Climate Adaptation in Asia: Knowledge Gaps and Research Issues in China Final Report to IDRC and DFID

The Full Report of the China Team

Chinese Academy of Sciences
Institute of Geographic Sciences and Natural Resources Research (IGSNRR)
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FROM RESEARCH
TO CAPACITY, POLICY
AND ACTION

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1. Executive Summary

INTRODUCTION

This is a summary of a longer report that has been commissioned by DFID (UK) and IDRC (Canada). These two donor agencies are considering support for a programme of applied research on climate adaptation in Asia. In preparation for that programme, they have commissioned a study of climate change adaptation research knowledge and capacity gaps in Asia, undertaken by ISET (Institute for Social and Environmental Transition) based in Kathmandu, Nepal. The study has engaged local teams in China, SE Asia and S Asia in a consistent approach to these questions over a relatively short and intensive study period, beginning in late November 2007. Our task in this study was to identify adaptation research issues that were likely to affect large numbers of vulnerable people, and addressed substantial gaps in knowledge or were under-represented in other research efforts. This document summarizes the conclusions of the China study team.

All the sub-regional studies have adopted a consistent conceptual framework that distinguishes planned and autonomous adaptation strategies. In accordance with donor priorities, the studies focus on adaptation issues among the most vulnerable groups in regions likely to face the greatest stress from climate change. The conceptual framework acknowledges the high uncertainties around climate change impact prediction, and the difficulty of assessing important but indirect effects of climate change on the livelihoods and living conditions of vulnerable social groups. The conceptual framework is elaborated in other documents.

The scoping study relied on information from the scientific literature, interviews with key informants, and four consultation workshops involving local and national experts (researchers and local government officials) in Beijing, Yinchuan, and Hangzhou. The timing of the study was challenging due to the conflicts of year end reporting by all government agencies followed by long national holidays, and the unexpected complications of two large scale natural disasters (snowstorms in January and February and earthquakes in May), all of which made it difficult for the team to capture the attention of key officials and research leaders. In spite of these complications, the team would like to acknowledge the generous assistance and cooperation they received from local governments, research units, senior experts and officials at all levels in response to our inquiries.

METHODOLOGY

As in the other sub-regions, the China study team sought to build interest and obtain expert feedback on the adaptation research agenda while simultaneously collecting data for the study. This process involved multi-disciplinary literature review, interviews with researchers in a variety of related fields, and with selected practitioners (technical experts and government officials) at the national, provincial and local levels. In order to focus our efforts in regions where the adaptation issues are likely to be most severe, the first stage of the study involved the identification of a limited set of geographical regions of high climate vulnerability. After preliminary literature review and an initial consultation workshop in Beijing with a limited number of Chinese experts, the study team was able to identify these geographical regions and plan two regional consultations and interviews to further assess adaptation issues on the ground. The final consultation in Beijing was able to allow participants to assess and comment on the draft summary report provided by the study team and we are pleased with the high acceptance of the report by people from different sectors and disciplines. Valuable comments and suggestions were also received from these discussions that have helped to improve this final report.

The four regions of high vulnerability identified for focused study included: the arid and semi-arid northwest (most parts of eastern Xinjiang, northern Qinghai, Gansu, Ningxia, Shaanxi, western Inner Mongolia); the Tibet-Qinghai plateau; the karst uplands of southwest China (parts of Guizhou, Sichuan, Chongqing); and densely populated peri-urban coastal zones. Although there are other areas, such as North China, with high vulnerability, these are representative areas in which climate impacts on key ecosystems are likely to compel significant changes in livelihood patterns, and where current populations are poor or otherwise vulnerable.

The arid and semi-arid belt of northwest China covers about 37% of the country's area, but includes only 9% of its population. It is an ethnically diverse area, with a high proportion of the population represented by ethnic minorities with indigenous cultures and languages (principally Uyghur, Mongolian, Tibetan, Hui, but also other groups). With a certain degree of variation in projections, this area will likely see larger increases in mean temperature than other parts of the country, particularly in the dry summer months. While mean precipitation may also increase, it is likely to be concentrated in high intensity rainfall events which can be destructive of the fragile soils in steep terrain that characterize much of this area.

