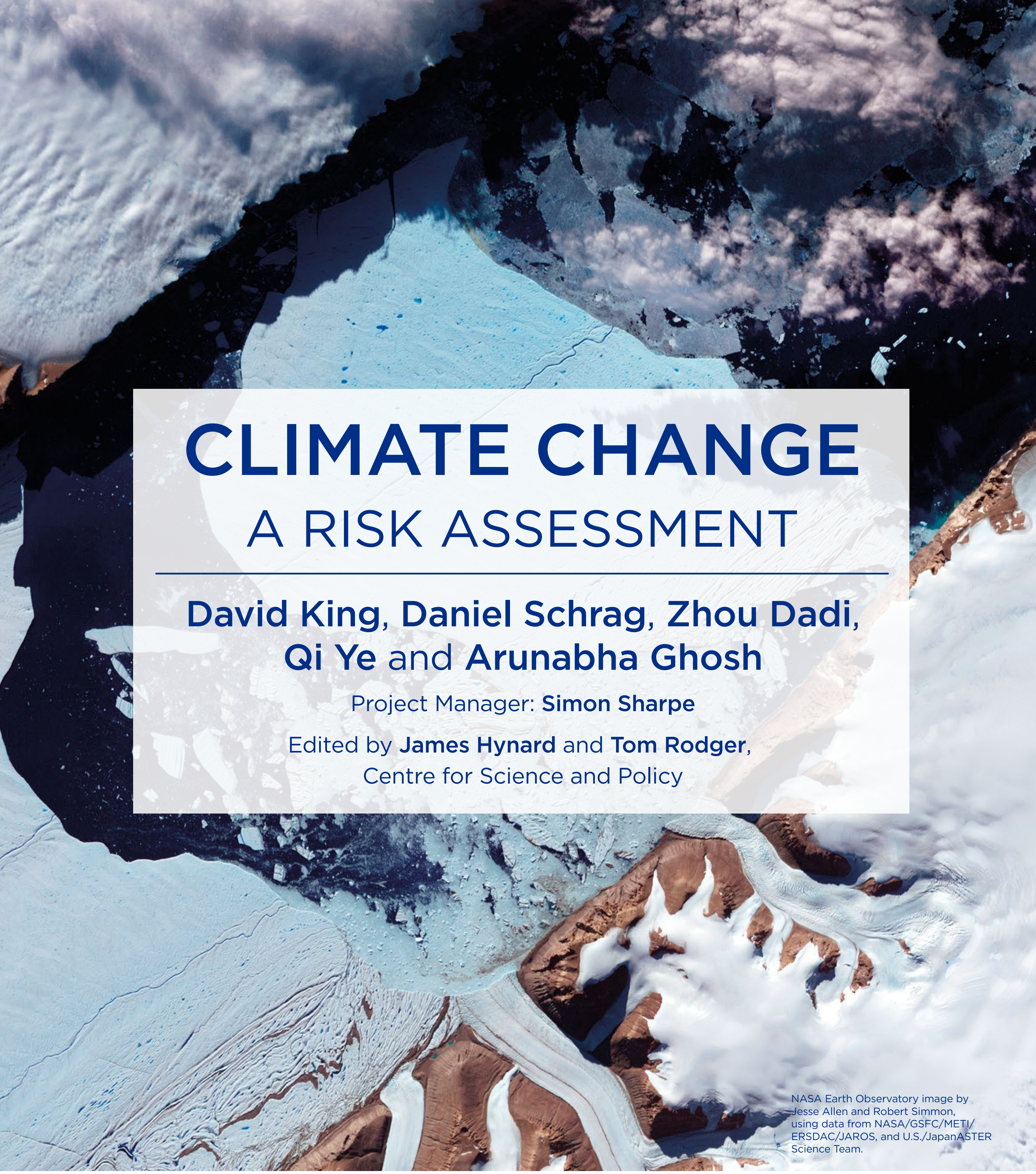
The risk of drought



CLIMATE CHANGE
A RISK ASSESSMENT

David King, Daniel Schrag, Zhou Dadi, Qi Ye and **Arunabha Ghosh**

Project Manager: **Simon Sharpe**

Edited by **James Hynard** and **Tom Rodger**, Centre for Science and Policy

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This report was edited and produced by the Centre for Science and Policy (CSaP) at the University of Cambridge. CSaP's mission is to promote the use of expertise and evidence in public policy by convening its unique network of academics and policy makers.

