# Resilient supply chains

## October 2022

Climate Change Committee

# Contents

# Executive summary

Access to food, goods and services is essential to the functioning of the UK's economy and to people's wellbeing. These are provided through a complex set of trading relationships within the UK and with the rest of the world. Climate change, both in the UK and abroad, can stress these supply chains causing price rises, disruptions, delays and even failures in the supply of goods and services. There is a need for greater resilience to reduce the frequency and severity of these impacts. This briefing summarises the evidence on climate-related risks to UK supply chains and the adaptation actions which can build resilience and maintain functioning supply chains. The key conclusions are:

- **Risks are rising for domestic and international supply chains.** Exposure to climate hazards is set to increase in the UK and internationally. Some supply chains may be at higher risk due to more vulnerable logistics or production processes. By investing in adaptation and resilience, the UK could gain a comparative advantage and be a more attractive destination for businesses to locate parts of their supply chains.

- **Risks are increasingly complex.** There is the potential for cascading and interacting risks, including between the Net Zero transition, nature recovery and climate impacts. Covid-19 and the Russian invasion of Ukraine, in combination with other sources of supply chain disruption, have highlighted these kinds of risks and the potentially significant impacts. Efforts to increase resilience after these impacts need to incorporate future climate risks alongside other changes, such as the Net Zero transition, increased digitalisation and changing trading patterns.

- **There are hotspots for both direct and indirect risks.** Climate risks will directly impact some regions and countries more than others. Some UK supply chains are geographically concentrated, increasing exposure. Supply chain risks arise not just through direct trade links but indirectly through energy and commodity markets and changes in the price of key inputs. Disruption of global trade can therefore have knock-on effects in the UK, even if not directly part of UK supply chains.

- **Businesses can take a range of actions to manage risks.** Businesses can take a range of actions to adapt their supply chains to climate change, building on a range of strategies, including business continuity planning and diversification. They can also create inventory buffers and monitor where and when risks may materialise. For climate risks, key actions involve understanding and diversifying the geographic location of suppliers, thus decreasing the impact of any single region's risks.

- **Clear frameworks are needed from Government to support businesses to build climate resilience.** Government has key roles in planning, monitoring and international cooperation to reduce the risk of weather-related disruptions and intervening to minimise impacts when disruptions do occur.

This briefing is set out in two sections:

1. Climate and weather risks to supply chains

2. Making climate resilient supply chains

# 1. Climate and weather risks to supply chains

The three UK Climate Change Risk Assessments (CCRA1, CCRA2 and CCRA3) since 2012 have identified supply chains as a key focus area - with risks from domestic and international floods, overheating and water scarcity already negatively impacting business processes across different sectors. This briefing document builds on the evidence coming from the CCRA3 process, reflects on lessons learned from recent disruptions and considers what this implies for climate adaptation. While focusing on the role of government in enabling and supporting adaptation, the briefing also reflects on measures that corporates can take.

Future UK supply chain risks will be affected by the combination of global climate change, international development and the UK's changing trading patterns (Box 1). This section summarises the combined effect these changes might have on the risks of weather-related disruptions to UK supply chains and the extent of resulting impacts on society. It is structured in three sections:

(a) Current risks to UK supply chains from weather-related disruption

(b) Changing risks of weather-related disruption due to climate change

(c) Learning from supply chain disruptions in recent years

Supply chains refer to the raw materials, organisations, people, information and resources to produce or provide a product or service.

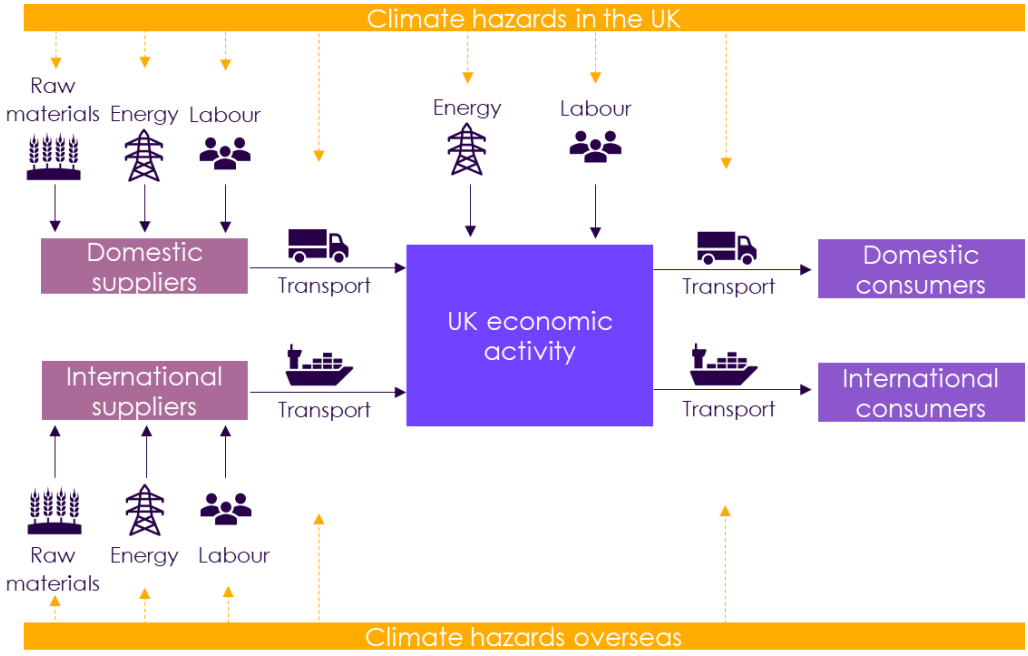
**Box 1**
Defining supply chains and supply chain risk

For the purposes of this briefing, UK supply chains refer to the raw materials, organisations, people, information and resources (both in the UK and internationally) which are required to produce or provide a product or service to a consumer in the UK.

Climate risks to supply chains can arise at different points along the chain:

- Disruption or failure of infrastructure services such as transport, energy and digital due to extreme weather.
- Direct impacts on business output (e.g. labour or agricultural productivity) and business locations (e.g. flooding).
- Impacts felt through markets – such as price increases for components or raw materials due to climate-induced changes in their demand or supply.

This briefing includes evidence across all types of supply chains but has a particular focus on food due to its sensitivity to climate impacts. It focuses on the perspective of businesses. It does not discuss in detail specific risks or their adaptation actions, outside of their direct relation to the supply of products or services. For example, this briefing covers disruptions to energy supply which may impact businesses and supply chains, but it does not discuss the resilience of the energy system more widely, which is covered separately in a forthcoming CCC briefing note.




Notes: Relevant risks within the UK's Third Climate Change Risk Assessment include: B1 Risks to businesses from flooding; B2 Risks to businesses and infrastructure from coastal change; B3 Risks to businesses from water scarcity; B5 Risks to business from reduced employee productivity due to infrastructure disruption and higher temperatures in working environments; B6 Risks to business from disruption to supply chains and distribution networks; ID1 Risks to UK food availability, safety, and quality from climate change overseas; ID7 Risks from climate change on international trade routes; ID10 Risk multiplication from the interactions and cascades of named risks across systems and geographies.