The Tibet-Qinghai plateau is sparsely populated by people whose traditional livelihoods and culture revolve around pastoralism. There is uncertainty about the effects of climate change on the quality of pastures and other resources in this region, but geographical and temporal variability are likely to increase, along with livelihood risks. Temperature changes will lead to earlier snowmelt and longer snow free seasons, which will affect late summer soil moisture and require modification of pasture management practices. Cultivated agriculture may be favoured in some parts of this region, subject to moisture limitations, but greater reliance on food grains may increase pressure on biomass for cooking fuel. Glacial melt will translate into higher spring/summer water levels for several decades, followed by decline in stream runoff and upstream flows in the region's many strategically important rivers.

The karst uplands of southwest China are more densely populated than the areas described above, and also receive much more rainfall. However, water supply is often a local issue due to the geological conditions, steep terrain and increasing climate variability. Climate change will mean increased precipitation and higher variability in this region, with attendant risks of drought, flooding, soil erosion and landslides. Agriculture is already fairly diversified, despite poor soils, with production of upland rice and maize varieties combined with vegetables, livestock and various industrial crops (e.g. bamboo). But because of the rugged terrain, communications and transportation infrastructure (including electricity distribution) is unavoidably vulnerable to disruption by extreme weather conditions.

The coastal zone is of interest for different reasons: this is a dynamic area of high population density and wealth accumulation, with large numbers of disadvantaged persons who have either been displaced by development or have recently migrated and lack residential registration. This is also a region of rapid and poorly planned development, where key natural buffer systems are converted to urban and industrial uses (e.g. wetlands, floodplains, deltas). The concentration of manufacturing and transportation infrastructure in coastal areas at or very near sea level is not only of national, but global importance.

Strategic Issues for Adaptation Research

Climate research has attracted considerable attention in China, in part because of the strategic importance of food production and the historical exposure of large rural and urban populations to extreme events (droughts, floods, typhoons). There is reasonable consensus on the broad nature of future climate change in different regions of the country under various global emission scenarios, but high uncertainty as to how these trends will be expressed locally. A great deal of research has dealt with impacts on agricultural production, particularly in the highly productive North China Plain and floodplain regions of the south. There are divergent views about the implications of climate change on overall national grain production (partly reflecting different methodological approaches to this assessment), but recent work suggests effects attributable to climate change will vary regionally, with some regions benefiting and others losing. The principal agricultural areas of China are unlikely to be severely affected: they are also reasonably prosperous, dynamic and well served by infrastructure and agricultural inputs. In the northern plains, where water constrains agricultural productivity, the future effects of the South-North water transfer scheme, already committed by the national government, will far outweigh the impacts of climate change on water supply in drought years. For these reasons, from the perspective of vulnerability, other regions of the country were of greater interest to our study.

Scientific research capacity in China is strong. Most research attention continues to be devoted to assessing the *effects* of climate change, including issues of data collection (which remains weak in many mountainous and remote areas of the country), modelling and climate forecasting. These are important areas for continuing research effort, particularly when results can be better linked to decision-making through user oriented information products. There is also growing attention to the impacts of forecast changes on ecosystems and biodiversity, and to assessment of aggregate costs of climate change impacts and adaptation. However, adaptation as a specific domain of research effort in China is a new concept.

For example, so far there has been limited research attention to the process of decision-making and response to anticipated or observed climate variability, especially at the micro level (households, communities, local government). Nor has there yet been much interdisciplinary adaptation research that integrates analytical perspectives across social and natural sciences. While there is a great deal of experimental research on agricultural technologies and techniques, there is limited long-term assessment of farmer behaviour, particularly as economic factors change (relative factor prices, resource availability, accessibility and markets).

Research Themes

We identified four domains of adaptation research that would seem to be relevant for China. These are thematic entry points, in the sense that they provide a way to frame and link research across different disciplines and at different scales to provide insight for adaptation strategies that can respond to emerging needs of Chinese people who are vulnerable to climate change.

