



POLICY BRIEF

CASE STUDY OF SCOTLAND



INTEGRATED SOLUTIONS TO ADDRESS HIGH LEVELS OF CLIMATE CHANGE

Region: North-western Europe

Scale: National

Sectors: Agriculture, Forestry, Water, Health, Tourism, Biodiversity

Scotland has a strong commitment to addressing climate change, with the 2009 Climate Change (Scotland) Act being one of the world's most ambitious climate mitigation strategies at the time. However, the Scottish economy, particularly its rural economy, is vulnerable to climate change, and further action is needed to minimise climate risks. This study has explored the risks posed to Scotland by high levels of climate change (global mean temperatures more than 2°C above pre-industrial levels). It focused on the implications for key economic and land-based sectors under different scenarios of climate and socio-economic change, using simulation models. Key stakeholders and decision-makers worked with the project team to co-create a common vision of a sustainable Scotland in 2100 and to explore how to achieve this 'Vision for Scotland' through pathways of mitigation and adaptation options. The study provides evidence for decision-makers when incorporating high climate change scenarios into decision-making strategies, and can inform key strategies such as the Scottish Climate Change Adaptation Framework, the Land Use Strategy and the Forestry Strategy, supporting Scotland in building resilience to climate change.



Glencoe today (top) and as it might appear in the year 2100 (bottom)



Key Findings

- The socio-economic context exerts a critical influence on the impacts of high levels of climate change. Integrated modelling (across coupled socio-economic and biophysical systems) is crucial in understanding how different sectors might be affected by climate change, especially in land-use sectors.
- Climate change in Scotland provides opportunities as well as threats. None of the scenarios assessed result in solely positive or negative outcomes, and trade-offs in decision-making are inevitable.
- Food production will benefit from a warming climate, but models predict a mix of positive and negative impacts on crop yields depending on geographic location. Yields of native Scots pine might decrease in many places whereas some non-native species such as Douglas fir could become more productive.
- Biodiversity outcomes are mixed. Some charismatic species such as the capercaillie may lose suitable habitat due to climate stress, while others such as the golden eagle might gain habitat. Decreases in biodiversity (the number of species present) are strongly linked to agricultural activity.
- Landscape-based tourism in Scotland is relatively robust to high climate change, but changes in landscape aesthetics may have some negative consequences. A warmer climate may also increase exposure to Lyme disease as tick populations increase and people spend more time outdoors.
- In all scenarios, integrated governance strategies can play a key role in dealing with climate change, and a number of policy actions exist to achieve this.

What could a future above 2°C look like?

Four scenarios were co-created with stakeholders during a series of workshops, to reflect contrasting plausible futures for Scotland to 2100. These were based on the global Shared Socio-economic Pathways (SSPs) paired with relevant climate scenarios based on the IPCC Representative Concentration Pathways (RCPs). Two fossil-fuel dependent scenarios (SSP3 and SSP5) were paired with an extreme warming scenario (RCP8.5) that is expected without additional climate change mitigation, and two low carbon scenarios (SSP1 and SSP4) were paired with a moderately high warming scenario (RCP4.5).

Socio-economic scenario	Climate scenario ¹	Narrative for Europe to 2100
MacTopia (SSP1)	Moderately high (RCP4.5) Temperature	An engaged society combined with a strong and effective government ensures that Scotland successfully manages the transition to a sustainable society. A strong focus on social justice and equality enables Scottish Independence mid-century.
Tartan Spring (SSP4)	+0.9 to +2.2°C Precipitation +3 to +9%	Prosperity and a strong middle-class fuel technological innovation and responsible resource use. Scottish Independence is supported by strong economic growth. A strengthening private sector, welfare cuts, inequality and lack of government accountability lead to social unrest. Scotland enters turbulent times.
Techadonia (SSP5)	Extremely high (RCP8.5) Temperature	Society is heavily reliant on the use of fossil fuels, with fuel taxes (enabled by stable fuel prices) supporting extensive spending on health services, social housing and education. Public participation in politics is high and development is driven by technological advances, but the resulting environmental degradation eventually reaches a tipping point after which a slow shift towards renewables begins.
Mad Max (SSP3)	+1.7 to +3.8°C Precipitation +4 to +14%	Society is hugely unequal (divided into 'Haves' and 'Have-nots'), driven by increased pressures on resource exploitation and commodity speculations. Short-term thinking characterises government actions, as well as the everyday lives of people who have to ensure their own day-to-day survival. Multinational corporations exert great influence over almost every sector of society.

