ACCC
Adapting to Climate Change in China
Sharing Knowledge Globally

Key Research Findings

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MANAGING WATER AS CHINA WARMS: New insights from regional models

The most detailed climate impact projections to date call for aggressive measures to ensure China doesn't run dry.

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.

Key messages

- With water supplies per capita only 25% of the global average, and uneven rainfall already causing frequent floods and droughts, China must prepare for shifting water regimes under climate change. The Adapting to Climate Change in China (ACCC) research policy project shows how the latest climate modelling can be linked with impact assessment and decision-making across different sectors, including water.
- Climate change is one of a number of pressures affecting water resources in China. Population growth, urbanisation and industrialisation are increasing demand and polluting sources. At the same time, climate change is making flows more variable and amplifying existing drought and flood patterns.
- Although climate models agree warming will continue, rainfall projections are less certain. However, the prevailing pattern of 'north dry, south wet' looks set to persist; exacerbating water scarcity in some northern regions, which are important for agriculture.
- As China's economy grows and competition for water intensifies, China will need to develop robust systems for managing water in an uncertain but increasingly volatile climate, particularly in the water-scarce north. This may require a new style of adaptive management, combining use of non-traditional sources such as urban waste water with better management of existing storage, and much more emphasis on water conservation and reallocation.

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Background

In the next few decades, climate change in China will add pressure onto water resources, already under intense stress. China's successful investments in water-related infrastructure have helped mitigate climate variability and strengthen water, food and energy security; but the country's water supplies are now dwindling under a combination of population growth, rising per capita demand, urbanisation, industrialisation and pollution, particularly in the water-scarce north. Per capita water availability is only 25% of the global average (see Box 1). Climate change is exacerbating these strains, and so the water sector is one of four priority areas for adaptation identified in China's national climate change adaptation programme.

Climate change in China adds pressure on water resources already under stress, making the water sector a top priority in China's national adaptation programme.

But adaptation planning has been hampered by uncertainty about how climate change will affect the country's surface and groundwater systems. Now, early findings from an innovative research project are beginning to provide a clearer picture.[1] The project, Adapting to Climate Change in China (ACCC), aims to demonstrate how the latest climate modelling can be linked with impact assessment and decision-making across different sectors, including water.

This Policy Brief summarises the ACCC's interim findings on the past and future impacts of climate variability and change on water resources in China, and explores the implications for management and policy.

Declining water resources in China: is climate change a cause?

Across China as a whole, water resources have shrunk since the 1980s though some regions have dried less or become wetter (Box 2). The World Bank estimates the cost of water scarcity and pollution at around 2.3% of GDP.[2]

Agriculture remains China's biggest water user, accounting for roughly 63% of withdrawals, mainly in the north.[3] This share is slowly declining as water conservation policies generate more 'crop per drop' and release water for fast-growing urban and industrial sectors. As combined demands rise, so does the production of wastewater and pollution, making clean water even scarcer.

BOX 1. China's water challenges: too little, too uneven

According to estimates of surface and groundwater flows, China has the world's sixth largest renewable water resources, roughly 2841 km^3/year — but the water available per capita is only about 2151 m^3/year, 25% of the global average. Moreover, these scant water resources are unevenly distributed across the country (Figures 1 and 2) and fluctuate dramatically over time.

South and east China receive strong rains during the summer monsoon, raising their annual average rainfall to around 2,000mm/year. Rainfall in the much drier west and north is less than one-fifth of this, only 200-400mm/year. Regions with less than 1000m^3 of renewable water per capita are commonly defined as 'water scarce' [10]. Northern China has only 750m^3 of renewable water per capita, less than one-fourth of that available in the south, and one eleventh of the world average. With very limited water, the north nonetheless supports over 40% of the national population, has 60% of the arable land and generates over 40% of China's GDP. The region produces roughly half of China's grain and nearly all its wheat and maize.

