Indicators and trends

Monitoring climate change adaptation

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What are the links between resilience, resource use and the challenges of climate change?	Version 31/03/16

The impact that a climate or weather event has on society depends on many factors. These include resource usage, exposure, the back-up available, and our ability to respond and recover. The list below sets this out in a little more detail, and is followed by an example of each aspect:

1. **Service or asset use and dependence -** the impact of extreme or challenging weather can be reduced by minimising unnecessary over-use or dependence on resources such as water, energy and transport
2. **Hazard Avoidance and Resistance -** e.g. flood protection or buildings designed to withstand storms
3. **Maintenance and Reliability** - e.g. infrastructure and buildings that are well maintained and less likely to fail in the event of extreme weather
4. **Service and Asset Back-up -** e.g. distributed energy networks
5. **Preparedness, Response and Recovery -** e.g. response plans, trained personnel, resources

A road or bridge cut off by flooding for two hours may disrupt thousands of journeys or just a few hundred depending upon the **dependency** and use of that asset. When long journeys are embedded into the economy and society there is inevitably a greater risk of transport disruption. One illustration is the Forth Road Bridge. Traffic volumes grew by nearly 500% between 1965 and 2005 (with 11.9 million north-bound crossings recorded in 2005). Since the abolition of tolls in 2008, traffic has continued to grow and now stands at an estimated 80,000 vehicles per day. Any event that disrupts use of such a link today will disrupt more people and businesses than 50 years ago – simply because more people rely on it (the region's bridge asset dependency has increased). This was amply demonstrated in December 2015, when the Forth Road bridge was closed to all traffic for several weeks.

Planning that ensures that new developments are not sited in areas of flood risk is an example of **hazard avoidance**. Lightning Protection Systems (lightning conductors) for buildings are an example of **hazard resistance.** Resistance may also be embedded in structures. For example, climate-informed building standards and design can provide 'built-in' resistance to hazards– for example through design that can withstand wind-driven rain and thus reduce the risk of internal dampness in buildings.

Maintenance is critical for reliability. **Reliability** helps ensure that climate impacts are not magnified unnecessarily. For example, intense rainfall may cause flooding if road gullies are left blocked, or if flood defences are neglected and left in poor condition.

Back-up (also known as redundancy) may be physical or virtual. Premises with water tanks are better placed to deal with an interruption to the water supply. Some of those unable to travel to work or study due to flooding may be able to achieve similar outputs by working from home. However, back-up may only provide a reduced or compromised level of service or asset.

Finally, **preparedness, response and recovery** all help to minimise the disruption caused by disruptive events and disasters, including weather and climate. 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. The publication 'Preparing Scotland' provides guidance on preparedness and is one of 10 different awareness-raising initiatives.

Adaptation options

Scotland's new National Centre for Resilience is expected to play an important role in taking the resilience agenda forward and in reducing vulnerability and supporting adaptation. Some examples of how legislation, capacity and practice can create resilience and reduce vulnerability are given below.

Service or asset use and dependence: Building legislation now requires water efficient fittings for new homes. Water metering for industrial premises also has a role in controlling usage. Both of these mechanisms reduce unnecessary service usage and thus can reduce the impact of water scarcity.

The (energy) smart meter roll-out is a UK-wide initiative that should enable energy consumers to monitor and reduce energy consumption. At a Scottish and UK level, this will increase energy security and resilience. If proposals for a Scottish Demand Reduction strategy are met this would add to energy security.

Legislation and funding requirements both play a role in **Hazard Avoidance and Resistance.** For example, Scottish legislation that specifies the use of SUDS helps to ensure that drainage systems contribute to flood resistance. Strict planning conditions ensure that power stations are not built in flood risk areas, and that they are designed to withstand extreme flooding events.

The **reliability** of utility services (water, energy) is governed by the UK's regulators such as Ofwat and Ofgem. These bodies stipulate minimum protection standards for key assets, and also apply financial penalties for service failure.