1) Local management of natural resources:

The proximate impacts of climate change are already being felt in areas of China where people depend on local ecosystems for their livelihoods. In Ningxia, for example, longer growing seasons have led to a northward shift of winter wheat cultivation and increased potato production. These changes will have direct implications for how natural resources are managed. The challenges faced by farmers and other resource users will be manifest differently in different locations. In some areas, water scarcity will be the main focus as the frequency of drought events increases, or as higher summer temperatures and increased water demand lead to reduced irrigation water volumes. Land management practices will have to change in areas of steep slopes as the intensity of rainstorms increases. As carbon sequestration acquires commercial value through global capital flows from a post-2012 UNFCCC framework, this will also affect land and resource management strategies in new ways.

Many areas of natural resource management already receive research attention. We refer to agricultural research above. Water resource management is another example of a domain that will become more important in many areas of the country, but is already receiving considerable research attention. In these cases, future research investments should consider the relevance of climate change in their planning and execution. However, one example of local resource management that does not now receive much research attention, but is likely to grow in importance, is rangeland management for livestock production.

In both the arid northwest and the Tibet-Qinghai plateau, agricultural intensification is problematic as a long-term livelihood strategy. For example, northwest China receives large subsidies from national poverty alleviation programmes, many of which are currently invested in the expansion of irrigated agricultural production (now 40% of cultivated area). Surface and groundwater extraction already exceed safe limits and climate change will only exacerbate water scarcity. There is already a substantial research community engaged in improving the resource use efficiency of irrigated agriculture, but the area suitable for these kinds of systems will be reduced by future water availability. Meanwhile, many areas of rangeland are experiencing severe degradation, and various conservation programmes and incentive schemes have been launched to reduce grazing pressure, with

limited success (see Box 1). In order to minimize further degradation and desertification, innovative rangeland management practices will be essential.

Pastoralists are the poorest and most vulnerable social groups in these regions, and have traditionally relied on culturally embedded ecological knowledge that is no longer reliable. Current management strategies (sedentarization, enclosure, ecological migration) may exacerbate social conflict and local economic disparity, and yet fail to address the increasing risk exposure of livestock production in a variable climate. At the same time, there may be opportunities for both biodiversity conservation and carbon sequestration in actively grazed rangelands. These issues will become more serious under more frequent droughts, as irrigated agriculture fails and more area becomes suitable only for pasture land.

Key knowledge gaps revolve around options for fodder and pasture management, alternative livelihoods and asset diversification in a relatively unproductive agro-ecosystem that is isolated from markets and infrastructure. Increased risk of forage vulnerability poses special concerns for a livestock based economy, where it can take many years to re-build productive herds. Another issue is how to re-build knowledge systems when traditional pastoral-ecological knowledge based on a stable climate becomes less reliable. The research issues in this domain go beyond questions of animal husbandry, health and natural science to include social issues of benefit sharing and household roles, as well as institutional issues of resource tenure and local governance in the face of changing environmental, economic and policy conditions.

2) Local disaster risk reduction and resilience

In the karst uplands, and in peri-urban coastal areas, poor people are vulnerable to further impoverishment as a result of increasing frequency of extreme climatic events, such as heavy rainstorms, floods, typhoons and storm surges. Essential infrastructure and new construction are built to current standards for extreme hydrological or storm events, but as climate changes those standards become outdated. Yet there is surprisingly little critical assessment of the trends in wetland degradation or lowland vulnerability to sea level, storm surges and flooding.

Current approaches to disaster management and infrastructure engineering may be less appropriate when climate becomes more variable. The issues may be not simply engineering standards, but the whole approach to engineering (e.g. safe fail designs instead of failsafe). Institutional mechanisms for local risk reduction, disaster preparation and limited self-reliance in some domains may prove to be more resilient than very costly high standard infrastructure that cannot be feasibly protected from extreme events. In low-lying areas this may include planning for floods by designing retention basins and minimizing flow barriers, rather than building dikes. Innovative engineering and infrastructure construction approaches need to be balanced with new approaches to risk assessment and organizational, institutional and social communication methods (awareness building, warning measures, hazard specific responses, credit and strategic reserve facilities for recovery). Some of these innovations are emerging already, but there is need for research on how they can be better integrated at the local level to address diverse and context specific conditions.

