Indicators and trends

Monitoring climate change adaptation

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How is climate change affecting Scotland's natural water environment?	Version
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Scotland's water environment provides resources essential to the country's health and prosperity- drinking water, water supply for agriculture and industry, as a source of energy and location for recreation. Furthermore, Scotland's lochs, rivers, estuaries and coast support a great diversity of habitats and species, with many of national and international importance. The management of Scotland's water resources is likely to face important challenges due to the impacts of climate change. Projected changes in the condition of water environments is likely to lead to significant changes in how ecosystems function, which in turn will affect the provision of ecosystem services, and the associated goods and services (e.g. clean water, food and energy) that are important to human well-being.

- Rising mean water temperatures and an increase in extreme temperature events combined with changes in precipitation patterns are likely to impact on the growth and survivorship of freshwater fish; enhance plant/algal growth; and alter the distribution and abundance of both native and invasive species.
- Increased temperatures and reduced precipitation will result in low summer flows and increase the vulnerability of aquatic ecology when water temperature is at its highest and habitat space and dissolved oxygen are at their lowest; migratory fish may also be prevented from moving upstream.
- An increase in high intensity rainfall events is likely to result in an increase in erosion of river banks, particularly where they have been destabilised by the removal of tree cover and other deep rooting vegetation.

The water environment cannot be viewed in isolation from the terrestrial environment in which it sits. Many of the risks posed by climate change to water bodies are due to knock-on impacts from the surrounding land and from potential changes in land use.

- Changing precipitation patterns and an increased likelihood of summer droughts will lead to reduced resources but higher water abstraction demands (particularly from irrigation).
- When combined with the presence of pollution sources the impact upon ecosystem functions from hydrological changes can be particularly severe.
    - During low flow events, there is reduced dilution capacity in rivers and, as a consequence, the concentrations of pollutants can increase markedly.
    - Warmer standing waters receiving high nutrient run-off as a result of greater intensity rainfall events could exacerbate algal blooms and eutrophication and increase loading of pollutants to the sea.
- Changing patterns in agricultural land-use in response to the changing climate may alter the distribution and magnitude of these pressures.

Adaptation options

The state of Scotland's water bodies as a whole has significantly improved over the last few decades. However, the Scottish Government recognises the need to continue to improve the general 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 primary legislative driver for improving water quality is the EU Water Framework Directive (WFD) that led to the Water Environment and Water Services (Scotland) Act 2003 (WEWS Act). The WEWS Act provides powers to regulate water activities, including wetlands and groundwater as well as rivers, lochs, transitional waters (estuaries) and coastal water. River basin management planning (RBMP) in Scotland sets out how these improvements to Scotland's water environment will be phased, taking into account the time needed to develop and implement technical solutions, and make the required investments and adjustments without creating disproportionate burden. This should enable the pressures on water bodies to be reduced in a sustainable way to allow maintenance of or recovery to good or better status and enable the water environment as a whole to cope with the effects of climate change. Targets have been set for each waterbody for the time periods 2009-2015, 2015-2021 and 2021-2027.

Fundamental to the RBMP process is the legislative framework intended to ensure action on the most significant pressures on the water environment, supported by economic incentives, funding, and education to promote, encourage and support action. Examples of measures being undertaken include:

- Increasing investigative work to improve understanding of the problems
- Working with local stakeholders to find solutions that maximise social and economic benefits
- Building partnerships with land managers, other businesses and voluntary organisations
- Improving communication of good practices, including among land managers

Working with farmers is part of a co-ordinated national level approach to reduce the risk of diffuse pollution. A partnership approach to reducing rural diffuse pollution is led by the Diffuse Pollution Management Action Group (DPMAG). In addition to its national strategy, DPMAG targets 'Priority Catchments' where a particular focussed approach is needed. A whole catchment approach is also being taken with regard to abstraction management. Declining river flows may require regulatory intervention in order to maintain environmental flow conditions. SEPA are currently trialling a new approach to abstraction management, working with land managers in catchments that have been identified at risk of impact from irrigation abstraction and focussing on crop requirements, water efficiency, irrigation programming and use of storage ponds. 'Farming for a Better Climate' (Scotland's Rural College) and 'Future Proofing Scotland's Farming' (Soil Association Scotland, Quality Meat Scotland) provides practical advice to farmers which helps to support this approach.

The threat of invasive non-native species to freshwater habitats is addressed by Scotland's Biodiversity Strategy and in addition to targeted management of notified habitats by Scottish Natural Heritage, a combination of public awareness campaigns, innovative 'citizen science', and the development of strong partnerships is aimed at reducing this growing risk. The Rivers and Fisheries Trusts of Scotland (RAFTS) are leading on biosecurity in many Scottish river catchments.

RAFTS has recently begun developing the Scottish Invasive Species Initiative (SISI) project. This will create a network of volunteers to eradicate and control several invasive non-native species across a large area in the north of Scotland, focusing on rivers, lochs and riparian corridors.

Currently, there are limited long-term, quality controlled water temperature data available in Scotland which makes it difficult to accurately assess some climate related pressures and impacts and to therefore enable more focussed and effective management. In response to this need, the Scotland River Temperature Monitoring Network (SRTMN) is being established to provide an evidence base that can inform local fisheries management and adaptation strategy at a local and national level.

