An overview of the *ClimateXChange Adaptation Indicators* for freshwater: approach, utility and the way forward

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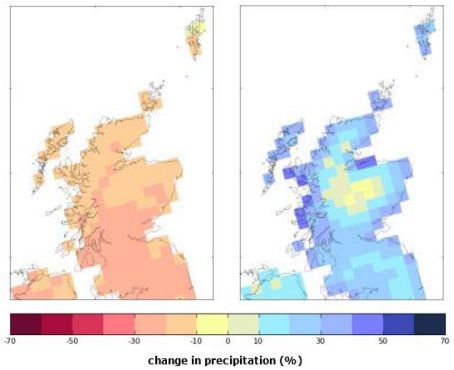
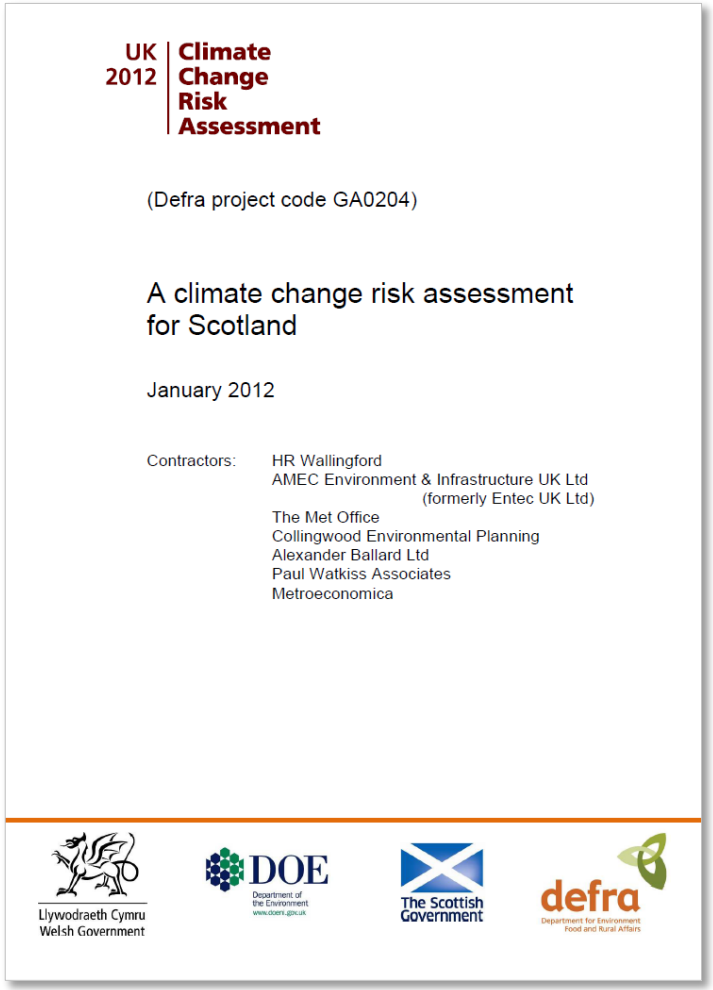


climate change

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

Adaptation Indicators- origin and policy context

- ↑ Temperature
- ↑ Heat waves
- ↓ Rainfall (summer)
- ↑ Rainfall (winter)
- ↑ Extreme rainfall events
- ↑ Sea level
- ? Wind storms



UK 2012 Climate Change Risk Assessment

(Defra project code GA0204)

A climate change risk assessment for Scotland

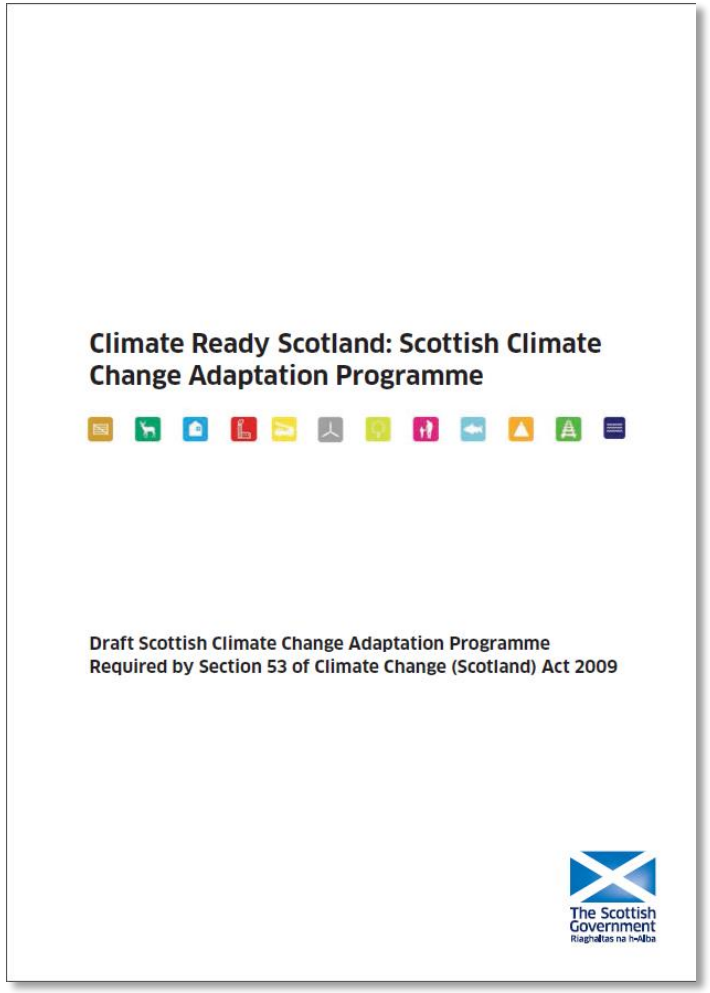
January 2012

Contractors: HR Wallingford
AMEC Environment & Infrastructure UK Ltd (formerly Entec UK Ltd)
The Met Office
Collingwood Environmental Planning
Alexander Ballard Ltd
Paul Watkiss Associates
Metroeconomica

Llywodraeth Cymru Welsh Government · DOE Department of the Environment · The Scottish Government · defra Department for Environment Food and Rural Affairs

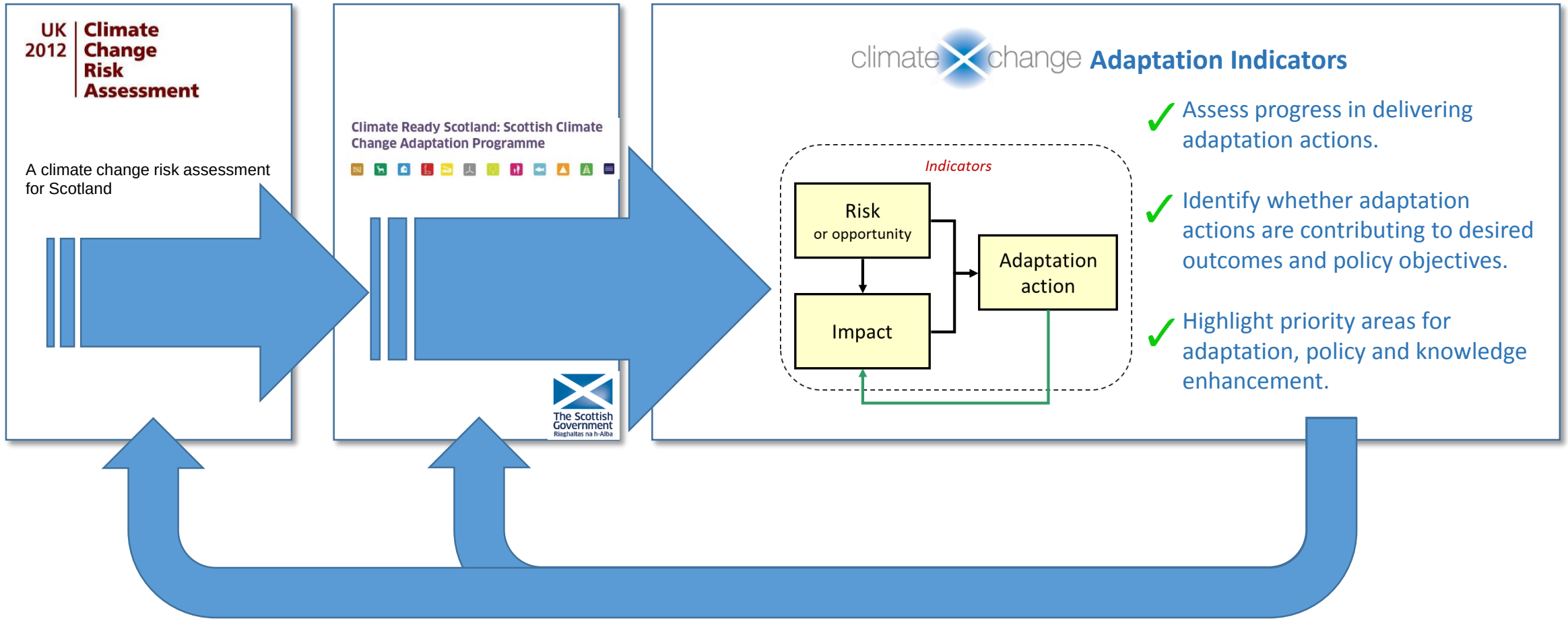
- Climate Change Act 2008: 5-yearly assessments of risk
- First Climate Change Risk Assessment (CCRA) published January 2012
- Assessment of **current and predicted threats and opportunities** from climate change up until 2100
- Five themes:
  - Natural Environment
  - Agriculture and Forestry
  - Business and Services
  - Infrastructure and Buildings
  - Health and Wellbeing

Adaptation Indicators- origin and policy context

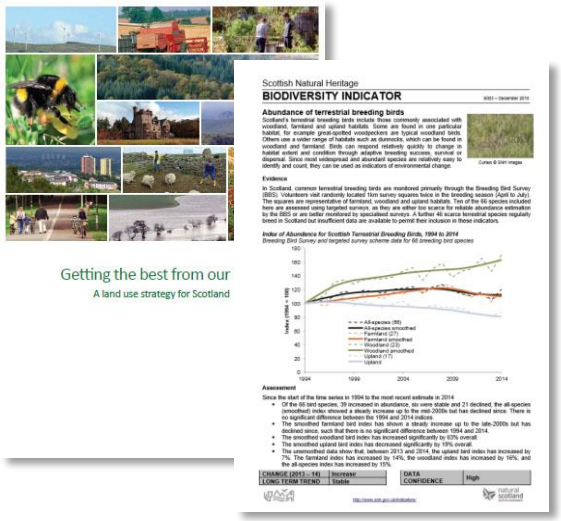


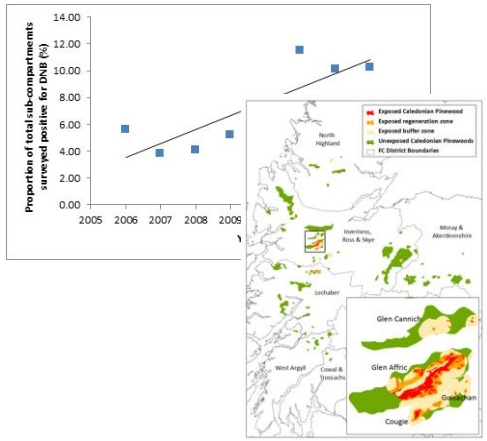
- Objectives in relation to adaptation to climate change
- Proposals and policies for meeting those objectives
- Three themes:
- Natural Environment
- Buildings and Infrastructure Networks
- Society

Adaptation Indicators- origin and policy context

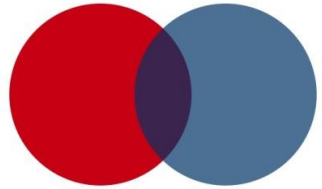


Indicator approach





- Priority – indicators relevant to Scotland
- Using existing indicators where appropriate
- Use existing data but some new analysis also
- High level and cross-cutting where possible