## (a) Current risks to UK supply chains from weather-related disruption

Business self-reporting through global surveys, including responses from UK businesses, indicates that extreme weather is already a significant source of supply chain disruption. Currently there is disruption to domestic supply chains from floods, droughts, high temperatures and other extreme weather in the UK (Box 2).

- 67% of respondents to the Business Continuity Institute's most recent climate risk and extreme weather survey reported that they had witnessed an increase in the number of extreme weather events.[1] 42% of all respondents identified that extreme weather events had resulted in supply chain disruptions.

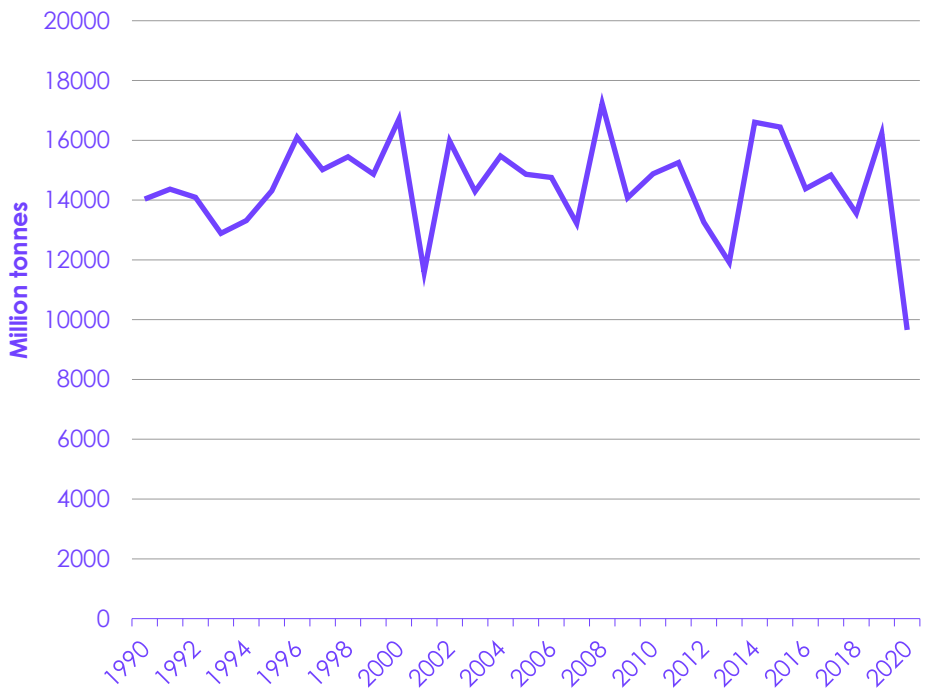
Extreme weather events are already resulting in delays, higher costs and even supplier liquidation.

- Respondents reported that climate risks and extreme weather affected supply chains in a range of ways. 50% of respondents had been unable to acquire critical products, or suffered delays in acquisition, as transportation routes had been disrupted, and 22% because a supplier's manufacturing operations had been destroyed. 33% had to stockpile more, 32% had or pay more to source goods and 9% experienced supplier liquidation, where extreme weather had destroyed a business.

**Box 2**
UK Wheat yields in 2020

Wheat yields in 2020 (9.7million tonnes) were the lowest since 1981, with the value of wheat output falling by £526m or 25% compared to the average for 2016 to 2019. This was due to unusually poor weather conditions at critical points of crop production: very wet weather for preparing the soil and sowing, too dry in the spring when the crops should have established, and bad weather for harvesting. Provisional yields for 2021(14 million tonnes) indicate a return to the 2016 to 2019 average due to better weather conditions across the year.

Figure B2 Volume of harvested wheat production in the UK




Source: Defra (2021) *Agriculture in the United Kingdom.*

Source: Defra (2021) *UK Food Security Report.*

The UK economy is vulnerable to disruption of both domestic and international supply chains.

In addition to domestic supply chains, the UK economy currently depends on a large number of complex and diffuse international supply chains.

- The UK's international trade has been growing over time (when measured relative to GDP) due to globalisation, rising from 43% in 1970 to 63% in 2019.[2]

- At an economy-wide level, international supply chains to meet UK consumption create economic value that flows mostly to industry sectors in the EU, followed by USA and China. Most of this is accrued to service-related industries and is connected to the supply chains for service-related products consumed in the UK, such as food and beverage, and financial services activities (Figure 1).

Concentration of supply chains in particular countries or regions creates greater vulnerability to climate and weather hazards.

- A range of supply chain products and services are geographically concentrated. For example;

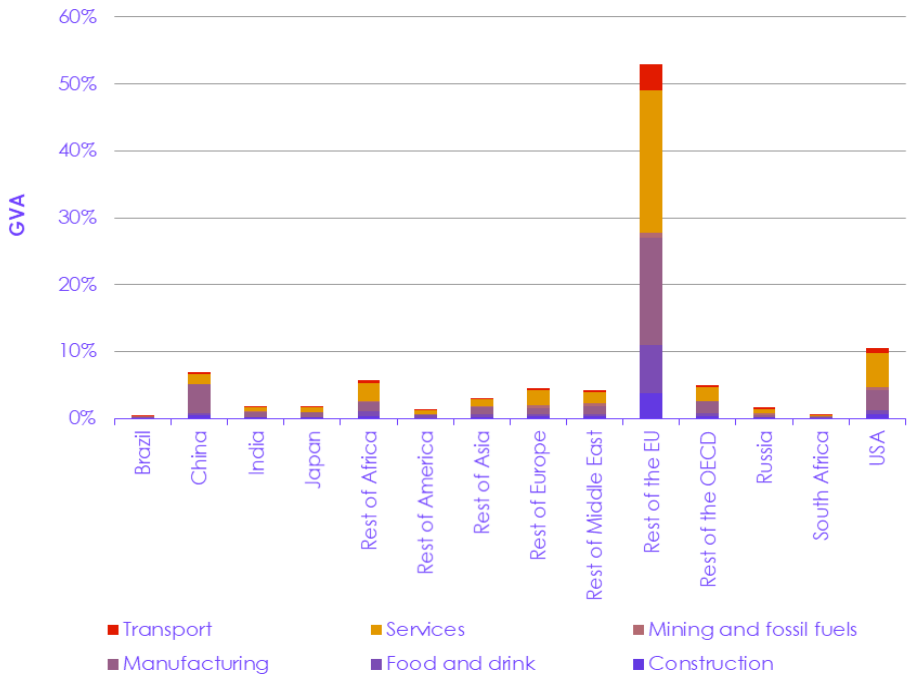
  – critical minerals[3] and semiconductor supply chains are concentrated in East Asia;[4]

  – citrus fruits and lettuce are almost exclusively imported from South Africa and parts of the EU at certain times of the year;[5] and

  – tea and coffee are primarily produced in Asia and South America, though countries such as Kenya and Sri Lanka act as key exporters in the case of tea.[6,7]

These strong connections to the global economy expose the UK to climate and weather hazards around the world as well as domestic ones (Box 3). Transportation systems are key to the effective functioning of this global trade-network – with instances where low-water levels have disrupted global trade already apparent (Box 4).

