impacts of climate change on
chinese agriculture

Summary

Modelling the interaction of climate change

water availability and socio-economic scenarios on cereal production

The project, *Impacts of Climate Change on Chinese Agriculture*, sought to understand how climate change will affect rural China.

Phase I (2001–2004) of this joint UK/China collaboration examined the impact of climate change on crop yields. Phase II (2005–2008) built on this work to investigate the impacts of climate change on national cereal production and the cereal quantities available to each person in China to 2100. This pamphlet gives an overview of the main findings of Phase II relating to the modelling of the interaction of the separate effects of climate change, population growth, technological progress, water availability and the direct effects of carbon dioxide on cereal production.

Competing pressures on agricultural production in China

China is undergoing rapid changes in economic structure and development, lifestyle, demand on land and water resources, and pressures on the environment. Agriculture faces significant challenges in sustaining and increasing output to meet growing demand for food.

The availability of water is critical for agricultural production and is already a major stress factor for China's grain production (particularly in northern areas). The pressure of increasing population and per capita consumption on land and water use are major factors in determining the characteristics of future scenarios of food security and are likely to be key factors in increasing the risk of food shortages in the future.

Climate models predict an acceleration of recent warming in China, with associated changes in rainfall and the frequency of extreme events.

However, studies of climate change impacts on crops in China show conflicting results and uncertainties, mainly relating to the methods used and the effect of carbon dioxide (CO_2) on plant growth (referred to as CO_2 fertilisation) which tends to increase yields.

There is little previous work on the interactions between climate change, crop production, land use, water availability and socio-economic change. This pamphlet summarises our work in combining 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.

OUR APPROACH

We considered the effects and interactions of multiple drivers of change (climate, CO_2 fertilisation, water availability and land use change) in relation to their impacts on staple cereal production in China in the 2020s (2011-2030) and 2040s (2031-2050).

We addressed the following key questions:

- What are the likely impacts of climate change on China's cereal production?
- How do climate impacts compare to socio-economic pressures over this century?
- Where and how do significant interactions arise?
- What are the effects of broad level adaptation policies on future impacts?

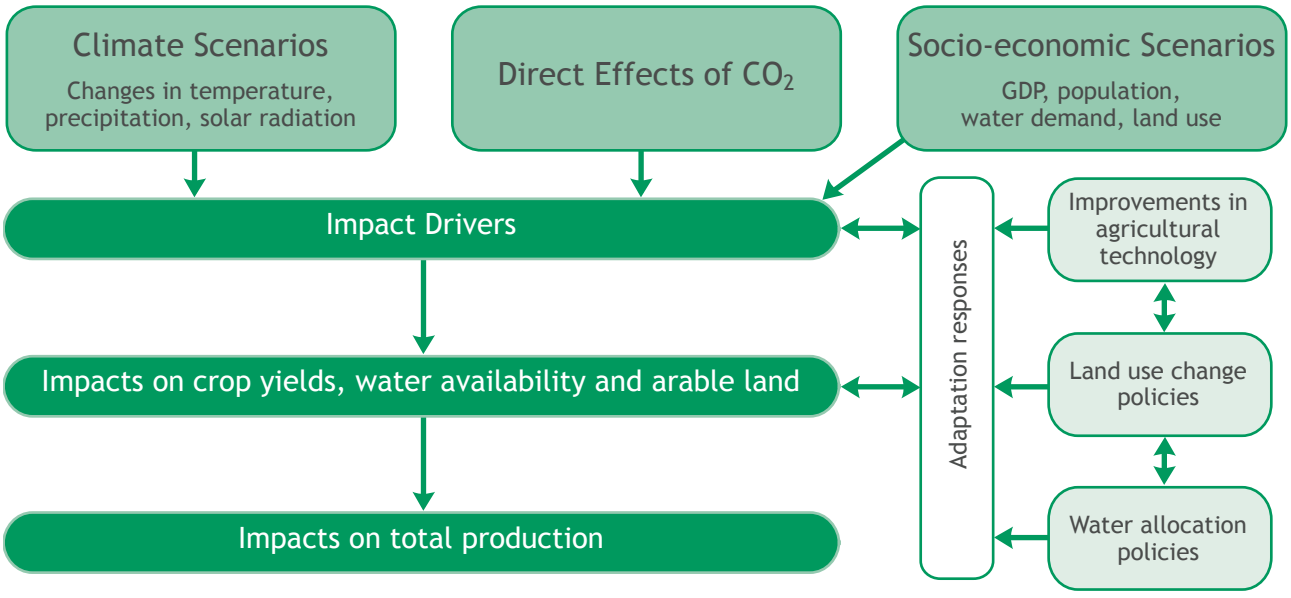


Figure 1: Main steps and interactions between different components in the analysis

To do this we combined socio-economic storylines for China with the results obtained from a high-resolution regional climate model, PRECIS, and the CERES suite of crop models. We used newer versions of PRECIS scenarios, updated versions of the crop models and some revised assumptions about progress in agricultural technology to those used in the national cereal production pamphlet and report. As before we limited our analysis to two of the emission scenarios for greenhouse gases developed by the Intergovernmental Panel on Climate Change (IPCC), (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

We used the step-wise approach summarised in Figure 1 to assess the direct effects of climate change on yields of cereal crops (rice, maize and wheat) and the indirect effects of changes in water availability (as it affects the supply of irrigation water). Within this framework we also considered factors such as the effects of CO_2 fertilisation, changes in arable land and demand for water due to population increase and economic development based on socio-economic scenarios for China (see Figure 2).

