



## Understanding past and future impacts of climate change in agriculture: implications for adaptation planning

### About the ACCC Project

The Adapting to Climate Change in China Project (ACCC) is an innovative policy research project, supporting China's response to the impacts of climate change and evidence-based adaptation planning. ACCC provides decision-makers with the policy-relevant information they require, taking into account current and future climate change and variability. ACCC aims to improve understanding and assessment of impacts, vulnerability and risk in key sectors in China by bringing together policy and research, national and subnational planning, social and physical science for an integrated response. The project shares this experience and lessons learnt with other developing countries in order to reduce their vulnerability to the impacts of climate.

#### ACCC does this by:

- supporting evidence-based adaptation planning through access to relevant and robust data, tools and information.
- mainstreaming climate change adaptation policies into development planning.
- producing comprehensive impact, vulnerability and risk assessments at the national and subnational level.
- building capacity and providing technical support on adaptation responses at the subnational level.
- sharing China's experience with other developing countries to enhance their own resilience to the impacts of climate change.

For more information, please visit our website at [www.ccadaptation.org.cn](http://www.ccadaptation.org.cn).

### Key messages

- Annual average air temperature in China has risen slightly faster than the average rate of global warming. The warming has led in places to a lengthening of the growing season and has affected cropping systems and management practices.
- Droughts are responsible for the largest direct economic losses due to natural hazards in China. Average annual grain losses were 14 million tons between 1949 and 2001 accounting for 4.6% of average grain production over the same period. Flood events also disrupt agriculture and accounted for 28% of the total economic losses due to meteorological disasters during 2004-2009.
- There is a tendency for wheat, rice and maize yields to decrease in the southern parts of China, where crops are already grown close to their temperature tolerance and warmer conditions speed up crop maturation; yields tend to increase in central, north and north-eastern China benefitting from the longer growing season.
- The effects of recent climate trends and extremes highlights the challenge they pose for agriculture in China. Improved understanding of their impacts can help the design of adaptation strategies.
- Preliminary studies show there is good potential to increase food production if the right strategies and technologies can be identified.

## Background

Climate change poses a serious risk to global food security and agriculture. Nowhere is this issue more pressing than in China, as identified in China's First National Communication to the UNFCCC, published in 2004 (presented at COP 10, NDRC, 2004).

Climate change impacts research has a long history in China, with early examples supported by the Ministry of Science and Technology (MoST) during China's 8th (1991-1995) and 9th (1996-2000) five-year planning periods. Major reviews have been produced such as the recent 'National Climate Change Assessment Report' (EBNCCA, 2007), and there is a growing body of literature on impacts across sectors.

## Climate and agriculture in China

Agriculture is of critical importance to China with 54% of its population living in rural areas. In 2005, total increased value of agricultural GDP was 2.27 trillion RMB (336.6 billion US \$, NBSC, 1996 and 2006), and farmland comprised an estimated 130 million ha (EBCAY, 2006).

Due to its size and geographical diversity, China experiences many types of climate change impacts and because of its transitional economy, production and employment in sectors such as agriculture remains very important, such that hundreds of millions of livelihoods are

## The impacts of climate extreme events

Agriculture is one of the sectors most affected by natural hazards. Droughts, floods, low temperature stress, and hail constitute the major hazards that affect China's agriculture and are responsible for 71% of the losses caused by natural hazards annually (Huang et al., 2005).

Droughts are responsible for the largest direct economic losses. It was drought that triggered the loss of 26 million tonnes of grain between 1991 and 2000 (around 5.4% of net production) and caused dramatic economic losses (Liu et al., 2005). Figure 1 shows the area of cropland damaged by drought in China between 1978 and 2005.

The Chinese Academy of Agricultural Sciences (CAAS) is the leading ACCC partner conducting research on climate change and agricultural resources. CAAS is using government statistics on climate extremes and their impacts to assess their effects on crop production. While the overall scale of the impacts of drought in Northern China (which includes an ACCC Pilot province, Inner Mongolia) is significant, there is no clear trend in the impacts over time.

Flood events also disrupt agriculture and accounted for 28% of the total economic losses due to meteorological

disasters during 2004-2009.

However, climate change adaptation research and the linkage between impacts, adaptation and decision-making processes is a new and emerging area.

This briefing outlines the key research highlights to date on the impacts of climate change on agriculture. This work is part of the ongoing research by the Chinese Academy of Agricultural Science (CAAS) for the Adapting to Climate Change in China (ACCC) Project. It also highlights key findings from a recently published review on the effects of climate variability and change on Chinese agriculture.

vulnerable to climate change impacts.