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;

The second RBMP also includes an assessment of how the main management actions may contribute to greenhouse gas emissions and to preparing Scotland for a future climate, as well as considering how effective the action will remain under a changing climate. This is an important development as it helps to identify potential conflicts and reduce the risk of maladaptation. Climate change is likely to increase the need for coordinated land and water management as conflict arises due to e.g. reduced summer water availability (conflicts for a limited resource) and high intensity rainfall events (the need to utilise farmland for flood prevention).

What do the indicators tell us?

CXC's indicators focus on various aspects of exposure and vulnerability of the water environment to climatic changes, some of the critical resulting impacts and highlights action to address these risks:

The direct and indirect RISK to the natural water environment due to changes in temperature and precipitation, and vulnerability to pressures exerted on water quality and quantity from climate related changes in the terrestrial environment:

- *Summer low flow events in Scottish rivers (Normalised Flow Index)* identifies 30 and 90 day periods of regional relative water scarcity. During the summer of 2014 the Clyde region experienced the lowest flows relative to the long term average. Currently there is no detectable trend, but it is projected that by the 2050s, exceptional events currently experienced once every 40 years may become as common as every 9 years.
- *Proportion of water bodies not meeting Good Overall Status* utilises SEPAs annual monitoring to provide an indication of the likely resilience of water bodies to the pressures of climate change. Whilst targets have been missed, there has been an overall decrease in the number of sites failing to meet good status, with improvements largely being secured by the reduction of impacts from discharges of pollution or water abstraction, and the removal of barriers to fish migration.

- *Drought risk to agricultural land* examines constraints on land use options through limitations on soil water availability, and hence the potential increased demand on abstraction of water for irrigation to maintain agricultural productivity. Currently around 2.5% of prime land is at moderate/severe drought risk but no long-term trend is currently detected.
- *Agricultural land at significant flood risk* uses SEPA's assessment of the area of prime agricultural land at risk of 10, 50 and 200 year flood events. Over 160,000ha are currently identified as at risk of frequent flooding with consequential risk of soil erosion and run-off into water bodies.
- *Wetness risk for agriculture* examines the constraints on land use options through limitations on trafficability and workability of the land and the risk of poaching resulting in increased pollution to surrounding water bodies. Whilst there has been no significant change across Scotland as a whole, East Scotland shows a slight trend to reduced wetness risk.

The IMPACT on the condition and distribution of native and non-native freshwater species and potential indirect impacts from the influence of land use on the water environment:

- *Condition and distribution of climate sensitive species: Abundance of Arctic charr in freshwater lochs* examines the impact of temperature changes on a cold water specialist which is physically restricted from shifting range in response. Whilst climate change is not the only pressure on their populations, there is evidence to show that it is having a significant impact on the southerly distribution of this species.
- *Freshwater habitats with reported presence of key invasive non-native species (INNS)* utilises SNH's Site Condition Monitoring and shows that currently around a third of Scotland's notified freshwater features have a reported pressure from INNS.
- *Freshwater bodies affected by diffuse pollution due to agriculture* utilises pressure data collected by SEPA for all water bodies. Over 16% of water bodies in 2012 were under pressure from diffuse pollution from arable, livestock or mixed farming and at less than good status overall.
- *Abstraction of water for irrigation* shows that during 2013 approximately 17 million cubic metres of water were abstracted for irrigation purposes, which was 39% of the total licensed volume. Abstraction levels were significantly higher in the East reflecting the dominance of arable farming in this area. The greatest abstraction occurred in the Tay region which coincides with the area projected to see the greatest increases in irrigation demand.

Examine the success of management ACTION to improve the resilience of the water environment and the ability to adequately assess climate induced impacts:

- *Progress towards the environmental objectives of the River Basin Management Plans* uses SEPAs water classification data to assess achievement of environmental improvement targets. There has been good progress with regard to addressing many measures, but some targets for improvement are likely to be missed in a number of areas (particularly with regard to rural diffuse pollution and the risk posed by the spread of INNS)

- *Freshwater monitoring: temperature* assesses the change in temperature monitoring capability at SEPA water monitoring stations. There has been a significant increase since 2002 however the availability of high resolution, quality controlled temperature data remains inadequate but is being addressed by the establishment of the Scotland River Temperature Monitoring Network (SRTMN).

Possible future indicators for which data is not currently available or suitable:

- Freshwater temperature means and extremes
- Condition and distribution of climate sensitive species: Salmon
- Organic carbon levels in rivers and lochs
- Wetland restoration area
- River restoration projects and riparian planting schemes
- River area/catchments with invasive species eradication programme
- Uptake of water conservation measures
- Change to more drought resistant crop varieties

Other relevant indicators

Projected increases in prolonged and heavy rainfall events may lead to an increase in soil erosion and hence the pollution of aquatic environments through enhanced sediment load and associated chemicals:

- *Soil erosion risk*
- *Agricultural production methods which reduce erosion risk*

The availability and quality of water for Scotland's natural environment is intricately linked to the adequate supply of drinking water and meeting the needs of Scotland's industries and energy demands, as well as the sustainable management of these needs:

- *Water leakage and loss*
- *Zones and customers vulnerable to water supply deficit (domestic/industry sector)*
- *Total household water usage per day*
- *Total non-household water usage per day*