Indicators and trends

Monitoring climate change adaptation

climate change
Scotland's centre of expertise connecting climate change research and policy

Indicator name				Version
BB1 & BB3: Property at risk of flooding (BB1 residential, BB3 non-residential)				**31/03/16**
Indicator type:	**Risk/opportunity**	**Impact**	**Action**	
	X			

SCCAP Theme	SCCAP Objective	CCRA risk/opportunity
Buildings and Infrastructure Networks	B2: Provide the knowledge, skills and tools to manage climate change impacts on buildings and infrastructure S1, S2 and S3	BE10, BE11, BE12, BE15, BE18, FL6, FL24 Property at significant risk of flooding

At a glance

- Flooding is already a widespread issue in Scotland, causing significant economic and social damage. Climate change is projected to increase flood risk
- Flooding can originate from pluvial (rain), fluvial (river) or coastal waters. The risk from each of these is modelled separately by SEPA
- Met Office records show that precipitation increased by an average of 27% across Scotland between 1961 and 2011. This trend is projected to continue due to climate change.
- The increase in winter precipitation intensity and frequency 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, and that flood protection schemes receive appropriate levels of resource

Latest Figure

Risk of 1 in 10 year flood	Number affected	Percentage equivalent
Non Residential Property (NRPs)	9,900	2.9%
Residential Property (RPs)	21,000	0.8%

Risk of 1 in 200 year flood	Number affected	Percentage equivalent
Non Residential Property (NRPs)	29,000	8.6%
Residential Property (RPs)	79,000	3.2%

Figures are from SEPA's FRM Strategy Characterisation Data (2015). Number of properties affected given to 2 significant figures.

Trend

Not yet available

Why is this indicator important?

Flooding is already a significant and widespread issue in Scotland. Floods cause major economic losses and associated disruption and misery to those affected by them. The social disruption caused by floods can seriously undermine the quality of life of individuals and impact on the fabric of affected communities (Gordon, 2004).

Estimates of the cost of annual flood damage to property in Scotland lie at around £210 million (Scottish Government, 2014, JBA Technical report) to £250 million (SEPA, 2015). Individual flooding events can have a huge cost - losses of £30 million were estimated for the Tay/Earn flood in 1993 and £100 million for the Strathclyde flood in 1994 (Scottish Executive, 2002).

Climate change is projected to increase existing flood risk and flood damage. Annual rainfall levels in Scotland have already increased 27% between 1961 and 2011, and average winter rainfall has increased even more – at 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.

If such rainfall trends continue they will increase the frequency, severity and extent of flood events. The realised impact of flood events depends on factors including the number and location of properties, infrastructure and communities in flood risk areas. This indicator highlights the *underlying risk* and so can help inform decisions about adaptive actions ranging from flood avoidance through planning, minimising flood damage through preparation, investing in flood defences and strategic relocation.

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

What is happening now?

Figures for the numbers of property identified as at risk from flooding are shown below in Table 1. The table covers three levels of flooding between high and medium risk (from any flood source)

Table 1 Risk to Property from flood events.

Likelihood of Flood Occurrence	**No. of Property type affected**		
	Residential	Non-residential	All Property
1 in 10 year flood (high risk)	21,000	9,900	31,000
1 in 200 year flood (medium risk)	79,000	29,000	110,000

Likelihood of Flood Occurrence	**Percentage of Property type affected**		
	Residential	Non-residential	All Property
1 in 10 year flood (high risk)	0.8%	2.9%	1.1%
1 in 200 year flood (medium risk)	3.2%	8.6%	3.8%

Figures are from SEPA's FRM Strategy Characterisation Data (2015). Number of properties affected given to 2 significant figures.

Less than 1% of residential property is at risk of a high probability flood even (a '1 in 10 year' event), but 3.2% are at risk from a medium likelihood event (a 1 in 200 year event). Non-residential property is at greater risk than dwellings.

Sources of Flood Risk

The number and percent of properties affected by each flood source are shown below in Table 2. The greatest cause of flood risk to residential property comes from fluvial flooding, which contributes over 50% of the flood risk for this group. Non-residential property is at roughly equal risk from fluvial and surface water flooding, each of these contributing around 40% of the total risk to this group.