STATUS OF THIS REPORT

Sir David King led this project in his official capacity as the UK Foreign Secretary's Special Representative for Climate Change. The Foreign and Commonwealth Office commissioned this report as an independent contribution to the climate change debate. Its contents represent the views of the authors, and should not be taken to represent the views of the UK Government.

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13 THE RISK OF DROUGHT

Professor Nigel Arnell, Director of the Walker Institute for Climate System Research

What do we want to avoid?

Drought is a major challenge to people, agriculture and economies across the world. Broadly speaking, there are four types of 'drought'.

- **A meteorological drought** – a lack of precipitation
- **An agricultural drought** – a lack of water in the soil
- **A hydrological drought** – a deficit in river flows and groundwater levels
- **A water resources drought** – a deficit in the amount of water available for distribution to consumers (such as irrigators).

One type of drought does not necessarily map directly onto another. Droughts – of whatever type – also vary in their duration, intensity (amount of deficit) and spatial extent. It is therefore much more difficult to characterize both the 'impact' and the 'risk' of drought than the impact and risk of flooding. There are also many different indicators of drought, tailored to different characterizations of drought.

This section focuses on meteorological drought, and characterises drought on the basis of an indicator of accumulated deficits of precipitation. More particularly, it looks at the average proportion of cropland at any given time experiencing 'extreme' drought. We have defined 'extreme drought' for this purpose as being the level of precipitation deficit that occurs approximately 2% of the time in the current climate.[i] It is important to note that this measure does not take into account the effect of raised temperatures, which, by increasing rates of evaporation, will further increase the risk.

How does the likelihood of drought change over time?

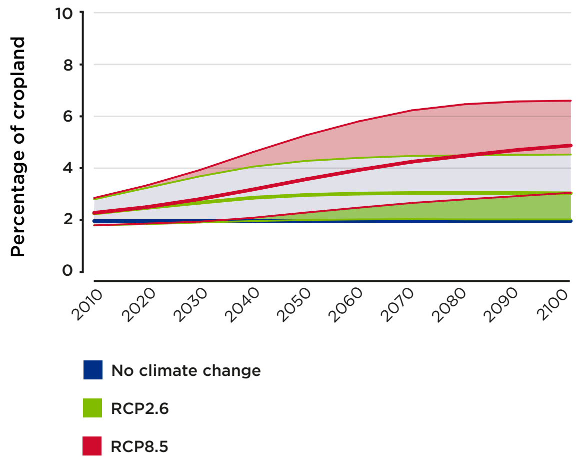
Figure D1 shows the proportion of cropland[ii] affected by drought under high (red) and low (green) emissions pathways, for the globe as a whole and for four major regions, as a function of time. This is equivalent to the probability that a given part of that cropland is in drought, in any given year.

For the high emissions pathway, the proportion of cropland exposed to drought increases by around 75% by 2050 and more than doubles by the end of the century, under the median estimate. On this pathway, the incidence of drought roughly triples in Southern Africa, and increases by about 50% in the US and South Asia, over the course of the century. For the low emissions pathway, the increases are much less. At the same time, what is very clear is that there is there is considerable uncertainty in the projections. The uncertainty ranges suggest that while in the best case, drought incidence could halve in some regions, in the worst case, it could increase by a factor of three or four.

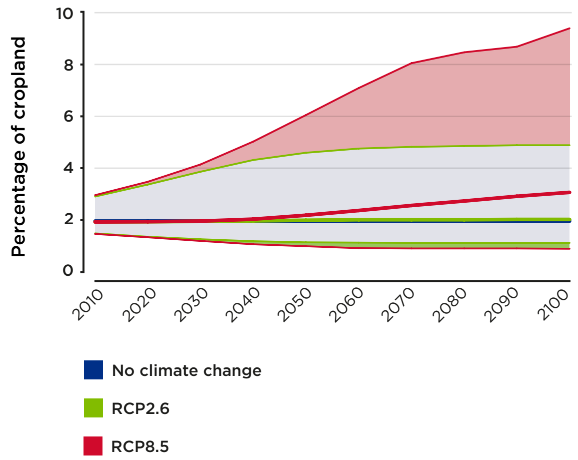
1. See Annex'
2. (assuming no change in total cropland area)

Figure D1: **The proportion of regional cropland affected by drought with and without climate change.** The plots show two climate pathways (RCP2.6 and RCP8.5). The solid line represents the median estimate of impact for each pathway, and the shaded areas show the 10% to 90% range.