This vulnerability is clearly demonstrated by recent events like the serious drought across five provinces in southwest China from the end of 2009 to April 2010. Roughly 7.7 million ha of farmland was affected by the drought, and over 24 million people and 15 million livestock had difficulty accessing drinking water. As of late 2010 direct economic losses in the five provinces exceeded 23.66 billion Yuan RMB (3.58 billion US \$ MCA, 2010a).

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Between 1950 and 1998 flooding in China produced a total loss of life of 259,000, damaged 110 million houses, and affected (or damaged) 9.1 (5.1) million ha of agricultural land per year, which amounts to 10% and 5% of the total cropland area, respectively.

The annual total rainfall in China gives a complicated picture of different patterns over the past 100 years, during the past 100 years, with considerable differences among provinces. From 1956 to 2000 precipitation decreased in the Yellow, Haihe, Liaohe and Huaihe River Basins and increased in the

lower reaches of the Yangtze River, along the coastal areas in southern China and in north western China.

There is some evidence for an increase of impacts on agriculture due to floods for the whole of China between

1950 and 2007. It is certainly the case that over large parts of southern China rainfall intensities have increased leading to more frequent and intense flood events, with significant socio-economic impacts, including on agriculture.

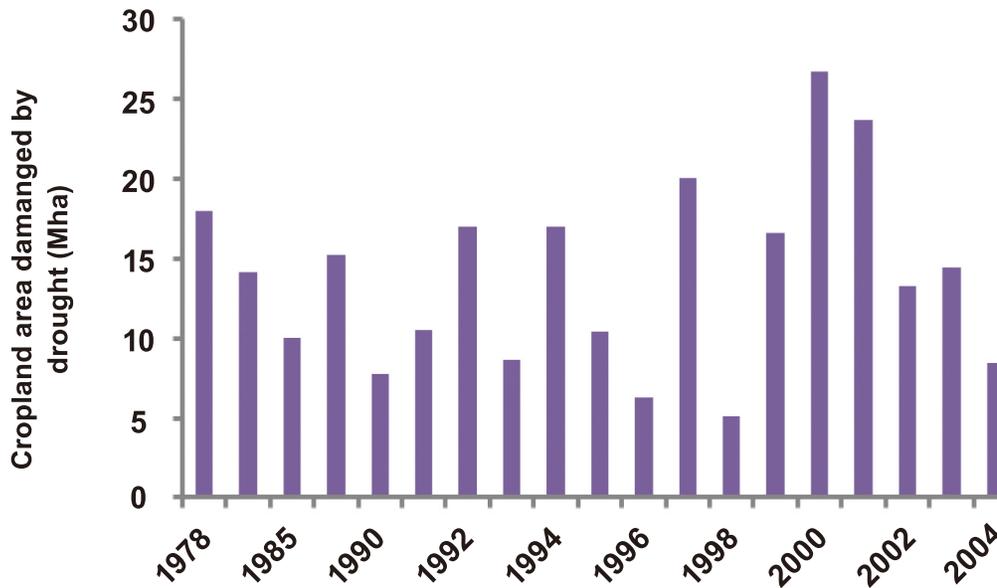


Figure 1: Cropland area damaged by drought in China. Source: EBCAY, 2005.

## How has warming affected agriculture in the last fifty years?

Climate change means rising temperatures for China, and in terms of air temperature, the annual average is rising slightly faster for China than the global average. Most of this warming has happened in the last 50 years.

For agriculture, this has meant a lengthening of the growing season and has affected cropping systems and management practices. However, results show complex patterns highlighting the difficulty of disentangling climate and crop yield/production relationships across diverse

agricultural conditions, crop types and the rapidly changing management and socio-economic conditions in China.

ACCC research with farming communities in the provinces of Inner Mongolia and Ningxia aims to understand how recent warming and extreme climate events have affected farmers' livelihoods as a step towards characterising vulnerability and identifying appropriate adaptation measures.

## What are the implications of future climate change for crop production in China?

In order to plan effectively for future climate change it is necessary to develop projections of how the climate may change in the future. The most widely used and rigorous approach to doing this is to use results from computer models of the global climate system as a starting point for impact and risk assessments in key sectors such as agriculture and water.

