AVOID is a UK research programme funded by DECC/Defra and led by the Met Office in a consortium with the Walker Institute, Tyndall Centre and Grantham Institute

Can we avoid dangerous impacts?

Key findings

- **Stringent mitigation action** to limit warming to 2˚C avoids a large amount of the climate impacts that would otherwise occur in the 21st century. However, since even this stringent action will not avoid all climate change impacts, significant damage or adaptation costs will still occur but they will be much reduced compared with business-as-usual (A1B).
- Some **benefits** of mitigation policy are already realised by the 2050s. The benefits continue to increase in the second half of the century.
- Reducing the risk of triggering **accelerated or irreversible climate change** is one of the strongest reasons for imposing stringent climate mitigation policies. Limiting future climate change leads to a lower probability of irreversible melting of the Greenland and Antarctic ice sheets and the release of large natural stores of methane from under parts of the ocean, which could cause further warming. It will also limit the die back of tropical forests.
- For impacts during the 21st century, achieving an **early peak** in global emissions leads to greater avoided impacts on many sectors later in the century.
- Some impacts depend on both temperature and CO_2 concentration, so considering 'CO_2-equivalent' emissions **obscures** the picture. For example, in our agricultural model a higher CO_2/non-CO_2 ratio typically benefits agriculture in the short term. In practise, processes not included in our agricultural model, such as increases in tropospheric ozone, may cancel out this effect. In the longer term, further climate change has negative impacts on agriculture due to the continuing rise in temperature. Furthermore, higher CO_2 concentrations will also lead to greater ocean acidification, damaging coral reefs.
- There is a significant **regional variation** of avoided impacts (and remaining impacts). However, some impacts will be felt **non-locally** because of global trade, migration and potential international conflicts over fertile land and access to water.

Avoiding the most serious climate change impacts will require informed mitigation policies. This requires information about emission reductions, the impacts that can be avoided and the total cost.

Calculating avoided impact

The AVOID programme has modelled the climate change impacts that can be avoided by taking mitigation action to reduce emissions instead of following a business-as-usual path (A1B) for a number of sectors including food security, agriculture, water resources, human health, biodiversity and coastal systems.

A subset of five mitigation scenarios from the full 150 AVOID scenarios was used in this impacts investigation. The AVOID impacts scenarios use emissions that peak in 2016 or 2030, decrease at a rate of 2% or 5%, and have two different long-term emissions levels. The results presented here are based on patterns from the HadCM3 climate model, but the general conclusions are also valid for patterns from alternative climate models.

> *"Can nine billion people be fed? Can we cope with the demands in the future of water? Can we provide enough energy? Can we do all that while mitigating and adapting to climate change?*
>
> Prof John Beddington, UK Chief Scientist

Water — resources and flooding

Water resources

The regions with greatest avoided water stress are in Central America, Africa (North, South and East) and in Europe. Benefits are also seen in the Middle East, India and the US.

Fluvial flooding

Mitigation reduces, but does not eliminate, the impact of climate change on global exposure to flood risk, with little effect before 2050 (**Figure 1**). Most fluvial flood-related impacts are in south and east Asia.

Coastal flooding

Cuts in emissions will reduce the number of people experiencing coastal flooding by 2050, and the benefits are substantial by 2100, assuming no adaptation. However, mitigation will only delay (to the 22nd or 23rd century), rather than avoid, 21st century flood impacts due to the inertia in sea-level rise. This delay has the benefit of reducing adaptation costs. Stringent mitigation also reduces the risk of irreversible melting of Greenland and Antarctic ice sheets. Hence, for sea level, mitigation is able to reduce sea-level rise to manageable rates but adaptation is still required to avoid coastal impacts.