- Extensive stakeholder engagement

The Scottish Government

Forestry Commission Scotland

SCOTTISH NATURAL HERITAGE

HISTORIC ENVIRONMENT SCOTLAND

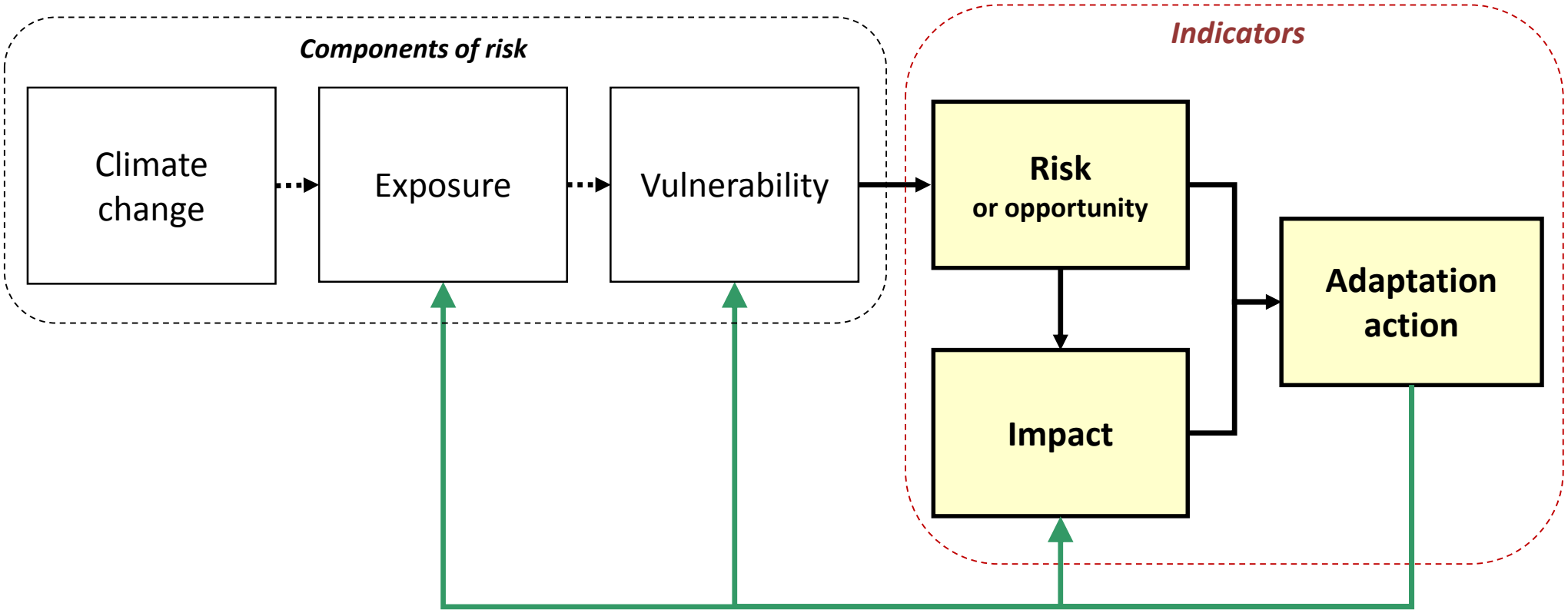
SEPA Scottish Environment Protection Agency

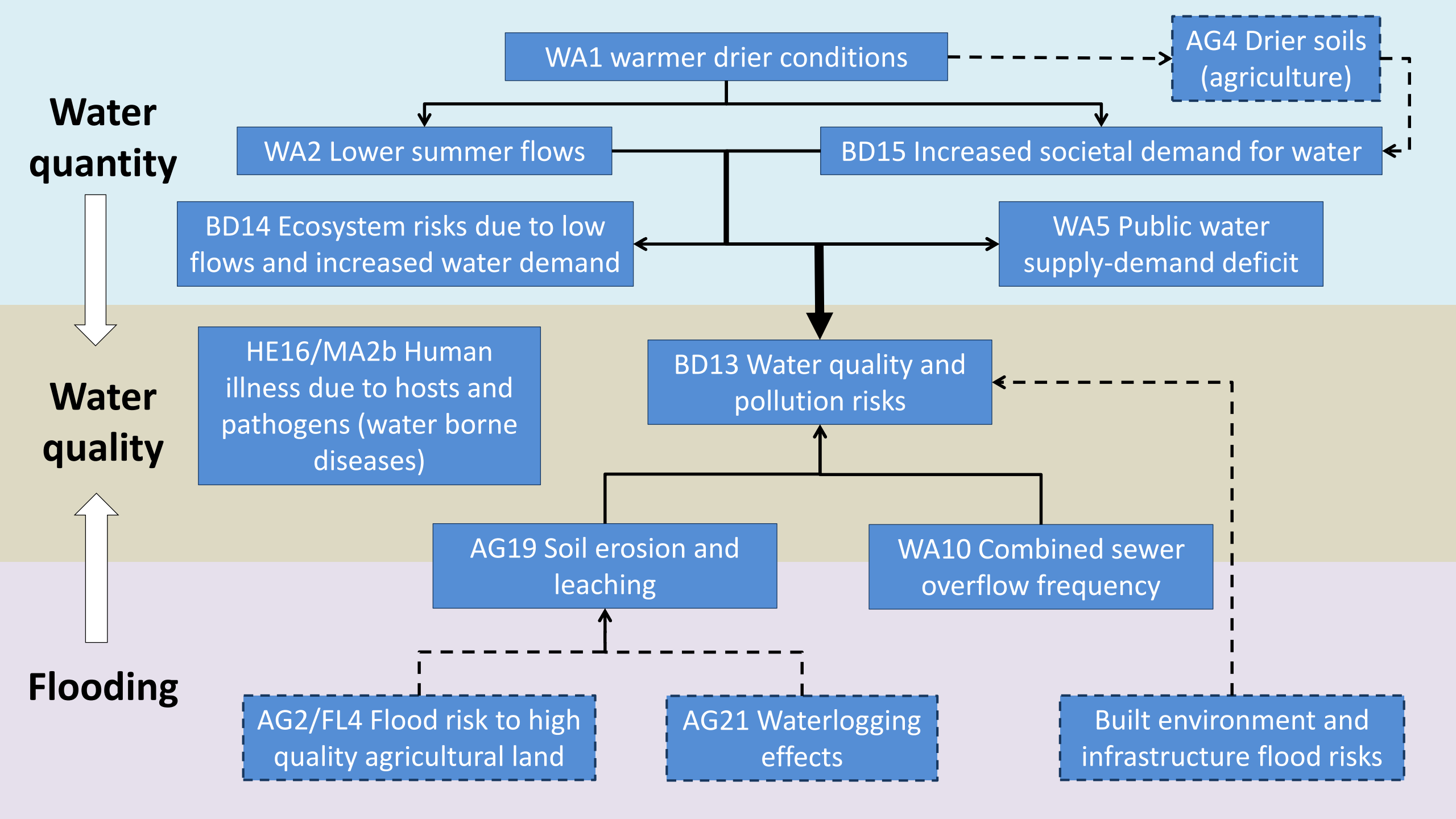
TRANSPORT SCOTLAND CÒMHDHAIL ALBA

Scottish Water Always serving Scotland

NHS SCOTLAND

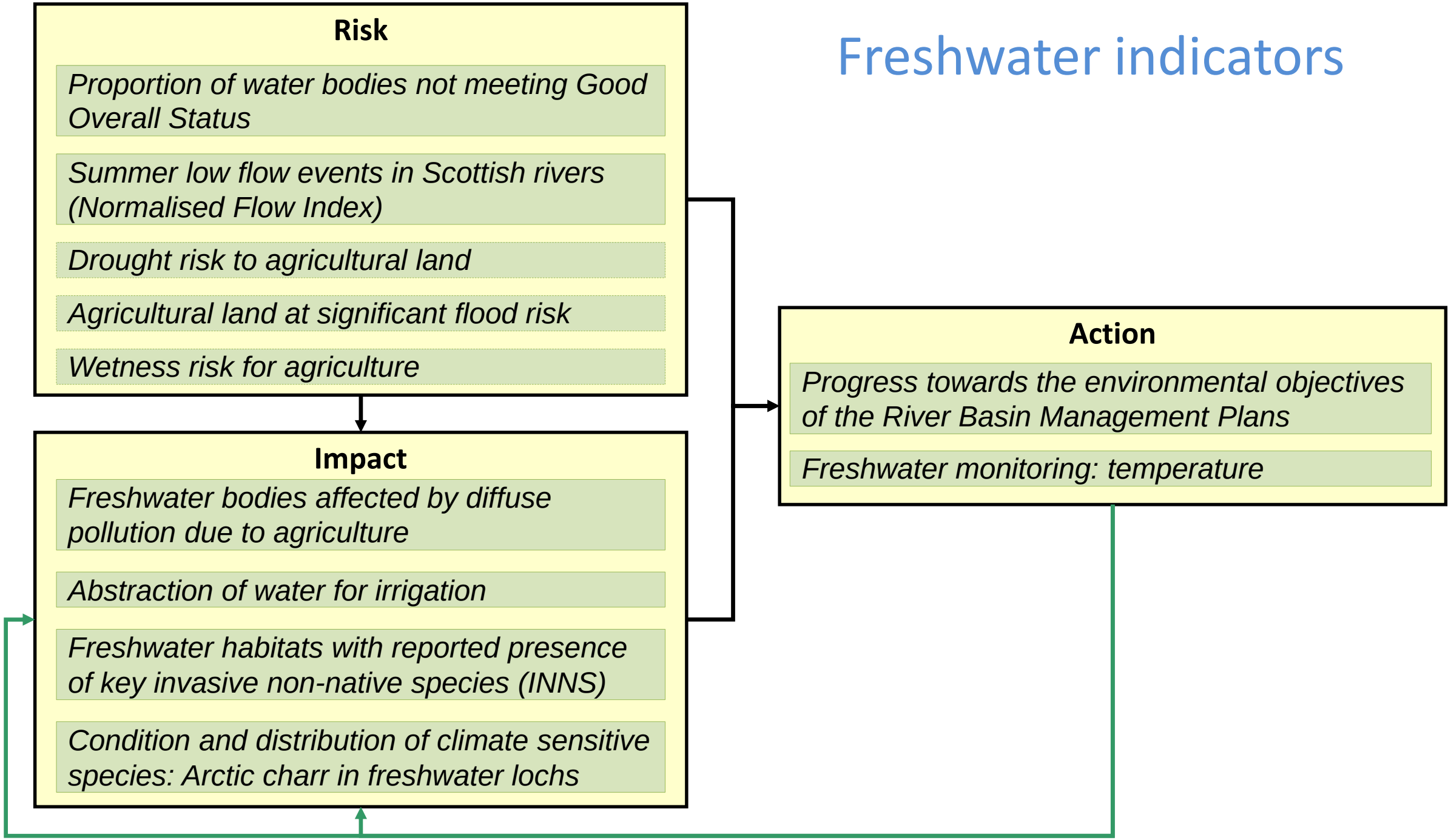
Indicator approach



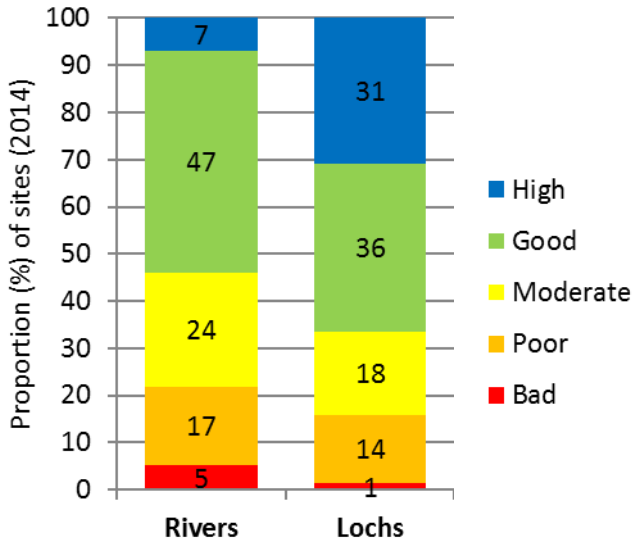

Water quantity
Water quality
Flooding
WA1 warmer drier conditions
AG4 Drier soils (agriculture)
WA2 Lower summer flows
BD15 Increased societal demand for water
BD14 Ecosystem risks due to low flows and increased water demand
WA5 Public water supply-demand deficit
HE16/MA2b Human illness due to hosts and pathogens (water borne diseases)
BD13 Water quality and pollution risks
AG19 Soil erosion and leaching
WA10 Combined sewer overflow frequency
AG2/FL4 Flood risk to high quality agricultural land
AG21 Waterlogging effects
Built environment and infrastructure flood risks