## Figure 1 UK trade footprint in 2019




Source: CCC Analysis using University of Leeds multi-regional input-output trade data.
Notes: This analysis uses trade data and an international input-output model to estimate the value generated (gross value added - GVA) around the world for categories of goods and services consumed in the UK. Data on the y-axis is normalised to the total trade footprint accruing outside of the UK.

Flooding in Thailand caused extensive disruption for the automotive and high-tech sectors.

**Box 3**
Impacts from 2011 Thailand floods

An example of a climate-related supply chain shock is the flooding that affected Thailand extensively in 2011, impacting the supply of components – particularly for the automotive and high-tech industries – which led to global disruption in these sectors. The flooding was reported to cost the Lloyd's of London insurance market $2.2 billion. Japanese car makers were particularly hard hit by the inundation of Thai factories and related disruptions to their operations. Toyota and Honda lost operating profit of US$1.25 billion and US$1.4 billion respectively, equivalent to 37% and 55% of their operating profit. The floods also affected Thailand's role as the world's second largest producer of hard disk drives, accounting for 43% of world production. Many of the factories that make hard disk drives were flooded, leading to worldwide shortages of hard disk drives in the short term, increasing the price of desktop drives by 80–190% and mobile drives by 80–150%, with losses for re-insurers of around $10 billion. The World Bank estimated that the total economic cost of flood damage in Thailand was US$45.7 billion, around 13% of Thailand's GDP.

Source: CCC (2021) *CCRA3 Advice Report* using information from Paul Watkiss Associates (2021) *Monetary Valuation of Risks and Opportunities in CCRA3*.

Low water levels around the world reduced agriculture production, disrupted cargo transport and created risks of power blackouts for millions of people.

**Box 4**
Disruptions in 2022 from low water levels

Record low river levels in Europe, China and the US in the summer of 2022 have caused factories and agriculture to reduce production, cargo ships to carry smaller loads and the risks of power blackouts for millions of people.

- In Europe, unusually hot and dry weather pushed down the level of the Rhine, a major transportation channel that is critical for industry throughout Germany, Switzerland and the Netherlands. Cargo ships have had to reduce their loads, which has led to higher transport costs and supply chain delays. Coal supplies are delivered along the river, leading to potential knock-on effects on energy output.
- In China, companies including Toyota and Foxconn halted factory operations due to hydropower shortages, which the province of Sichuan relies heavily on. Shipping along the nation's most important waterway was affected. There were also record low water levels in Chongqing, China's most populous municipality.
- In the US, the historic lows in water levels in the critical Colorado Basin as a result of the southwestern 'megadrought' prompted a federal demand for the states of Arizona and Nevada to cut their river water allocations by 21 and 8 per cent respectively in the year ahead, affecting the amount available for agriculture. This was to help protect major dams from structural damage and the ability to generate power.

Source: Financial Times (2022). *Climate graphic of the week: Record lows for rivers across China, US and Europe sap economies;* The Arizona Republic (2022) *Arizona loses more of its Colorado River water allocation under new drought plan.*

## (i) Food supply chains

Food supply chains are sensitive to weather extremes and climate change.

This section of the briefing focusses specifically on food supply chains. This is because of their sensitivity to weather extremes and climate change, and because their resilience is critical for ensuring people have access to healthy and affordable food.

The UK imports food from a wide range of countries and is therefore potentially exposed to weather-related disruption around the world (Figure 2).

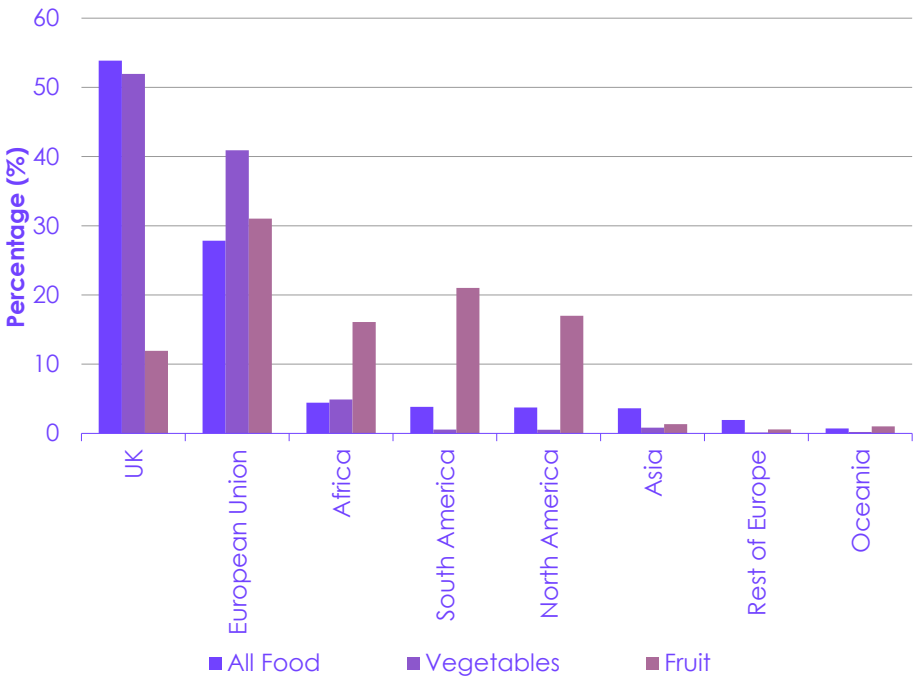
- In 2020, 54% of domestic consumption came from UK production, 28% from the EU and the remaining 18% from the rest of the world.
- 42 countries accounted for 90% of imported supply, and 27 for 80%.[8]

There are significant geographic dependencies for certain types of food like fresh fruit.

- However, there are significant geographic dependencies for certain types of food. Fresh fruit imports come from different regions to many other food types, with a much lower proportion of UK consumption produced domestically and higher reliance on imports from Africa, South America and North America. This reflects UK consumer demand for tropical and out-of-season fruit which cannot be sourced domestically or from Europe. Some countries or regions are important to the supply of particular products like bananas from the Caribbean and Central America.

Weather-related impacts on these food supply chains have the potential to widen existing societal inequalities. This is due to the high levels of exposure to food price spikes, which usually impact those on lower incomes more than those on higher incomes, and existing levels of food insecurity in the UK (Box 5).

## Figure 2 Sources of supply for food consumed in the UK, 2020




Source: Defra (2021) *UK Food Security Report.* Data originally from HMRC
Notes: Based on volume consumed/produced.

Lower income households are disproportionately affected by food price spikes.

