Overall summary of results

The project, *Impacts of Climate Change on Chinese Agriculture*, combined cutting-edge scientific research with practical development policy advice.

The project was funded by the UK's Department of Energy and Climate Change (DECC, previously Defra) and the Department for International Development (DFID), conducted in partnership with China's Ministry of Science and Technology (MOST). The research was led by the Chinese Academy of Agricultural Sciences in collaboration with leading UK climate change researchers.

Phase I (2001–2004) sought to understand how climate change will affect Chinese agriculture overall. Phase II (2005–2008) built on this work, recognising the need to understand more about the science of climate change and to incorporate the views of local people before developing policy measures to adapt to climate change. This pamphlet gives an overview of the main findings of Phase II. Each topic is covered by a separate pamphlet backed up by detailed technical reports.

DEVELOPING SCENARIOS OF FUTURE CLIMATE CHANGE FOR CHINA

The best way of developing descriptions of how we think the climate may change in the future is to use results from computer models of the climate system. We used a regional climate model system, PRECIS (Providing Regional Climates for Impacts Studies), to provide detailed maps of climate change across China during the 2020s (2011-2040), 2050s (2041-2070) and 2080s (2071-2100).

We confirmed the PRECIS values by comparing them with the average of the values for potential changes in temperature and precipitation (rainfall) during the 2020s and 2050s for China given by 17 global climate models. Because the level of future emissions of greenhouse gases is uncertain, we used two emissions scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) which incorporate different possible social, economic and technological developments (for full definitions see *Special Report on Emissions Scenarios, IPCC 2000*):

- **A2 scenario**: medium-high emissions from a continuously increasing global population
- **B2 scenario**: medium-low emissions and lower population growth

Figure 1 shows changes in a) temperature and b) precipitation. Overall we found that the climate in all parts of China will continue to warm, possibly by as much as 4.5°C by the 2080s (relative to the mean annual temperature for 1961–1990). There will be a consistent and progressive shift to wetter conditions, although some seasons and regions will have moderately drier conditions in the 2020s.

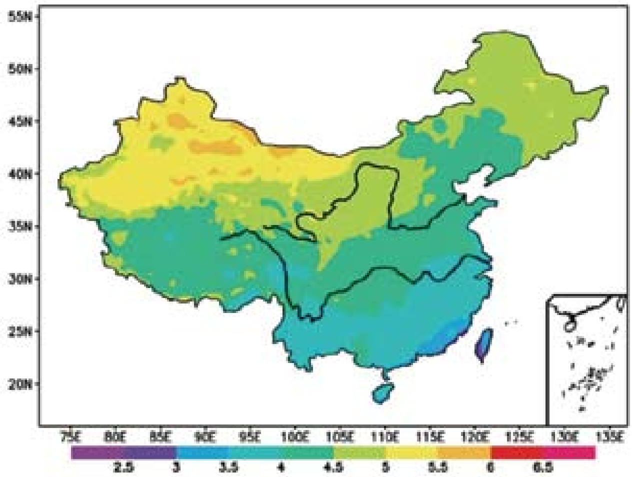
There is considerable uncertainty about the detail of future climate change at the regional scale and especially in how the frequency and magnitude of extreme events will evolve. But we are confident that heatwaves, temperature extremes and precipitation intensities will tend to increase.

CROP PRODUCTION AND YIELDS UNDER DIFFERENT CLIMATE SCENARIOS

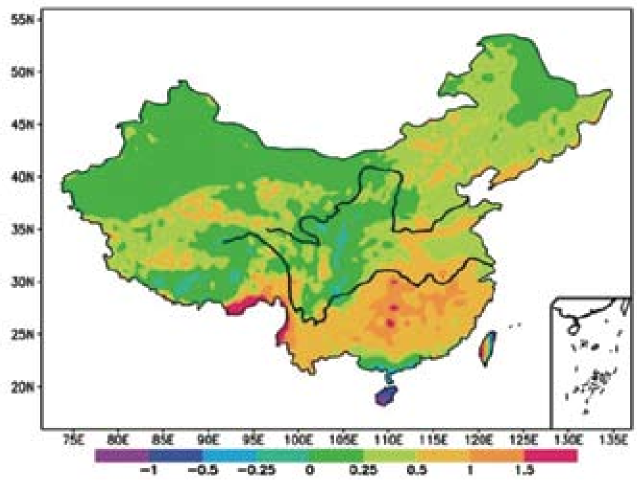
We used the CERES (Crop Environment Resource Synthesis) models for rice, maize and wheat with our climate change predictions from PRECIS to assess the impacts on crop yields, national production and the amount of cereal available for each person in China (per capita production).