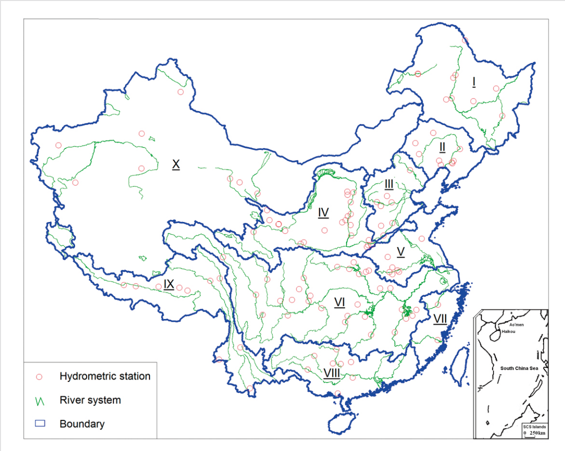

Figure 1:** **Major river basins and hydrometric stations in China. *I – Songhuajiang; II – Liao; III – Hai; IV – Huang (Yellow); V – Huai; VI – Yangtze; VII – Southeast; VIII – Zhujiang (Pearl); IX – Southwest; X – Northwest. Source: Wang et al (2011).*

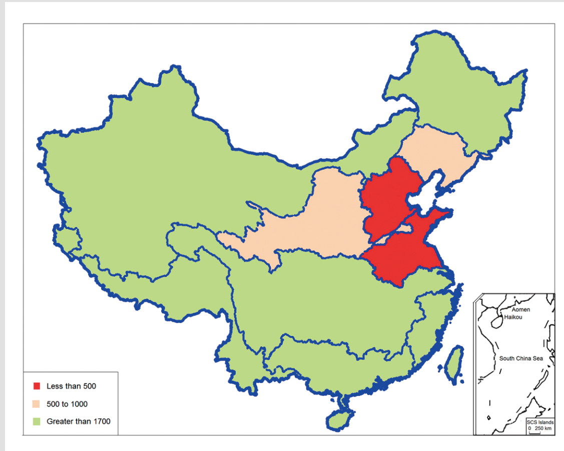

Figure 2:** **Spatial distribution of annual per capita water resource availability in China. *Source: World Bank (2007)*

Rainfall in China also varies greatly from season to season and year to year, with a strong monsoonal influence. Droughts and floods are frequent, often occurring simultaneously in different regions. The Yangtze basin, for example, sees severe floods roughly once every 10 years, most recently in 1998, when flood water inundated 21 million ha of land and destroyed five million houses, causing an economic loss of over US$20 billion.[11] Droughts, however, are responsible for the biggest economic losses and can devastate livelihoods in rural areas. A serious drought across five southwestern provinces in 2009-2010 affected roughly 7.7 million ha of farmland and left 24 million people and 15 million livestock struggling to access water. Direct economic losses, by late 2010, were estimated at US$3.6 billion.[12] ACCC research examines whether climate change is likely to exacerbate these extreme events, increase the disparity between dry and wet regions, or alter seasonal patterns.

It is challenging to untangle how much of the decline in water supply is due to rising demand and pollution, and how much to climate trends. The ACCC project is using climate records, water consumption statistics and high-resolution hydrological models to separate these two drivers.[1]

China's climate overall has warmed since 1960 (by 1.2 °C); the northeast has warmed most, the southwest least. Country-wide precipitation over the same period has not changed significantly, but there are significant differences between the northeast (decreasing), the northwest (increasing) and the southeast (increasing).

In the Yellow River basin in north China, with less rainfall and higher temperatures, river flows have fallen sharply over the last 40 years, particularly in the lower reaches of the basin (Figure 3). This reflects both climate trends and human activity, but increased withdrawals of water for irrigation, industry and domestic use are dominant [5]. In the Haihe basin in the northeast, one of China's most water-stressed, human activities are also the major cause of declining flows.