**Box 5**
Distributional impacts of food supply chain disruption

Lower income households spend on average a higher portion of their household budget on food. This means they are disproportionately affected by food price spikes. Recent experimental research has also shown that some of the lowest priced grocery items in major supermarkets were increasing in price at a higher rate than average. For example, prices for the cheapest options of pasta, bread and rice increased above the average inflation level, impacting lower income households more than others.[9] This indicates that supermarkets passing on those costs to households will have distributional impacts. Households receiving Universal Credit are already vulnerable to increases in food prices, with 47.7% in April 2022 experiencing food insecurity, defined as having smaller meals, skipping meals or going hungry as a result of not being able to afford or access food. People with disabilities, non-white ethnic groups and households with children are disproportionately likely to experience food insecurity. There are also significant regional inequalities in food security, with Northern Ireland reporting the highest percentage of food insecurity of the nations in the UK.[10]

## (ii) Energy supply chains

Disruptions to energy supply can cascade through infrastructure systems and disrupt essential services and supply chains.

This section of the briefing focusses specifically on energy supply chains. This is because they are exposed to climate risks in many different ways, including risks to domestic energy generation and distribution, and international energy dependencies, from floods, low water availability, high temperatures and other extreme weather in the UK and abroad. Weather and climate impacts on energy supply, transmissions and distribution can rapidly cascade across infrastructure systems disrupting essential services and supply chains (Box 6).

Floods, low water availability, high temperatures and other extreme weather are already disrupting energy supply chains.

**Box 6**
Weather-related disruption of energy supply in 2021/2022

The most recent year has shown the impacts that extreme weather and climate can have on energy supply right across the world:

- Storm Arwen hit the UK in November 2021. Exceptionally strong winds impacted property, transport, and energy networks across a section of the East coast from Aberdeenshire in the north, to the Tees Estuary in the south. There were few examples of such high-wind speeds in a north to north-easterly direction in the previous 50 years. A review of the response to Storm Arwen by Scottish Government identified loss of power interacting with the loss of telecoms, loss of water supply, cancellation of train and ferry services and disruption to road travel. Such impacts significantly affected businesses' ability to operate and there are clear interdependencies with the resilience of energy and transport infrastructure.
- Electricity provider EDF was forced to reduce output at its nuclear power stations on the Rhône and Garonne due to river temperatures increasing during a heatwave in summer 2022. This was to comply with regulation following the 2003 heatwave in France, which ensures that the water used to cool plants does not affect wildlife when it is pumped back out. This came at a time when many of EDFs reactors were shut down for maintenance, resulting in its lowest output levels for 30 years. Nuclear output in France fell by 15% in the first six months of the year, while drought and unusually low river levels meant hydroelectricity production declined by 23%.
- From May to July 2022, heavy rainfall flooded Sichuan, China's hydropower hub resulting in surplus power production. A month later, the region was affected by drought, with reservoirs dried up, power generation disrupted, and factories ordered to shut down. High temperatures increased cooling demand while hydropower output was much lower due to lower levels of rainfall. Hundreds of industries including component suppliers for Toyota, Foxconn and Tesla temporarily closed. Provincial authorities restricted household electricity use. The heatwave lasted for more than 60 days, the longest since 1961.

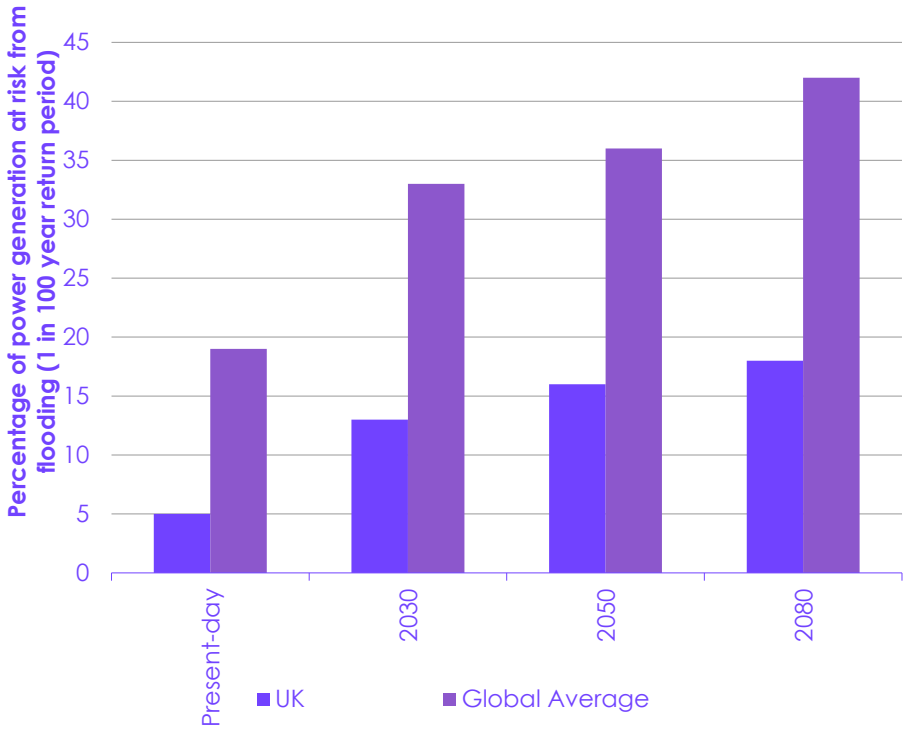
Source: Scottish Government (2022) *Storm Arwen review;* The Independent (2022) *Heatwave threatens France's nuclear energy output;* Reuters (2022) *EDF issues fourth profit warning as nuclear output drops;* S&P Global (2022) *Sichuan drought jeopardizes hydropower in China's decarbonization;* Climate Home News (2022) *Factories shut down as heatwave hits hydropower in China's Sichuan province.*

Global climate changes will increase risk to energy supply from some of these hazards both in the UK and around the world simultaneously.

The UK imports and exports energy, with net imports making up 35% of UK energy needs in 2019 - most imports are of gas and oil, with the main sources being pipelines to Norway or connection to Norwegian gas fields.[11*] Trade of electricity through interconnectors also plays a key role in balancing the UK's electricity system. This trade of energy exposes the UK to weather and climate impacts outside of the UK, including flooding, low water availability, extreme heat and storms, which can all impact the energy supply chain. Global climate changes over the coming decades will act to increase risk from some of these hazards both in the UK and around the world simultaneously (Figure 3 and Box 7).

* The UK's 2022 Energy Security Strategy details Government plans to reduce energy import dependency alongside the transition to Net Zero. However, risks from climate hazards will remain, particularly related to the electricity system.