We also considered changes with and without the direct effect of carbon dioxide (CO_2) in the atmosphere on plant growth, as the fertilising effect of CO_2 on yields in the field is not well known. The CERES models produced realistic simulation of rice, maize and wheat yield patterns across China for the present. For the future impacts the results are quite mixed:

Figure 1: Changes over China from PRECIS for the 2080s relative to the baseline period (1961–1990) under the A2 scenario (medium-high emissions)



(a) Mean annual temperature change (°C)



(b) Annual precipitation change (mm/day)

irrigated rice and rainfed maize tend to show reductions in yield while yields of rainfed wheat tend to increase when averaged across China: all crop yields decrease without the effects of CO_2. The changes get bigger further into the future. Without improvements in agricultural technology, per capita production declines dramatically relative to today's production.

Including the effects of CO_2 on plant growth in the model simulations leads to higher estimates of per capita cereal production, but these still fall significantly as the century progresses. The results demonstrate the need to improve our understanding of the effects of CO_2 on plant growth and to obtain better projections of future improvements in agricultural technology.

We judge our results to be optimistic because PRECIS simulates much wetter conditions than a multi-climate model average for China, the fertilisation effect of CO_2 is highly uncertain and the effects of extreme events on crop growth and water availability are likely to be underestimated.

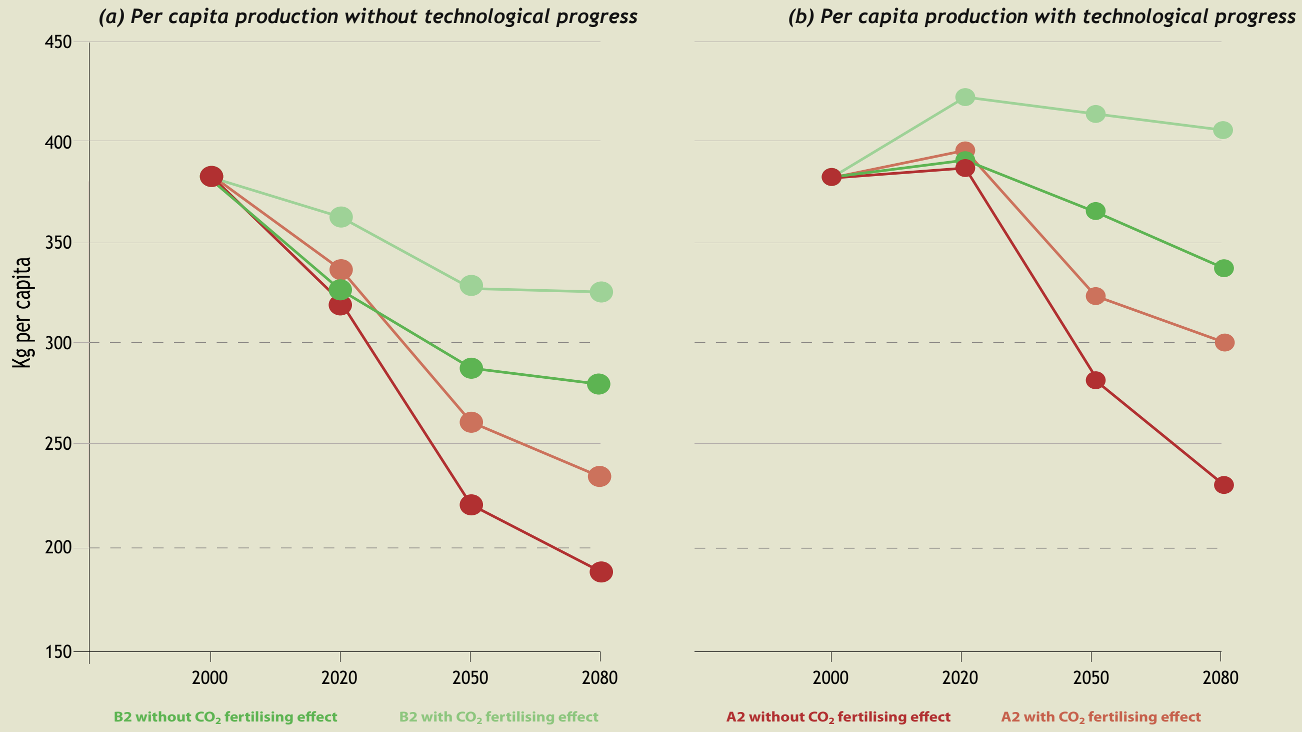


Figure 2. Changes in per capita cereal production simulated to 2080 under two emission scenarios

COMPETING PRESSURES ON AGRICULTURAL PRODUCTION IN CHINA

Climate change is not the only challenge facing Chinese agriculture. We combined crop and water simulation models with climate and socio-economic scenarios to explore how changes in cereal production and water availability due to climate change will interact with other socio-economic pressures in China.

This modelling work suggests that in the future, water availability plays a significant limiting role on potential cereal production, due to the combined effects of higher crop water requirements and increasing demand for non-agricultural use of water. The interactive effects of all drivers together led to significant decreases in total production by the 2040s (-18%, A2 and -9%, B2). Outcomes are highly dependent on socio -economic development pathways and the effects of CO_2 fertilisation which partially offset the negative effects of other drivers.

The combined effects of higher requirement for irrigation and increasing demand by other sectors (industry, domestic) makes water availability a key factor. Successful adaptation policies based on sustained improvements in agricultural technology will be essential to produce enough cereal to keep pace with population growth and the effects of other drivers such as land use change.

