Indicators and trends

Monitoring climate change adaptation

climate change
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How will climate change affect impacts caused by extreme weather?	Version
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There are a wide range of impacts that arise from extreme and challenging weather in Scotland. Some of these are likely to be exacerbated by climate change, while others may be relatively unaffected. Four major impacts of extreme weather on infrastructure are given in the table below which shows the different effects of climate change on each issue. Challenges due to snow and ice are expected to reduce as the century progresses. Geo-hazards such as landslides are expected to increase. Flooding, which will also increase, is covered in a separate narrative – *Flooding, Infrastructure and Climate Change*.

Impacts from extreme and challenging weather	Climate projections and their implications
Transport links interrupted by geo-hazards including landslides and scour damage to bridges.	Winter rainfall, and periods of intense rainfall are both projected to increase, particularly in the north and west of Scotland. Landslide frequency is thus likely to increase, as rainfall is a major factor in landslide generation. Scour (of bridge supports) is caused by high river flows. Increased precipitation will lead to an increase in high river volumes and flows, and so scour of vulnerable structures is also likely to increase.
Reduced water availability due to periods of reduced rainfall	Summer rainfall in the East of Scotland is projected to decrease. Reduced summer rainfall could lead to periods of drought, or reduced water availability, especially for agriculture in some areas.
Dampness in buildings due to wind-driven rain. (When wind and rain coincide, water may penetrate vertical walls).	In the UK, most wind-driven rain is associated with winter storms and the intensity of rainfall in storm events is projected to increase. This is likely to lead to an increased risk of wind driven rain. There is some evidence that storminess may also increase. Projections for all types of winter rainfall are for an increase, but projections for wind-speed are unclear. Overall it seems likely that there will be an increase in wind-driven rain, which may cause an increase in the water penetration of vertical walls.
Damage to energy and ICT networks caused by storms, winds and lightning	As noted above, projections for wind-speed are unclear. Consequently, it is not yet certain whether wind-damage to power lines will change or not. Lightning frequency is projected to increase, and this is likely to increase impact on power and ICT lines.

Adaptation options
Adaptation actions for all four impact types fall into the following three categories:

- Reduce exposure to hazards (e.g. by providing more robust / better designed structures)
- Reduce the consequences of the hazard (e.g. by using the affected resource more prudently, by reducing other pressures, and through preparation and readiness)
- Improve recovery from the hazard impact (by investing in effective recovery procedures).

Policy levers to reduce impacts and to speed up recovery times may often work indirectly – for example through the regulations that govern the operations of utility and service providers (of water, energy, telecoms, trunk road operators). As an example, penalties for service interruption act to incentivise operators to invest in appropriate defence and recovery schemes (energy suppliers are subject to such a scheme). In this case, adaptation is achieved by third parties (utility providers) responding to regulations and incentives / penalties that favour good performance in the face of climate change.

Appropriate standards and regulations are important both for the Built Environment and for transport networks. In this sector the policy levers that can help to achieve adaptation and resilience are ***'climate-informed'*** standards and regulations. Scottish Government's Building Standards Division has already assessed several of its building regulations in relation to climate change. Examples include water efficiency requirements and resistance to wind-driven rain. Trunk road and rail track specifications are also subject to updates that reflect changing climate challenges.

Preparedness also plays a vital role in reducing impacts. Utilities, the emergency services and communities can all benefit from measures that improve preparedness and recovery mechanisms. The Scottish approach is set out in 'Ready Scotland' which supports integrated emergency management (IEM) to deal with emergencies. Scottish Government's Resilience Division and a wide range of associated delivery agencies manage the strategies, resources and actions needed to address climate impacts, as set out in the publication 'Preparing Scotland'. Examples of adaptation actions include:

Transport Scotland works with others to minimise the impact of geo-hazard interruptions to transport networks. Initiatives include the following:

- Improved design of new or replacement structures to render them more resistant (e.g. slope stabilisation to reduce landslide risk)
- Planned assessment and maintenance programmes for existing infrastructure
- Improvements in transport hazard warning systems (e.g. the service 'Traffic Scotland')
- Improving the readiness and coping capacity of business and communities for such events
- Improving response and recovery mechanisms

Scottish Water is a key player in addressing reduced water availability, and actions include:

- Promotion of water efficiency measures and behaviours in homes and businesses
- Addressing water leakage rates
- Capital investment in water infrastructure
- Improving the readiness and coping capacity of business and communities for such events
- Graded tariff structures designed to promote water efficiency (not yet in use in the UK)

Building Standards ensures that building regulations keep pace with climate change, so as to minimise the potential problems stemming from wind-driven rain. Actions in this area include:

- Updating building standards so as to accommodate increasing climate challenges such as wind-driven rain and reduced water availability in summer

- Improving ventilation, drying facilities and occupant practice within existing buildings so that other sources of dampness and condensation are reduced
- Supporting the retrofit of remediation measures for existing building stock

A range of utility providers work to ensure that the impact from damage to energy and ICT networks caused by storms, winds and lightning is kept to a minimum. Actions include:

- Upgrading infrastructure to improve resilience to climate challenges
- Providing back-up servicing for vital facilities (eg power and ICT in hospitals)
- Improving the readiness and coping capacity of business and communities for such events
- Improving response and recovery mechanisms to hasten the return to normal service

What do the indicators tell us?