## Figure 3 Power generation at risk of flooding




Source: Marsh McLennan Flood Risk Index (2022).
Notes: Percentages of power generation affected by flooding estimated from the World Resources Institute (WRI)'s Global Power Plant Database and 100-year return period hazard information for riverine, coastal, and rainfall flooding. The 100-year riverine and coastal inundation maps were obtained from WRI's Aqueduct Floods for present-day conditions and for years 2030, 2050, 2080 under an RCP8.5 forcing scenario. Information on extreme rainfall was derived from multiple historical data sets for present-day conditions and from CMIP5 models for years 2030, 2050, 2080 under an RCP8.5 forcing scenario. Estimates do not account for flood defences. See the Flood Risk Index Methodology document for detailed information on data sources, the calculation process and limitations.

**Box 7**
Global and Great Britain hydropower disruption risks

- Power-generation system vulnerability and adaptation to changes in climate and water resources (van Vliet, M., Wiberg, D., Leduc, S. et al., 2016)
  - Hydropower and thermoelectric power both strongly depend on water availability, and water temperature for cooling also plays a critical role for thermoelectric power generation. Climate change and resulting changes in water resources will therefore affect power generation while energy demands continue to increase with economic development and a growing world population.
  - Using data on 24,515 hydropower and 1,427 thermoelectric power plants, this research finds reductions in usable capacity for 61–74% of the hydropower plants and 81–86% of the thermoelectric power plants worldwide for 2040–2069.
  - However, adaptation options such as increased plant efficiencies, replacement of cooling system types and fuel switches are effective alternatives to reduce the assessed vulnerability to changing climate and freshwater resources.
  - Transitions in the electricity sector with a stronger focus on adaptation, in addition to mitigation, are thus highly recommended to sustain water–energy security in the coming decades.
- Drought and climate change impacts on cooling water shortages and electricity prices in Great Britain (Byers, E.A., Coxon, G., Freer, J. et al., 2020)
  - This research investigates the electricity price impacts of cooling water shortages on Britain's power supplies using a probabilistic spatial risk model of regional climate, hydrological droughts and cooling water shortages, coupled with an economic model of electricity supply, demand and prices.
  - On extreme days (99th percentile, annualized frequency of ~3 days per year), almost 50% (7GWe) of freshwater thermal capacity is unavailable.
  - Based on the baseline climate, annualized cumulative costs on electricity prices are in the range of £29m–£66m per year. However, in around 20% of model samples the costs are higher and in the range of £66m-£95m per year.
  - With climate change, the median annualized impact exceeds £100million per year.
  - The single year impacts of a 1-in-25 year drought event exceed >£200m.

Source: van Vliet, M., Wiberg, D., Leduc, S. et al. (2016) *Power-generation system vulnerability and adaptation to changes in climate and water resources*. Nature Clim Change 6, 375–380 (2016); Byers, E.A., Coxon, G., Freer, J. et al. (2020) *Drought and climate change impacts on cooling water shortages and electricity prices in Great Britain*. Nat Commun 11, 2239.

## (b) Changing risks of weather-related disruption due to climate change

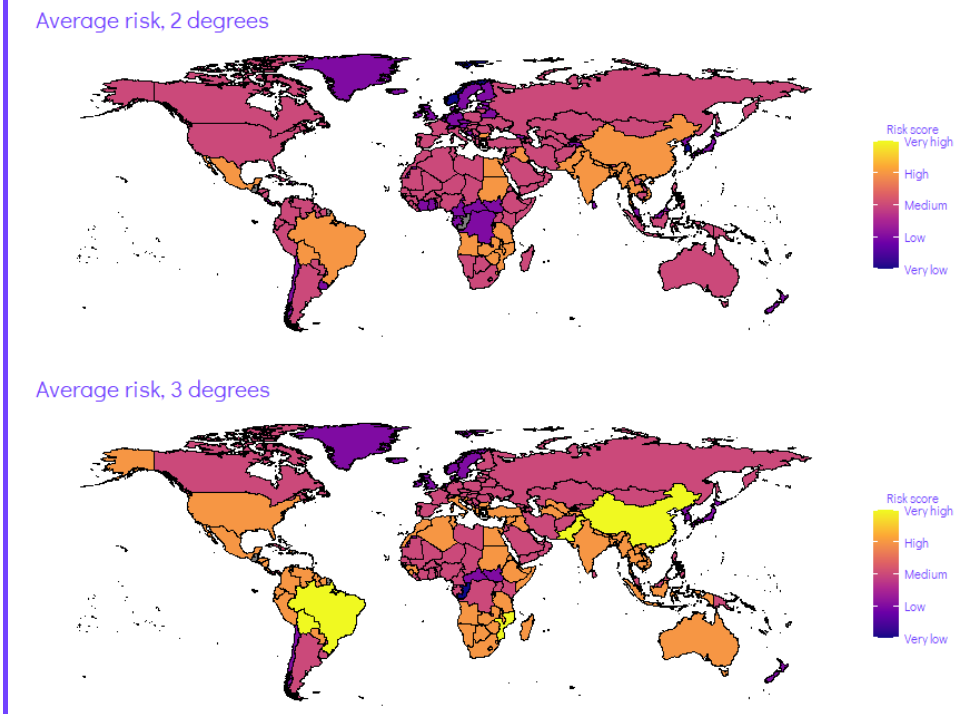
Climate change is increasing the risks of flood, drought, and heatwaves with more disruption to supply chains expected in the UK. Additional future climate change, globally and in the UK, is inevitable. Global temperature will keep rising until global $CO_2$ emissions reach Net Zero, and some aspects of the climate (such as sea-levels) will keep changing for centuries. This will increase the climate-related risks to economic activity around the world (Figure 4).*

* Within this overall picture there is significant variation between climate risks to individual supply chains given the variation in company preparedness for climate impacts within individual sectors.

Inevitable climate change means that exposure of UK supply chains to climate hazards in the UK and internationally is set to increase in the future.