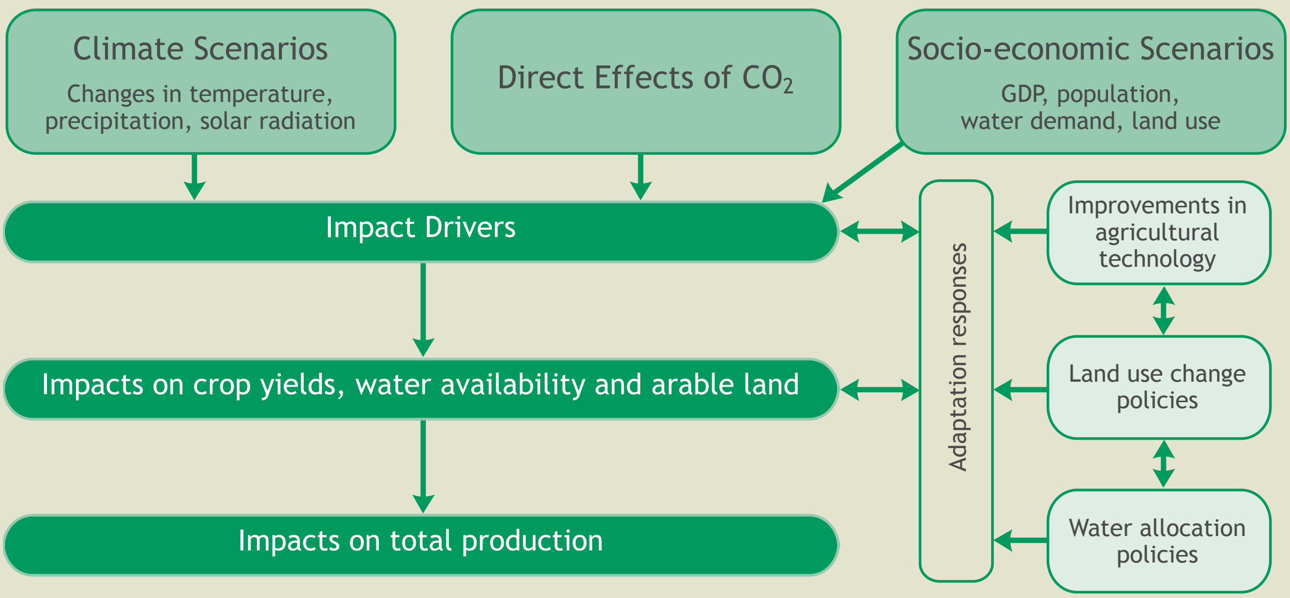


Figure 3: Main steps and interactions between different components in the analysis

THE IMPACT OF CLIMATE CHANGE ON RURAL COMMUNITIES IN CHINA

We carried out a survey in the three different agricultural areas of Ningxia (an autonomous region in northwest China) to examine the impacts of climate change on rural livelihoods. We also looked at how farmers respond and adapt to current environmental change.

Agriculture in Ningxia is vulnerable to climate variations and extremes, though people in the three areas show differing levels of vulnerability to the effects of climate change. Drought is the most serious climate hazard for rural communities in Ningxia; the major drought of 2004–2006 led to crop failure in some areas and caused a direct economic loss of RMB 1.27 billion. Farmers and their supporting institutions in Ningxia have adopted a range of adaptation measures, but these may not be sufficient to deal with longer term climate change. The constraints most often mentioned by farmers in adapting to climate change were lack of money, water shortage and poor infrastructure.

AN ADAPTATION STRATEGY FOR AGRICULTURE IN NINGXIA

Some level of climate change is now inevitable, so society and individuals must adapt to the changes which will occur – either to avoid negative impacts or to take advantage of new opportunities. Drawing on the findings of our survey on the impacts of climate change on rural livelihoods, we produced an adaptation framework and strategy for agriculture in Ningxia.

