

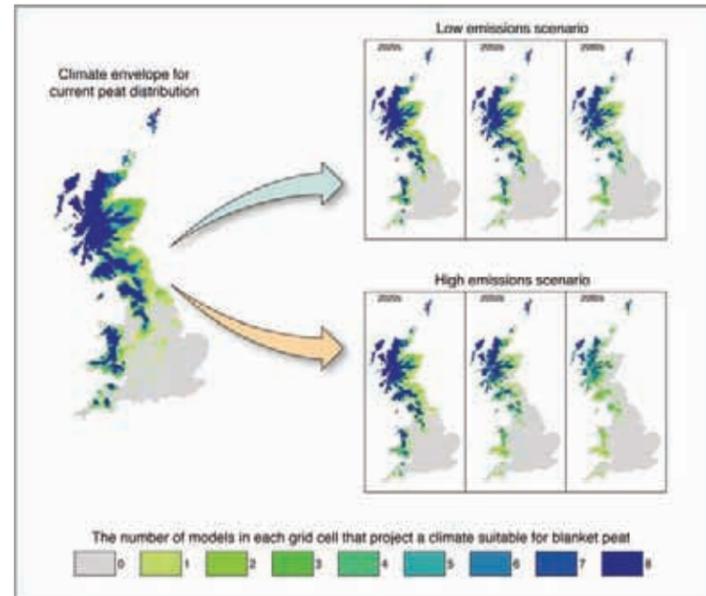


Climate Impacts: Fish stocks, Food security and Biodiversity

Climate change and UK peatlands

- UK peatlands include globally rare habitats and constitute the largest terrestrial store of carbon in the UK. They are also important for good water quality and flood control. Work done jointly by QUEST and the Environment Agency suggests that more than 50% of UK peat will be vulnerable to change by 2050.
- In areas that no longer experience a suitable climate, peat may still accumulate for a while but over time it is likely to decline. More extreme projections risk rapid mass erosion, loss of flood regulation and decline in water quality. Climate change will exacerbate current pressures on these landscapes such as grazing and wildfires. The resilience of existing peatlands can be enhanced by reducing these pressures and by re-vegetating bare or eroding peat.

Figure 7. The peat-growing areas most vulnerable to a changing climate under UKCIP02 climate projections. (Clark et al. 2010)



Biodiversity and climate change

- A QUEST expert workshop concluded that the impacts of climate change on biodiversity may not be as universally catastrophic as recent predictions have suggested. This conclusion is based on a variety of observational evidence with a long-time perspective. The most recent glacial-interglacial cycle included several periods of rapid warming, including at rates comparable to those projected for the future. Yet records show virtually no extinctions of plants and

insects. Throughout the world, species responded to changing climate by moving, effectively tracking the changes. These results are consistent with observations that species are on the move today. An important difference is that human activities have greatly fragmented habitats, and much land area has been lost to agriculture. However, a land use policy that facilitates natural migrations and protects suitable habitat throughout the landscape can reduce climate impacts on biodiversity.

Projects involved

QUEST Global Scale Impacts, QUEST_Fish, Biodiversity working group, Climate change and UK Uplands working group (in conjunction with the Environment Agency).

Publications

A full listing of QUEST research publications is constantly being updated by the QUEST synthesis team at the University of Bristol. Contact quest-info@bristol.ac.uk for more information.

Allison E, et al. (2009) Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries* 10 (2): 173-196

Barange M et al (in press). Predicting the impacts and socio-economic consequences of climate change on global marine ecosystems and fisheries: the QUEST_Fish framework. In: Ommer, R. et al., *Coping with climate change in marine socio-ecological systems*. Blackwell FAR Series

Clark, J.M. et al. (editors) (2010) Climate change and the British Uplands. *Climate Research: Special Issue*. <http://www.int-res.com/journals/cr/cr-forthcoming/>

HM Government/Met Office (2009) *Mapping climate impacts in a 4°C world*. [http://www.fco.gov.uk/en/global-](http://www.fco.gov.uk/en/global-issues/climate-change/priorities/science/)

[issues/climate-change/priorities/science/](http://www.fco.gov.uk/en/global-issues/climate-change/priorities/science/)

Scholze M, et al. (2006) A climate-change risk analysis for world ecosystems. *PNAS* 103 13,116-120