The Adapting to Climate Change in China project is working to improve the development of and access to climate science in China. This includes the development of a more complete and reliable set of climate models to assess future climate change. The first multi model data set for China will be based on two regional climate models

(known as RegCM3 and PRECIS) developed respectively by the Chinese Meteorological Administration (CMA) and CAAS. These models will be higher resolution and will therefore give more information for the whole East Asian Monsoon Area and provide more relevant data to policy makers and academics regionally.

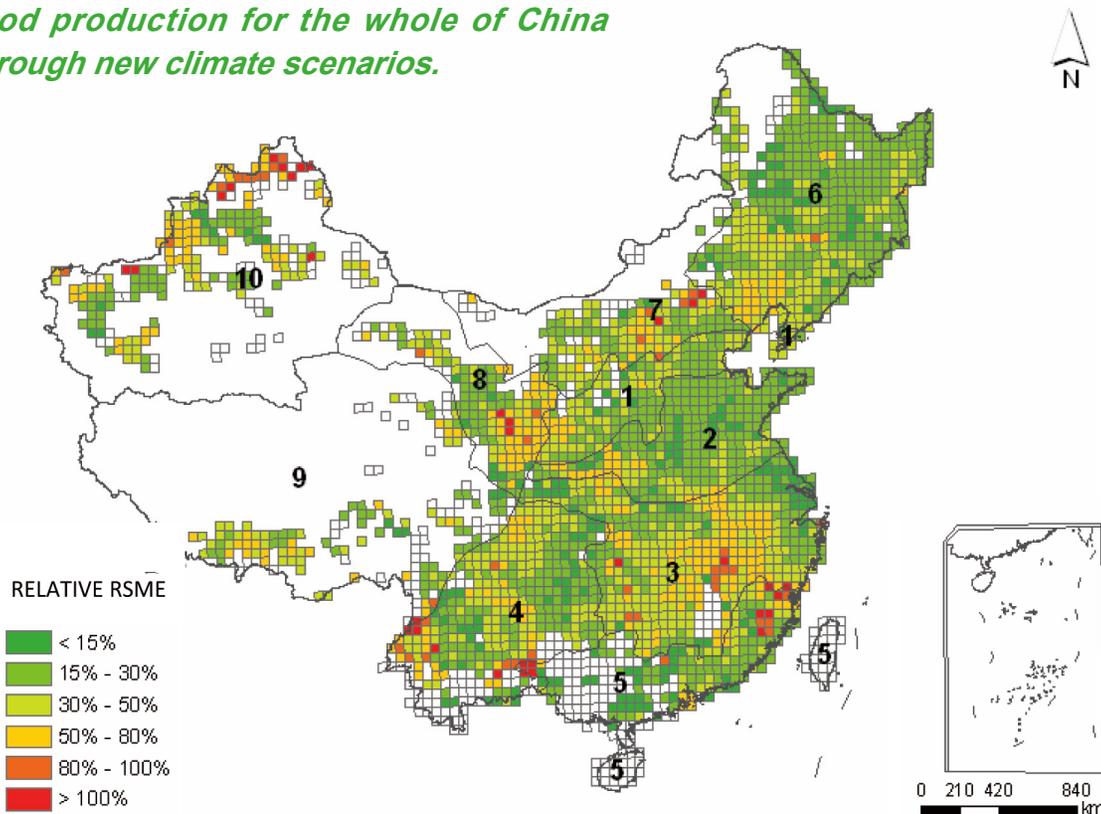
A multi-model approach is important to bring together the full range of results for a more accurate projection of future impacts. Results differ depending on climate model scenarios (looking at rainfall or temperature), methods and inclusion of wider factors (like CO<sub>2</sub> fertilisation) and time and regional scales.

## Going Deeper

Most crop climate impacts studies for China have used process-based simulation models to estimate changes in crop yield of wheat, rice and maize, the main cereal crops in China. The key findings from existing research are:

- Factors such as crop variety, cropping season (complicated by multiple cropping systems), whether crops are irrigated or rain fed and differences in the spatial patterns of precipitation, radiation and evapotranspiration all contribute to complex spatial patterns of impacts on yields and differences between the results of published studies.
- The main spatial patterns are: a tendency for wheat, rice and maize yields to decrease in the southern parts of China, where crops are already grown close to their temperature tolerance and warmer conditions speed up crop maturation; yields tend to increase in central, north and north-eastern China benefitting from the longer growing season.
- Wheat is more sensitive than rice and maize to the CO<sub>2</sub> fertilisation effect. Irrigated maize and wheat are the least sensitive to increased temperature and rain-fed maize and rice are the most sensitive.
- Studies that consider the effects of changing water availability alongside the direct effects of climate change on crop yields in irrigated areas tend to show that water availability becomes an important limiting factor, primarily through growing demand from non-agricultural sectors.