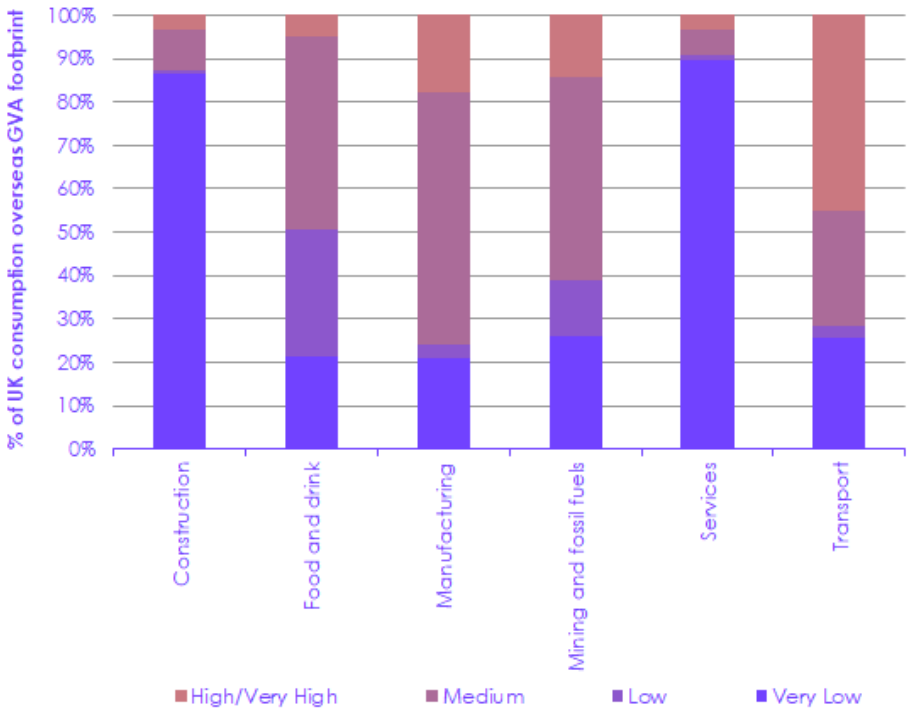
This increase in climate risk globally will create risks to UK trade. For example, an analysis of changes in relevant climate hazard indicators to economic sectors suggests 20% of the economic value in the overseas supply chains serving current UK consumption is dependent on economic production in foreign sectors and regions with 'medium' to 'very high' levels of increased risk from relevant climate hazards. Particularly large fractions at higher levels of climate risk increase for the UK's consumption of food and drink products, manufactured products, transport services and fossil fuel and mining products. Lower fractions are seen for the UK's final demand for services and construction with overseas economic dependence predominantly falling within other European countries (generally at lower future increases in climate risk compared to other parts of the world).

## Figure 4 Aggregate index of global climate risks under 2°C and 3°C global warming levels




Source: CCC Analysis using BEIS CS-NOW climate data.
Notes: An assessment of the climate vulnerability of each region or country based on quantitative analysis of the BEIS CS-NOW climate data has been made to place countries or regions into each of the risk score categories.

## Figure 5 Climate risks to UK overseas economic relationships under a 2°C scenario




Source: CCC analysis, University of Leeds, Warren, R. et al. (2022) *Literature review: climate impacts at the global, regional and country scale. Climate services for a net zero resilient world.* UK Government.
Notes: UK trade data is used consistent with the datasets used to estimate UK consumption emissions (University of Leeds) and an international input-output model to estimate the value generated (gross value added) within each country for final goods and services consumed in the UK. This GVA footprint is categorised into groupings of climate vulnerability based on classification of changes in relevant climate hazard indicators to that economic activity (averaged over counties in a trade data region) from the dataset compiled by Warren et al.

Supply chains requiring significant amounts of outdoor labour may be particularly impacted by more frequent and extreme heatwaves.

Some parts of supply chains will come under particular stress from more extreme weather. For example, supply chains which involve occupations or sectors requiring significant amounts of outdoor labour (such as agriculture and construction) may be particularly impacted by more frequent and extreme heatwaves (Box 8). In addition to higher temperatures, more frequent and severe droughts and floods in the UK and internationally are projected to cause greater disruption to supply chains.

**Box 8**
Potential impacts of higher temperatures on labour productivity in agriculture and construction

- Kjellstrom et al. (2019) found that the effects of rising average temperatures are felt differently across occupations and employment sectors. For example, jobs involving high levels of physical exertion or prolonged work outdoors are particularly affected by increasing heat levels. Agricultural and construction workers are expected to be the worst affected.
  - The agricultural sector alone accounted for 83 per cent of global working hours lost to heat stress in 1995 and is projected to account for 60 per cent of such loss in 2030. Whereas construction accounted for just 6 per cent of global working hours lost to heat stress in 1995, this share is expected to increase to 19% by 2030. Significantly, most of the working hours lost to heat stress in North America, Western Europe, Northern and Southern Europe and in the Arab States are concentrated in the construction sector.

- Vivid Economics modelled the impacts of rising temperatures on five countries; India, Ghana, Jordan, Ethiopia and Tanzania. The results suggested that labour productivity losses due to high temperatures may be substantial, even under relatively moderate climate scenarios. Effective working hours could be reduced by up to 20 per cent by 2050 (for example in India), and Gross Value Added – a measure of national economic output – may fall by up to 3.6 per cent (for example in Ghana). These aggregate numbers mask important distributional effects, as the losses are to a large extent concentrated in traditionally low income sectors such as agriculture and construction.
- Somanthan et al. (2021) found that heat stress can also lead to absenteeism as well as productivity losses. Using evidence from Indian manufacturing, the authors found that productivity drops by as much as 4 percent per degree when temperatures rise above 27°C in workplaces requiring manual labour. A 1-degree increase in the ten-day temperature average raises the probability that a worker will be absent by as much as 5 percent.

Source: Kjellstrom et al. (2019) for the International Labour Organization. *Working on a WARMER planet: The impact of heat stress on labour productivity and decent work*. Vivid Economics (2017) *Impacts of higher temperatures on labour productivity and value for money*. Somanathan, E., Somanathan, R., Sudarshan, A., and Tewari, M (2021) *The Impact of Temperature on Productivity and Labor Supply: Evidence from Indian Manufacturing*.

## (c) Learning from supply chain disruptions in recent years

Recent events have shown how reliance on single sources of supply, lack of substitute goods or strategies like 'just in time' supply chains can increase vulnerability.

In recent years there have been major demand and supply shocks to supply chains, including the Covid-19 pandemic, Brexit and the Russian invasion of Ukraine. These events, in combination with others, have highlighted the wide range of factors that can disrupt supply chains and also demonstrated that reliance on single sources of supply, lack of substitute goods or strategies like 'just in time' supply chains can increase vulnerability. These examples provide lessons for assessing and responding to future risks, including from climate change and extreme weather (Box 9).

**Box 9**
Examples of supply chain disruption in recent years

The multiple large supply chain disruption events over the last few years suggest several lessons for resilience to climate and weather-related disruption:

- **Disruption can occur from multiple sources, including extreme weather, to affect both demand and supply and resulting in larger or more persistent impacts.**
  - During the Covid-19 pandemic demand increased for consumer electronic goods and therefore for semiconductors which are a critical component. At the same time, the supply of semiconductors was hit by several unrelated shocks, including storms and power outages for manufacturing plants in Texas and drought in Taiwan. This combination of factors led to longer delivery times and increased import prices. These impacts have been persistent as it is difficult to expand the supply of semiconductors in the short-term.
- **Disruption is not just through direct trade links but indirectly through energy and commodity markets and the supply of key inputs.**
  - For the UK, disruption is less likely to come from direct trade links due to relatively small volumes of trade with Russia and Ukraine, but more from the indirect effects through price rises and volatility in commodity markets. Even though the UK has much lower reliance on Russia for its energy than other countries, UK energy prices have been affected through purchasing gas on wholesale markets. There have also been implications for agriculture supply chains as ammonia and fertilizer depend on gas. Russia and Ukraine are also major suppliers of commodities such as wheat, and of products such sunflower oil which was already affected by drought in the region.