Simelton et al (2009) Typologies of crop-drought vulnerability: an empirical analysis of the socio-economic factors that influence the sensitivity and resilience to drought of three major food crops in China (1961-2001). *Environmental Science and Policy* 12 4, 438-452

Taylor, R. et al. (editors) (2009) Uncertainty in climate change impacts on basin-scale freshwater resources. *Hydrology and Earth System Sciences: Special Issue, 7*



Highlights:

- QUEST has analysed the risks of different degrees of climate change across the entire globe for food, water, flooding, ecosystems and human health.
- QUEST's risk analysis methodology for climate change has been used in over 50 studies in various contexts since publication.
- An innovative vulnerability analysis shows how climate change will affect global fisheries resources and how this risk is highest in fishery dependent nations.
- A joint QUEST-Environment Agency study suggests that more than half of UK upland peat environments will be vulnerable to change by 2050, potentially affecting carbon storage, water quality and flooding.
- QUEST scientists have engaged actively with the policy community, including UK Government Departments and Agencies, water companies, NGOs, the UN's Food and Agriculture Organization, the UN Environment Programme, the World Bank, and the World-Fish Center.
- QUEST contributed to the UK Government's 4°C Impacts map.

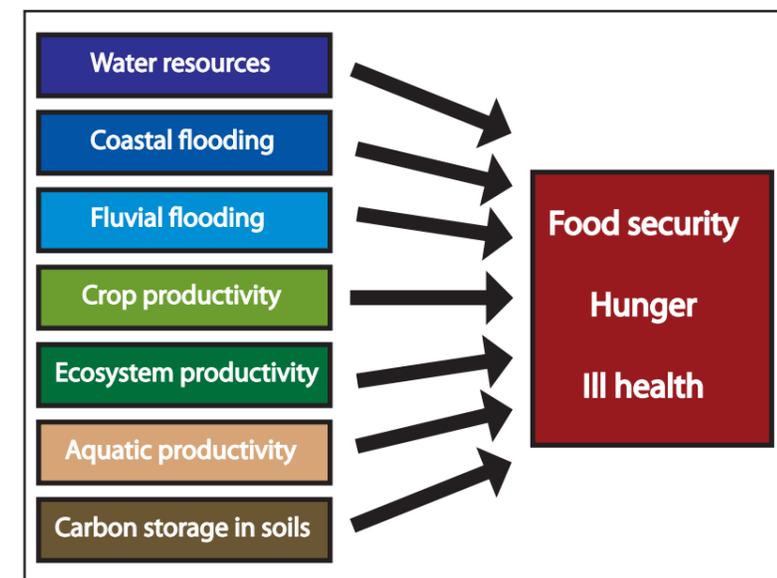


Figure 1. QUEST considered how impacts in several sectors might affect each other and how they combine to affect food security and human health.

Global-Scale Impacts of Climate Change

- As temperatures increase across the globe, those areas most vulnerable to climate change may also vary. QUEST has investigated these risks across a range of sectors, including water, food, health and ecosystems, enabling areas of multiple risk to be identified (Figure 1).
- The risks of water scarcity rise steeply as global temperatures increase up to 2°C, and increase more slowly thereafter. The problems of water scarcity will be worse for up to 40% of the world's population with a global temperature rise of 4°C (Fig. 2). Differences between climate model predictions of rainfall change mean there is considerable uncertainty. Most models agree that the worst hit areas are likely to be the areas already affected by water scarcity, such as the Middle East and countries around the Mediterranean. Some parts of the world, such as parts of southern Asia, could see increases in rainfall. This could potentially increase water availability, depending on the capacity to store water.

- QUEST developed a new set of climate change scenarios, for temperature increases ranging from 0.5° to 6°C by 2100, to estimate the effectiveness of climate mitigation policies. In order to address model uncertainty, these scenarios have been created using several different climate models.