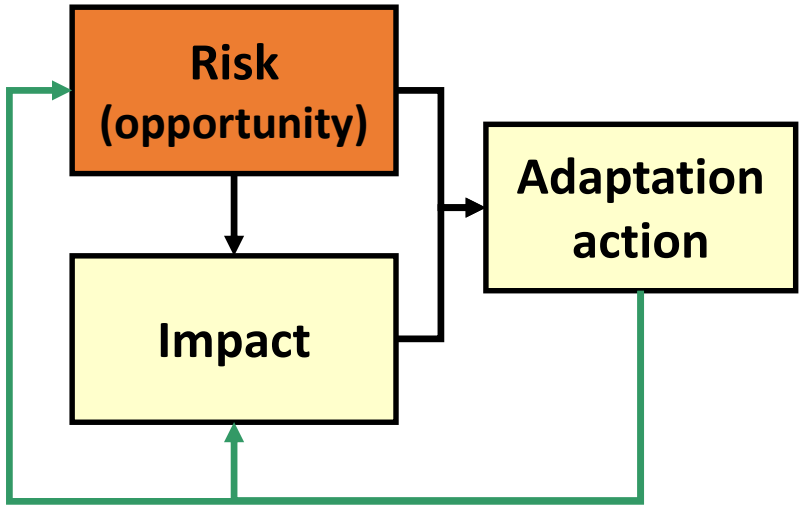

BD5 Species unable to track changing climate space
BD3/4 Risks of pests and diseases to biodiversity
BD11 Generalist species more able to adapt than specialists
BD46 Loss of service through loss of keystone species

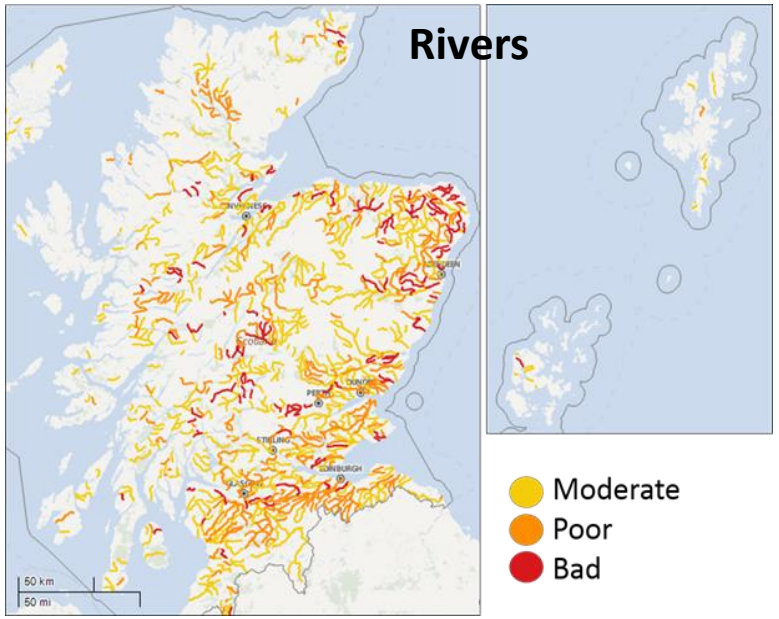
Freshwater indicators



Risk Proportion of water bodies not meeting Good Overall Status



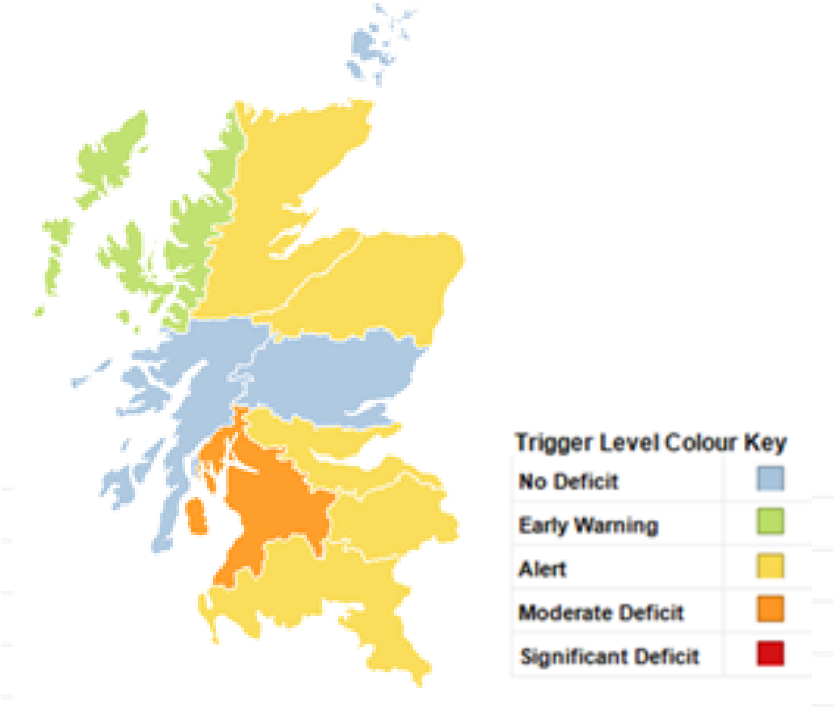




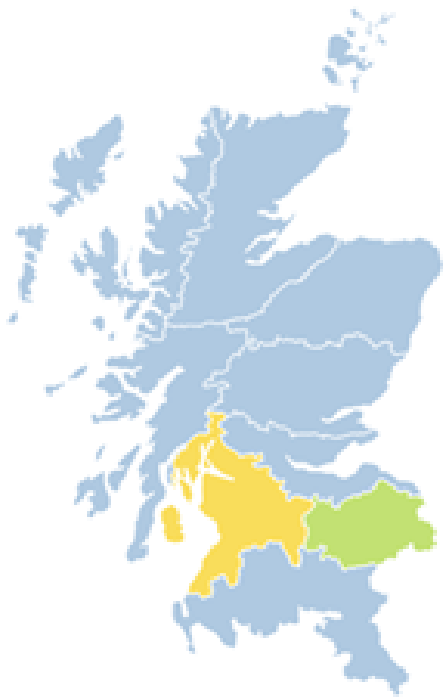
Source: SEPA WFD classification system

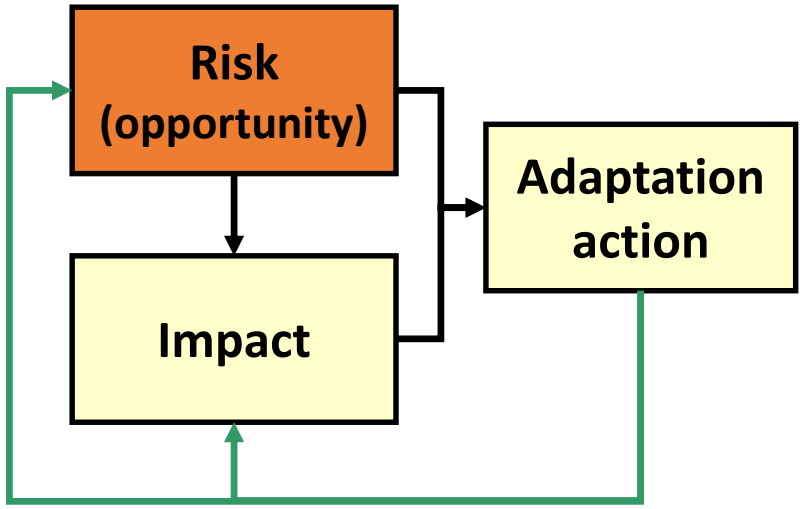
Risk Summer low flow events in Scottish rivers (Normalised Flow Index)

