ACCC
Adapting to Climate Change in China

POLICY BRIEF

August 2011

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

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 productionif the right strategies and technologies can be identified.

Background

Agricultural production and food security are widely seen as critical areas where anthropogenic climate change is likely to produce significant impacts. Nowhere is this issue more pressing than in China. China's First National Communication to the UNFCCC was published in 2004 (presented at COP 10, NDRC, 2004).

Research on climate change impacts 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. Research on adaptation and linking of climate impacts assessments with decision-making and policy processes, however, is only now emerging.

This Policy Brief outlines the scope and initial findings from the agricultural impacts assessments research conducted by the Chinese Academy of Agricultural Sciences (CAAS) within 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.

Climate and agriculture in China

Agriculture possesses special importance for 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 climatic hazards 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 vulnerable to climatic hazards.

This is clearly demonstrated by recent events such as 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).

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).

Overall, droughts are responsible for the largest direct economic losses. Average annual grain losses were 14 million tons between 1949 and 2001 and 26 million tons between 1991 and 2000, accounting for 4.6% and 5.4%, respectively, of average grain production over the same periods (Liu et al., 2005). Figure 1 shows the area of cropland damaged by drought in China between 1978 and 2005.

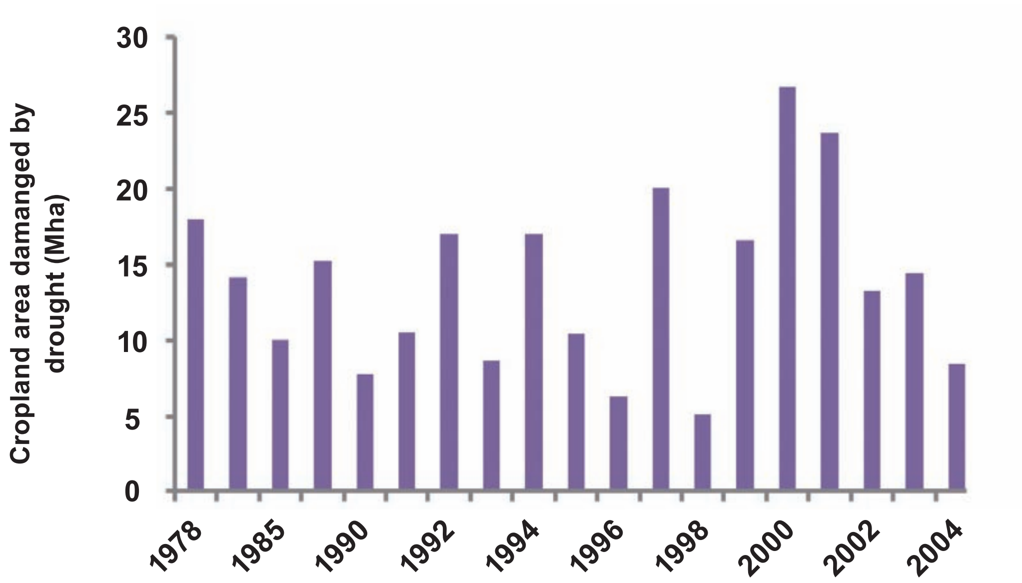

Figure 1: Cropland area damaged by drought in China. Source: EBCAY, 2005

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.

Annual average air temperature in China has risen slightly faster than the average rate of global warming.

Flood events also disrupt agriculture and accounted for 28% of the total economic losses due to meteorological disasters during 2004-2009.

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.

Annual total precipitation in China shows complex patterns of spatial and temporal behaviour 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.

The effects of observed warming during the last fifty years

Annual average air temperature has risen slightly faster than the average rate of global warming.Most of the temperature rise occurred during the last 50 years. The warming has led in places to 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 descriptions 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.

One of the key actions of ACCC is the improvement of climate science over 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. The information will have a higher spatial resolution and is expected to provide better simulation of the East Asian Monsoon Area.

Studies of climate change impacts on crops in China show a wide range of results, reflecting, among other things, differences among climate model scenarios (temperature, precipitation, etc.), the methods used to assess impacts (e.g. crop models), and whether and how the effects of CO2 fertilisation are included. The spatial and temporal scale of analysis is also important: some studies focus on national aggregate impacts which may obscure differences at provincial levels; and some focus on the near-term future and some out to the end of the century.

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 CO2 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.

With the aim of improving the understanding of climate change impacts and possible adaptation options, the ACCC project is using a crop modelling system called CERES (Crop Environment Resource Synthesis) to simulate rice, maize and wheat yields under future climate scenarios.CERES is a process-based, management-oriented model that simulates the effects of environmental factors and crop management on crop growth, development, and yield. The crop model will be linked with a fully distributed hydrological model for China to simulate the effects of climate change on water availability for irrigated agricultureand other uses. As part of the ongoing research a country widesimulation is being updated; a more detailed spatial resolution with grid cells of about 55 Kilometres, similar to the scale of the regional climate model outputs,is among the key improvements introduced. This will increase the relevance and usability of results for formulation of agriculture adaptation policies. Figure 2 shows the preliminary results of improvements to the modelling system and its ability to simulate observed wheat yield over the past 20 years.