Flows recorded at Datong in the lower Yangtze River show no marked trends in the period 1950 – 2010 (Figure 3). Flows have actually declined in the upper basin, due in part to less precipitation. In the middle and lower basin, however, increased precipitation and frequent rainstorms have swelled summer flows. A similar pattern is found in the Pearl River further south.[4–6]

Declining flows in the Yellow and Haihe river basins are mostly due to human consumption, whereas climate change is already a major factor affecting the Yangtze and Pearl rivers.

China's future water supply under climate change

Before now, assessments of future climate change in China have been based on the average of several Global Climate Models. These suggest that with medium levels of greenhouse gas emissions (a scenario known as A1B), China's air temperature will rise by up to 3.7 ˚C and precipitation will increase by an average of 13% by 2100, with more frequent heavy downpours. However, multi-model averages conceal significant variation, with different climate models projecting very different climate futures.

Box 2. Changes in river flows and groundwater levels

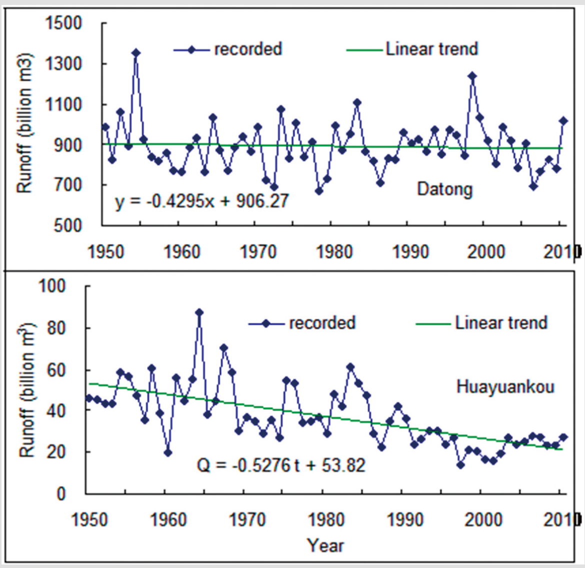

Figure 3: *Observed inter-annual variation in annual river flow in the Yangtze and Yellow Rivers, China, 1950-2010. Yangtze flow was recorded at Datong station (lower basin), Yellow River flow at Huayuankou (lower basin)*

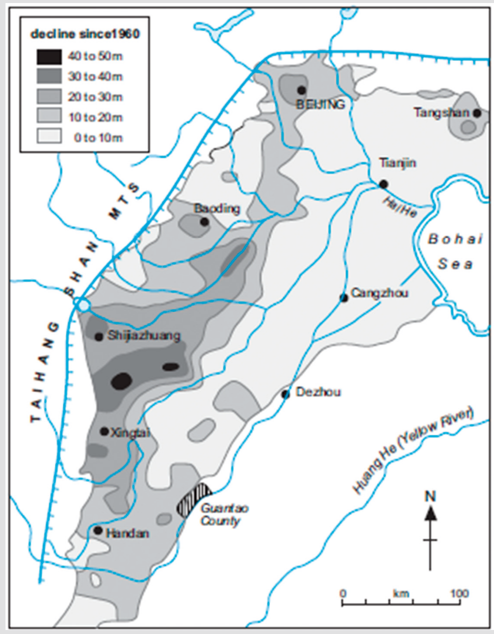

Figure 4: *Cumulative water table lowering of the shallow aquifer of the North China Plain 1960–2000.[13] The biggest drops in water levels have occurred in and around urban areas.Source: Foster and Garduno (2004)*

For a more reliable view, ACCC is using two regional climate models that have a higher spatial resolution and can better simulate the East Asian Monsoon Area. In preliminary projections, these models differ on expected rainfall changes, but agree that central China will grow drier.