Summer 30-day low flow index



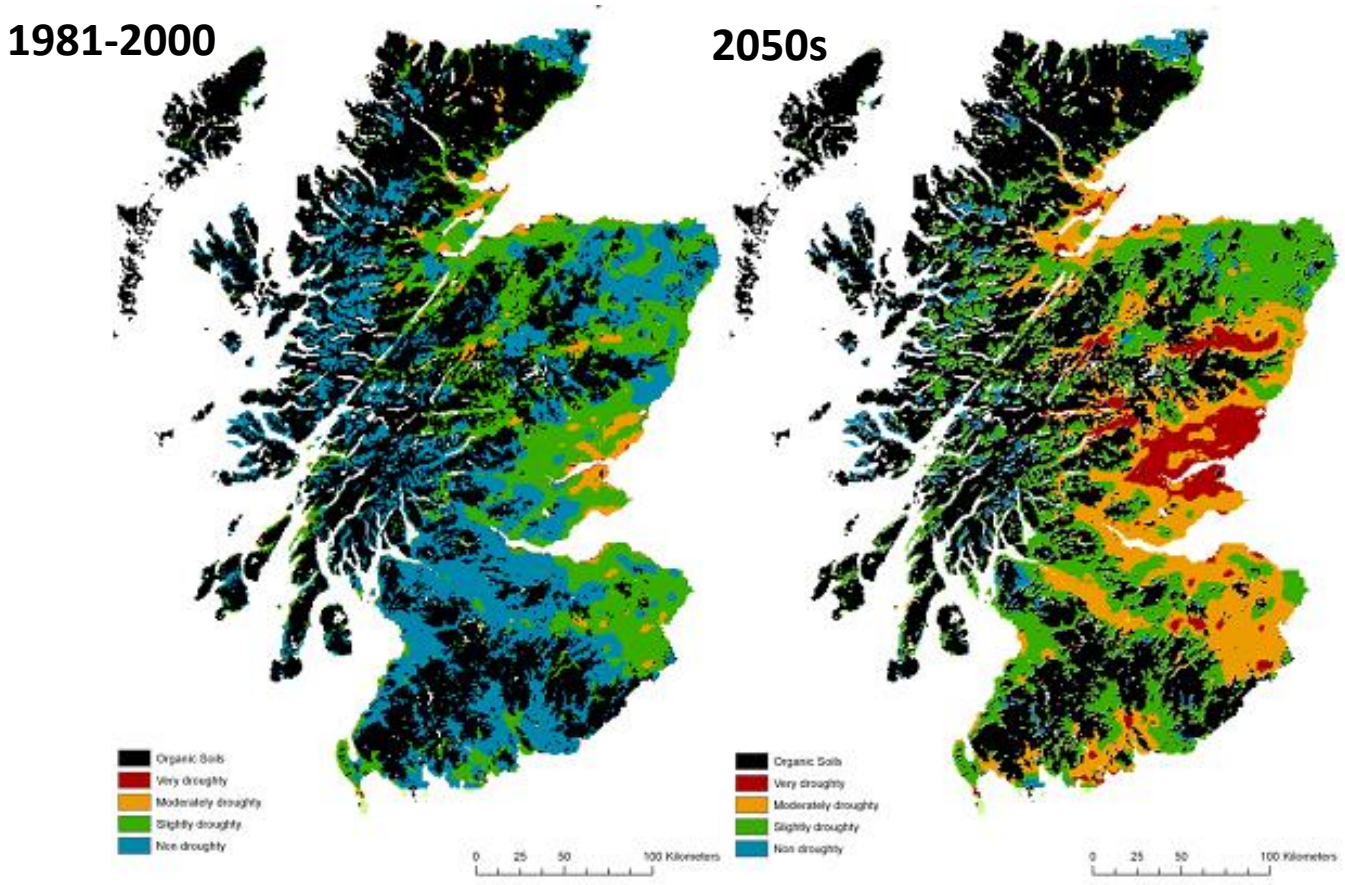
Summer 90-day low flow index



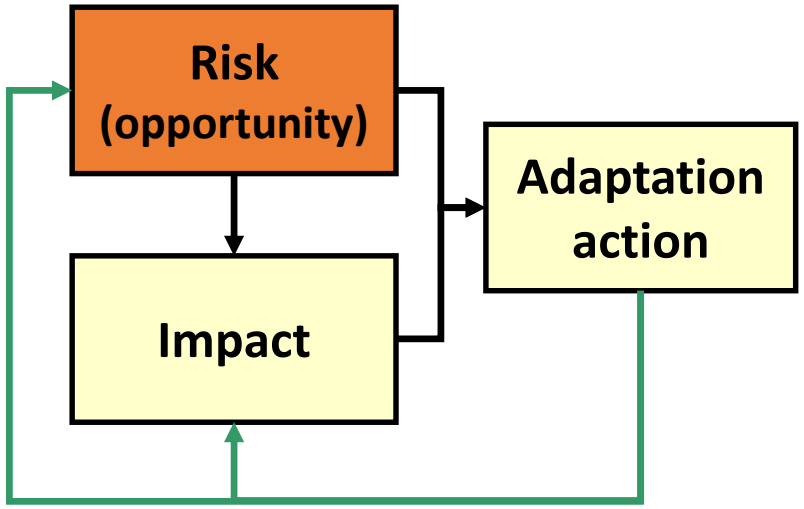


Source: SEPA- indices calculated from flow gauging station data

Risk Drought risk to agricultural land



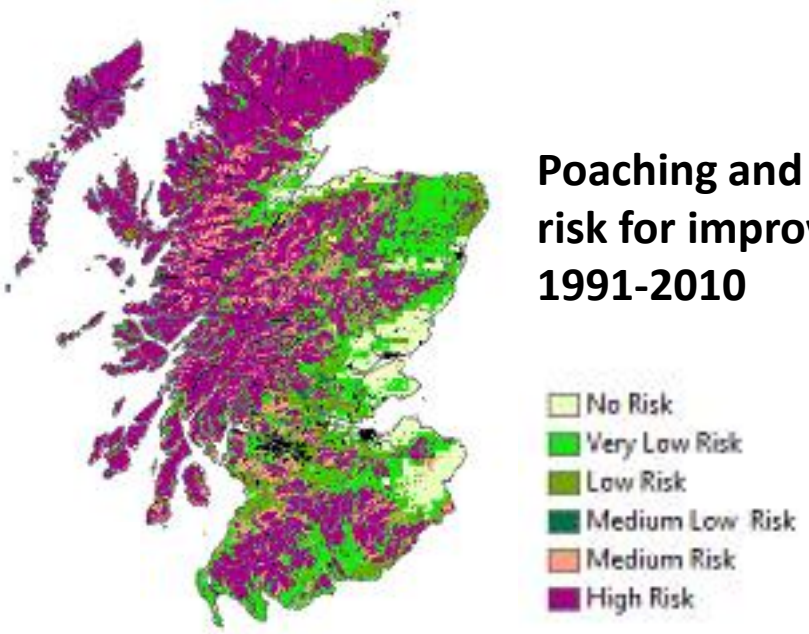
Drought risk for wheat (HadRM3 SCP q3 scenario)



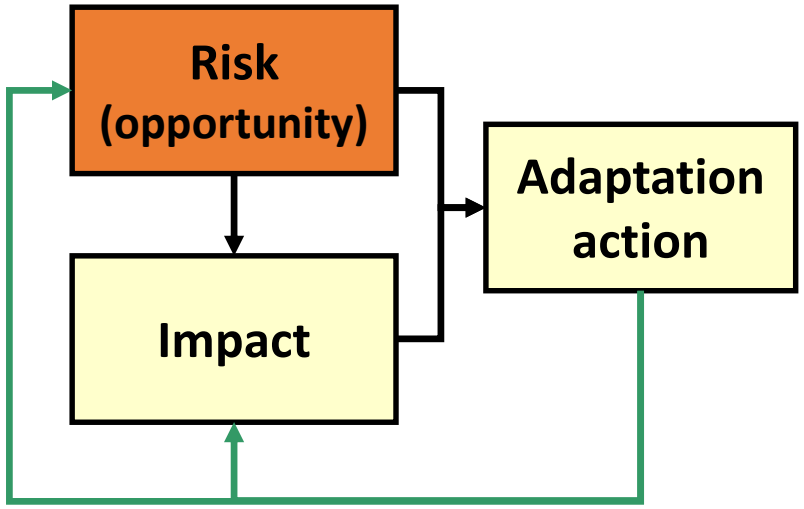
Source: JHI- Land Capability for Agriculture

Risk Wetness risk to agriculture

	Arable land	Improved grassland
Low risk	ca. 24000km^2	ca. 27000km^2
Medium risk	ca. 4000km^2	ca.7000km^2
High risk	ca. 44000km^2	ca.38000km^2



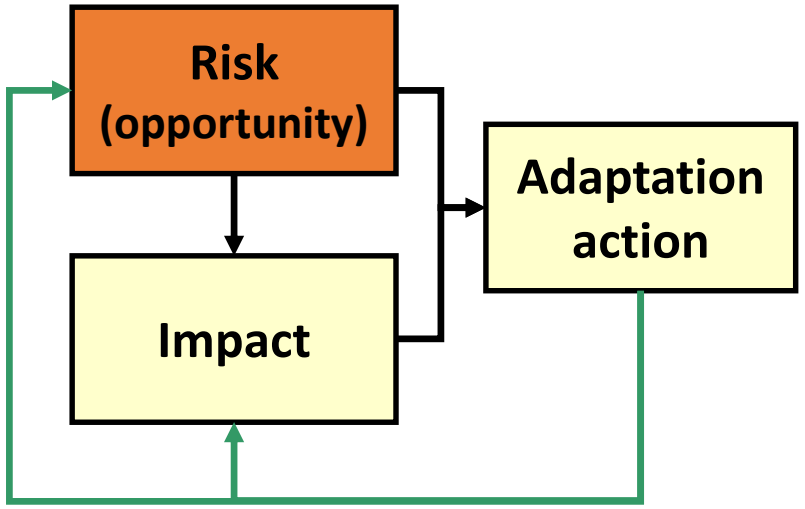
Poaching and trafficability risk for improved grassland 1991-2010



Source: JHI- Land Capability for Agriculture

Risk Agricultural land at significant flood risk

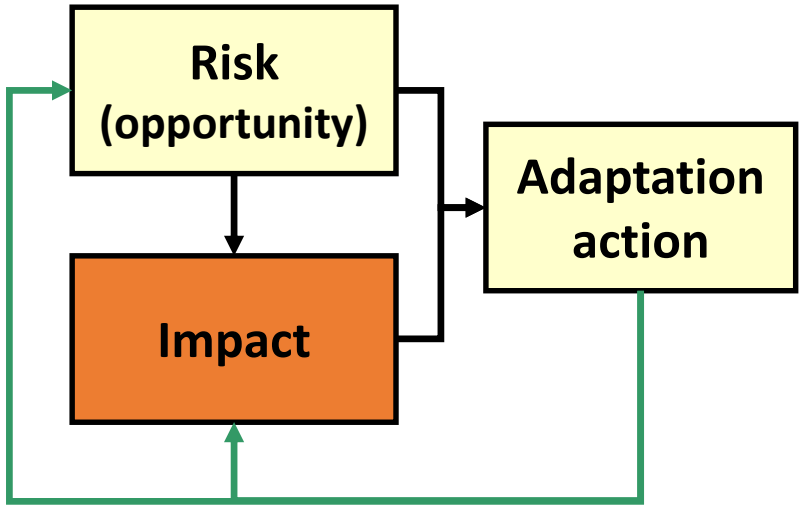
	Area of arable agricultural land at risk (ha)		
	10 year	50 year	200 year
Fluvial	150,000	170,000	190,000
Coastal	17,000	19,000	22,000



Source: SEPA- FRM Strategy Characterisation Data

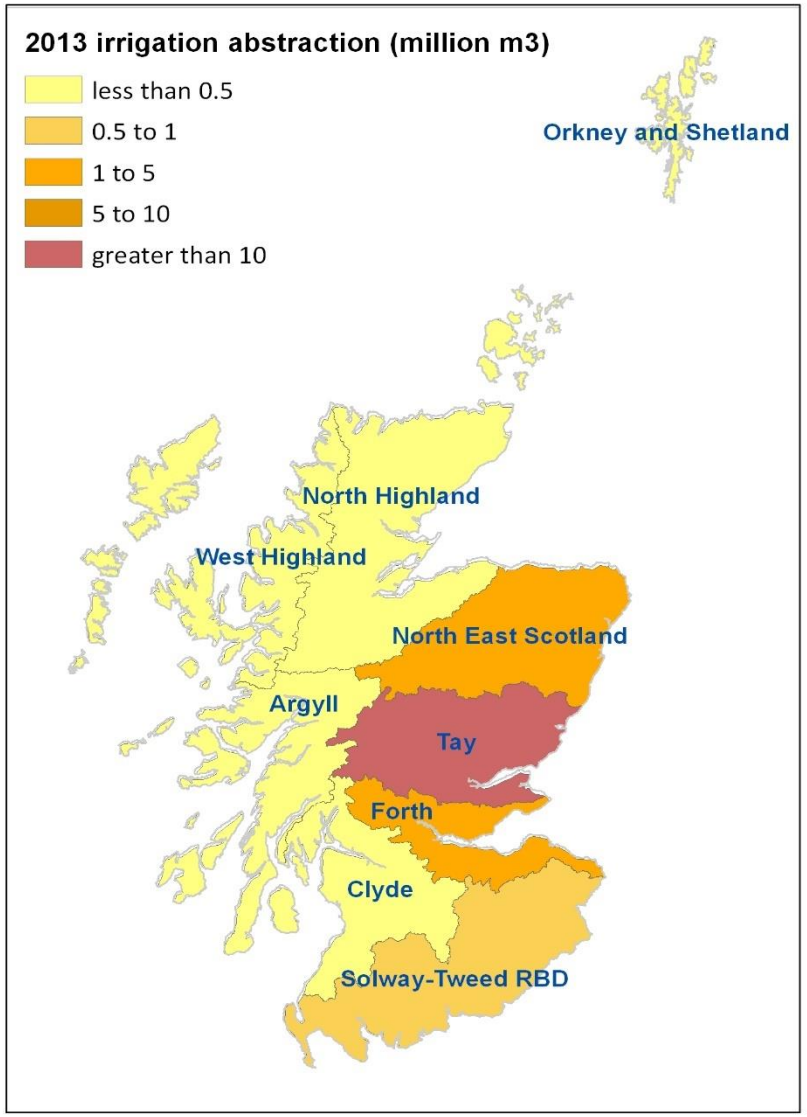
Impact Freshwater bodies affected by diffuse pollution due to agriculture

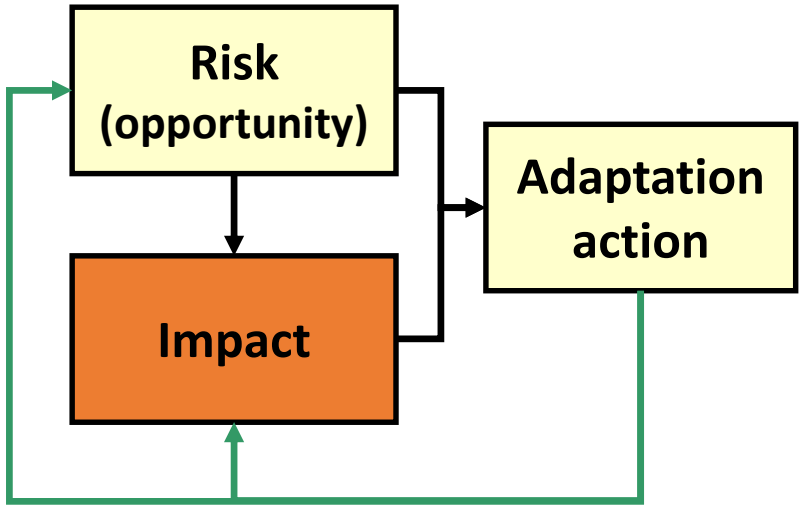
Water body type	Proportion of water bodies (%)	Proportion of area/ length (%)
River	9.4	9.3
Lake	7.5	3.5
Estuaries	4.1	1.1
Coastal	0.0	0.0
Groundwater	9.9	6.6