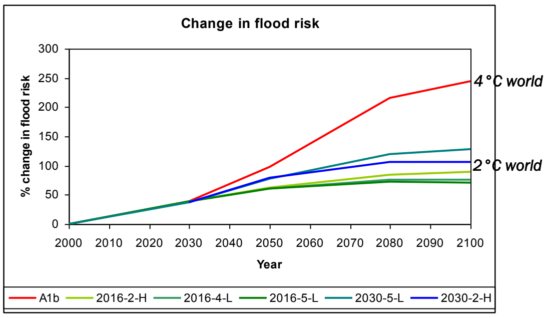


***Figure 1**: Global change in fluvial flood risk.*

Environment — ecosystems and biodiversity

Biodiversity

Mitigation reduces the number of species which are at risk of extinction from climate change. For example, in Europe by 2080, a mitigation scenario peaking in 2016, reduces the number of endangered mammals from 25 to 6.

Wetlands

Coastal wetlands respond to sea-level rise by migrating inland, accreting vertically, or through transitions to other wetland types. In the absence of mitigation policy, and assuming evolving coastal defences constraining wetland migration, sea-level rise would lead to a loss of approximately 20% of global mangroves by the end of the century; mitigation scenarios with emissions peaking in 2016 or 2030 slow this loss to around 15% (**Figure2**).

Land ecosystem

Mitigation slows the rate of change, but does not prevent major ecosystem productivity changes. For example, the Amazonian rainforest has some loss at 2°C, but the loss is much greater in a business-as-usual 4°C world.

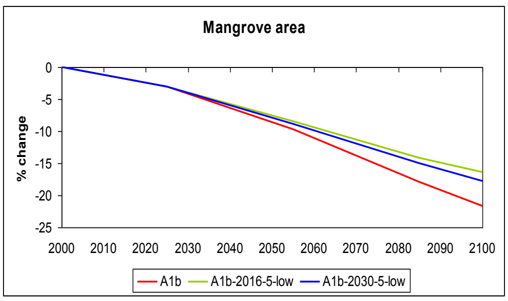


***Figure 2**: Global change in mangrove area.*

The habitat suitable for the Mustela Ermine in Europe is considerably reduced by the end of the century to pockets in Scotland, Northern Ireland and Norway and Sweden due to climate change. Mitigation sees these species staying in England, Denmark and the Alps.

Agriculture and food

Land suitability

The suitability of land for cultivation depends upon climate, topography and soil properties. Climate change tends to increase land suitability for cultivation at high latitudes (due to higher temperatures), but decreases suitability in many dry tropical and subtropical regions (due to lower moisture availability).

Climate mitigation reduces the effect of climate change on land suitability. For example, early reduction of emissions decreases the area which becomes unsuitable by over 60% by 2080.

Food production

The effects of climate mitigation on food production have been calculated for soybean, a major global crop used for producing both protein and oil.

Climate change leads to a reduction in soybean yield and production. Mitigation reduces this decrease in production slightly (**Figure 3**).

The consequences of climate mitigation on production reflect a complex relationship between climate change and CO_2 concentration. For example, avoided impacts for 2050 are greater when emissions peak in 2030 compared to a peak in 2016. This is because the balance between the effects of CO_2 fertilisation and increased temperature is favourable for soybean growth. At the end of the century the percentage of avoided impacts is greater than in 2050.

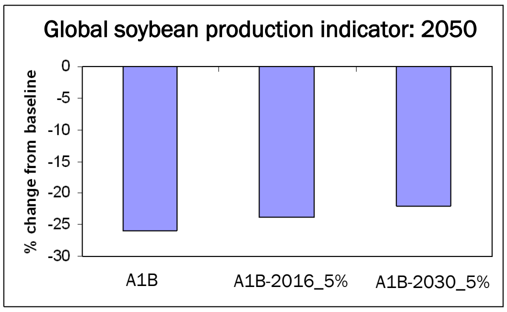


Figure 3: Global soybean production for 2050, assuming no explicit adaptation to climate change.

Global benefits of early mitigation by 2100

A large fraction of the global impacts in 2100 can be avoided. In **Figures 4, 5 and 6**, the red bar represents an unmitigated world that reaches 4°C by 2100, while the green bar shows the impacts at 2100 for a world in which early and rapid mitigation limit warming to 2°C by 2100.