3) Migration

Long-standing regulatory controls over residential registration to control the rate of urban growth in the prosperous eastern part of the country have increased the cost to migrants of relocation. However, benefits from participation in China's urban economic boom have

exceeded these costs, and there is growing recognition at the policy level of the economic value of the labour force provided by rural-urban migrants in eastern cities. Yet because they lack official registration, and the social welfare protection it brings (health insurance, pension, unemployment benefits and subsidized housing), migrants are particularly vulnerable in urban areas. The government already recognizes the need for ecological migration and subsidizes local and regional relocation (both voluntary and involuntary) from ecologically fragile zones. Relocation is identified through international experience as a common autonomous adaptation to climate variability and extremes. Migration is a complicated socio-economic decision, simultaneously creating a new form of individual vulnerability and yet offering the prospect of reducing household vulnerability. Gender and ethnicity are factors in determining how migration plays out in both source and destination areas. The process creates social issues at both ends, and can be mediated by many types of information and communication strategies as well as by transportation and communication infrastructure. There are many potential areas of research and of policy intervention in order to improve the social and economic effectiveness of migration and to foster climate adaptation in both rural and urban areas.

4) Practical and flexible organizational strategies for government

Climate impacts and adaptation actions are inevitably local in nature, but local adaptation can be enabled by government actions and socio-economic networks at multiple scales. Research could help to identify and describe these enabling actions and the types of government institutions to best address them. Government structures, budgets and programmes are normally administered sectorally, for example, in vertically articulated "silos" that are not well integrated or coordinated. In these structures in China, accountability is almost entirely upwards to the centre. As a result, even when significant government resources are devoted to ecosystem management and climate adaptation, local implementation is often uncoordinated and unresponsive to contextual priorities (see Box 3 for an example from Ningxia). Effective climate adaptation will recognize and support the initiative of local actors. This suggests that policies and programmes be flexible enough to be implemented differently in different places, and that oversight mechanisms encourage accountability and transparency of decision-making both upward and downward.

There is also a need for greater flexibility in responding to emerging and unpredictable local issues without necessarily creating new government organizations. For example, climate vulnerability of poor migrants in peri-urban coastal areas is not only a function of geographic exposure, but also their insecure livelihoods and lack of access to social welfare benefits. In high density urban areas, all of these factors combine to create public health risks as well. To address climate adaptation issues for this group will require innovative and coordinated responses not only between local government agencies with different sectoral responsibilities, but also with national level ministries. Some kind of flexible task force or "ad hoc" local coordinating committee will be needed. Similar types of issues will emerge in rural areas as well. The mechanisms for combining budgets and technical resources from different agencies to tackle such emerging adaptation issues need to be better researched.

In the long term, climate change will demand better institutions for adaptive management; i.e. a willingness to take management decisions for complex systems in the face of uncertainty and risk, but to view interventions as learning opportunities, examine outcomes critically and share lessons (see below). Research can help to develop such institutions suited to Chinese conditions.

KNOWLEDGE SYSTEMS

In all of these research themes, a pervasive challenge is the way that knowledge and learning are structured in China's expert driven society. Adaptation will require local learning as part of adaptive management. Technological innovations are likely to require local modification for effective climate adaptation. Ecosystem response to new techniques will inevitably vary depending on dynamic local conditions (including climatic factors, but also pollution and intensification of resource use). Experts will not be able to predict how specific techniques will perform in diverse and dynamic contexts. Surprise will be the rule, rather than the exception. Under these conditions, new approaches to shared learning and expertise will be needed. These approaches will recognize the value of diversity, rather than uniformity, in local and regional response strategies to foster resilience. They will address plural sources of knowledge and evidence. Most of all, these new approaches will have to build practical local strategies for experimentation, local and scientific assessment, and systematic sharing of learning.

With high uncertainty about ecological changes linked to climate and resource exploitation, together with urgent livelihood needs, there is not enough time for comprehensive research and analysis of long-term options. Yet innovation will be essential. New ways must be found to support local initiative and creativity in combination with scientific expertise and knowledge of good practice. Relevant issues could include the reform of agricultural extension systems, strengthening regional expertise and capacity in both government and research, the role of private enterprises in responding to innovation incentives, and how best to connect local adaptation opportunities to national and global resource flows (such as market incentives for carbon sequestration).