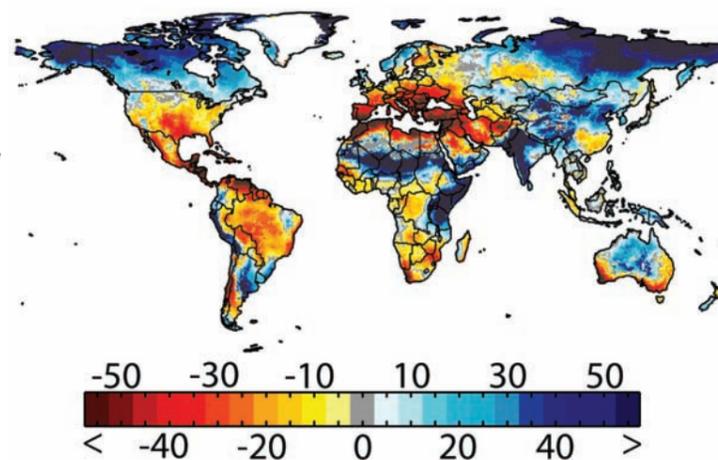
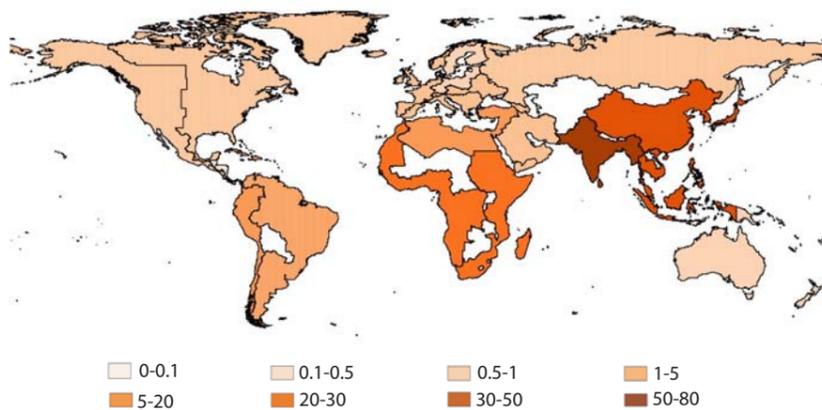


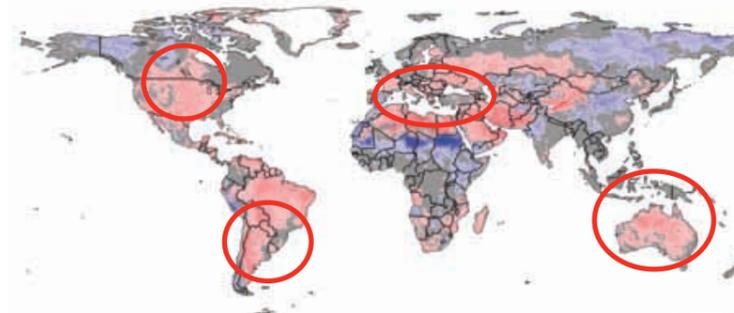
Figure 3. (below) Map of additional number of people flooded per year (millions) due to the extreme water levels assuming no upgrade to coastal defences for a 4°C global temperature rise by 2050.



- A 40 cm rise in sea level resulting from a 3°C temperature rise by 2100 could put an additional 90 million people at risk from flooding globally. For a 7°C temperature rise by 2100, 200 million additional people per year could be expected to be flooded. Of the total number of people at risk at 7°C, three-quarters are in Asia due to high population densities. The coasts of North and West Europe are greatly threatened, but adaptation seems likely. Small islands will be especially vulnerable as they have reduced ability to adapt.

Food Security

- Crop yields will decline in most areas despite the "CO₂ fertilisation" effect. Initial results indicate that the global population at risk of under-nourishment is expected to increase from 10% to 40% by 2050, due to population growth and pressures on agricultural land if no adaptation measures are taken. By 2050, around 1.7 billion additional people could be at risk of undernourishment as a result of climate change, raising the proportion at risk from 40% to around 60%.
- National socio-economic data have been used to identify factors that have made cereal production resilient or sensitive to past droughts. Countries undergoing economic and political transition are most vulnerable to droughts. Factors related to investments in the agriculture sector help reduce vulnerability. Figure 4 shows that where these countries overlap with areas prone to an increase in droughts, climate impact "hot spots" can be identified.

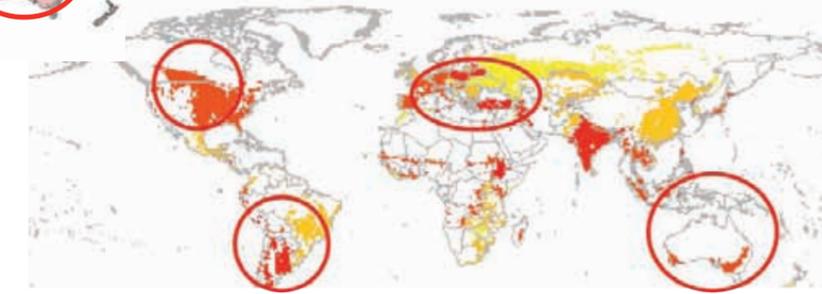


The red circles show vulnerability "hot spots" where there is both low adaptive capacity and high risk of bad droughts. For the world's cereal farmers, vulnerability to climate change involves being exposed to problems such as drought and not being able to adapt.