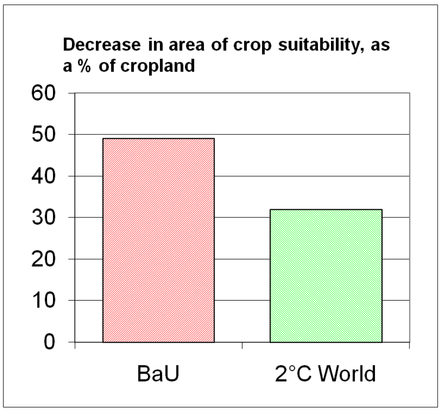


*Figure 4: Global benefits of early mitigation by 2100 for **crop suitability.***

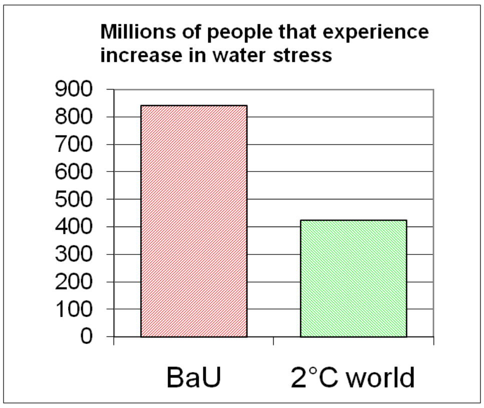


*Figure 5: Global benefits of early mitigation by 2100 for **water stress.***

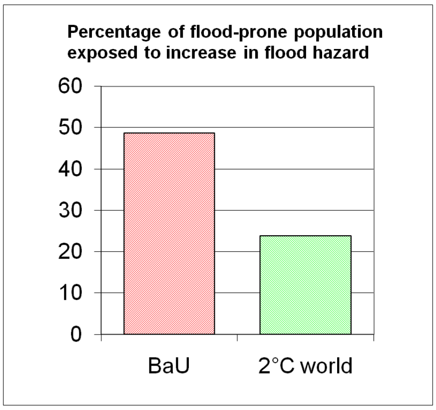


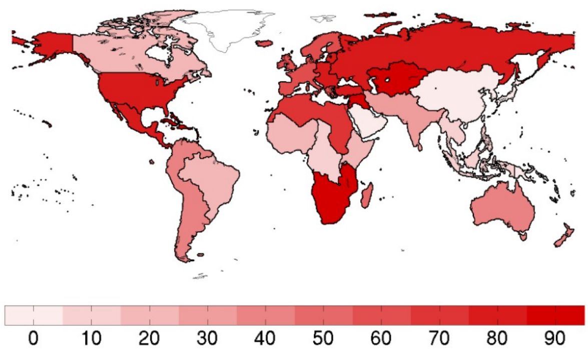
*Figure 6: Global benefits of early mitigation by 2100 for **fluvial flood hazard**.*

The research described in this leaflet has been conducted by many institutions within the AVOID programme, largely via the NERC funded QUEST-GSI project, including the Met Office Hadley Centre, the University of Reading, the University of Southampton, the University of East Anglia, the University of Aberdeen, the University of Oxford and CEH Wallingford. The University of Cambridge and the University of Canterbury also contributed to this work. This AVOID Work Package was coordinated by Rachel Warren, Tyndall Centre, University of East Anglia.

Regional benefits of early mitigation by 2100

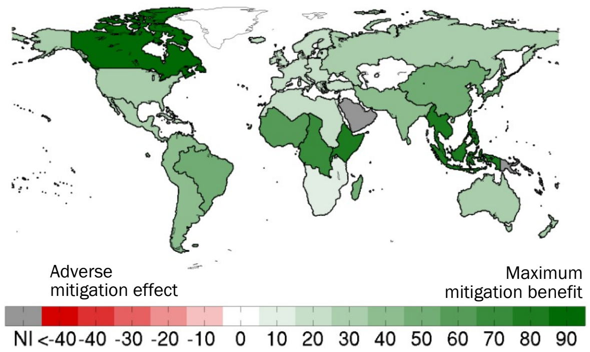
CROPS

IMPACT: Crop suitability



Percentage of regional **cropland with a decrease in suitability** for crop production in an unmitigated world (A1B) by 2100.