The **maintenance** of gullies and drainage systems is set out in legislation. The Roads (Scotland) Act 1984 requires Local Authorities to keep road drainage systems clear and to clear roads of flooding. Rented property is covered by legislation that aims to protect tenants, and this includes the state of repair. The state of repair of privately owned property is not regulated in the same way.

Service and Asset Back-up: Utility providers are required to have back-up plans. For example, Scottish Water will distribute water bottles in areas where water supply fails. A networked power grid provides greater reliability, and the power inter-connectors between England and Scotland increase security of supply on both sides of the border. In addition, for many power supply zones there is the option of supplying electricity to customers from more than one sub-station.

Legislation can ensure the provision back-up options. For example, Scottish Building Standards requires that 'Every building must be designed and constructed in such a way that every level can be reached safely by stairs or ramps'. This ensures access and safety in the event of a power failure.

However, back-up may only provide a reduced or compromised level of service or asset. For example, when rail lines fail, operators are obliged to provide service back up by road. However, such replacement services generally result in far longer journeys. The failure of the Lamington Viaduct in early 2016 doubled the journey time between Lockerbie and Edinburgh, and the journey time from Edinburgh to Carlisle and thence connection to the English rail network was at least 3 hours each way (slightly less from Glasgow). The connection between England and Scotland on the West Coast mainline was out of action from early January to February 22nd 2016, causing significant cost and inconvenience to society, the wider economy and Network Rail.

Preparedness, Response and Recovery: In addition to having the capacity (the resources – human, financial and practical - required to actually deliver adaptive actions), the ability to be prepared, respond and recover also depends on the Society's capability (the development and dissemination of the knowledge and skills needed to adapt). For example, plans and training that focus on climate impacts can improve the ability of the emergency services to deal with such challenges effectively. Improving community awareness of threats and how to respond to them is also important, for example through Scotland's flood warning schemes.

What do the indicators tell us?

Resource use and resilience are commonly affected by a complex system of factors, often acting in opposing directions. For this reason, some of these systems have been presented in overview reports that describe such relationships, rather than as individual indicators.

Factors affecting **transport resilience** (such as average journey lengths and travel modes) are addressed in the *Transport Indicators Overview*. This shows a trend towards increased journey lengths and mileage per person per annum, which reduces both resource efficiency and travel resilience.

Energy resilience is affected by many factors, including the energy demand for heating. This is covered in the short report *Energy Demand for Heating Overview.* The factors examined include occupants per household, dwelling and household numbers and population trends in Scotland. The overview shows a positive trend for important drivers such as energy efficiency measures. However other drivers, such as fewer occupants per household (and thus more households overall) and a preference for higher internal temperatures, are reducing resource efficiency. The projected increase in the Scottish population will also increase energy demand, as well as demand for other resources and services.

RISK INDICATORS:

Water: These show positive progress in terms of reducing water leakage, usage per capita, and the threat of water deficit. However, while Scotland is relatively well-off in terms of water resources, the projected changes in rainfall patterns suggest that deficits may become an issue in the future.

Water leakage and losses BW6
Customers and zones vulnerable to supply deficit BW7
Domestic water usage BW8
Non-domestic water usage BW9
Abstraction of water for irrigation NA13
Summer low flow events in Scottish rivers (Normalised Flow Index) NB27
Drought risk to agricultural land NA29

Transport: Flood risk to transport networks has multiple implications for mobility, the economy and access to services and goods. Flood disruption is of particular significance to communities in remote regions that lack alternative routes, as it may effectively cut off services and resources. The risk of road and rail travel disruption is assessed by combining flood risk data with service usage. At present less than 2% of the trunk road network is at risk of high levels of disruption from flooding, located mainly in the Central Belt. The risk of rail disruption is fairly low, with only 2% of the network at risk of moderate disruption.