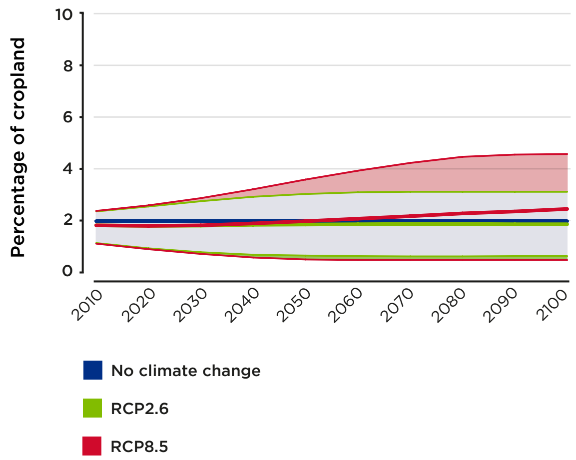
Global: drought affected cropland



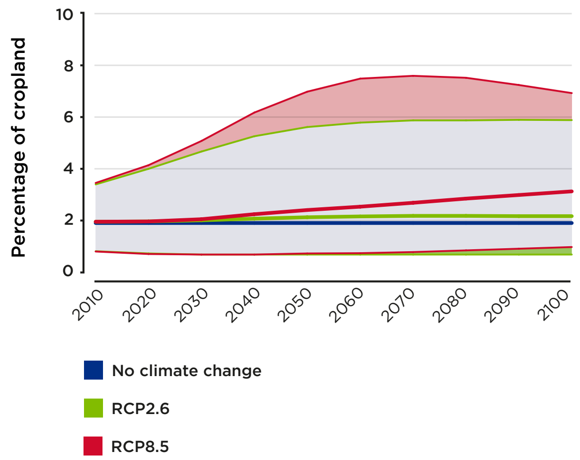
US: drought affected cropland



East Asia: drought affected cropland



South Asia: drought affected cropland



Southern Africa: drought affected cropland

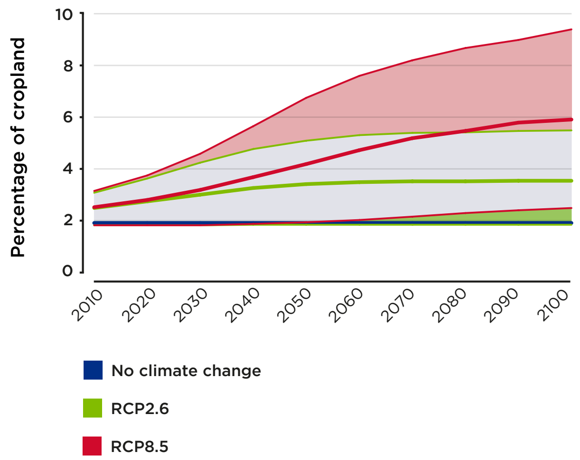
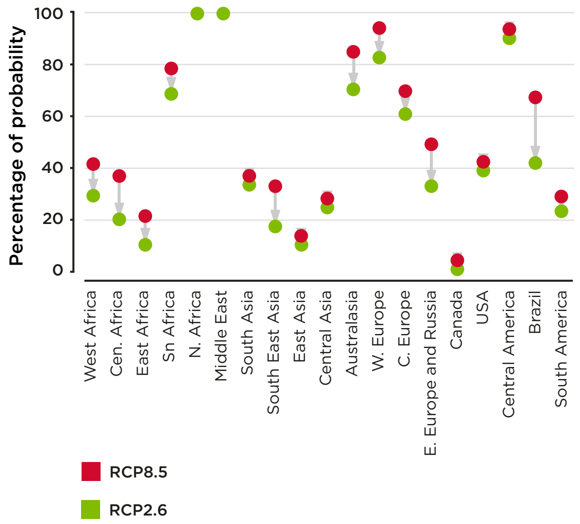
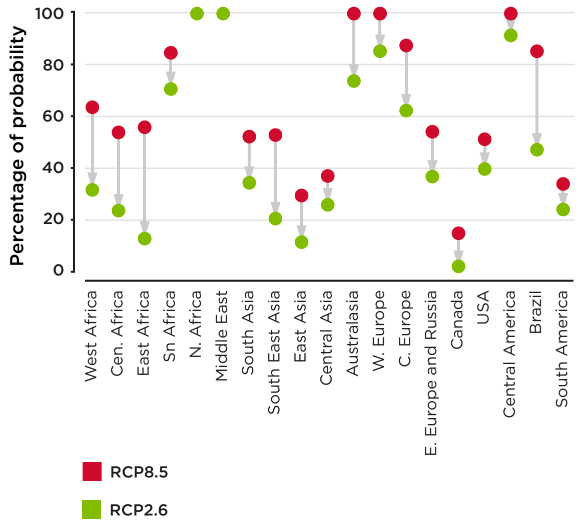