Table 2 Numbers of Properties at risk from each flood source

Flood Source	Surface Water		Fluvial		Coastal	
Annual Probability of Flood	10% High	0.5% Med	10% High	0.5% Med	10% High	0.5% Med
Residential	5,600	28,000	13,000	49,0000	4,200	11,000
% of total residential at risk	0.2	1.1	0.5	2.0	0.2	0.4
Non-Residential	4,600	16,000	4,7000	13,000	1,600	4,400
% of total non-residential at risk	1.4	4.7	1.4	3.9	0.5	1.3

Figures based on SEPA's FRM Strategy Characterisation Data (2015). Number of properties affected given to 2 significant figures.

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 land from flooding continues to lie with land and property owners. Notwithstanding, Scottish Government provides some funds to local authorities for flood protection schemes. For example, in 2014 they increased funding for flood defences, allocating an additional £40 million[1].

The roles and responsibilities of various public bodies to help manage and reduce flood risk are set out in the FRM Act[2]. These bodies include SEPA, Local Authorities, Scottish Water, Forestry Commission Scotland, National Parks Authorities and Scottish Government.

The FRM Act introduced a new approach to flood management in Scotland by considering whole catchments and all types of flooding, and introduced a requirement for sustainable flood management. The Act has introduced a coordinated process to manage flood risk at a national and local level. Specific measures within the Act include:

- A framework for coordination and cooperation between all organisations involved in flood risk management
- Assessment of flood risk and preparation of flood risk management plans
- New responsibilities for SEPA, Scottish Water and local authorities in relation to flood risk
- A revised, streamlined process for flood protection schemes
- Methods to enable stakeholders and the public to contribute to managing flood risk

[1] See http://scottishgovernment.presscentre.com/News/Flood-funding-af1.aspx and http://www.waterbriefing.org/home/flooding/item/8949-scottish-govt-awards-%C2%A340million-extra-flood-defence-funding

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

- A single enforcement authority for the operation of Scotland's reservoirs (SEPA)

Flood Risk Management Strategies (FRM Strategies) coordinate efforts to tackle flooding in Scotland. They set out a national approach to flood risk management and help coordinate action and investment across public bodies. FRM Strategies for each of Scotland's 14 Local Plan Districts (LPDs) were published in December 2015 (SEPA, 2015).

In addition, Local Flood Risk Management Plans (FRM Plans) will provide local detail on the funding and delivery timetable for actions between 2016-2021. The publication date for Local Flood Risk Management Plans is June 2016. Local Flood Risk Management Plans and Flood Risk Management Strategies will be updated every six years (ibid).

What has happened in the past?

Fluvial and Surface Water Flooding: Trends in Precipitation

Precipitation is the primary driver for flooding. Data collected by the Met Office for the UK's Climate Projections 2009 (UKCP09; data from 1914 – 2011) shows clear trends (of 95% statistical confidence) in increased precipitation in the following ways (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). 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%.

As well as precipitation, other factors such as the extent of impermeable surfaces will also affect flood extent and severity. Based on precipitation data alone, one would expect the risk of flooding to have increased since 1960.

Fluvial Flooding since 1950

River flow records show high variability in both the frequency and severity of floods since the 1950s. 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, and notably those draining from the west) have recorded their highest flows (reflecting vigorous westerly storms prevalent during the late 1980s and 1990s). This 'flood rich' period suggests that the probability of experiencing a fluvial flood has substantially increased.

Coastal Flooding

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

Scotland has relatively tight controls on planning to ensure that future developments are not sited in areas at risk (see Indicator BE11). Nonetheless, projected increases in precipitation will undoubtedly increase the number of properties at flood risk.

A study conducted for Scottish Government by JBA Consulting has examined the increase in flood risk to all property by 2035 in some detail. Some of their findings are shown in the Table 3 below (Pettit et al, 2014b). The figures allow for the expected increase in property numbers as well as a modelled increase in the extent and frequency of flood events. Note that their figures were derived using an early version of SEPA's flood hazard modelling, and a slightly different approach to estimating flood risk, thus there are differences between the two sets of estimates. Their methodologies are given in full in their report. In addition, the JBA study was based on data provided by SEPA before it was fully finalised. Nonetheless, their study provides useful insight into the likely upward trends for flood risk and their analysis indicates significant increases in both the percentage of and the numbers of properties affected by flooding.

One important aspect is that these projections show that "with relatively small increases in sea level, (river) flow and rainfall, the number of properties at risk of flooding could increase substantially, ***particularly for the more frequent flood events***." (i.e. those events likely to occur once every 10 years) (JBA, Sept 2014). If this prediction is backed up by further research, this could have implications for flood risk management in Scotland, which may need to increase the emphasis on dealing with more frequent lower return period floods.