ACCC researchers have combined data from one of the regional models, PRECIS, with hydrological models to project how much runoff will be feeding Chinese rivers by mid-century.[1] Whether future emissions are high (A2 scenario), medium (A1B) or low (B2), annual runoff in the Yellow River basin of north-central China — a key grain-producing area — declines by roughly 2-6% from the period 1961-1990 to 2021-2050 with increasing risk of extreme events including flood and drought to some extent. For other river basins, the expected changes depend on the emissions scenario (Figure 5). In some cases recent declines are projected to reverse: for example, the A1B scenario leads to greater flows in the northern, water-stressed Haihe and Huaihe basins.

Under all emissions scenarios, annual runoff in the grain-rich Yellow River basin is expected to decline 2-6%.

Particularly important for agriculture are changes during June-September, the flooding and growing season. Trends for this period are similar but more pronounced (Figure 5). Hence, droughts affecting areas such as the Yellow River basin are most likely to hit during summer and harm crops, while other basins experience more intense summer rainfall and, potentially, flooding.

Impacts underground

Compared with river flows, there are less data to show how China's groundwater supplies have changed over recent decades. Yet groundwater is increasingly important to the economy. In the water-short breadbasket of northern China it supports substantial domestic, industrial and agricultural use, including about 40% of irrigation — and as much as 70% in some areas — in part because surface water sources have become scarcer and/or more polluted.[8]

But over-exploitation and pollution are now incurring high costs. On the North China Plain in the northeast, for example, groundwater levels in the shallow aquifer have fallen by more than 15m over the past 40 years, with even greater declines in urban areas (Figure 4). The value of agricultural production throughout China that could be at risk from unsustainable groundwater use has been estimated at around US$840 million/year (2003 prices).[13] Many remaining groundwater sources are becoming polluted: in a recent survey, 57% of urban wells had 'bad' water quality, with a worsening trend.[9]