Source: SEPA- All pressure and measure data

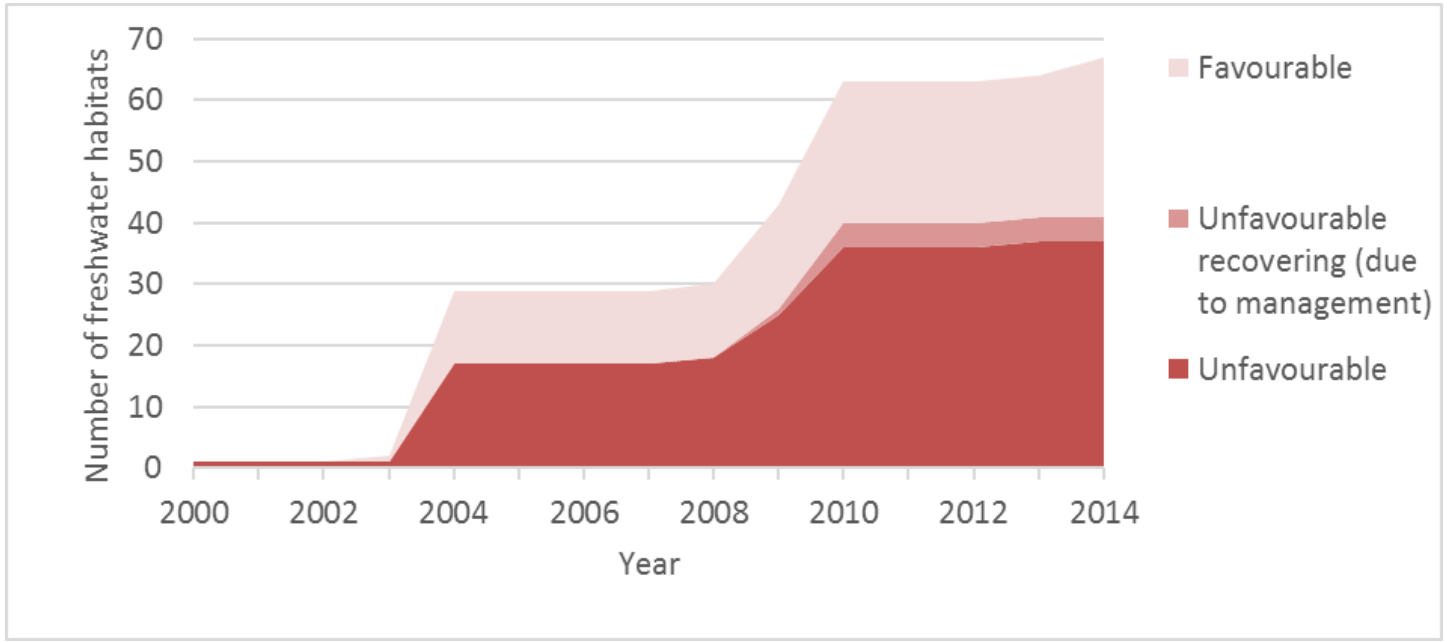
Impact Abstraction of water for irrigation

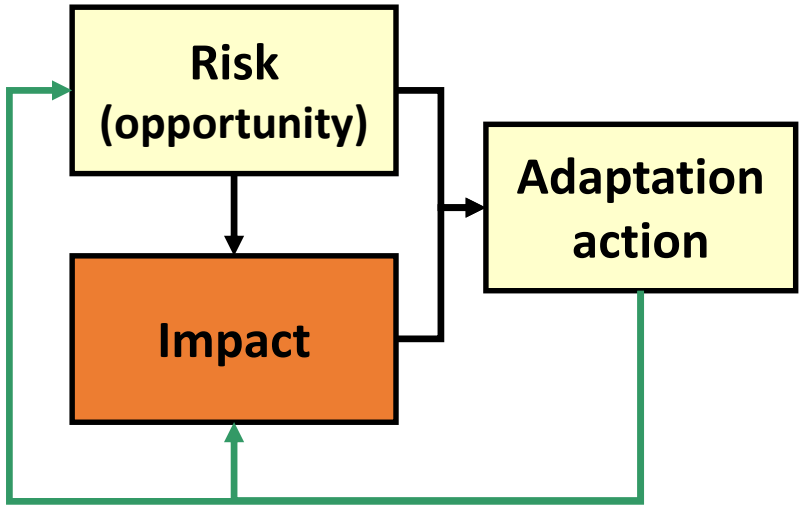




Source: SEPA- analysis of Controlled Activities Regulations Water Use Licences and Water Resources Data Returns

Impact Freshwater habitats with reported presence of key invasive non-native species

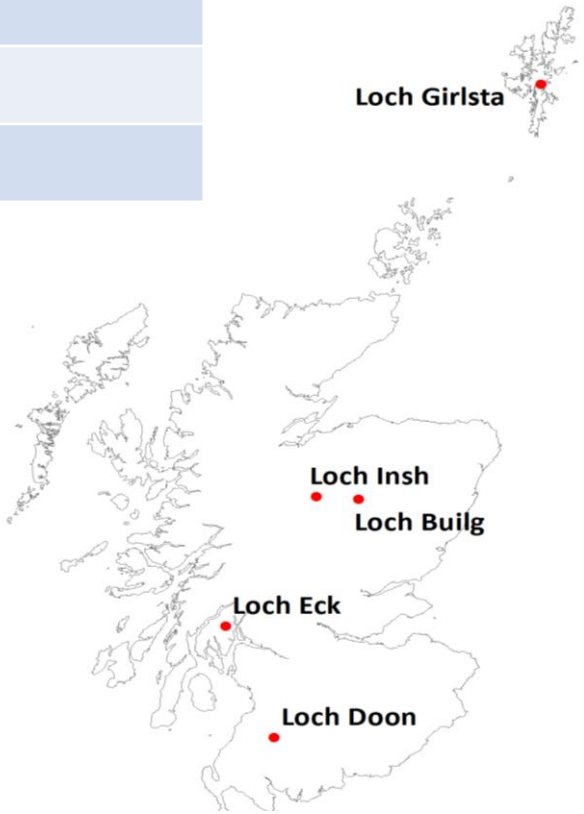


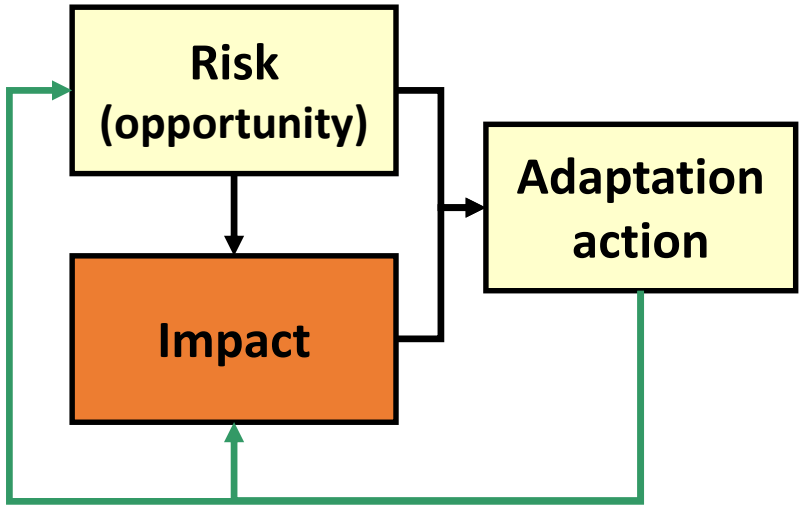


Source: SNH- Site Condition Monitoring

Impact Condition and distribution of climate sensitive species: Abundance of Arctic charr in freshwater lochs

Location	Significant trend (P <0.05)
Loch Builg	↓
Loch Doon	↓
Loch Eck	↓
Loch Girlsta	↑
Loch Insh	↓

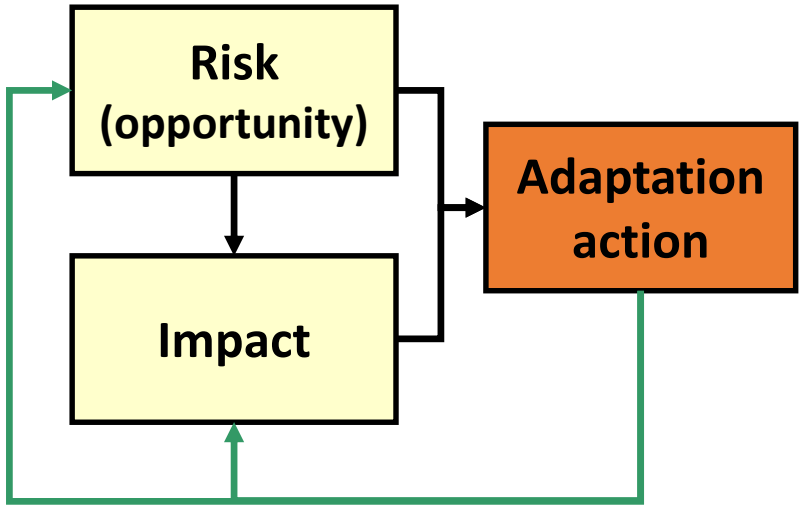




Source: Winfield *et al*- Hydrobiologia (2010)

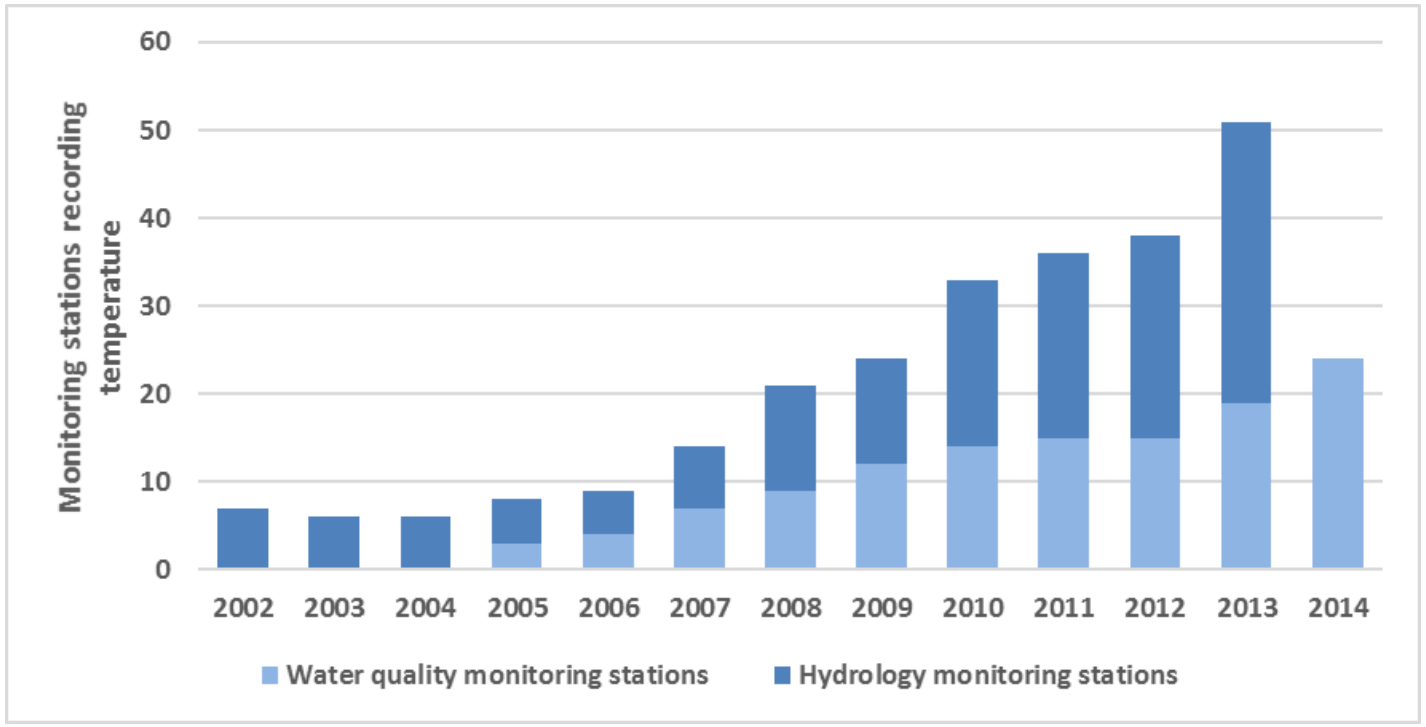
Action Progress towards the environmental objectives of the River Basin Management Plans

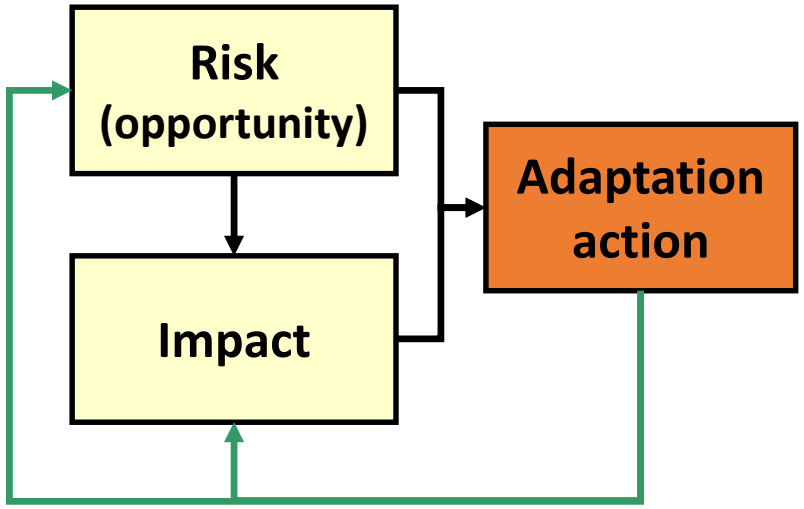
Surface water bodies	Proportion meeting 2015 objective (%)	Proportion in good or better status (%)*	
		Scotland RBD	Solway RBD
Rivers	75	55 (63)	46 (52)
Lochs	82	70 (71)	16 (52)
Estuaries	82	90 (85)	90 (83)
Coastal	83	97 (97)	100 (100)
		* 2015 target in brackets	



