# Indicators and trends

## Monitoring climate change adaptation

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| Indicator name | | | | Version |
|---|---|---|---|---|
| **BB6 Cultural Heritage in Flood Risk Areas** | | | | **31/03/16** |
| **Indicator type:** | **Risk/opportunity** | **Impact** | **Action** | |
| | X | | | |

| SCCAP Theme | SCCAP Objective | CCRA risk/opportunity |
|---|---|---|
| Built Environment | B1: Understand the effects of climate change and their impacts on buildings and infrastructure networks<br><br>B2: Provide the knowledge, skills and tools to manage climate change impacts on buildings and infrastructure | BE4 / FL15 Cultural heritage at flood / erosion risk |

**At a glance**

- Scotland's built and natural cultural heritage represents a unique economic and cultural asset that includes iconic, internationally recognised sites
- Flooding is already a widespread issue in Scotland, causing significant economic and social damage that affects many assets including cultural heritage
- Records show that precipitation increased by an average of 27% across Scotland between 1961 and 2011 and the upward trend is projected to continue due to climate change. This will increase flood risk, as will the projected increases in coastal storm surges
- Using modelled flood risk can help ensure that planning decisions take account of future risk to cultural assets, and that flood prevention schemes receive appropriate levels of resource

**Latest Figure**

Cultural Heritage Assets (all types[1]) located in areas at flood risk

| Flood Source: | 1 in 10 year flood | 1 in 200 year flood |
|---|---|---|
| **Fluvial** | 1,400 | 1,500 |
| **Coastal** | 560 | 600 |
| **Pluvial** | 1,100 | 1,400 |

Source: SEPA Flood Risk Management Strategy Characterisation Data 2015. Numbers given to 2 significant figures.

**Trend**

*These figures represent a baseline. No trend is available for this year*

[1] The cultural heritage assets considered here include scheduled monuments, Gardens and Designed Landscapes, and Battlefields. It does not include listed buildings (these are covered within property, BB1/BB3).

## Why is this indicator important?

Scotland's built cultural heritage represents a unique economic and cultural asset that includes iconic, internationally recognised sites (Historic Scotland, 2014). Most physical cultural heritage assets are irreplaceable, immoveable assets, and their exposure to flood risk is increasing with climate change. Tracking the change in this risk can help inform the resourcing of flood defence and recovery schemes (Historic Scotland 2012).

Scotland has a huge range of cultural heritage assets, including five World Heritage Sites - places whose value is considered to transcend national boundaries and to be of importance for future generations.[2]

The vast majority of these assets are in private ownership, including over 400,000 traditional buildings (built before 1919) and 47,000 listed buildings. Historic Environment Scotland (HES)[3] provides *guidance* on management issues for these privately owned assets which also include over 8,200 scheduled monuments, 641 conservation areas, 389 gardens and designed landscapes, and 43 battlefields and wrecks. In addition, HES looks after a portfolio of 335 properties on behalf of Scottish Ministers; this is the HES Estate. Taken together they are a significant national asset. In the year 2014 / 15 the Historic Scotland sites alone attracted 3.5m visitors, generating an income of £38.2m. Taken as a whole, the historic environment contributes in excess of £2.3 billion (2.6%) to Scotland's Gross Value Added (GVA) and supports 60 000 jobs[4].

The impacts of climate change on the historic environment are wide ranging and potentially devastating. Rising sea levels, increased storm events and coastal erosion endanger historic landscapes, buildings, archaeology and coastal landscapes (Historic Scotland 2015).

More frequent intense rainfall events will cause flooding and erosion to some of the most treasured historic buildings and heritage sites. More rainfall will mean that traditional buildings will be wetter for longer periods of time resulting in increased weathering of stone, algal and fungal growth and metal corrosion. It will be vitally important that buildings are well maintained and managed to ensure that they can withstand increased rainfall, weathering and flooding. Impacts to historic buildings from these weather changes include water penetration into masonry, increased risk of dampness, condensation, accelerated mould growth and, at worst, structural collapse (Historic Scotland, 2015).