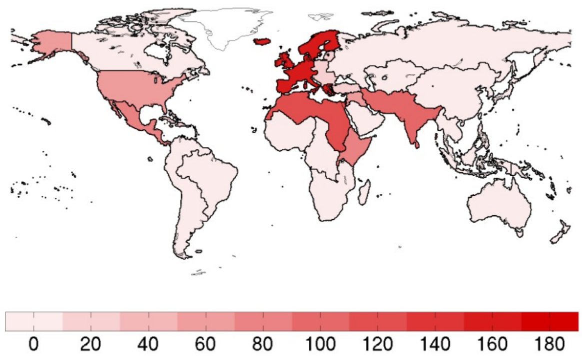
AVOIDED IMPACT: Crop suitability



Percentage of impact avoided by early and rapid mitigation (2016 peak in emissions and 5% post-peak reduction rate) by 2100.

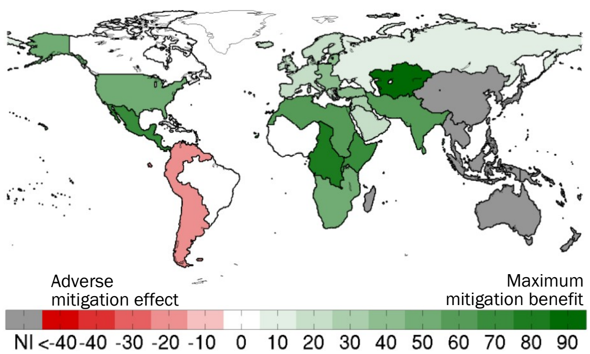
WATER

IMPACT: Water stress



Millions of people, by region, that experience **increase in water resources stress** by 2100 in an unmitigated world (A1B).

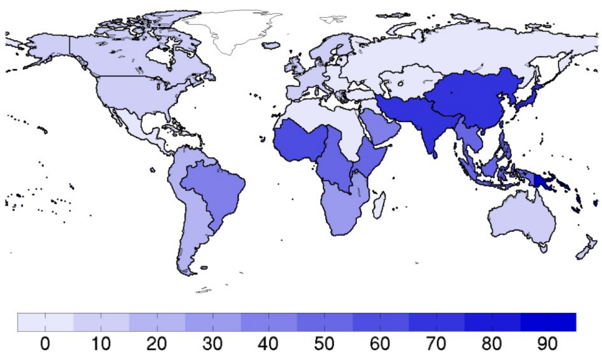
AVOIDED IMPACT: Water stress



Percentage of impact avoided by early and rapid mitigation (2016 peak in emissions and 5% post-peak reduction rate) by 2100.

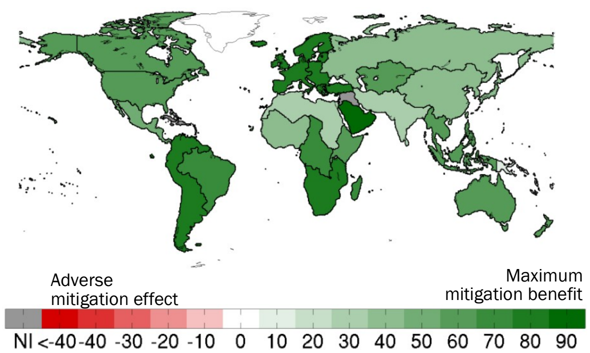
FLOOD

IMPACT: Fluvial flood



Percentage of regional flood-prone population exposed to **increase in fluvial flood hazard** by 2100 in an unmitigated world (A1B).

AVOIDED IMPACT: Fluvial flood



Percentage of impact avoided by early and rapid mitigation (2016 peak in emissions and 5% post-peak reduction rate) by 2100.

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