Table 3 Flood Risk to Property - Predicted Changes (*note that 'AP' stands for Annual Probability).* (Pettit et al, 2014b)

Fluvial	10% AP 10yr	3.33% AP 30yr	2% AP 50yr	1% AP 100yr	0.5% AP 200yr	0.1% AP 1000yr
Current estimates	15,420	29,775	33,974	39,030	49,657	76,341
2035 estimates	18,456	35,731	40,892	46,910	59,985	94,801
Increase	3,036	5,956	6,918	7,880	10,328	18,460
% increase	**19.7%**	**20.0%**	**20.4%**	**20.2%**	**20.8%**	**24.2%**

Coastal	10% AP 10yr	4% AP 30yr	2% AP 50yr	1% AP 100yr	0.5% AP 200yr	0.1% AP 1000yr
Current estimates	4,121	6,132	7,258	9,380	11,192	17,438
2035 estimates	6,107	7,677	9,770	11,958	15,402	18,698
Increase	1,986	1,545	2,512	2,578	4,210	1,260
% increase	**48.2%**	**25.2%**	**34.6%**	**27.5%**	**37.6%**	**7.2%**

Surface Water	10% AP 10yr	3.33% AP 30yr	2% AP 50yr	1% AP 100yr	0.5% AP 200yr
Current estimates	9,672	15,093	18,882	24,438	31,491
2035 estimates	12,052	18,021	21,811	28,153	33,348
Increase	2,380	2,928	2,929	3,715	1,857
% increase	**24.6%**	**19.4%**	**15.5%**	**15.2%**	**5.9%**

Coastal flooding will be exacerbated by sea level rises and storm surges. The range of absolute sea level rise for the UK (i.e. before land movements are included) is projected to be between 12 and 76 cm for 1990–2095 (Medium emissions scenario).[3] This will be accompanied by a small increase in the 'storminess-driven' component of extreme sea level, predicted to be under 0.9 mm yr.[4]

Patterns of change

It is possible to identify the areas of least and greatest change between the current risk and the risk projected for 2035 (Pettit et al, 2014b). The following figures all refer to flood events of an annual probability (at present) of 0.5%.

The increase in property numbers at risk from surface water flooding is fairly even across Scotland, with an average increase of 5.9%, which represents around 1800 additional properties at risk. Coastal flooding will affect over 4000 additional properties, with the increase concentrated in certain areas, for example in Aberdeenshire (50% increase in property at risk) and in Dundee City (250% increase), each of which will have over 280 additional properties at risk by 2035.

Over 10,000 additional properties that will be at risk of fluvial flooding in 2035. Table 4 below shows a few of the areas with the least and greatest increase in numbers at risk.

Table 4 Example areas with least and greatest increases in property at risk of Fluvial Flooding

Local Authority Area	% Increase	Additional dwellings at risk
Minor Increase (<5%)		
Aberdeen	2.61	123
Moray	3.42	81
Major increase (>20% or > 1000 additional properties at risk)		
Highland	23.53	1048
Stirling	51.88	1049
Falkirk	91.65	911

Source: (Pettit et al. 2014b).

Interpretation of indicator trends

No measured trend is available as yet. However, the predicted trend is upward, reflecting both an increase in the extent and severity of flood events as well as a modest increase in the number of properties at risk in Scotland (though flood risk assessment during the planning processes ensures that very few developments are created in flood risk areas – see associated indicator BB11).

[3] http://ukclimateprojections.metoffice.gov.uk/22549

[4] See UK Climate Projections science report: Marine & Coastal, Chapter 4. Also http://ukclimateprojections.metoffice.gov.uk/22569

Limitations

If there are any future changes to either the input data or the flood risk modelling currently used by SEPA this will make tracking flood risk trends more difficult. For example, coastal modelling doesn't currently include wave overtopping.