Climate change not only threatens Scotland's heritage of ancient and historical monuments but has wider impacts as well. Scotland's Built Heritage supports the tourist industry and there is also risk to the wider historic environment that forms the physical backbone of many communities and transport routes. Buildings constructed using traditional materials such as Georgian terraces, Victorian villas, city tenements, rural dwellings, bridges, railways and canals are affected. Much of this traditionally constructed infrastructure indirectly supports Scotland's economy and society through accommodating business and economic growth, and their upkeep makes a significant contribution to employment in the construction industry (Historic Scotland, (2012).

[2] Antonine Wall, Heart of Neolithic Orkney, New Lanark, Edinburgh Old and New Towns, St Kilda, Forth Bridge. See http://www.historic-scotland.gov.uk/index/heritage/worldheritage/world-heritage-sites-in-scotland.htm

[3] Historic Environment Scotland (HES) was launched on 1st October 2015. Its remit is to investigate, care for and promote Scotland's historic environment. It combines the functions previously performed by Historic Scotland and the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS).

[4] These and other statistics on assets, visitor figures and the economic impact of the historic environment are provided in the Scottish Historic Environment Audit: http://www.historic-scotland.gov.uk/heritageaudit

However, it should be noted that not all cultural heritage sited in flood risk areas is actually 'at risk'. The 'at risk' figures include sites that are already waterlogged (e.g. scheduled crannogs that are intended to be in water) and infrastructure such as listed bridges, which by their nature are by watercourses. Localised topography may protect sites and buildings from flooding even if they are in flood zones -this is particularly true for historic buildings. In short, for many sites proximity to, and the effects of flooding may pose a lower risk to the historic asset (Mairi Davies, HES, pers. comm.).

**Related Indicators:**
BB1 / BB3 – Property at risk of flooding (BB1, residential; BB3, non-residential)

## What is happening now?

Cultural heritage assets in areas at flood risk were identified by SEPA in the work that led to their Flood Risk Management Strategy Characterisation Data (SEPA, 2015), and are shown in Table 1. A figure for the total number of assets used in this modelling has been requested, but at present is not known to the authors. Nonetheless, this data provides a useful baseline for reference in future assessments.

**Historic Environment Scotland and Adaptation**
As already noted, physical cultural heritage assets are predominantly irreplaceable, immoveable assets. HES has a range of initiatives to help understand and manage the impact of climate change on the historic environment. These include recording, monitoring and researching climate impacts, and providing advice and guidance to others on a range of issues (Historic Scotland, 2012). Their adaptation initiatives include combating masonry falls, trialling soft capping of exposed wall heads, researching the effects of moisture on building stone, running an apprenticeship scheme (to generate the skilled professionals to maintain and adapt historic buildings), a pilot scheme to support owners of historic buildings in repairing and maintaining their properties[5] (this assists with being 'climate ready') and dune stabilisation works at Links of Noltland. [6]

**Table 1** Cultural Heritage Assets (all types) located in areas at flood risk

| Flood Source: | 1 in 10 year flood | 1 in 200 year flood |
|---|---|---|
| **Fluvial** | 1,400 | 1,500 |
| **Coastal** | 560 | 600 |
| **Pluvial** | 1,100 | 1,400 |

Source: Flood Risk Management Strategy Characterisation Data 2015

**Coastal Erosion**
In response to coastal erosion and increased storminess, over 10% of Historic Scotland's £1.5m Archaeology grants budget was spent on coastal erosion projects in 2014-15 (£158,680Mairi Davies, personal communication) . Increased quantity and intensity of rainfall also increases soil erosion, which can have a major impact on buried archaeological sites.

**Legislation and Management of Flood Risk**
Scottish flood risk legislation and management was comprehensively updated with the Flood Risk Management (Scotland) Act 2009 (FRM Act). Under this act, the primary responsibility for protecting

[5] The scheme is based in Stirling. For details, see http://traditionalbuildingshealthcheck.org/

[6] Some of these are described in the 2014 edition of HS's Focus magazine – see http://conservation.historic-scotland.gov.uk/publication-detail.htm?pubid=10414

land from flooding continues to lie with land and property owners. Historic Environment Scotland therefore has a two-fold task –

- To take appropriate action to protect its own estate, and
- To endeavour to protect cultural heritage in private ownership through advice and support

In addition to the responsibility for action by land and property owners, the roles and responsibilities of various public bodies to help manage and reduce flood risk are set out in the FRM Act[7]. These bodies include SEPA, Local Authorities, Scottish Water, Forestry Commission Scotland, National Parks Authorities and Scottish Government.