There is no shortage of innovation and local initiative in China, but local access to scientific knowledge, as well as systems of adaptive management and shared learning are not well developed even in coastal areas where capacity and resources are plentiful. In poorer and more remote areas research capacity is relatively weak even at the level of provincial academies, never mind the county (local) government. Part of the issue is providing better local access to national scientific knowledge networks, and part of the issue is translating scientific and technical innovations into practical and locally relevant formats that can be easily accessed by practitioners. Reforms of the agricultural extension system could contribute to building more responsive local knowledge and learning systems. Another way to approach this would be to build participatory research capacity among provincial academies, who can then engage with both national-level interdisciplinary scientific support, and county level implementing agencies, as appropriate to test adaptive management interventions.

2. Approach to the Study

This is one of three coordinated sub-regional studies undertaken for DFID and IDRC as an Asia-wide review of climate change adaptation research, intended to identify current knowledge, research leadership and important strategic gaps in knowledge of adaptation science and application. This study, alone among the three, focuses on a single nation: China, whose size and geographical diversity, consistent linguistic and governance features, economic growth, social dynamism and massive research system all justify special attention in the context of global climate change.

All the sub-regional studies have adopted a consistent conceptual framework that distinguishes planned and autonomous adaptation strategies and identifies ways in which key social and physical infrastructure contribute to adaptive capacity (see section 6 in overall report). This framework was helpful in the analytical stage of our work to help identify important strategic gaps and research issues from the materials collected in the course of the study. In accordance with donor priorities, the studies focus on adaptation issues among the most vulnerable groups in regions likely to face the greatest stress from climate change. The conceptual framework acknowledges the high uncertainties around climate change impact prediction, and the difficulty of assessing important but indirect effects of climate change on the livelihoods and living conditions of vulnerable social groups.

The scoping study relied on information from the scientific literature, interviews with key informants, and four consultation workshops involving local and national experts (researchers and local government officials) in Beijing, Yinchuan, and Hangzhou. The study team invited local experts in a variety of disciplines to present information about climate change and adaptation in each of the two local consultations, as a way to build awareness of the issues and provide an opportunity for interdisciplinary research dialogue on the issues. In total, the study team contacted more than 500 informants through consultation meetings and interviews in order to collect information about existing and planned adaptation research in China.

The summary draft report was reviewed by a panel of three experts at the final consultation meeting in Beijing May 29. They provided written comments and feedback that has been taken into account in this revised report (cf. Beijing consultation report and peer review comments).

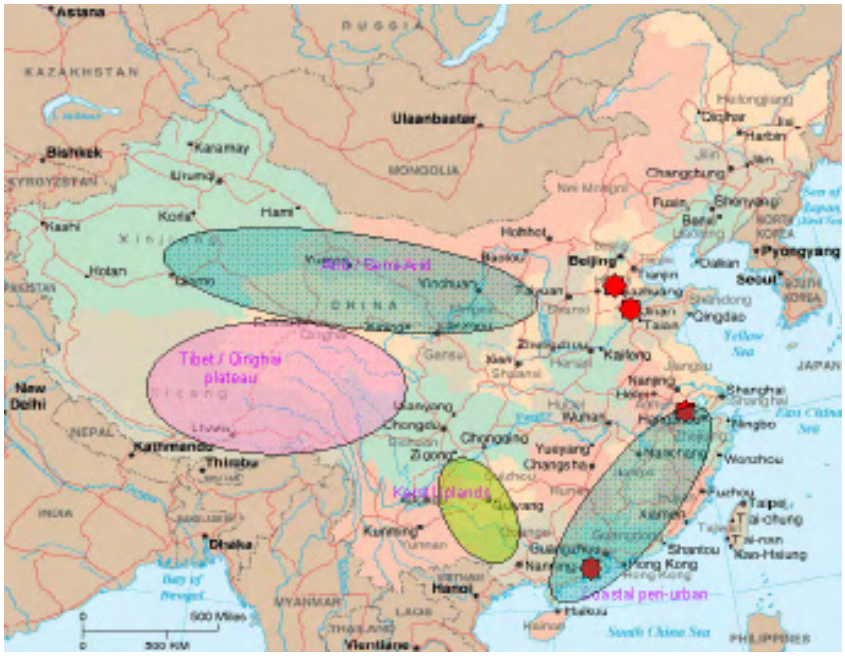
The time constraints for the study were challenging due to the heavy workloads of key government officials and researchers combined with unavoidable distractions caused by the extended Spring Festival national holidays, and two large scale natural disasters (snowstorms in January and February and earthquakes in May). In spite of these complications, the team would like to acknowledge the generous assistance and cooperation they received from local governments and local farmers, research units, senior experts and officials at all levels in response to our inquiries.