*The research assesses the impacts on food production for the whole of China through new climate scenarios.*



**Figure 2:** Comparison of simulated and observed wheat yield in the past 20 years. Green areas represent good model performance. Source: Chinese Academy of Agricultural Sciences (CAAS), ACCC Technical reports (2010, 2011).



The Adapting to Climate Change in China project is improving understanding of climate impacts and evaluating policy options to deal with them. In order to do this for food production, the project uses a crop modelling system called CERES (Crop Environment Resource Synthesis) which simulates future rice, maize and wheat yields.

The model is particularly practical because it is process-based and management-oriented. It simulates how yield would be affected by different environmental factors and ways of managing the crops. It also simulates how water scarcity issues would impact crops, due to unavailability for irrigation and other uses.

ACCC is also improving data to support evidence based decision making, through the updating of a country

wide simulation. The more detailed model will increase the resolution of grid cells to 55km. This increased the relevance and usability of results for making adaptation policies in agriculture. Figure 2 shows the preliminary results of the improved model and its ability to simulate yields.

The modelling system will be used with new climate scenarios from ACCC to provide assessments of impacts and their uncertainties for the whole of China. More detailed studies will be carried out at provincial level using local crop data and information from farming systems; this will not only improve the quality of the information but also contribute to building the capacity of research organizations in the provinces to develop comprehensive assessments of impacts of climate change on agriculture.

## What implications will climate change have for grassland and livestock in China?

Grasslands and livestock grazing are of great importance to China's rural population and are particularly key in the provinces of Inner Mongolia and Ningxia, two of the pilot provinces for ACCC. To enable appropriate these key industries to respond to the strains of climate change, ACCC researchers are developing models to simulate the future productivity and how this would be affected with different management practices. This work involves establishing climate, soil and grassland databases and collecting socio-economic data.

These data include: the agricultural phenological data and yield observations of 37 stations in Inner Mongolia, nation-wide data of livestock weather stations gathered by the Chinese Meteorological Administration, previous observations and survey data of grassland collected from networks and literature, grassland areas per county and socio-economic data per county.

Changes in biological productivity of grassland have been analyzed and the grassland biomass in Inner Mongolia has been calculated using the Miami Model. It was found that the grass biomass has decreased during the 2000s in Northern and Eastern Inner Mongolia, where the overall biomass is decreasing.

The grassland productivity for North China was simulated using three different future scenarios, depending on the level of carbon emissions globally (A2, B2, A1B). It was found that there is no change of grassland biological distribution pattern under the different scenarios and different decades. By the 2080s under A2 emissions grassland biomass would increase largely in Northeast China and Tibet and decrease in Southern Ningxia and Southern Gansu. Further work is necessary to understand the causes of these response patterns and researchers are applying a more detailed grassland model (CENTURY) to simulate climate change impacts.

## Implications for adaptation planning

The ACCC approach supports evidence-based adaptation policies by providing more accurate and accessible data on the impacts, risk and vulnerability of climate change. The research highlighted in this paper shows the threat climate change poses to agriculture in China. But the research is also providing useful analysis, case studies and evaluation of responses and strategies. Extreme events may act as triggers in policy processes by providing a window of opportunity for new policies and are likely to form a major component of adaptation.

### Preliminary results show that:

Adjusting crop planting structure, changing sowing time and planting new crop varieties are feasible adaptation options.

The differences of the effects of adaption technologies are significant in space and time.

It is necessary to study and disseminate integrated adaptation technologies for agriculture. Further work will explore how entry points in these pathways can

be used to define adaptation strategies.

For the agricultural components of this work ACCC is developing approaches to identify and prioritise agricultural adaption technologies. Ongoing studies have shown that human adaption measures contribute more to increases in food production. Based on technological progress, there is good potential for increasing food production if the right strategies and technologies can be identified and sustainability issues addressed.

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## Main sources of this Brief

The second edition of this briefing was produced in June 2012.

**Li Yue, Conway, D., Xiong Wei, GaoQingzhu, Wu Yanjuan, Wan Yunfan, Li Yan, Zhang Silong** (in press) Effects of climate variability and change on Chinese agriculture: a review. *Climate Research*. DOI: 10.3354/cr01038

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