## What has happened in the past?

Data on previous flood risk to cultural heritage is not available. However, there is good data on past trends in precipitation and flooding.

**Fluvial and Surface Water Flooding: Trends in Precipitation**

There have always been large fluctuations in precipitation and the flooding associated with it (Scottish Executive, 2002). However, Met Office data for the period 1914 – 2011 (and as used for the UK's Climate Projections 2009) shows clear upward trends[8] in precipitation (SNIFFER, 2014):

1. Total annual precipitation has increased on average by 27% across Scotland since 1961, with most of the increase falling in winter.
2. In each region, and across the country, the change in winter precipitation since 1961 shows a clear upward trend (with a 45% average increase, rising to over 50% for the north of Scotland). No clear trends in average summer rainfall have been noted
3. Since 1961 there has also been a trend of increasing 'heavy rainfall days' in winter (where 'heavy rain' is defined as over 10mm in 24 hours). In particular, North and West Scotland have seen increases of more than seven and eleven days respectively.
4. The maximum precipitation recorded within any five day period in a year has also increased across Scotland. The average increase since 1961 is over 20%.

Precipitation is the primary driver for fluvial and surface water flooding, although other factors such as the extent of impermeable surfaces will also affect flood extent and severity. Based on precipitation data alone, one would expect flooding to have increased in frequency since 1960.

**Fluvial Flooding since 1950**

River flow records show high variability in both the frequency and severity of floods since the 1950s (Scottish Executive, 2002). Whilst the 1980s and 90s were exceptional for many rivers, the frequency of flooding was higher in the 1950s, especially in the north. However, since 1989 more than half of Scotland's largest rivers (8 out of 16, notably those draining from the west) have recorded their highest flows (reflecting vigorous westerly storms prevalent during the late 1980s / 1990s). This 'flood rich' period suggests that the probability of experiencing a fluvial flood has substantially increased within this time.

**Coastal Flooding**

Coastal flooding is exacerbated by sea level rises and by storm surges during high or spring tides. Global sea levels have risen by 1-2 mm per annum over the last century - the observed global mean sea level rise during the period 1961–2003 is 1.8 mm per year (IPCC, 2007). However, the change in relative sea level varies as different parts of Scotland are uplifting at different rates after de-

[7] See http://www.sepa.org.uk/environment/water/flooding/responsibilities-for-flooding

[8] Trends are based on figures with a 95% statistical confidence level .

glaciation. In Scotland the Aberdeen tidal gauge (dating back to 1862) records an average sea level rise of 0.69mm per year (Scottish Executive, 2002).

## What is projected to happen in the future?

Historic Environment Scotland will track progress in improving the resilience of its estate by developing a methodology for assessing climate change risk to historic sites, the creation of a climate change risk register for properties and the incorporation of these into management planning and resource allocation. It will publish the results of research into climate change threats to the historic environment and amend current guidance where appropriate.

HES is developing a comprehensive Climate Change Impact and Risk Assessment to cover the 335 buildings and sites of the HES estate. The first phase of this work will be completed in March 2016. The assessment, which is being carried out in partnership with BGS, makes use of data from a range of sources including SEPA (on flood risk and coastal erosion), BGS (slope stability and groundwater flooding), the Met Office and of course the HES data on each asset. It will provide a GIS-based spatial tool to support the conservation and maintenance of physical assets. Adaptation plans and measures are site-specific due to the wide variation in buildings, sites and their operating conditions (e.g. the extent to which they are roofed, staffed and open to the public). The results of the assessment will ultimately inform conservation and management plans for individual sites.