¹Annual average change in Scotland in 2071-2100 compared to 1961-1990

What are the impacts and risks in a future above 2°C?

Advanced simulation models predict that climate change will have a range of positive and negative impacts, providing both opportunities and threats.

Forestry: Forest productivity is projected to increase in most of Scotland in a warmer climate. However, not all tree species benefit equally. Yields of the native Scots pine are projected to decrease, while yields of some non-native species (Douglas fir and Sitka spruce) could increase. This has implications for the selection of tree species in Scottish reforestation policy, which in turn could affect biodiversity and landscapes.

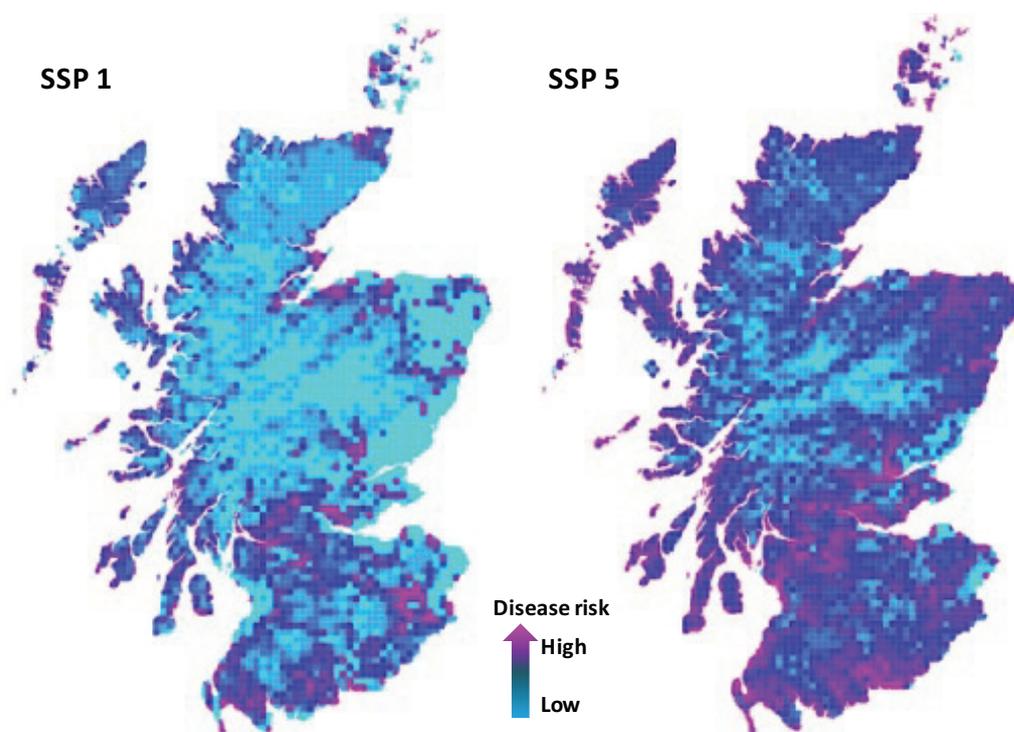
Land Use/Agriculture: Socio-economic scenarios have an important influence on land use change. Under MacTopia (SSP1), the area used for intensive agriculture is projected to increase (at the expense of forest area), due to the government focus on growing food within Scotland. Under Techadonia (SSP5), technological advances increase yields so the agricultural area shrinks. These extremes highlight the need to discuss the implications of agricultural land use change for biodiversity and ecosystem services in the context of the land-sparing/land-sharing debate. Modelling of crop yields reveals some increases for winter barley and winter wheat, particularly in the early part of the century. However, overall a mix of increases and decreases in productivity across the country is expected under all scenarios.