Risk of traffic disruption as a result of flooding BT17
Disruption risk to railway services as a result of flooding BT9

Energy: Power stations may generally be considered robust in the face of flooding, but the power supply may also be compromised by the flooding of substations. Existing data suggests that less than 4% of substations are in areas at risk of a 1 in 200 year flood event. Some 'critical' customers could be affected by this (such as hospitals, water and wastewater pumping stations and underground stations). Many such critical sites and Emergency Service control rooms have back-up capacity – either in the form of diesel generators (hospitals, Scottish Water key sites), or battery back-up (telecoms service providers and some mobile masts).

Customers reliant on substations in areas at flood risk BE6.

IMPACT INDICATORS:

Transport: Flooding impacts on transport networks, and access to services and goods appear to be well managed in Scotland. However, summary data may mask some important local variation. Just over 50% of the trunk road floods were in 'Potentially Vulnerable Areas' (PVA's), and thus more likely to affect remote communities where flooding may have more impact. Disruption to the rail network from flooding can be tracked by the penalty payments incurred by Network Rail. This shows that almost a fifth (18%) of the penalties incurred for weather-related disruptions were caused by flooding.

Flood events affecting the trunk road network BT4
Flood events affecting the railway network BT12

Energy: There have been no recorded power outages due to flooding of power stations in Scotland. Disruption to the power supply due to flooding of sub-stations is very rare, and caused only 0.034% of the annual 'customer minutes lost' in 2011 (Lightning strikes and high winds are far more common causes of power disruption).

Electricity supply disruption due to flooding BE4 / 14.

As a proxy for flood events and the response to them, see:

Number of flood incidents attended by SFRS each year CRS20

ACTION INDICATORS:

Service or asset use and dependence:

Some water indicators can be viewed as both risk and action indicators. For example, high water usage or leakage rates would represent a risk to resilience, but the same indicators also track the actions that address such factors. See above for relevant water indicators.

The indicators which address energy use for heating all show positive trends and suggest that Scotland will be able to benefit from the opportunity to reduce energy demand for heating. A combination of factors has resulted in domestic gas consumption reducing by 20% in the period 2005 – 2013. For an overview see the report *Energy Demand for Heating*. See also

Energy Performance of Scottish Housing Stock BB20
Uptake of Energy Efficiency Measures CRS64
Natural gas usage (domestic) BB26
Natural gas usage (non-domestic) BB27

Trends in the use of transport are covered in the document *Transport Indicators Overview*. Freight and passenger mileage declined with the economic downturn in 2008 but has since been increasing.

Hazard Avoidance and Resistance:

Data on compliance with SEPA's flood risk advice for new developments suggests that the planning system is generally working well, and complying with such advice.

Planning Decisions that do not reflect SEPA's flood risk advice BB11

The electricity network is well protected. All 43 major substations in flood risk areas have completed or planned flood risk assessments, and of the substations for which data was available, 19 out of 22 have planned or implemented flood protection works.

Substations in areas at flood risk with completed Flood Risk Assessments BE7
Substations in flood risk areas with completed / planned flood protection works BE8

Around 6% of the trunk road network is protected by area-based flood management schemes. Of the railway network at risk of fluvial flooding, 9% benefits from area-based flood management schemes.

Trunk road network benefitting from fluvial flood protection BT6.
Rail network benefitting from fluvial flood protection BT16

Maintenance and Reliability:
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.

Building condition and disrepair BB16

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.

Water leakage and losses BW6

Preparedness, Response and Recovery:
Improving society's awareness of flood events can be tracked by the number of users signed up for SEPA's flood forecasting service. This was set up in 2011 and now has over 18,500 registered users.

Number of registrations for flood warnings/alerts CRS34.

However, it has not yet been possible to develop several other indicators that could have been used to chart trends in resilience. This has been due primarily to data constraints, and in some cases, due to a lack of coverage in the Climate Change Risk Assessment.

Other relevant indicators

Many of the individual indicators that show trends in resilience and resource use are discussed in the other two infrastructure narratives:

Flooding and infrastructure
Extreme weather and infrastructure

The overarching Society narrative provides further analysis of some of these issues.

Climate change risks to society and our capacity to adapt

More in-depth analysis is also provided by the following associated documents:

Capability and capacity
Social resilience