Subsequent phases of the assessment may cover additional hazards and aspects, such as the risks to visitor access and revenue.

**Climatic Aspects:** It is predicted that Scotland will become warmer and wetter and there will be an increase in annual rainfall of between 5 to 20 percent by the end of the next century, along with a rise in sea level and storminess. This will increase the current flood risk to cultural heritage.

Scotland's archaeology and coastal landscapes are vulnerable to coastal erosion, rises in sea level, flooding and storminess, and some of the most unique sites such as Skara Brae in Orkney are most at risk (Historic Scotland, 2015).

The maps below show changes to winter rainfall for the 2050's as predicted by the latest climate projections (UKCP09). Significant areas of Scotland are anticipated to experience increases of between 10 to 20% in winter precipitation. The high emissions scenario has been used as the current rate of carbon emissions tracks this scenario most closely. The figure on the left shows the change considered to be most likely, and that on the right shows the precipitation pattern that is unlikely to be exceeded. The trend of increased winter rainfall continues and predictions for the 2080's show even greater levels of increase.

The realised impact of flood events on cultural heritage depends on factors such as site location and the nature and state of any flood defences. This indicator highlights the *underlying risk due to precipitation patterns* and can help inform decisions about adaptive actions e.g. minimising flood damage to heritage assets through preparation or investing in flood defences.

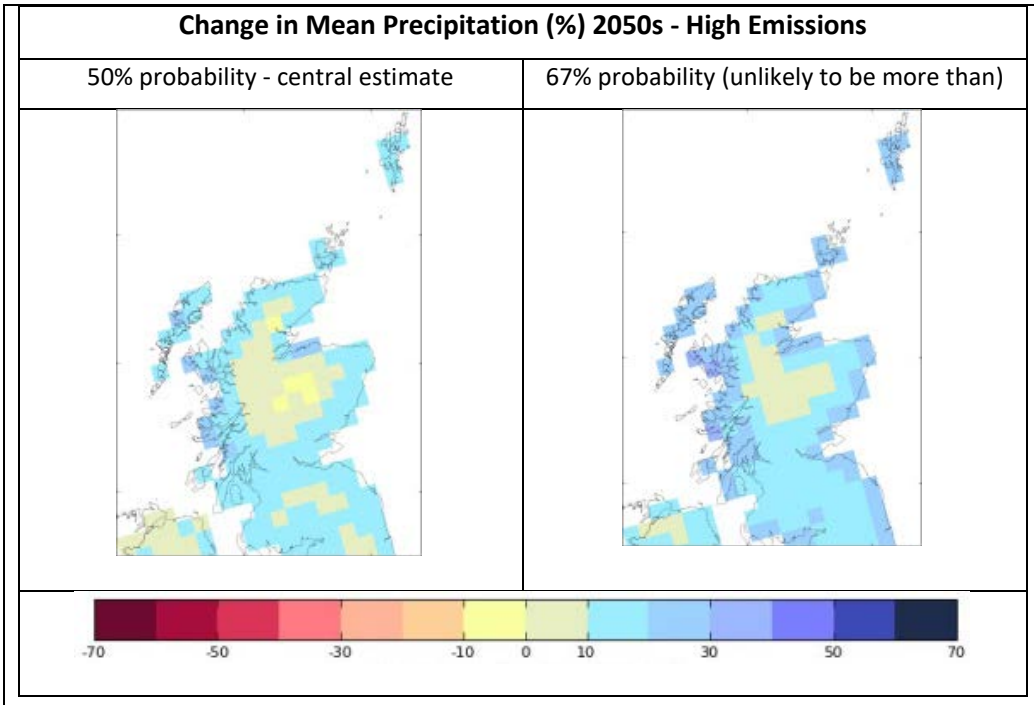


**Fig 1.** Projected changes to winter rainfall for **the** 2050's

## Patterns of change

There have always been large fluctuations in rainfall and flood patterns (Scottish Executive, 2002). However, monitoring of records from 1960 shows an upward trend. Annual rainfall levels in Scotland increased 27% between 1961 and 2011, and average winter rainfall has increased even more –over 45% on average, with this rising to over 50% in the north of Scotland (SNIFFER, 2014).