3. Methodology: Identifying geographic contexts of vulnerability

As in the other sub-regions, the China study team sought to build interest and obtain expert feedback on the adaptation research agenda while simultaneously collecting data for the study. This process involved multi-disciplinary literature review, interviews with researchers in a variety of related fields, and with selected practitioners (technical experts and government officials) at the national, provincial and local levels. In order to focus our efforts in regions where the adaptation issues are likely to be most severe, the first stage of the study involved the identification of a limited set of geographical regions of high climate vulnerability. After preliminary literature review and an initial consultation workshop in Beijing with a limited number of Chinese experts, the study team was able to identify these geographical regions and plan two regional consultations and interviews to further assess adaptation issues on the ground.

The four regions of high vulnerability identified for focused study included: the arid and semi-arid northwest (most parts of eastern Xinjiang, northern Qinghai, Gansu, Ningxia, Shaanxi, western Inner Mongolia); the Tibet-Qinghai plateau; the karst uplands of southwest China (parts of Guizhou, Sichuan, Chongqing); and densely populated peri-urban coastal zones (See Map 1), although North China would be another region vulnerable to climate change and variability. The four regions are representative in terms of high vulnerability to climate change. These are all areas in which the literature and expert opinion suggest climate impacts on key ecosystems are likely to compel significant changes in livelihood patterns, and where current populations are poor or otherwise vulnerable.

MAP 1:
Location of four regions of high vulnerability identified.



The arid and semi-arid belt of northwest China covers about 37% of the country's area, but includes only 9% of its population. It is an ethnically diverse area, with a high proportion

of the population represented by ethnic minorities with indigenous cultures and languages (principally Uyghur, Mongolian, Tibetan, Hui, but also other groups). Although researches are debating the degree and magnitude of the likely climate trends in this area, the general assessment is that this area will see a larger increase in mean temperature than other parts of the country, which will be more pronounced in winter than in summer. While mean precipitation may increase, it will be accompanied by more evaporation due to high radiation levels, high wind speeds, and low humidity. Relevant studies show that during 2010-2030, there will be about 20 billion m^3 water deficit every year as a result of climate change. (Lin *et al*. 2006; China National Plan for Coping with Climate Change, 2007) (China Renmin University, 2003; China National Plan for Coping with Climate Change, 2007; Ren and Yang, 2007) (Tao *et al*. 2005) (Wang, Zheng and Cheng, 2003; Lin and Zou, 2006) (Ren and Yang, 2007)

The Tibet-Qinghai plateau is sparsely populated by people whose traditional livelihoods and culture revolve around pastoralism. Many studies show that there is strong evidence that the Tibetan Plateau is exposed to thermal and dynamical influences on the weather and climate as well as atmospheric circulation. There are a lot of controversies about the future climate change in this area, such as whether the snowmelt time in Spring has been delayed, and whether the increased temperature will decrease the snow cover. There are also great uncertainties about the effects of climate change on the quality of pastures and other resources in this region, but geographical and temporal variability are likely to increase, along with livelihood risks. Cultivated agriculture may be favoured in some parts of this region, subject to moisture limitations, but greater reliance on food grains may increase pressure on biomass for cooking fuel. Glacial melt will translate into higher spring/summer water levels for several decades, followed by decline in stream runoff and upstream flows in many strategically important rivers of that region (Manabe and Terpstra, 1974; Yeh and Gao 1979; Yanai *et al*. 1992; Zhang *et al*. 1996; Liu and Chen, 2000; Fan *et al*. 2005; China National Plan for Coping with Climate Change, 2007; Du *et al*. 2004; Wu, Cheng and Ma 2004; Chang, Chen and Kong 2005; Cheng and Wu 2007; Wang *et al*. 2007)