Biodiversity: All scenarios feature a mix of increases and decreases in biodiversity, with decreases particularly prominent in areas where agricultural intensity increases. Some charismatic species are projected to lose substantial areas of suitable habitat due to climate change, including the capercaillie, osprey and wildcat under all scenarios. For others, such as the golden eagle, a warming climate could increase their range.

Tourism: The Scottish landscape attracts tourism, but the aesthetic quality of landscapes will be affected by climate change. Surveys and photo-shopped landscape photos were used to explore whether altered vegetation patterns and water levels could negatively affect tourism. While the current Scottish landscapes were generally preferred, the modified landscapes were also perceived as either very attractive or somewhat attractive. This finding indicates that the Scottish tourism industry will be resilient to climate change induced landscape changes.

Lyme disease: Lyme disease has important implications for outdoor recreation, with incidences increasing recently due to increased exposure as more people pursue outdoor activities. Lyme disease risk is projected to increase across all scenarios as tick habitat expands in a warmer climate. Understanding potential tick habitat will help design adaptive disease management strategies and information campaigns.

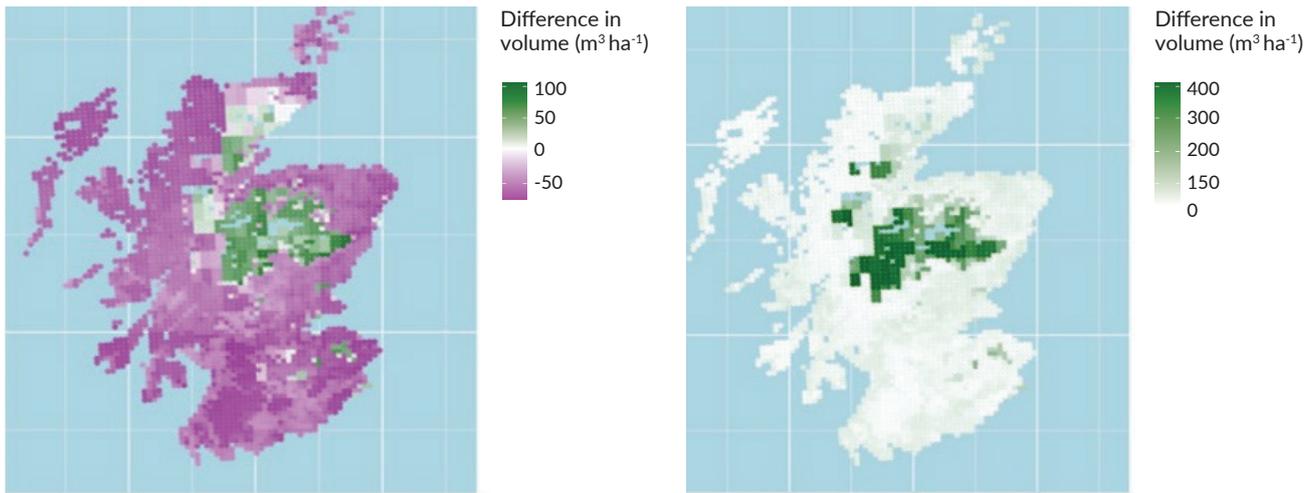
Water: Modelling in the Tay river catchment suggests that discharge is likely to increase in the spring and winter and decrease slightly in the summer. High-flow events are also likely to increase, potentially resulting in flooding.