Days of heavy rainfall (defined as over 10mm within 24 hours) have also increased, particularly in the north and west of Scotland, which show an average increase of 8 days between 1960 and 2011. Likewise, the maximum rainfall recorded over any five day period in a year has also increased - on average by 20% across Scotland (ibid).

## Interpretation of indicator trends

The data shows a relatively small difference in numbers of sites at risk from medium occurrence flood events (1 in 200 year) compared with high occurrence events (1 in 10 year floods).

**Table 2** Ratio of properties at risk from medium probability flood: low probability flood. Property numbers are given to 2 significant figures

| Flood Source: | 1 in 10 year flood | I in 200 year | Ratio of properties at risk from medium probability flood: low probability flood |
|---|---|---|---|
| **Fluvial** | 1,400 | 1,500 | 1:1.07 |
| **Coastal** | 560 | 600 | 1:1.08 |
| **Pluvial** | 1,100 | 1,400 | 1:1.24 |

For fluvial and coastal flood sources there is less than 10% increase in numbers, while for pluvial floods the increase is 24%.

This suggests that the bulk of sites are in high risk areas, and this may well reflect the nature of the sites (eg crannogs, bridges, structures sited on tidal islands and so on). This is in contrast to the picture for residential property, where there is a quadrupling of number of properties at risk between high frequency floods (1 in 10 year) and medium frequency (1 in 200 year) (see indicator BB1).

No trend data is available yet. It should be noted that this indicator tracks the underlying *flood risk to the area*, and so does not and cannot show the protective effects of adaptation actions such as property-level flood defences. These will be tracked through other indicators, for example, 'Cultural Heritage benefitting from conservation and maintenance plans that account for climate change'. This indicator is not yet available, but it is clear that Historic Environment Scotland is already taking action to address climate change risks. They have contributed to a range of national strategies which aim to tackle the impacts of climate change including the Flood Management Strategy for Scotland and the Scottish Climate Change Adaptation Programme. The latter sets out specific adaptation tasks for Historic Environment Scotland.[9]

As already noted, it is important that traditional buildings and historic infrastructure are well managed and maintained to ensure that they can withstand the pressures of climate change. Historic Scotland is promoting and sustaining the availability of traditional skills and materials at national and local level throughout Scotland to ensure future viability of the historic built environment. They also provide advice, technical support and financial assistance to the owners of listed buildings (Historic Scotland, 2012). Their research provides information on adaptation to the changing climate and ways of improving energy efficiency and reducing carbon consumption.

## Limitations

SEPA carried out the National Flood Risk Assessment in 2011 (SEPA, 2011), followed by work to create the Flood Risk Management Strategy Characterisation Data (SEPA, 2015). Figures for this indicator were obtained from an early version of the latter by request to SEPA. This provides a baseline only, so no trends are available as yet.

Only **designated** assets are covered in the analysis. These are buildings and sites that have legal protection through the Ancient Monuments and Archaeological Areas Act 1979.

Not all cultural heritage in flood risk areas is actually 'at risk'. The 'at risk' figures include sites that are already waterlogged (e.g. scheduled crannogs that are intended to be in water) and infrastructure such as listed bridges, which by their nature are by watercourses. Localised topography may protect sites and buildings from flooding even if they are in flood zones -this is particularly true for historic buildings. In short, for many sites the proximity to, and effects of, flooding may pose a lower risk to the historic asset (Mairi Davies, Historic Scotland, pers. comm.).