Typical karst agriculture in Guangxi

The karst uplands of southwest China are more densely populated than the areas described above, and also receive much more rainfall. However, water supply is often a local issue due to the geological conditions, steep terrain and increasing climate variability. Climate change will mean increased precipitation and higher imbalanced of precipitation between seasons in this region, with attendant risks of drought, flooding, soil erosion and landslides. Agriculture is already fairly diversified, despite poor soils, with production of upland rice and maize varieties combined with vegetables, livestock and various industrial crops (e.g. bamboo). But because of the rugged terrain, communications and transportation infrastructure (including electricity distribution) is unavoidably vulnerable to disruption by extreme weather conditions (China Renmin University, 2003; Lin and Zou, 2006; China National Plan for Coping with Climate Change, 2007; Ren and Yang, 2007; Tao *et al*. 2005).

The coastal zone is of interest for different reasons: this is a dynamic area of high population density and wealth accumulation, with large numbers of disadvantaged persons who have either been displaced by development or have recently migrated and lack residential registration. The urban areas of the Yangtze and Pearl River deltas, dominated by metropolitan Shanghai, Hangzhou, Ningbo, Nanjing, Wuxi, Guizhou, Shenzhen and their related conurbations, contribute almost 30% of national GDP (this contribution valued at over 5000 billion RMB in 2006). (Data source: http://www.stats.gov.cn/tjsj/qtsj/csjztjsj/2006/t20080108_402456915.htm)
This is also a region of rapid and poorly planned development, where key natural buffer systems are converted to urban and industrial uses (e.g. wetlands, floodplains, deltas). The concentration of manufacturing and transportation infrastructure in coastal areas at or very near sea level is not only of national, but global importance. Climate change is expected to lead to increased precipitation intensity and total amounts, and to sea level rise of at least 60 cm this century (Dasgupta, Laplante *et al*. 2007; China National Plan for Coping with Climate Change, 2007; Wu *et al*. 2002; Lin and Zou, 2006; Lin and Zou, 2006)

The identification of these geographical contexts of climate vulnerability in China provided the team with a focus for approaching specific research institutes, and for planning and scheduling its consultation meetings in areas where we would have ready access to relevant expertise, in order to assess adaptation issues on the ground in areas where they would be most serious.

4. Climate Research and Existing Knowledge of Adaptation (Literature Review)

Expected climate change in China: conventional forecasts.

While details of forecast climate changes vary between models, there is general consistency in conclusions about trends. For example, it is commonly agreed that both the surface temperature and precipitation will increase across much of the country (IPCC, 2007; Xu, 2005; Ding, 2006) (Table 1). In more detail, the temperature in north China will increase much more than that of south China and the temperature in winter and spring will increase more than that of summer and autumn. When it comes to the change of precipitation, the mean annual precipitation across the entire country is expected to increase by 2%-3% by 2020, and 5%-7% by 2050, but regional trends are less certain (Ding, 2006; Yin, 2006).

TABLE 1 | **Forecast climate change in China**

Expected climate trend	Regional effects
Temperature change	Increase as a whole - Increase in southern China - Increase in north western China - Increase in Northern China
Precipitation change	Increase as a whole -Increase in southern China -Increase in north western China -Decrease in Northern China
Rising sea level	Sea level will rise at least 30mm on average in the forthcoming 10 years.

As for sea level, the China Sea Level Bulletin in 2007 issued by the State Oceanic Administration showed that the sea level in China has been rising by 2.5 mm/year, which is a little higher than the global average level. The sea level will rise by between 0.18m and 0.59m by the end of this century at a minimum (IPCC, 2007). On average, the coastal sea level in China increased 90 mm in the past 30 years. Especially, the coastal sea level in Tianjin has risen up to 196 mm in the same period. Generally, the sea level rise in northern areas is greater than that in southern areas, so for Tianjin the 30 year increase is as much as 196 mm.