Risk of Lyme disease based on the projected number of infected ticks per km² in SSP1 (left) and SSP5 (right)

Scots pine (*Picea alba*)

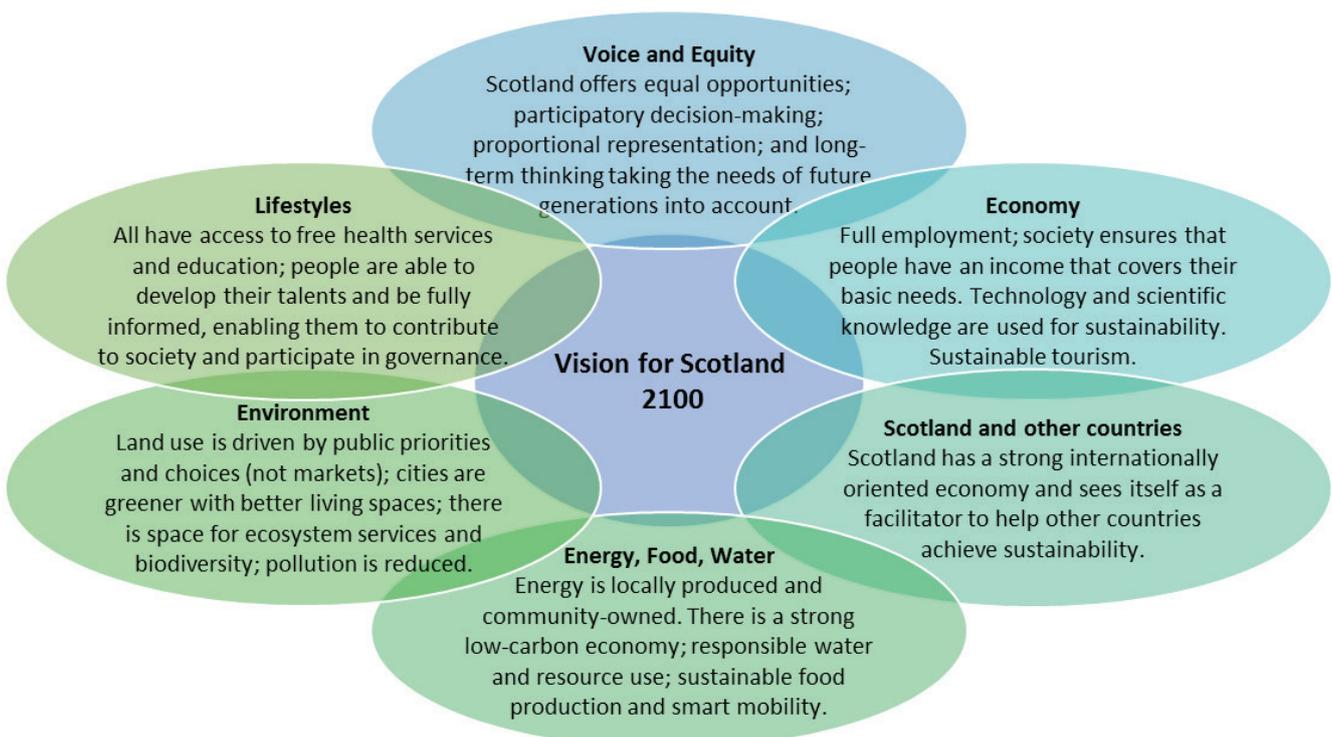
Douglas fir (*Pseudotsuga menziesii*)



Difference in harvested volume under high climate change (average of RCP4.5 and RCP8.5 compared to baseline)

What do we want our future to look like?

Stakeholders defined a common 'Vision for Scotland' providing a set of goals for a desirable, sustainable future in 2100. The vision is intentionally transformative to ensure provocative and interesting outcomes.



How can a sustainable future be achieved?

Stakeholders and researchers co-created a series of transformational pathways that reflect the strategies needed to achieve the 'Vision of a sustainable Scotland' in 2100 in the context of each scenario, envisioning not just measures to adapt and mitigate climate change impacts, but also to provoke significant societal change in the long-term. However, although these pathways bring the scenarios closer to the vision, they do not manage to fully achieve the vision goals.