References

Pettit, A., May, P., Bassett, D. (2014). *Assessing the Flood Risk Management Benefits of Property Level Protection - Evidence Summary.* Edinburgh: Scottish Government. Available at http://www.gov.scot/Topics/Environment/Water/Flooding/resources/research

Pettit, A., May, P., Bassett, D. (2014). *Assessing the Flood Risk Management Benefits of Property Level Protection - Technical and Economic Appraisal Report.* Edinburgh: Scottish Government. Available at http://www.gov.scot/Topics/Environment/Water/Flooding/resources/research

Scottish Government (2007) *Exploring the Social Impacts of Flood Risk and Flooding in Scotland* http://www.scotland.gov.uk/Publications/2007/04/02121350/5

Scottish Executive (2002) *Climate Change: Flooding Occurrences Review* http://www.scotland.gov.uk/Publications/2002/03/10817/File-1

SEPA (2015) *Flood Risk Management Strategy Characterisation Data*

SEPA (2016) Flood Risk Management Strategies. Available at http://apps.sepa.org.uk/FRMStrategies/

Sniffer (2014) *Scotland's Climate Trends Handbook*, Sniffer Project CC13, available online at http://www.environment.scotland.gov.uk/climate_trends_handbook

Further information

General Register Office for Scotland (Households and dwellings)
http://www.nrscotland.gov.uk/statistics-and-data/statistics

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

SEPA (2016) Flood Risk Management Strategies http://apps.sepa.org.uk/FRMStrategies/

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

Pettit, A., May, P., Bassett, D. (2014). *Assessing the Flood Risk Management Benefits of Property Level Protection - Blueprint for Local Authorities and Scottish Water.* Edinburgh: Scottish Government. Available at http://www.gov.scot/Topics/Environment/Water/Flooding/resources/research

Acknowledgements

Lead author: Katherine Beckmann (Heriot-Watt University).
Angus Pettit, Principal Analyst at JBA Consulting, and the main author of the JBA reports.
Mark McLaughlin and David Faichney of SEPA.

Appendix One: Indicator metadata and methodology

Table 1: Indicator metadata

	Metadata
Title of the indicator	BB1 & BB3: Property at risk of flooding (BB1 residential, BB3 non-residential)
Indicator contact: Organisation or individual/s responsible for the indicator	ClimateXChange
Indicator data source	SEPA'S Flood Risk Management Strategy Characterisation Data; General Registers of Scotland JBA's 2014 reports on Property Level Protection
Data link: URL for retrieving the indicator primary indicator data.	SEPA – data on request only JBA – some data provided in the Technical and Evidence Reports (see references above)

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	SEPA 2015. No comparable prior data.
Frequency of updates: Planned or potential updates	SEPA – Cycles of 5 years once the Flood Baseline Appraisal is in place
Spatial coverage: Maximum area for which data is available	Scotland
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	
Spatial resolution: Scale/unit for which data is collected	SEPA analysis utilises property level data; summary data supplied at LPD level. Outputs are not suitable for use at the property level.
Categorical resolution: Potential for disaggregation of data into categories	Data available at LPD level for each of pluvial, fluvial and coastal. For the purposes of this indicator, summary data divided properties into residential and non-residential

Data accessibility: Restrictions on usage, relevant terms & conditions	SEPA sets terms and conditions on re-use of its data. Further information about these and the use of SEPA's Data is available from: dataenquiries@sepa.org.uk Enquiries about the data supplied by JBA can be addressed to Angus Pettit, Port Neuk, 1 Longcraig Road, South Queensferry, Edinburgh, EH30 9TD

Table 3 Contributing data sources

Contributing data sources Data sets used to create the indicator data, the organisation responsible for them and any URLs which provide access to the data.
Flood Risk Metrics (FRISM, JBA see http://www.jbaconsulting.com/project/flood-risk-metric-tool-frism) National Flood Risk Assessment (NFRA) http://www.sepa.org.uk/flooding/flood_risk_management/national_flood_risk_assessment.aspx Flood Risk Baseline Assessment, SEPA (currently awaiting correct reference format from SEPA) For Table 3, the property numbers used by JBA, were obtained by them from the Scottish Property Dataset (SPDS). This is a national level property dataset commissioned by SEPA and was also used for the baseline appraisal of flood hazards. The Scottish Property Dataset (SPDS) was generated by CH2M HILL for SEPA and is derived from OS Addressbase Plus and OS MasterMap Topography

Table 4 Indicator methodology

Indicator methodology The methodology used to create the indicator data
Current Flood Risk: Figures for flood risk by flood type (fluvial, coastal and surface water) to residential and non-residential property were obtained from SEPA, and represent outputs from SEPA's Flood Risk Management Strategy Characterisation Data (2015). Details of SEPA's flood modelling methodologies are available via the references given above. NB: A breakdown of the number of properties at risk for each Local Planning District is available from SEPA ***For figures on the future changes increase in flood risk:*** Data on future flood risk was obtained from JBA Consulting. Details of their flood modelling methodologies are available via the references given above.