The framework has six main stages. It provides a useful policy tool for decision-makers in other parts of China to structure their thinking about adaptation and so start to develop their own adaptation strategies. The four main climate risks for Ningxia are drought, surprises/extreme events, drying/high temperature, and shifts in the flow regime of the Yellow River (the main water source). However, climate risks and adaptation priorities vary across the region and sectors. Opportunities for adaptation lie in reducing vulnerability to existing climate hazards, but consultation with stakeholders at all stages of the framework is crucial for identifying appropriate adaptation measures.

As a result of our work, the Ningxia Climate Change Response Office was set up in early 2008 to promote adaptation and mitigation programmes. Adaptation must be seen as a process and not a one-off activity. Awareness raising, flexible treatment of the framework and co-ordinated management across sectors are also essential for success.

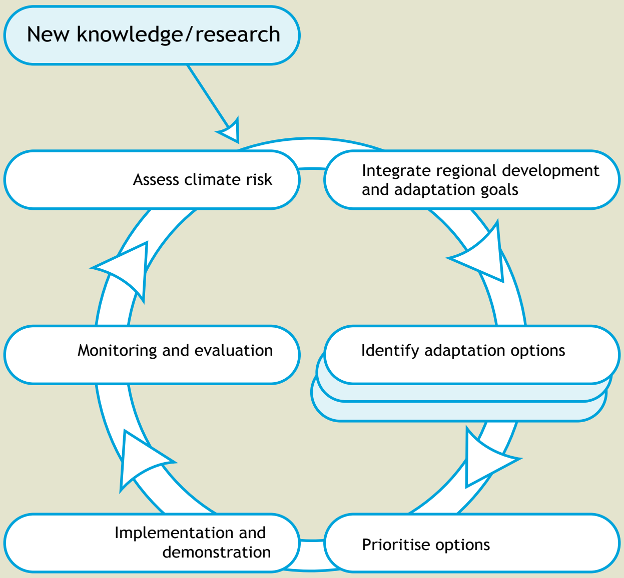


Figure 4. The adaptation framework

FURTHER INFORMATION

All detailed technical reports and six summary pamphlets from the project are available from the project website **www.china-climate-adapt.org** .

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