- **The resilience of transport systems underpins supply chain resilience and many of the services that people depend on.**
  - There have been labour shortages in UK logistics due to a combination of factors and this has had knock-on effects on other industries. 96% of members of the Chemical Business Association were experiencing issues with UK haulage in September 2021, up from 63% in its previous survey in June 2021. This included critical chemicals for the water and agriculture industries. In this case the Environment Agency relaxed regulations temporarily so water companies could use a lower amount of chemicals for the treatment of wastewater. Relaxing regulations may not always be possible as a solution for human safety reasons or the risk of damage to the environment.

It is clear that strategies which can provide resilience to a broad range of risks (including weather and climate) and risk interactions is required, since some such as geopolitical risks are difficult to forecast or influence.

Source: Bank of England (2021) *International trade, global supply chains and monetary policy - speech by Silvana Tenreyro;* Institute for Government (2022) *Russia–Ukraine war: how could it affect the UK economy?;* Chemical Business Association (2021) *Driver Shortage Media Brief.*

Government has a key role in planning for and delivering emergency response when key supply chains which are critical for the functioning of society come under stress – including from weather-related impacts. The Institute for Government has highlighted some of the actions that the UK Government has taken in response to supply chain disruptions in recent years.[12] Examples include assembling joint government and industry taskforces, providing financial support and increasing the capacity of government agencies. Although not in response to just weather-related disruption, they provide some indication of the ways in which government can work with the private sector to reduce the impacts of disruption on people and the economy.

These events highlight the need to understand the potential for interactions among risks and the potential for risk cascades.

The range of recent supply chain disruptions also highlights the need to understand the potential for interactions among risks and the potential for risk cascades. Modelling for the UK's Third Climate Change Risk Assessment found that weather-related disruptions to travel and delays to freight were key in many risk cascades and associated with some of the highest risk pathways considered in the research.[13] Interruptions to power supply and disruptions to IT and communication services were also identified as having the highest number of knock-on impacts across sectors.

# 2. Making supply chains climate resilient

The previous section describes the changing weather hazards that can affect supply chains over the coming decades alongside the other sources of disruption that supply chains are exposed to.

This section summarises the opportunities to address climate risks to supply chains and the role of business and government. It is structured in two sections:

(a) The roles of business and government in making supply chains resilient

(b) Recommendations for government

## (a) The roles of business and government in making supply chains resilient

Businesses are primarily responsible for improving supply chain resilience, but government must enable, support, and build capacity.

Increasing the resilience of supply chains is about both ensuring the provision of key materials and minimizing disruptions. Businesses will be primarily responsible for delivering improved supply chain resilience, but government has a key role to enable, support and build capacity. This section first covers the role of businesses and provides examples of the actions that they can take to improve resilience. It then focuses on the role of government.

Businesses have incentives to make their supply chains resilient to climate change and will have the best available information to manage their risks. There are a range of actions and strategies that businesses can use to make their supply chains more resilient, including to the risks from climate change. Some of these actions may be within a businesses' direct control, for example flood proofing a grain silo; others may be outside of their control and will require working with their suppliers, service providers and infrastructure operators, for example to ensure that the assets and infrastructure networks that they rely on are protected against risks. Many examples of business actions can be categorised into two types:[14]

Some actions are within a businesses' direct control while others will require working with their suppliers, service providers and infrastructure operators.

- **Bridging:** Bridging involves a business taking action to help build up its capacity and that of its suppliers to manage through and recover from disruptions. Examples include collaborative planning and control with suppliers and infrastructure operators; providing financing to help suppliers recover or improve their resilience; and strengthening relationships through long-term contracts.

- **Buffering:** Buffering involves a business taking action to protect itself from the consequences of supplier failures. Examples include creating inventory and lead time buffers, diversifying the geographic location of suppliers, which will spread supply disruption risk across more regions, thus decreasing the impact of any single region's risks; diversifying the supply routes and transportation modes, which will spread supply disruption risk across different parts of the transport system; and decreasing supply specificity or product designs which are reliant on unique inputs, which provides more options to a company should a disruption occur.

A small number of large businesses influence a high proportion of supply chains and therefore have an important role in ensuring the health and resilience of the places their suppliers are located in. Climate change is one of several environmental and social risks related to supply chains.

It is important that businesses consider these risks together, as many actions to improve supply chain resilience are applicable across risk types, and there is an opportunity for businesses to identify actions with multiple benefits. Large businesses may have many suppliers who they are able to influence or may account for a large proportion of output and operations within a sector (Box 10).

A small number of large businesses have an important role in ensuring the health and resilience of the places their suppliers are located in.

**Box 10**
Examples of responses to environmental impacts of supply chains by large companies

**Value Chain Risk to Resilience**

- BSR, a sustainable business network, launched a corporate initiative with multinational corporations including the Coca-Cola Company and Mars Incorporated.
- The initiative aims to build climate resilience for communities, farmers and workers along value chains by:
  - Assessing physical climate risks and integrating them into business processes.
  - Developing standard approaches, methodologies and metrics for business action on resilience.
  - Promoting collaboration among businesses and implementation of climate resilience measures.

**The Courtauld Commitment 2030**

- The Courtauld Commitment is a series of voluntary agreements to reduce the carbon and wider environmental impact of the UK food and drink sector. A large variety of organisations are signatories including major supermarkets and chain restaurants.
- One of the overall targets of the initiative is to ensure that 50% of fresh food is sourced from areas with sustainable water management by 2030.
- As well as businesses increasing water efficiency in their own operations, this aims to improve the quality and availability of water at catchment scale in the top 20 most important product and ingredient sourcing areas in the UK and overseas.

**UK Soy Manifesto**

- Protecting forests is critical to reduce greenhouse gas emissions and halt the loss of global biodiversity and to protect the rights and livelihoods of indigenous communities and forest peoples.
- The UK Soy Manifesto is a collective industry commitment to work together to make all physical shipments of soy to the UK deforestation and habitat-conversion free.
- There were an initial 27 signatories, representing nearly 60% of all UK soy bought every year and including major supermarkets and chain restaurants.
- Signatories commit to work together to achieve this goal and request that their suppliers adopt the same commitments and incorporate these requirements within commercial contractual requirements. All signatories commit to publicly disclosing on their progress annually.

**Unilever Climate Promise**

- Unilever has a goal to achieve zero emissions across its own operations by 2030, and net zero across its value chain by 2039. To do this, Unilever:
  - Launched the Unilever Climate Promise to engage its 56,000 suppliers.
  - Asked existing suppliers to adopt carbon reduction targets to cut their emissions and prioritise partnerships with new suppliers who already have science-based emissions targets in place.
  - Assessed 300 suppliers as having the most significant impact on climate and will offer guidance and tools to support this group.

Risks may not be fully managed without additional government action.

While many of the actions which improve supply chain resilience are for business, there are reasons that risks may not be fully managed without additional government action. These relate to market failure, social implications, matters of national resilience and the need for capacity building and enabling action:

- Businesses making decisions based on their own risk preferences and with limited information or resources can lead to a socially undesirable level of risk for supply chain disruptions, particularly for supply chains which are critical to the wellbeing of people and the functioning of the economy.

