality, and carbon sequestration. The following examples illustrate these interconnections:

- Declines in pollinators linked to climate change (N1) increase risks of crop failure and threaten the horticultural industry, with implications for food security (N6) (IPBES, 2022).
- Trees (N1, N8) play a critical role in cooling freshwater systems (N2); forest loss from climate change in riparian zones increases risks to aquatic species.
- Soil erosion during storms (N4) increases sediment and pollutant loads in rivers (N2) while degrading soil quality and reducing agricultural resilience (N6).
- Flooding and storm-driven agricultural runoff carry nutrients and pesticides into water bodies, harming water quality and biodiversity (N2, N1).
- Coastal habitats (N1) regulate carbon and nutrient transfer between land and sea, but the impacts of climate-driven increases in terrestrial carbon input to marine systems (N3) remain uncertain (Burden et al., 2020).
- Marine systems (N3) are impacted by climate change in way that directly link to fisheries and aquaculture (N7). But also with impacts on food security (N10), economy as jobs in the fishing industry, and anything related to the blue economy, are at risks (E7, E8), infrastructure (marine artificial structures like wind farms) from the changes in storms (BE6, BE7) and health through access to healthy diet and the mental health benefits from blue spaces (H5, H7). Climate mitigation measures (e.g., tree planting or bioenergy crops) can inadvertently heighten emissions and reduce carbon stores if poorly located, for example when planted on peat or organic soils (Friggens et al., 2020; Lloyd et al., 2024; Evans et al., 2024).

Climate change creates cascading risks that link nature, land, and food systems with infrastructure, the economy, and human health. Terrestrial and coastal ecosystems (N1), freshwater (N2), marine (N3), and soil systems (N4) are directly affected by water pollution driven by extreme weather events (I9 and I10), which also influence agriculture, fisheries, and aquaculture (N6 and N7). Loss of productivity across these sectors translates into economic risks (E3 and E7), as declining yields and ecosystem degradation undermine livelihoods and food supply chains. Climate-driven increases in pests and pathogens across crops, livestock, and aquatic species (N7), as well as in freshwater (N2) and coastal habitats (N1), also have the potential to affect domestic supply chains (E3) and elevate health risks from climate-sensitive infectious diseases (H4). In addition, eutrophication and algal blooms in UK lakes and rivers linked to warming exacerbate risks to people from extreme weather (H2) and waterborne illness. Healthy ecosystems (N1, N3) play a vital role in regulating climate; their loss and degradation as a result of climate change, can reduce natural cooling, increasing exposure to heat and storms, interacting with risks to people from heat (H1) and extreme events (H3).

Interconnected risks to food security are particularly relevant in the UK due to the complex hazards and interconnecting risks, both domestically and in overseas production regions (H5, E3, E1, E7):

- Increased pests and diseases providing challenges to crops, livestock, and aquatic populations resulting from climate change. These could include changes in the population and distribution of fungal, bacterial, viral or insect pests and diseases and their biological vectors (e.g., some insects are vectors which transport bacterial diseases onto crops) which already exist in the UK. Pests and disease impacts could be exacerbated by climatic hazards (e.g., crops weakened by drought or heat stress would be more susceptible to pest and disease threats). Overall, this would reduce the yield and quality of crops, livestock and edible fish.

- Climate change will lead to compound hazards, increased exposure times and therefore increase vulnerability of people, crops and animals. For example, high temperature increasing crop stress and increasing post-farm gate waste; high humidity and heat in combination cause livestock heat stress. In both cases production volumes and quality will be compromised.

- Food systems rely fundamentally on healthy ecosystems for pollination, soil fertility, water regulation, and pest control. Climate change and land use change from agriculture and development is degrading these natural systems at home and overseas, increasing the risk of crop failures, lower yields, and food quality losses. In the absence of nature-based resilience measures, this will negatively impact food security.

- Differences in climate impacts on the lifecycle timing of crops and their pollinators so that there is a mismatch between crop flowering and insect pollinator abundance. There is evidence that this has already occurred in the UK (Büntgen et al., 2022) and yields of pollinator-dependent food and feed crops such as beans, oilseeds and most fruits will be most affected.

- A similar spatio-temporal mismatch is likely to occur between species targeted by fishery and aquaculture (specifically shellfish) activity and their food source.

- Changes in primary production (e.g., which crops are grown, the duration over which animals can graze land) will interact with the natural environment and alter wild species' food webs. Ecological niches will disappear and invasive new species may displace others important for biodiversity or food production.

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