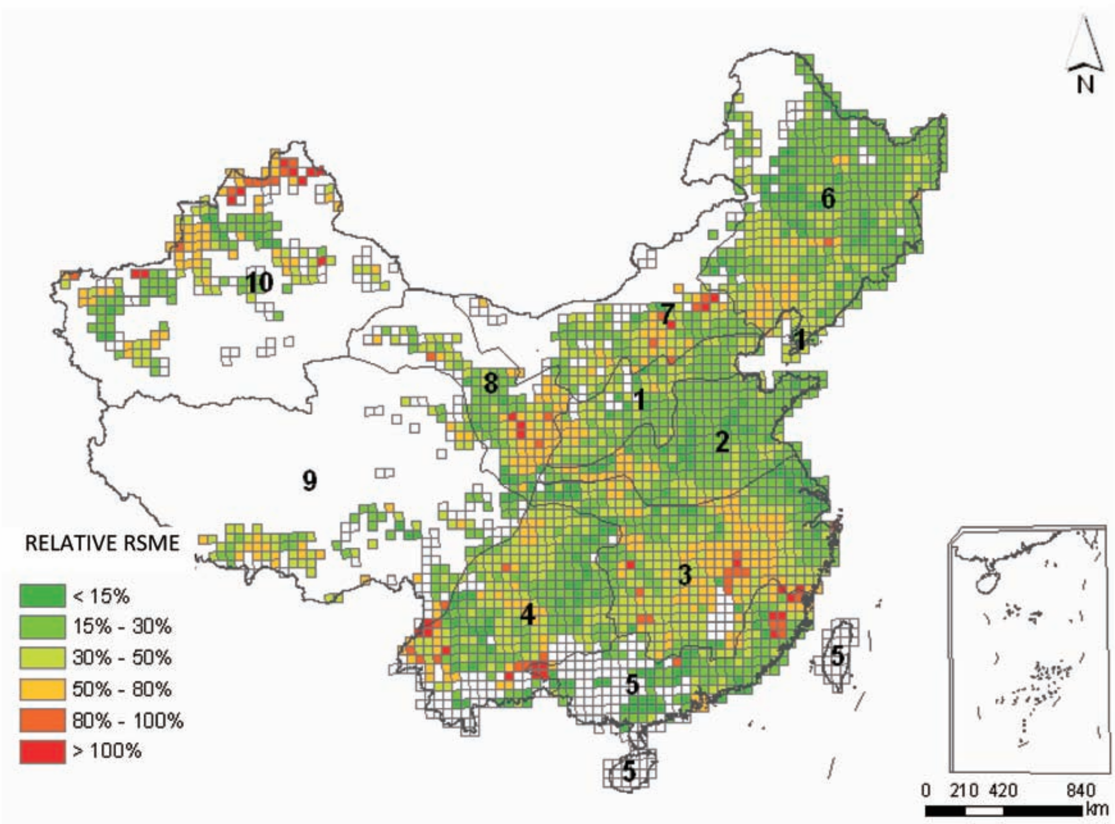

Figure 2: Comparison of simulated and observed wheat yield in the past 20 years. Green areas represent good model performance.Source: Chinese Academy of Agricultural Sciences (CAAS), ACCC Technical reports (2010, 2011)

The 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 build the capacity of research organizations in the provinces to develop comprehensive assessments of impacts of climate change on agriculture.

New climate scenarios from ACCC will be used with crop models to provide assessments of impacts on food production for the whole of China.

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What are the implications of future climate change for grassland and livestock production in China?

In recognition of the importance of grassland and livestock grazing systems in China and particularly in Inner Mongolia and Ningxia, provincial and national ACCC research teams are developing models to simulate productivity under climate change and alternative 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 is found that the grass biomass has decreased during the 2000s in Northern and Eastern Inner Mongolia, where the overall biomass is decreasing.

Based on climate change scenarios with three different sets of greenhouse gas emission scenarios (known as A2, B2, A1B) as inputs to the Miami Model, the grassland productivity in North China has been analyzed. It is 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 links impacts assessments with vulnerability studies; they will then feed into the design and implementation of adaptation strategies. Analysis of recent climate trends and extremes highlights the challenge they pose for agriculture in China. Such research can also provide useful case studies for designing adaptation 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.

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.

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.

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Main sources of this Brief

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About the ACCC Project

ACCC is an innovative policy research initiative focusing on linking climate change research with policy making and development. This 3 years project started in June 2009 as a collaboration between UK, China and Switzerland; it is funded by the UK Department for International Development (DFID), the Swiss Agency for Development Cooperation and the UK Department for Energy and Climate Change.
For more information and updates visit the project web site:www.ccadaptation.org.cn
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