- Business continuity professionals report several barriers which mean that climate change risks are not yet being properly addressed in their organisations. These barriers include costs, staff time, lack of external demand to meet targets and lack of regulatory requirements or pressures.[15] Government has a role in enabling businesses and building capacity to help overcome these barriers.

- Businesses are also not able to determine the rules and regulations for international trade and financial markets, or to form overall assessments of national security, or the resilience of key infrastructure systems and sectors. These are critical for matters of national resilience and have knock-on implications on the ability of business to manage supply chain risks.

Key government actions fall under stress testing, international and trade policy, reporting, information provision and procurement.

Actions for government to make supply chains resilient fall under several key responsibilities (Table 1) and will require collaboration across multiple government departments. It is important for regulated sectors, such as utilities, that regulation is in place which creates incentives for managing risk and sharing information to inform other assessments of risk. If delivered effectively, the UK has an opportunity to gain a comparative advantage by investing in adaptation and resilience in the UK. As the risk of weather-related disruption increases, resilience to climate change risks may become an increasingly important characteristic when businesses decide where to invest and locate parts of their supply chains.

**Table 1**
Government responsibilities for making supply chains resilient

| Responsibility | Aims |
|---|---|
| **Stress testing** | Mapping supply chains at the economy-wide level to understand the places which the UK depends on for essential goods and services and their weather and climate-related risks. |
| **International and Trade policy** | Using international cooperation and overseas programmes to increase resilience and stability globally. This benefits people and businesses in the UK through more stable prices and access to goods and services. |
| **Reporting** | Requiring large businesses and key organisations such as infrastructure providers or utility companies to report on their own risks from climate change and the adaptation actions they have taken in response, including engagement with their suppliers on resilience. This ensures that investors and other suppliers have high quality information which allows them to assess their resilience and make informed business decisions. |
| **Information provision** | Monitoring weather and climate-related risks and communicating this risk information with people and businesses to aid planning. |
| **Procurement** | Ensuring public sector supply chains are resilient and influencing suppliers by having specific criteria and minimum standards for climate change adaptation supported by appropriate metrics and targets. |

## (c) Recommendations

The CCC's **Independent Assessment of UK Climate Risk** produced for the UK's Third Climate Change Risk Assessment (CCRA3) highlighted risks to the supply of food, goods and vital services due to climate-related collapse of domestic and global supply chains and distribution networks as one of the top eight risks requiring urgent action from Government.

Table 2 summarises the Committee's key recommendations for Government to help make UK supply chains resilient to future weather extremes:

**Table 2**
Recommendations

| Department | Responsibility | Recommendation |
|---|---|---|
| **DIT** | Stress Testing and ensuring resilience of critical supply chains and systems | Carry out stress testing exercises to understand the resilience of essential goods supply chains. This should include assessing the effectiveness of solutions like parallel supply chains or diversifying supplier locations based on assessments of climate risk. |
| **DfT** | Stress Testing and ensuring resilience of critical supply chains and systems | Identify key dependencies of the transport system such as providing access to medicine or clean water. It should assess how it can make resilient the transport infrastructure and services these rely on as part of its climate change adaptation strategy. |
| **Defra** | Stress Testing and ensuring resilience of critical supply chains and systems | Set out specifically how it will implement the Government's Food Strategy with regard to making UK food supply chains more resilient to extreme weather. This should include funding innovative farming approaches, improving data on current disruptions and future risks and ensuring there are minimum environmental and health standards for determining future trading relationships for food. |
| **BEIS** | Stress Testing and ensuring resilience of critical supply chains and systems | Ensure that resilience to extreme weather and climate change is part of industrial and security strategies such as the British Energy Security and Critical Minerals strategies. It should also consider ways it can support businesses and energy companies to improve their resilience through facilitating provision and sharing of information. |
| **Cabinet Office** | Stress Testing and ensuring resilience of critical supply chains and systems | Carry out a review of the impacts of recent supply chain disruption and how businesses and governments responded. It should use the findings from this review as part of building a strong resilience capability for the UK by taking an overarching view of systemic and interacting risks. This could include an early warning system for global climate shocks and enhancing the ability of the Government to make fast decisions by bringing in technical advice and expertise quickly when needed, and both protecting, and enhancing, monitoring and surveillance systems to enable faster reactions as events unfold. |
| **Defra** | Reporting | Act on the Climate Change Committee's recommendations to improve the effectiveness of the Adaptation Reporting Power (ARP). In particular, making the next ARP cycle mandatory and extending the scope to include relevant local authority functions in England, more health and social care organisations, canals, reservoirs and food supply chains. Defra should also ensure that all organisations who meet the criteria for participation are being invited to report. |
| **HMT** | Reporting | Ensure that its Sustainability Disclosure Requirements and supporting policies result in large businesses disclosing their current and future supply chain risks from extreme weather and climate change. This should include reporting the financial impacts of supply chain disruption and considering multiple climate change scenarios. |
| **FCDO** | International and Trade Policy | Increase capacity building through its overseas programmes to improve global capacity for climate resilience, including supply chains, health systems and early warning systems for climate hazards. Overseas programmes should work to reduce underlying vulnerabilities to climate risks and not just respond to disasters. |

# Endnotes

[1] Business Continuity Institute (2022). *BCI Extreme Weather & Climate Change Report 2022*.

[2] The World Bank (2022). *World Development Indicators, World Bank Open Data: Trade (% of GDP)*.

[3] Parliamentary Office for Science and Technology (2019). *Access to Critical Minerals*.

[4] Written Evidence from the Department for Digital, Culture, Media and Sport to the Business, Energy and Industrial Strategy Select Committee's Inquiry, "The Semiconductor Industry in the UK".

[5] Defra (2021). *UK Food Security Report*.

[6] FAO Intergovernmental Group on Tea (2018) *Twenty-Third Session: Current Market Situation and Medium-Term Outlook*.

[7] FAO Database. Rankings. Countries by Commodity.

[8] Defra (2021). *UK Food Security Report*.

[9] ONS (2022). *Tracking the price of the lowest-cost grocery items, UK, experimental analysis: April 2021 to April 2022*.

[10] The Food Foundation (2022). *Food Insecurity Tracker*.

[11] BEIS (2021) *UK Energy in Brief 2021*.

[12] Institute for Government (Accessed September 2022). How has the government responded to supply chain disruption?

[13] WSP et al. (2020). *Interacting risks in infrastructure and the built and natural environments: research in support of the UK's third Climate Change Risk Assessment Independent Assessment*.

[14] The Sustainability Consortium for HSBC (2020) *Improving Supply Chain Resilience to Manage Climate Change Risks*.

[15] Business Continuity Institute (2022). *BCI Extreme Weather & Climate Change Report 2022*.

**Resilient supply chains**
October 2022

Climate Change Committee
1 Victoria St
Westminster
SW1H 0ET

www.theccc.org.uk
@theCCCuk

Climate Change Committee