The suite of indicators on challenging and extreme weather impacts cover the following:

RISKS:

Geo-hazards: Older bridges (pre-20th century) are more likely to be at risk of scour. Major modern bridges are rarely susceptible due to advances in structural design and understanding of scour. Recent figures show that under 11% of trunk road bridges have a moderate or higher susceptibility to scour. However, over 50% of rail bridges are at moderate or higher risk of scour. It is anticipated that climate change will increase scour risk for all bridges, but particularly for older bridge assets. See *Road and rail bridges vulnerable to scour BT26*

Buildings and wind-driven rain: Buildings in a good state of repair are more likely to be robust in the face of extreme weather. Disrepair may also increase the likelihood of penetrating damp. The proportion of housing with some form of disrepair has remained similar since 2004, and disrepair is more common in older buildings. 28% of the Scottish Housing stock has some critical element disrepair that is also urgent. *See Building condition and disrepair BB16* (note that this indicator is both a risk and an action indicator) and *Number of households/people falling below the SHQS & Tolerable Standard CRS58*

Water supply: At present, water shortages are not a serious problem in Scotland, and since 2003 there have only been four times where the water supply was at serious risk. The percentage of customers relying on zones in deficit fell from 30% to under 6% between 2007/2008 and 2013/2014. This was due to Scottish Water's investments to improve water supply and to reduce leakage levels. Nonetheless, nearly 40% of water supply zones still show a (theoretical) deficit in the calculated Supply Demand Balance (SDB) for 2014. The incidence of deficit may increase unless water network investments keep pace with rainfall changes. See *Customers and zones vulnerable to supply deficit BW7*

See also:
Summer low flow events in Scottish rivers (Normalised Flow Index) NB27
Off-grid water supplies at risk of flooding CRS54

IMPACTS:

Geo-hazards: Landslides and scour are the two main geo-hazards affecting transport networks. Over the 15 month period analysed there were 12 landslide events, causing 5 road closures (as compared to 567 flood events causing 8 road closures). Landslides may result in road closures for

several days. See *Landslide events affecting the road network; Road closures due to landslides BT22/23;* for comparison, see also *Flood events affecting the trunk road network BT4*

Effects of wind-driven rain: Dampness in housing can arise either from condensation or from penetrating or rising damp. Over 86% of housing sampled was free from any signs of damp or condensation in 2013. Of the remaining stock, around 3.7% shows signs of penetrating dampness, 0.7% had rising damp, and condensation affected 10.3%. Only 1.3% suffered from both dampness and condensation. See *Dampness in housing stock; Condensation in housing stock BB17/18*

Extreme weather and power supply: High winds and lightning are both a major cause of interruptions to the power supply. Winds and gales caused over 50% of lost time (570, 000 days-worth of customer interruption), snow, sleet and blizzard over 22%, and lightning over 15%. Solar heat has a negligible impact at present (causing less than 0.5% of lost time). Various other weather-related causes of disruption, also of negligible impact, include ice, rain, subsidence, and freezing fog. See *Electricity supply disruption caused by severe weather events BE15.*

ACTIONS:

Buildings: Those in a good state of repair are more likely to be robust in the face of extreme weather, and more resistant to penetrating damp. The proportion of housing with some form of disrepair has remained similar since 2004, and disrepair is more common in older buildings. 28% of the Scottish Housing stock, 28%, has some critical element disrepair that is also urgent. See: *Building condition and disrepair BB16* (this is also a risk indicator).

Reduced Water Supply: Scottish Water has successfully reduced leakage to the 'Economic Level of Leakage' (ELL) a year ahead of target – the point where the cost of reducing leakage becomes greater than the savings from reduced water production. See *Water leakage and losses BW6*

Water consumption per capita has fallen only very slightly since 2008/9. Non-domestic water usage has reduced more noticeably. See *Domestic water usage BW8,* and *Non-domestic water usage BW9.*

It is hoped that future availability of suitable data will enable the development of a number of additional indicators:

- Uptake of water efficiency measures by domestic users
- Uptake of water efficiency measures by water intensive industries
- Insurance claims due to storm damage
- Extent of Greenspace in Urban Areas
- Road network at risk of a landslide
- Risk of loss of road connectivity in remote areas as a result of landslides
- Landslide events affecting the road network
- Significant known road landslide risks addressed through intervention
- Road infrastructure spend on landslide mitigation measures
- Road and rail bridges in remote areas vulnerable to scour
- Bridge failures or unplanned closures due to scour-related issues
- Road closure days due to scour-related bridge damage

Other relevant indicators
Impacts from challenging weather such as high winds, storms, and lightning may occur at the same time as flooding impacts. The narrative covering *Flooding, Infrastructure and Climate Change* covers a wide range of indicators for this area. Some of the indicators covered in the *Resilience, Resource Use and Climate Change* narrative are also linked, for example those tracking reduction in water leakage. The health impacts as a result of storms, floods and extreme temperatures are covered by the narrative on *Climate change risks to society and our capacity to adapt*.