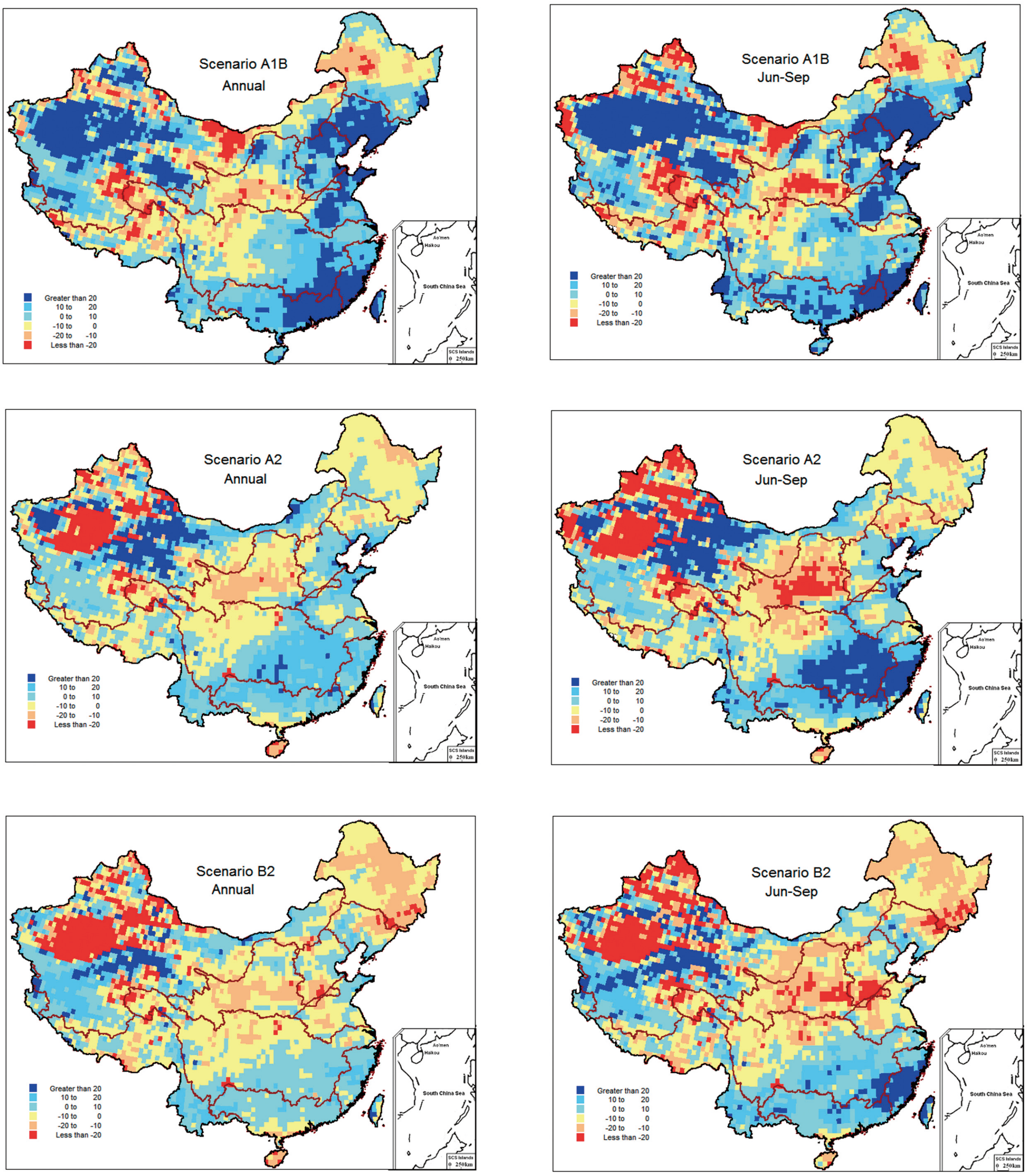

Figure 5: Changes in runoff (%) from 1961-1990 to 2021-2050, annually (left) and during flood season (right), based on PRECIS data.[1] Scenarios A1B, A2 and B2 assume medium, high and low greenhouse gas emissions, respectively. Blue indicates greatest increase in runoff, red indicates greatest decrease. Source: Wang et al, 2012

The ACCC project is modelling the response of groundwater in the Huang-Huai-Hai (3H) plain in northeastern China to climate change. Natural groundwater replenishment in this region is estimated at 54.6 billion m^3/year, 70% of which comes from rainfall. As noted above, however, the combination of climate change and human withdrawals has already lowered groundwater levels significantly. In the future, ACCC projections show that climate change may relieve stress on groundwater to some extent, but strictly limits on over-exploitation is needed to protect the groundwater.

Implications for adaptation planning

As China's economy grows and demand for water increases, China will need to develop robust systems for managing water in an uncertain but increasingly volatile climate, particularly in the water-scarce north. Although changes in projected runoff remain uncertain for most basins, regional water shortages and regional flooding remain key issues that are likely to grow in importance as climate change amplifies existing patterns of shortage and excess. These pressures and uncertainties may require a new style of adaptive water management, combining use of non-traditional sources such as urban waste water with better management of existing storage, and much more emphasis on water conservation and reallocation.

China's future measures to adapt to the coming changes should:

(1) Understand the importance and irreversible impacts of climate change on water resources, and incorporate the impacts of climate change into water resources assessment and planning.
(2) Improve the repeated and circular utilization of water resources, enhance management of water demand and build a water-saving society.
(3) In the most vulnerable regions, construct new water infrastructure, adopt strict water-conservation policies and maintain the capacity of water resources.
(4) Diversify available water resources by increasing the use of unconventional sources.
(5) Develop better emergency response plans, and improve institutions and capacity for emergency responses to extreme events.
(6) Accelerate the development of the national water resources management and information system, to provide reliable information for management and decision-making.
(7) Increase awareness of climate risks and adopt a new mindset on water resource management.

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