Figure D2: **The risk that climate change increases by more than 50% the average annual area of cropland affected by 'drought', relative to the situation with no climate change, under the two climate pathways.**

2050: probability of cropland area affected by drought increasing by >50%



2100: probability of cropland area affected by drought increasing by >50%



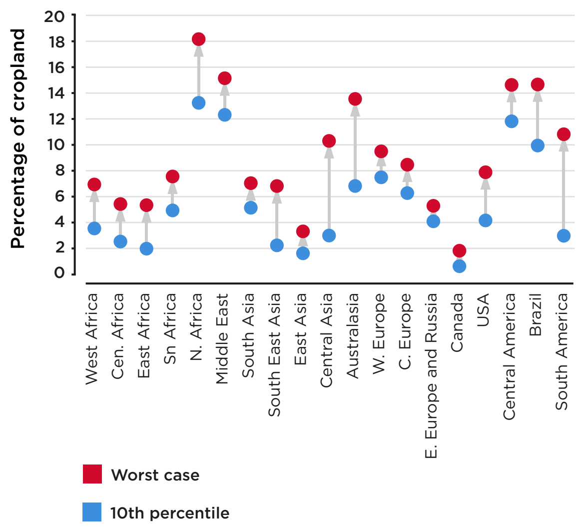
This uncertainty is illustrated in Figure D2, which shows the risk that climate change increases the average annual area of cropland in a region affected by drought by more than 50% in 2050 and 2100. By 2050, the probability is greater than 70% - under high emissions – in southern and northern Africa, the Middle East, Australasia, western Europe and central America. In contrast, there is a relatively low probability that climate change would increase drought extent in East Asia and Canada. Lower emissions reduce the risk, particularly by 2100.

What is a plausible worst case for changes in drought due to climate change?

At the global scale, there is a 10% probability that by 2050 the incidence of drought would have increased by 150%, and the plausible worst case would be an increase of 300% by the latter half of the century. The proportion of cropland affected by drought under the plausible worst case scenario more than doubles in every region (Figure D3) and in all except Canada and East Asia increases by a factor of at least three. The global worst case is not equivalent to the sum of the regional worst cases, because no one plausible climate scenario produces the biggest impact everywhere.

Figure D3 is based on the assumption that all the climate models used to estimate impacts are equally plausible and that they span the range of potential regional climate changes. This is not necessarily the case, so the numbers are to be regarded as indicative.

Figure D3: **Plausible 'worst case' impacts of climate change in 2050 on exposure to drought.** The graph shows the additional annual proportion of cropland affected by drought under the RCP8.5 climate pathway, relative to the proportion affected with no climate change. There is a 10% probability that the impact is greater than that shown by the blue dots, and the red dots show the maximum calculated impact. The average annual proportion of cropland affected by drought in the absence of climate change is just under 2%.



What do we know, what do we not know, and what do we think?

Estimates of how drought risk will change in the future are based on (i) projections of future regional climate change, (ii) projections of how these translate into changes in drought characteristics, and (iii) projections of future exposed land and people. There are uncertainties in all of these.

Projections of future regional climate change depend partly on the assumed rate of growth in emissions, and partly on projected changes in regional and seasonal precipitation. Climate model simulations typically show that whilst global precipitation goes up with climate change, there is strong variability across space. In general, wet regions get wetter, but dry regions get drier. However, the magnitude of the change in a region is uncertain, as are the boundaries of regions which see increases or decreases in rainfall. Temperature increases across all land areas with climate change, and this will exaggerate the effect of rainfall deficits by increasing evaporation.

The way in which changes in climate translate into changes in drought depends on local conditions. Most agricultural systems are tuned to local climatic conditions, so it is departures from those conditions that prove challenging. That is why our drought indicator is defined in relation to average local conditions, rather than being defined in absolute terms. However, different measures of drought are also possible to define, and these would give different indications of both current exposure and future risk.

Finally, the estimated future impacts on agriculture and society depend on changes in exposure to droughts and vulnerability to their effects. This will depend not only on population change, economic growth and the extent of croplands, but also on the degree to which drought mitigation measures (such as forecasting and warning, provision of supplementary water supplies or market interventions) are developed.

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