Figure 4.

Left: Soil moisture index; the pink shading highlights areas where climate change is likely to make droughts worse by 2030.

Below: Orange shading shows areas where socio-economic changes are likely to reduce grain farmers' ability to adapt to droughts by 2030.



Global Fisheries Resources

- QUEST has investigated the impacts on fishing-dependent nations of climate-induced changes in global fisheries. Working directly with stakeholders in different regions, QUEST's innovative modelling of fish resources informed assessments of national vulnerability (Figure 5). QUEST modelled the effects of changes in temperature on marine primary productivity, and in turn on the stocks of fish of different sizes. There are winners and losers; Peruvian seas in particular appear to be badly affected (although it is difficult to model the coastal upwelling of nutrients that fuels the high productivity of this region). Declines are also seen in parts of Africa and North America, while fish biomass increases in other parts of Africa, Europe and Russia.

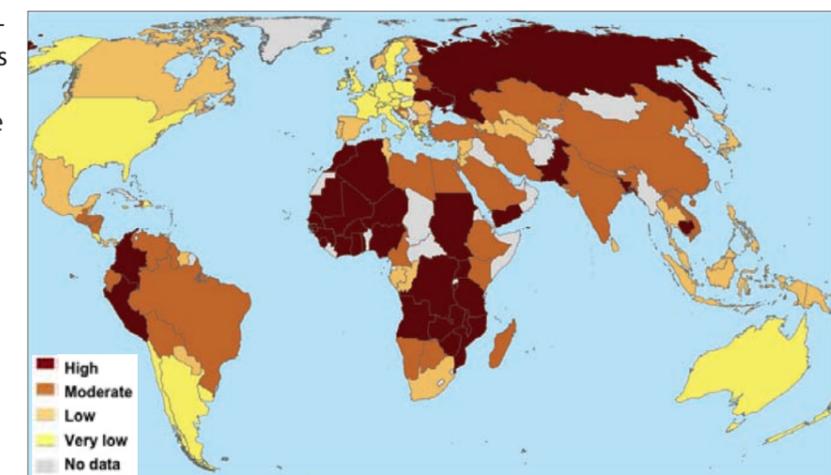


Figure 5 (above). Vulnerability of fishing-dependent nations to climate change. Allison et al (2009)

Sustainability scenarios, with % increase in price of the commodity

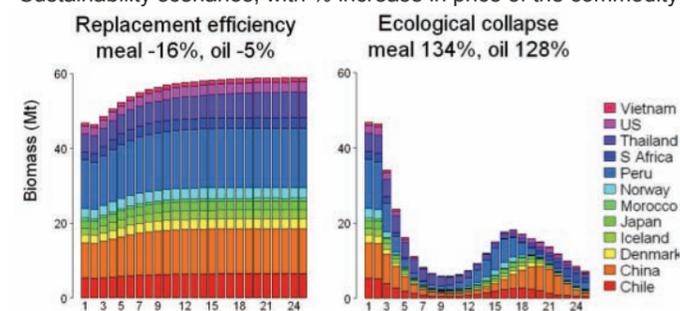


Figure 6. QUEST has modelled pathways of sustainability under different scenarios affecting prices of fishmeal and fish oil. The percentage figures reflect the expected price increase of the commodity in global markets in 2050 compared to today, where sustainability is only endangered if the price exceeds 42-50% of current figures. The colours represent the national stocks of resources contributing to the global commodity market.

- Fishmeal and fish oil are important globally-traded commodities that fuel the aquaculture and animal feeds market. A global bioeconomic model was used to determine pathways of sustainability in a globalised market (Figure 6).
- QUEST also helped run three scenario development workshops in west Africa, involving regional experts in discussion about the critical issues facing their fisheries in the next 40 years. Young people were engaged too, in order to raise awareness of their concerns. QUEST's coupled climate/fisheries scenario tools are proving useful in helping decision-makers develop appropriate strategies. All those present at the workshops agreed on the importance of coordination in sharing science, managing water resources, and developing new aquaculture opportunities.