Source: SEPA- RBMP data

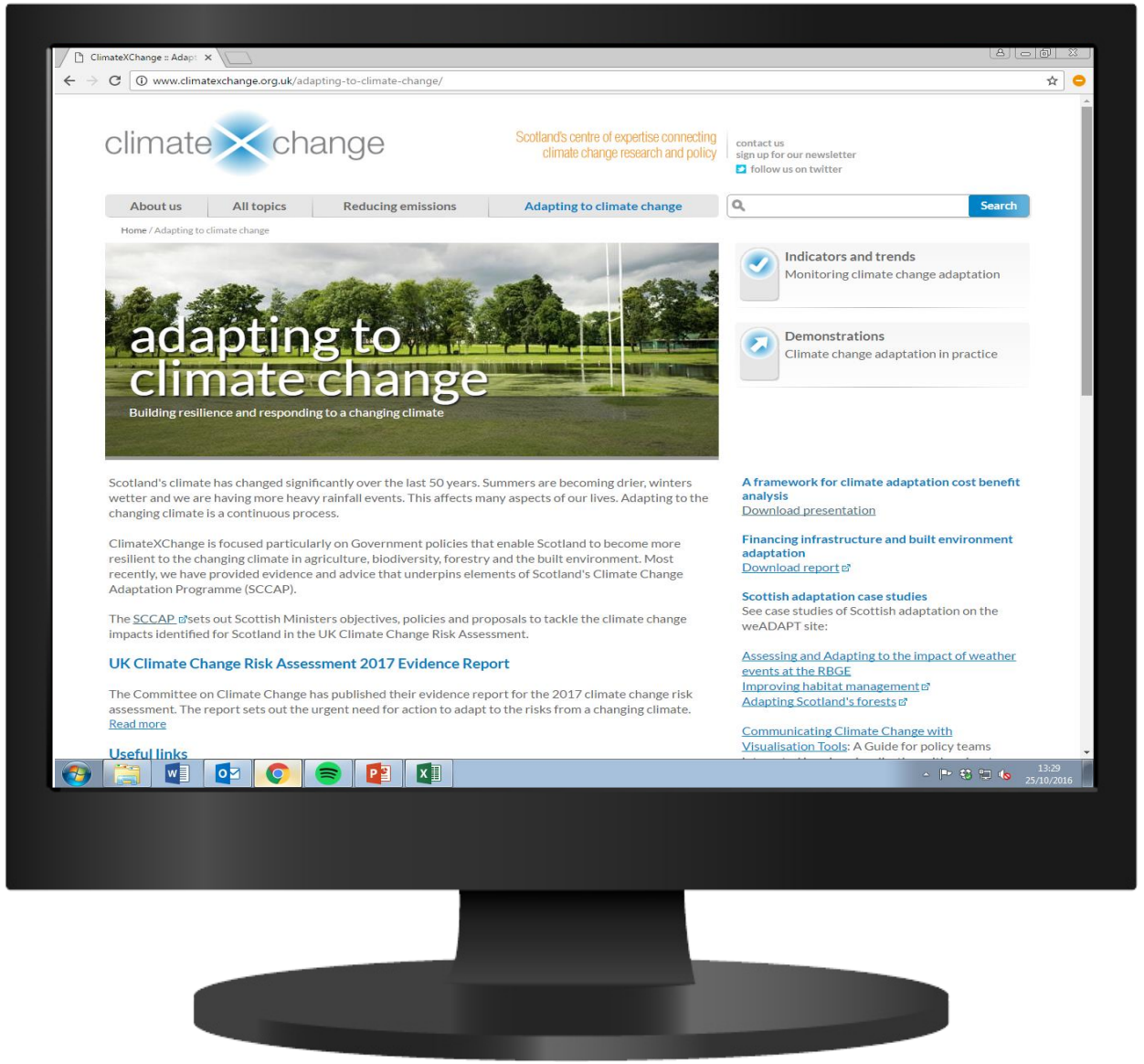
Action Freshwater monitoring stations: temperature



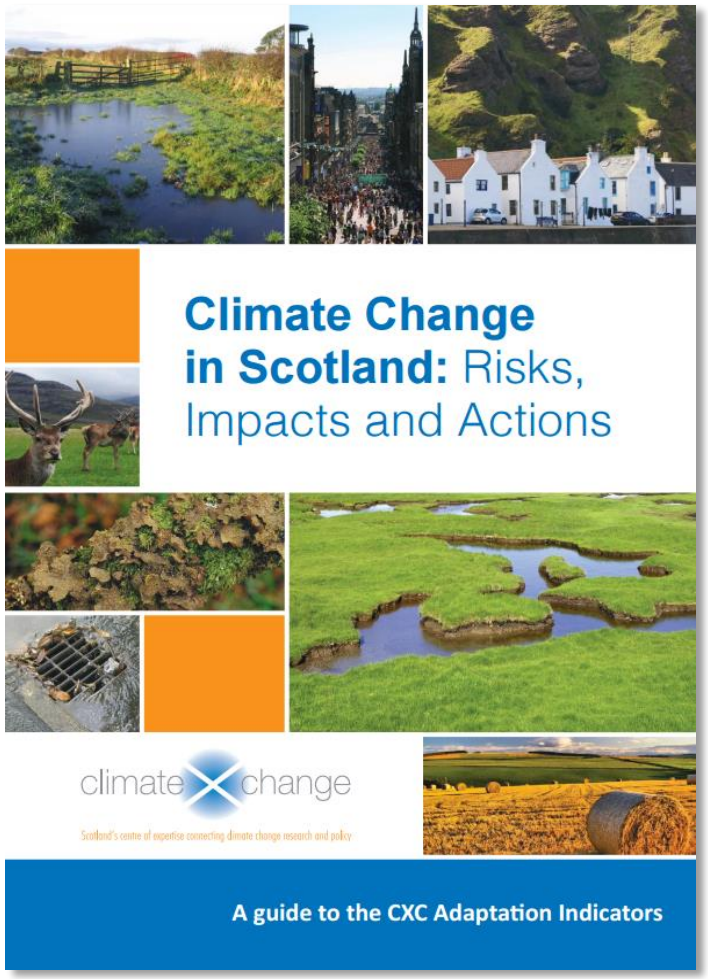


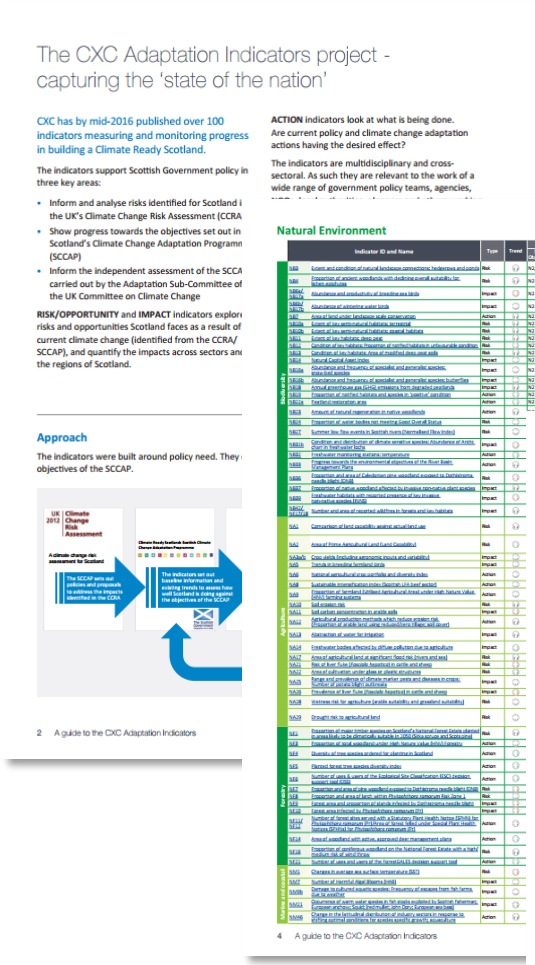
Source: SEPA- monitoring station records

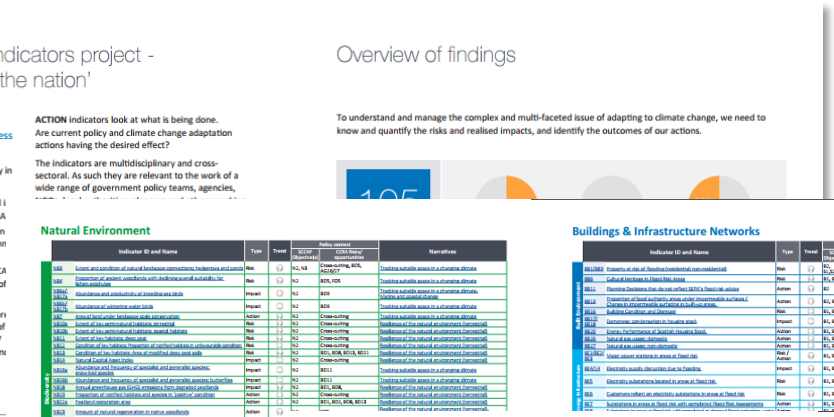
Communication of Adaptation Indicators: Website



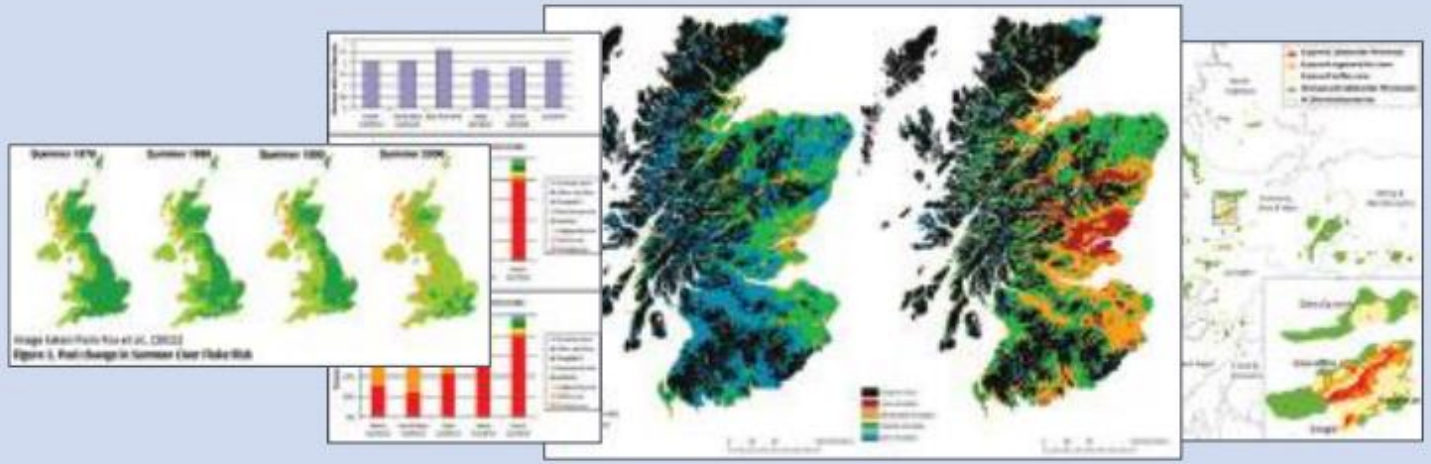
Communication of Adaptation Indicators: Indicator guide







Communication of Adaptation Indicators: Narratives



Narratives bring interlinked indicators together to explore key adaptation questions