## References

Historic Scotland (2012) *A Climate Change Action Plan for Historic Scotland 2012-2017*. Available at http://www.historic-scotland.gov.uk/climate-change-plan-2012.pdf (Accessed 9 April 2015)

[9] See http://www.gov.scot/Publications/2014/05/4669

Historic Scotland (2014) *Why is the Historic Environment Important?* Available at http://www.historic-scotland.gov.uk/index/heritage/valuingourheritage/why-is-the-historic-environment-important.htm (Accessed 9 April 2015)

Historic Scotland (2015) *Climate change: The effect on the historic environment*. Available online at: http://www.historic-scotland.gov.uk/index/heritage/climatechange/effectonenvironment.htm

Scottish Executive (2002) *Climate Change: Flooding Occurrences Review*. Available at http://www.scotland.gov.uk/Publications/2002/03/10817/File-1 (Accessed 20 Nov 2014)
SEPA (2015) *Flood Risk Management Strategy Characterisation Data*

Sniffer (2014) *Scotland's Climate Trends Handbook.* Available at http://www.environment.scotland.gov.uk/climate_trends_handbook/index.html (Accessed 20 Nov 2014)

## Further information

**Climate change:**
Adaptation Scotland. *Compendium of UKCP09 outputs for Scotland*. Available at http://www.adaptationscotland.org.uk/4/70/0/Scottish-Compendium-of-UKCP09-Climate-Change-Information.aspx

**Historic environment:**
Historic Scotland (2015) *Adapting to Change.* Available at http://www.historic-scotland.gov.uk/index/heritage/climatechange/adaptingtochange.htm (Accessed 20 May 2015)

Historic Environment Scotland (2015), *Baseline condition of the properties in the care of Scottish Ministers.* Available at http://www.historic-scotland.gov.uk/hes-baseline-condition.pdf

**Flood risk:**
SEPA (2011). *National Flood Risk Assessment (NFRA)*. Available at http://www.sepa.org.uk/flooding/flood_risk_management/national_flood_risk_assessment.aspx

Black, A, Burns JC. (2002) *Re-assessing the flood risk in Scotland*. Available at http://www.ncbi.nlm.nih.gov/pubmed/12169005

## Acknowledgements

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Flood data provided by SEPA.

## Appendix One: Indicator metadata and methodology

**Table 1: Indicator metadata**

| | **Metadata** |
|---|---|
| **Title of the indicator** | BB6 Cultural Heritage in Flood Risk Areas |
| **Indicator contact:** Organisation or individual/s responsible for the indicator | ClimateXChange |
| **Indicator data source** | SEPA |
| **Data link:** URL for retrieving the indicator primary indicator data. | N/A – SEPA data only available on request. The cultural heritage assets dataset includes scheduled monuments, Gardens and Designed Landscapes, and Battlefields. |

**Table 2: Indicator data**

| | **Indicator data** |
|---|---|
| **Temporal coverage:** Start and end dates, identifying any significant data gaps. | Baseline data only; 2015 |
| **Frequency of updates:** Planned or potential updates | Likely to be updated in line with the 6-yearly FRM Planning cycle – ie once every 6 years. |
| **Spatial coverage:** Maximum area for which data is available | Scotland-wide |
| **Uncertainties:** Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps | The cultural heritage assets dataset includes scheduled monuments, Gardens and Designed Landscapes, and Battlefields. It does *not* include listed buildings (these are covered within property, BB1/BB3). No figure yet available for the total asset base within this dataset. There may be duplication of sites between LPDs |
| **Spatial resolution:** Scale/unit for which data is collected | Scotland-wide, broken down into figures for each LPDs (Local Plan Districts) |
| **Categorical resolution**: Potential for disaggregation of data into categories | Not yet known |
| **Data accessibility:** Restrictions on usage, relevant terms & conditions | SEPA sets terms and conditions on the re-use of its data. Further information is available at: dataenquiries@sepa.org.uk |

**Table 3 Contributing data sources**

| **Contributing data sources**<br><br>Data sets used to create the indicator data, the organisation responsible for them and any URLs which provide access to the data. |
|---|
| Contextual data about cultural heritage was obtained from Historic Scotland. Downloadable from http://www.historic-scotland.gov.uk/climate-change-plan-2012.pdf (Accessed 9 April 2015) |

**Table 4 Indicator methodology**

| **Indicator methodology**<br><br>The methodology used to create the indicator data |
|---|
| Figures for flood risk by flood type (fluvial, coastal and surface water) to cultural heritage were obtained from Mark McLaughlin of SEPA, and come from an early version of SEPA's Flood Risk Management Strategy Characterisation Data (2015). |