SOCIO-ECONOMIC SCENARIOS FOR CHINA

Socio-economic scenarios are projections of a possible future based on a clear storyline interpreted in quantified terms. They generally incorporate key variables that are likely to change significantly over the period of study. Such scenarios provide the context for future climate change impacts and guide the development of plausible adaptation strategies. To be consistent with our climate scenarios, we developed socio-economic storylines for the A2 and B2 emissions scenarios up to 2050 using methods based on those used by IPCC. The following variables were generated:

- National annual population
- Rate of growth of gross domestic product (GDP)
- Water demand from four sectors – agriculture, industry, municipal and domestic
- Agricultural land use

Overall the socio-economic scenarios forecast that there will be a decrease in arable land and an increase in water demand accompanied by a shift in the proportional use of water by sector – primarily away from agriculture in response to greater demand from other sectors such as industry.

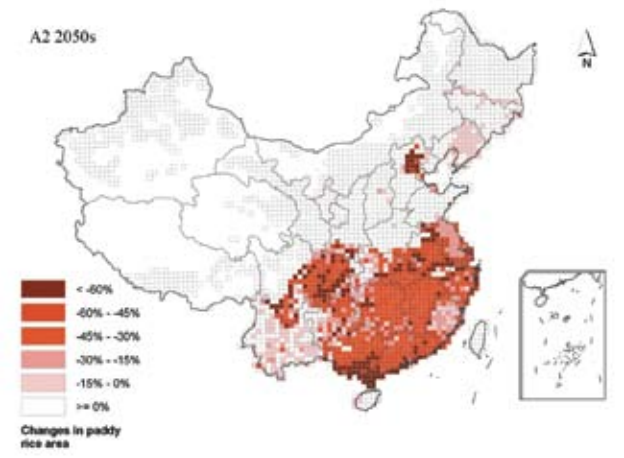
INTEGRATED RESULTS OF CEREAL PRODUCTION

We used our modelling framework to generate changes in crop yields and water availability. From the areas of the crops sown across China, we converted these changes into estimates of cereal production expressed as a national total or per capita based on population growth from the two emissions scenarios. We calculated the changes in arable land based on the socio-economic projections for each province and extrapolated them to a grid scale.

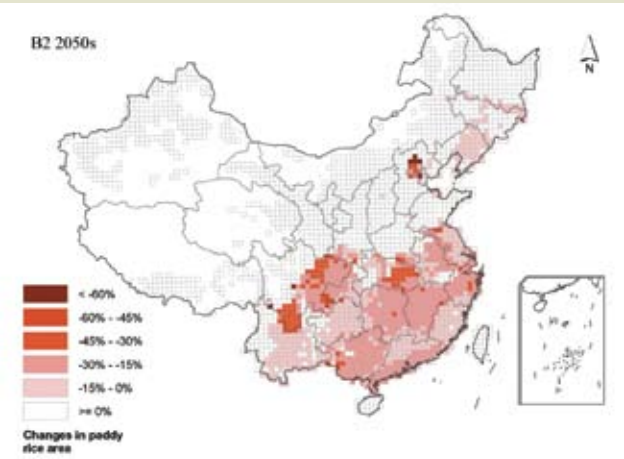
Three adaptation strategies, which reflected national agricultural policy objectives, were simulated to assess their effectiveness in offsetting climate change impacts on cereal production. The adaptations consider:

- Prioritisation of water allocation for cereal production
- Successful implementation of controls on agricultural land losses
- An optimistic scenario of improvements in agricultural technology in the future

Figure 2 shows the future reduction in the area of paddy rice that can be grown due to the effects of reduced water availability. Without adaptation, per capita cereal production will fall due to the combined effects of climate change, population increase, water scarcity and loss of arable land. By simulating adaptation responses up to 2050, our results show that China could maintain per capita cereal production given realistic assumptions about land and water management policies and the uptake of improvements in agricultural technology.



(a) A2 (medium-high emissions)



(b) B2 (medium-low emissions)

Figure 2: Per cent change in the area of paddy rice that can be grown in the future

KEY FINDINGS

Scenarios of future climate change project continued warming in all seasons over the whole of China, and consistent but modest increases in mean annual precipitation.

Without adaptation:

- With updated PRECIS scenarios, improvements to the crop models and taking a shorter time frame of analysis (the 2040s) we obtained smaller effects on China's potential cereal production than in earlier national impacts modelling (see 'Cereal Production' pamphlet).
- The general trend is that climate change will lead to a decline in cereal production in China throughout the first half of the 21st century. The only temporary exception to this trend may occur in the 2020s under the A2 scenario (medium-high emissions) as slight increases in rice and wheat production may lead to short-lived increases in total cereal production.
- In the future, water availability plays a significant limiting role on potential cereal production, due to the combined effects of higher crop water requirements (due to climate change) and increasing demand for non-agricultural use of water (due to socio-economic development).
- 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.

With adaptation:

- By simulating the effects of three adaptation scenarios we show that for PRECIS with two emissions scenarios China is able to maintain per capita cereal production, given reasonable assumptions about policies on land and water management and progress in agricultural technology.

CONCLUSIONS

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.

- Climate change represents an additional stress on China's future agricultural production. Over the next couple of decades the most significant impacts are likely to arise from the effects of extreme events.
- Our findings reinforce the need to achieve better environmental sustainability in agriculture, and to support adaptive management in the sector with appropriate investment levels in agricultural technology.

China's vulnerability to climatic hazards is high; because of its size and geographical extent it experiences many types of hazard and because of its transitional economy, production and employment in sectors such as agriculture remain very important, such that millions of livelihoods are exposed to climate related risks.

FURTHER INFORMATION

The full report, *Future Cereal Production in China: Modelling the Interaction of Climate Change, Water Availability and Socio-economic Scenarios*, together with all the other reports and six summary pamphlets from the project, are available from the project website **www.china-climate-adapt.org**.

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