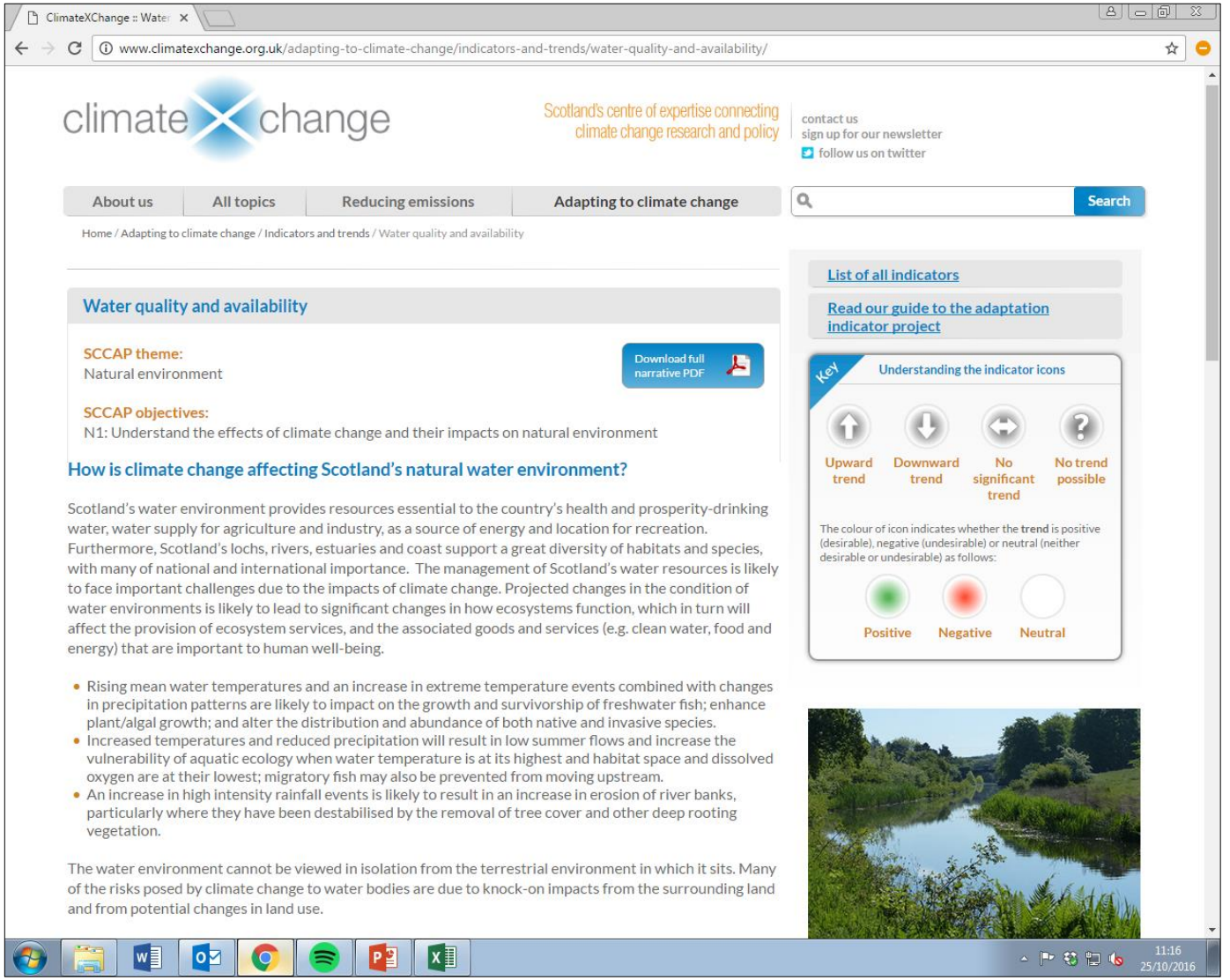
What is happening? What are the adaptation options? What are the policy levers?

An overarching storyline links related Risk, Impact and Action indicators in the context of the adaptation issue and policy landscape

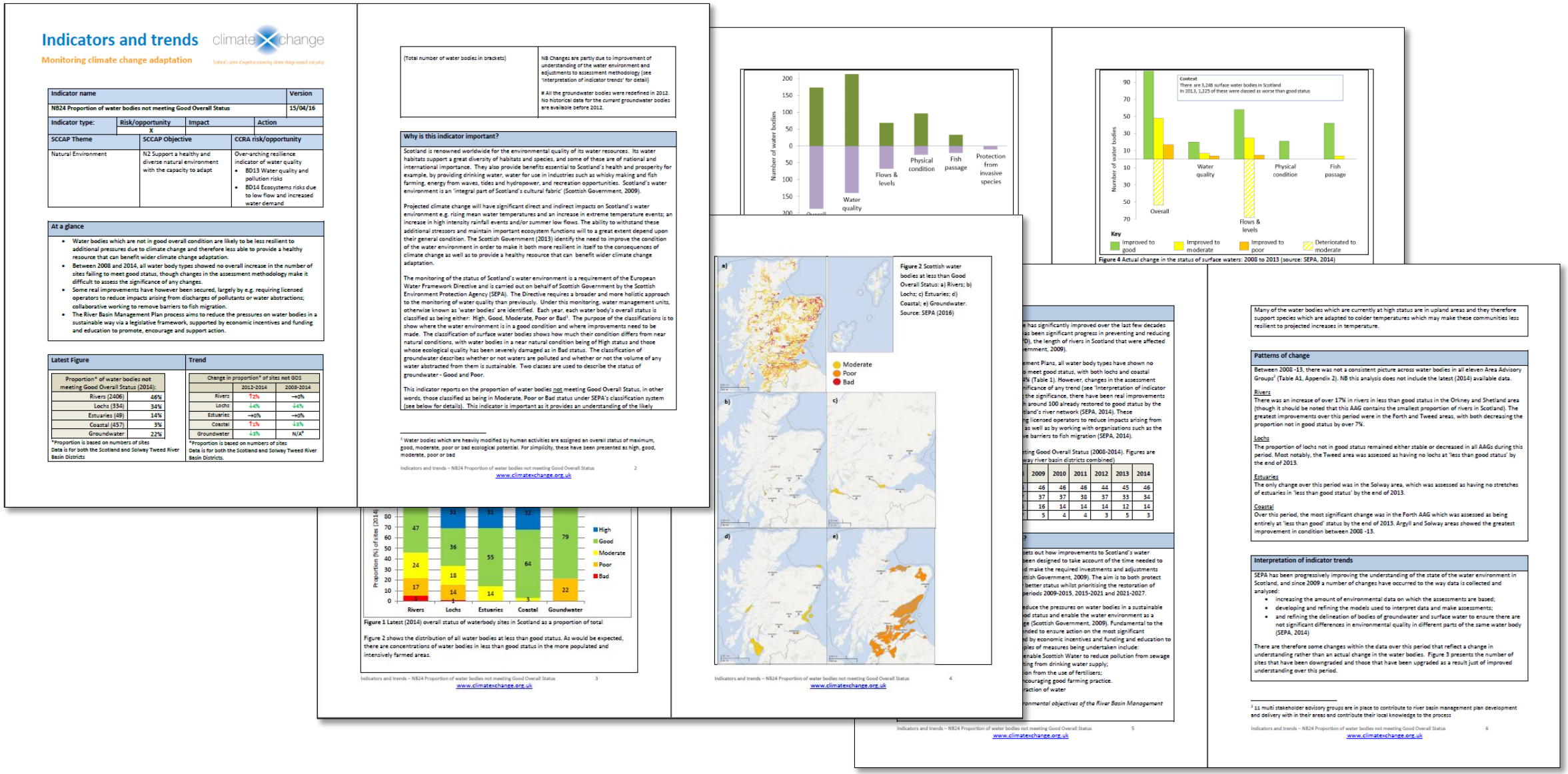
Communication of Adaptation Indicators: Narratives

Natural Environment:

- Tracking suitable space in a changing climate
- Resilience of the natural environment (terrestrial)
- Pests, diseases and invasive species (forestry)
- Suitability and productivity (forestry)
- Suitability and productivity (agriculture)
- Sustainable agriculture
- Condition of agricultural soils
- Water quality and availability
- Marine and coastal change



Communication of Adaptation Indicators: Indicator documents



Indicators and trends

Monitoring climate change adaptation

climate change

Indicator name				Version
NB24 Proportion of water bodies not meeting Good Overall Status				15/04/16
Indicator type:	Risk/opportunity	Impact	Action	
	X			
SCCAP Theme	SCCAP Objective	CCRA risk/opportunity		
Natural Environment	N2 Support a healthy and diverse natural environment with the capacity to adapt	Over-arching resilience indicator of water quality • BD13 Water quality and pollution risks • BD14 Ecosystems risks due to low flow and increased water demand		

At a glance

- Water bodies which are not in good overall condition are likely to be less resilient to additional pressures due to climate change and therefore less able to provide a healthy resource that can benefit wider climate change adaptation.
- Between 2008 and 2014, all water body types showed no overall increase in the number of sites failing to meet good status, though changes in the assessment methodology make it difficult to assess the significance of any changes.
- Some real improvements have however been secured, largely by e.g. requiring licensed operators to reduce impacts arising from discharges of pollutants or water abstractions; collaborative working to remove barriers to fish migration.
- The River Basin Management Plan process aims to reduce the pressures on water bodies in a sustainable way via a legislative framework, supported by economic incentives and funding and education to promote, encourage and support action.

Latest Figure	
Proportion* of water bodies not meeting Good Overall Status (2014):	
Rivers (2406)	46%
Lochs (334)	34%
Estuaries (49)	14%
Coastal (457)	3%
Groundwater	22%

*Proportion is based on numbers of sites
Data is for both the Scotland and Solway Tweed River Basin Districts

Trend		
Change in proportion* of sites not GOS		
	2012-2014	2008-2014
Rivers	↑2%	→0%
Lochs	↓4%	↓4%
Estuaries	→0%	→0%
Coastal	↑1%	↓3%
Groundwater	↓3%	N/A[a]

*Proportion is based on numbers of sites
Data is for both the Scotland and Solway Tweed River Basin Districts.

(Total number of water bodies in brackets)	NB Changes are partly due to improvement of understanding of the water environment and adjustments to assessment methodology (see 'Interpretation of indicator trends' for detail) # All the groundwater bodies were redefined in 2012. No historical data for the current groundwater bodies are available before 2012.

Why is this indicator important?

Scotland is renowned worldwide for the environmental quality of its water resources. Its water habitats support a great diversity of habitats and species, and some of these are of national and international importance. They also provide benefits essential to Scotland's health and prosperity for example, by providing drinking water, water for use in industries such as whisky making and fish farming, energy from waves, tides and hydropower, and recreation opportunities. Scotland's water environment is an 'integral part of Scotland's cultural fabric' (Scottish Government, 2009).

Projected climate change will have significant direct and indirect impacts on Scotland's water environment e.g. rising mean water temperatures and an increase in extreme temperature events; an increase in high intensity rainfall events and/or summer low flows. The ability to withstand these additional stressors and maintain important ecosystem functions will to a great extent depend upon their general condition. The Scottish Government (2013) identify the need to improve the condition of the water environment in order to make it both more resilient in itself to the consequences of climate change as well as to provide a healthy resource that can benefit wider climate change adaptation.

The monitoring of the status of Scotland's water environment is a requirement of the European Water Framework Directive and is carried out on behalf of Scottish Government by the Scottish Environment Protection Agency (SEPA). The Directive requires a broader and more holistic approach to the monitoring of water quality than previously. Under this monitoring, water management units, otherwise known as 'water bodies' are identified. Each year, each water body's overall status is classified as being either: High, Good, Moderate, Poor or Bad[1]. The purpose of the classifications is to show where the water environment is in a good condition and where improvements need to be made. The classification of surface water bodies shows how much their condition differs from near natural conditions, with water bodies in a near natural condition being of High status and those whose ecological quality has been severely damaged as in Bad status. The classification of groundwater describes whether or not waters are polluted and whether or not the volume of any water abstracted from them is sustainable. Two classes are used to describe the status of groundwater - Good and Poor.

This indicator reports on the proportion of water bodies not meeting Good Overall Status, in other words, those classified as being in Moderate, Poor or Bad status under SEPA's classification system (see below for details). This indicator is important as it provides an understanding of the likely

[1] Water bodies which are heavily modified by human activities are assigned an overall status of maximum, good, moderate, poor or bad ecological potential. For simplicity, these have been presented as high, good, moderate, poor or bad

Figure 1 Latest (2014) overall status of waterbody sites in Scotland as a proportion of total

Figure 2 shows the distribution of all water bodies at less than good status. As would be expected, there are concentrations of water bodies in less than good status in the more populated and intensively farmed areas.