Pathway	Scenario				Examples of strategies
	SSP1	SSP3	SSP4	SSP5	
Integrated environmental planning and resource management	✓	✓	✓	✓	Land use and resource management plans are coordinated to provide multiple benefits across sectors and scales, including nature-based solutions and integrated transport, energy and food systems. For example, in Tartan Spring (SSP4) a canal network provides low carbon transport while increasing access to remote regions.
Local, low-carbon and circular economies	✓	✓	✓	✓	Local economies build on alternative economic activities, such as sharing of goods and local trading systems. This is central in SSP3, where communities organise into smallholdings to grow food together, using alternative food sources (seaweed, algae, mussels) and finding innovative methods (e.g. vertical farming, aquaponics).
Local community empowerment and sustainable lifestyles	✓	✓	✓	✓	Local democracies and community cohesion are strengthened by devolving responsibility for environmental quality to the local level, while connecting communities via knowledge-sharing networks. This triggers a shift to community-owned resources, alternative working patterns and more sustainable lifestyles.
Brand "Sustainable Scotland"	✓		✓	✓	Scotland positions itself as a global sustainability leader. The "Sustainable Scotland" brand promotes a shared identity based on the appreciation and protection of Scotland's natural resources. Sustainability solutions are shared globally, creating new economic opportunities e.g. in eco-tourism and green technology.
Strong environmental policy and natural resource markets	✓			✓	There are fundamental shifts in the way market value is created, by using taxation, incentives, standards and regulation to integrate environmental costs into economic activities and incentivise long-term environmental protection.
Market potential of water				✓	In the technology and market-focused Techadonia (SSP5), the value of water for energy and human use prompts technological innovations to manage water more sustainably, reducing water usage and increasing flood resilience.

What are the transformative solutions?

Three of the pathways play a key transformative role in all scenarios. **Integrated environmental planning and resource management** was seen as the key to a successful society, because it co-ordinates policy actions across sectors and scales, enabling synergies to be exploited (including via the multiple benefits of nature-based solutions) and trade-offs (e.g. for competing land uses) to be managed. **Local community empowerment** ensures that people can make independent decisions over key areas of their lives (e.g. food, energy). By building the capacities of communities and individuals through learning and awareness, it enables and supports a shift to **sustainable lifestyles** and to the third pathway, **local, low carbon and circular economies**. Within these pathways, **technological innovation in food production** and shifting to more **sustainable dietary habits** can significantly increase the amount of land available for wildlife habitat and for reforestation.

Policy Recommendations

- **Early adaptation in forestry:** Modelling suggests that native Scots pine will not grow as well under high climate change as other non-native species. Using a mix of tree species will ensure the future viability and productivity of forests. This is important for provision of timber and also for the role of forests as a carbon sink. However, potential trade-offs with biodiversity and landscape value should be considered.
- **Trade-offs between land-uses need to be evaluated:** Despite some crop production benefits under high climate change, ambitious reforestation targets might come into conflict with local food production necessitating increased food imports. This underlines the need to continue cross-sectoral impact assessments.
- **Continue efforts to improve biodiversity outcomes of (intensive) agriculture:** Modelling has revealed that biodiversity decreases are particularly high in areas of intensive agriculture. To reduce impacts of agriculture on vulnerable species, policy to support sustainable farming practices is needed. Initiatives such as the “Farming for a better Climate” programme are a good starting point for education programmes for land managers.
- **Continue and improve efforts on Lyme disease, with a particular focus on awareness-raising:** Lyme disease risk is projected to increase under high climate change and it is likely that more people will pursue outdoor recreation. It is therefore important to increase efforts to educate the public as well as public health practitioners to ensure that both patients and doctors are aware of what to do in case of infection.

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Find out more:

Clarke et al. (2017) Regional/local scale CCIAV applications, IMPRESSIONS Deliverable D3C.2; Hölscher et al. (2017) Adaptation and mitigation pathways, and synergy mechanisms between them, for the case studies. IMPRESSIONS Deliverable D4.2.

Both available from www.impressions-project.eu.