Figure 2 Scottish water bodies at less than Good Overall Status: a) Rivers; b) Lochs; c) Estuaries; d) Coastal; e) Groundwater. Source: SEPA (2016)

Figure 4 Actual change in the status of surface waters: 2008 to 2013 (source: SEPA, 2014)

has significantly improved over the last few decades
as been significant progress in preventing and reducing
D), the length of rivers in Scotland that were affected
ernment, 2009).

ement Plans, all water body types have shown no
o meet good status, with both lochs and coastal
4% (Table 1). However, changes in the assessment
nificance of any trend (see 'Interpretation of indicator
the significance, there have been real improvements
h around 100 already restored to good status by the
tland's river network (SEPA, 2014). These
g licensed operators to reduce impacts arising from
as well as by working with organisations such as the
e barriers to fish migration (SEPA, 2014).

ting Good Overall Status (2008-2014). Figures are
way river basin districts combined)

	2009	2010	2011	2012	2013	2014
	46	46	46	44	45	46
	37	37	38	37	33	34
	16	14	14	14	12	14
	5	4	4	3	5	3

sets out how improvements to Scotland's water
been designed to take account of the time needed to
d make the required investments and adjustments
ttish Government, 2009). The aim is to both protect
better status whilst prioritising the restoration of
periods 2009-2015, 2015-2021 and 2021-2027.

educe the pressures on water bodies in a sustainable
od status and enable the water environment as a
ge (Scottish Government, 2009). Fundamental to the
nded to ensure action on the most significant
d by economic incentives and funding and education to
ples of measures being undertaken include:
enable Scottish Water to reduce pollution from sewage
ting from drinking water supply;
on from the use of fertilisers;
couraging good farming practice.
raction of water

ronmental objectives of the River Basin Management

Many of the water bodies which are currently at high status are in upland areas and they therefore support species which are adapted to colder temperatures which may make these communities less resilient to projected increases in temperature.

Patterns of change

Between 2008 -13, there was not a consistent picture across water bodies in all eleven Area Advisory Groups[2] (Table A1, Appendix 2). NB this analysis does not include the latest (2014) available data.

Rivers
There was an increase of over 17% in rivers in less than good status in the Orkney and Shetland area (though it should be noted that this AAG contains the smallest proportion of rivers in Scotland). The greatest improvements over this period were in the Forth and Tweed areas, with both decreasing the proportion not in good status by over 7%.

Lochs
The proportion of lochs not in good status remained either stable or decreased in all AAGs during this period. Most notably, the Tweed area was assessed as having no lochs at 'less than good status' by the end of 2013.

Estuaries
The only change over this period was in the Solway area, which was assessed as having no stretches of estuaries in 'less than good status' by the end of 2013.

Coastal
Over this period, the most significant change was in the Forth AAG which was assessed as being entirely at 'less than good' status by the end of 2013. Argyll and Solway areas showed the greatest improvement in condition between 2008 -13.

Interpretation of indicator trends

SEPA has been progressively improving the understanding of the state of the water environment in Scotland, and since 2009 a number of changes have occurred to the way data is collected and analysed:

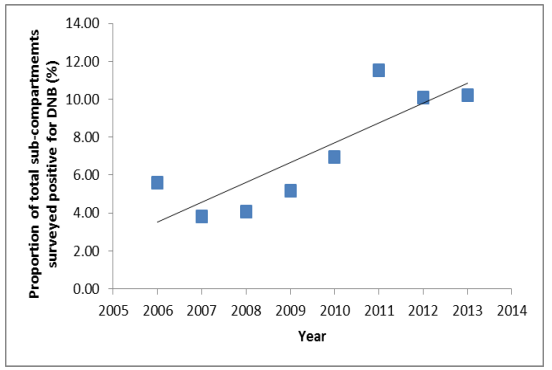
- increasing the amount of environmental data on which the assessments are based;
- developing and refining the models used to interpret data and make assessments;
- and refining the delineation of bodies of groundwater and surface water to ensure there are not significant differences in environmental quality in different parts of the same water body (SEPA, 2014)

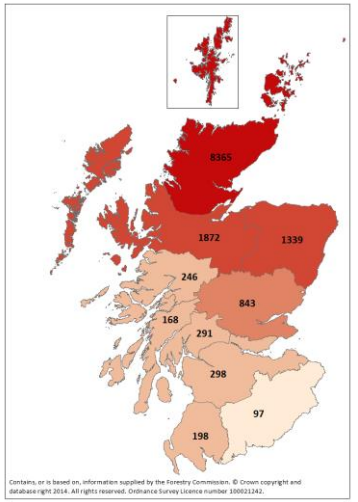
There are therefore some changes within the data over this period that reflect a change in understanding rather than an actual change in the water bodies. Figure 3 presents the number of sites that have been downgraded and those that have been upgraded as a result just of improved understanding over this period.

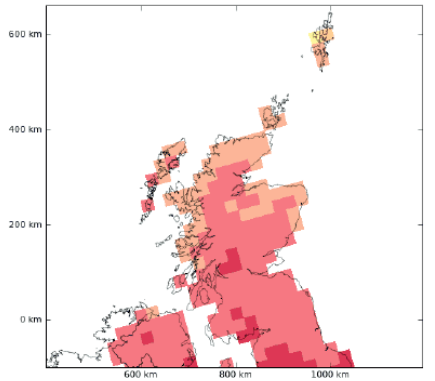
[2] 11 multi stakeholder advisory groups are in place to contribute to river basin management plan development and delivery with in their areas and contribute their local knowledge to the process

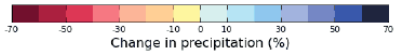
Communication of Adaptation Indicators: Context and analysis

- Relevance: to the climate risk, to other indicators and policy context
- Current state; past trend; future projection
- Critical spatial, temporal or categorical patterns
- Context: climatic and non-climatic drivers



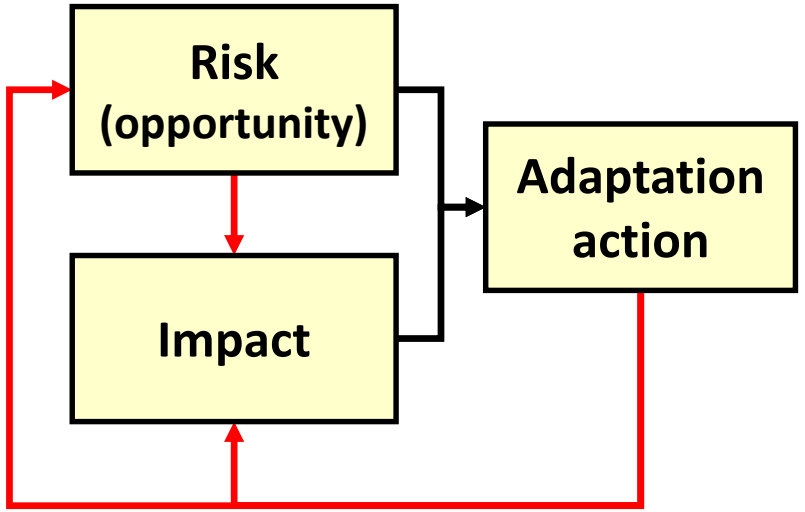






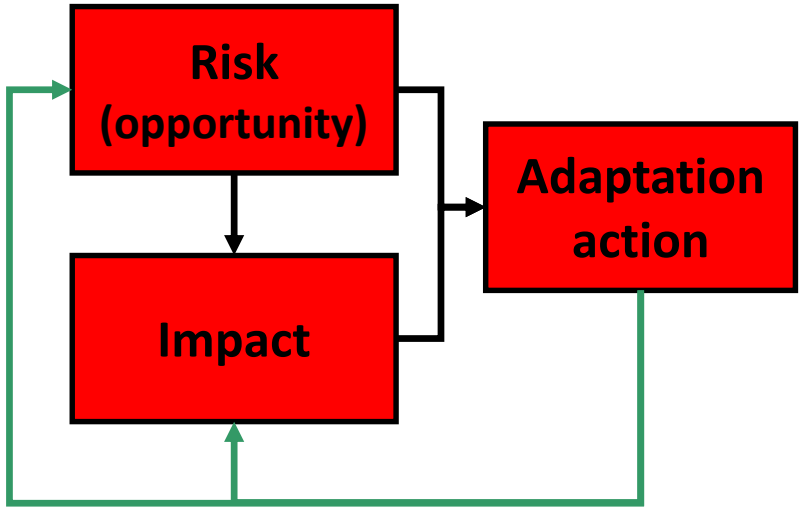
Adaptation Indicators- Development
Quantifying the system

- How significant are climatic drivers in comparison to others?
- How effective are adaptation measures in reducing exposure or vulnerability to that exposure?

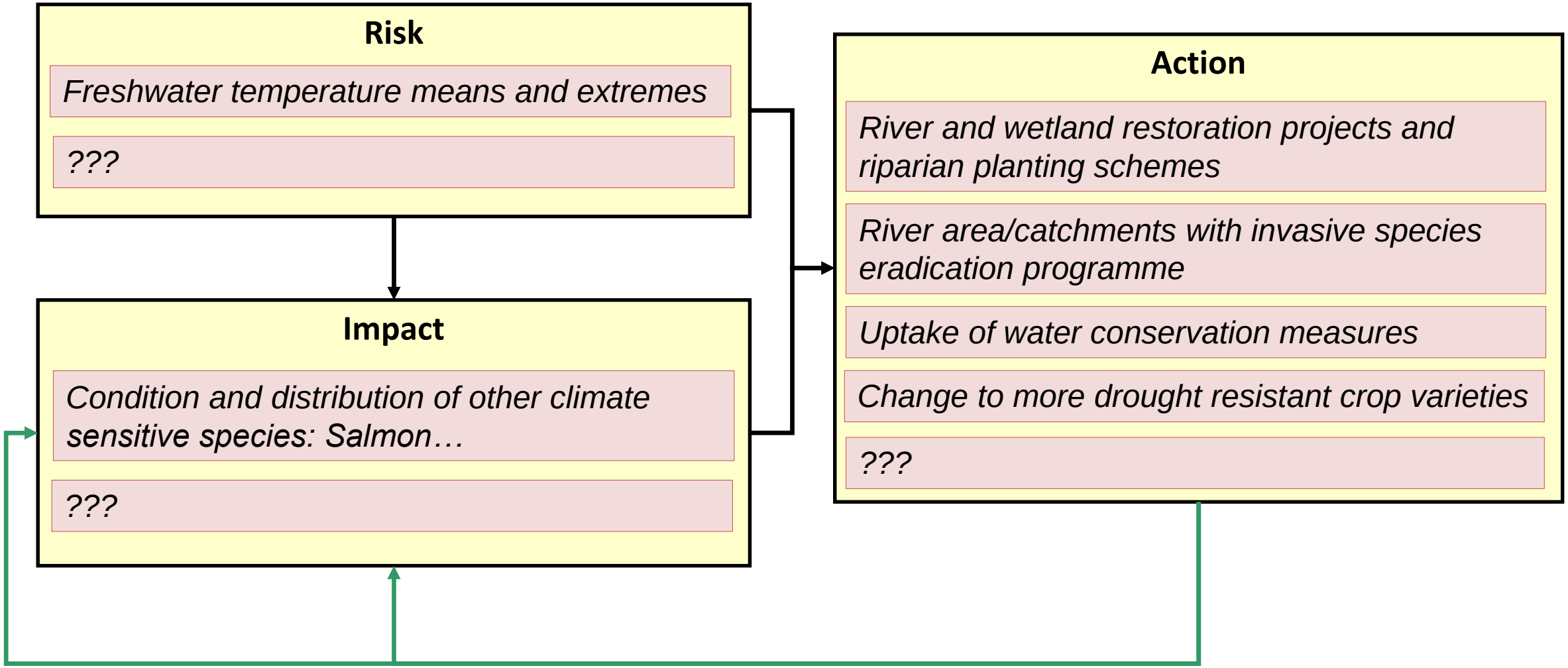


Adaptation Indicators- Development
Data gaps

- Lack of data
- Lack of suitable data
- Lack of available data



Adaptation Indicators- Development
Freshwater indicator gaps



Thank you

http://www.climatexchange.org.uk/

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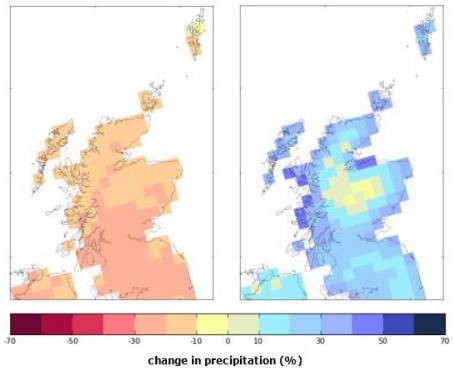

climate change

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