There still are many other changes in the climate system except temperature and precipitation according to the literatures about climate change (Table 2). For example, the Tibetan Plateau glaciers are shrinking and will eventually disappear (LU, 2005; EEA, 2005). Rainfall in Northwest and South China is increasing in recent years, a trend that is expected to continue (Ding, 2006). Sea level is expected to rise by up to 0.6 m. by the end of this century (IPCC, 2007) but recent evidence from Greenland and Antarctica suggests this estimate may be conservative (Rignot *et al*. 2008, Revkin, A. C., 2008). There will be reduced access to safe drinking water and expansion of drought affected areas in North China, and unfortunately, people living in South China will experience increased risk of flooding (Ding, 2006; Wang, 2006). It seems that desertification will be more serious in semi-arid areas of China and wetland surfaces will shrink because of regional warming and drying (Lee,

2007). While there is broad scientific consensus about future increases in mean temperature, the precipitation outcomes are much less certain, and will in any case be highly variable by location. While mean annual precipitation may increase in most parts of China, it may also become more variable, particularly in the north and west.

TABLE 2 | **Future climate in China**

Expected Events	Affected Area
Rising sea level	-Coastal low land
Glacier will eventually disappear	-The Tibetan Plateau and upstream areas of major rivers
More frequent drought	-North China -South part of northeast China -East part of northwest China
Increased flooding	-The mid-lower Yangtze -Southeast China
Increasing heavy rainfall days yearly	-Northwest China
Increasing rainstorm days yearly	-The mid-lower Yangtze -Hilly ground in southeast of China
Wetland surfaces will reduce	-Wetland areas in north and central China
Desertification of semi-arid areas	-Northwest China

SOCIO-ECONOMIC CONDITIONS

China's economy has experienced remarkable growth since the economic reforms initiated in the late 1970s. The per capita GDP and income have risen dramatically and the number of very poor people has declined by hundreds of millions in this period. Income sources are diversified in rural area, and off-farm job is becoming more important. Although grain output has increased rapidly due to increased productivity, many farmers have shifted into higher value-added crops such as vegetables, fruits and flowers. More than 40% of rural residents (187 million) have part time or full time off-farm employment, and at least 100 million have moved to urban areas (Tables 3 and 4).

TABLE3 | **The development of China in the past three decades**

	Per Capita GDP and sources			Per-capita Income (yuan)	
year	Per Capita GDP (yuan)	Share from Agriculture	Share from Industry	Urban area	Rural area
1980	463	29.9%	48.2%	2194	804
1985	858	28.2%	42.9%	2771	1364
1990	1644	26.9%	41.3%	3422	1426
1995	5046	19.8%	47.2%	5016	1857
2000	7858	14.8%	45.9%	6629	2462
2005	14040	12.6%	47.5%	10493	3255

Note: All numbers adjusted by 2005 prices.

TABLE4 | **Planting structure and off-farm employment in rural China**

year	grain output (million tons)	Planting structure (grain proportion)	off-farm employed person (million person)
1980			
1985	321	80%	30
1990	379	76%	70
1995	446	76%	108
2000	467	73%	164
2005	462	69%	169
	484	67%	187

Unfortunately, economic growth has been accompanied by increasing income disparities. The income gap between west and east China is becoming bigger and the income disparity between rural and urban area is also a serious policy concern. Despite a policy commitment at the national level to balanced and sustainable development, ecological, economic, political and social features make this difficult to implement. And things may become even worse because climate change will probably exacerbate the income gap.

Rural areas are more vulnerable to climate change, because the rural economy is tied to the agriculture sector, which has lower technology and where climate is a factor whose substitutability is very limited (Tor, 1995; Fankhauser, 1995). Less developed regions are more likely to be vulnerable to climate change, due to the weaker capacity of local residents to adapt and recover from impacts. This is tied not only to lower technology inputs and fewer management options in agriculture, but also to fewer infrastructure and less economic diversification. Farmers in less developed regions are currently more vulnerable than the farmers in more developed regions of China (Mendelsohn, 2001).

Even in rural areas, however, climate change brings mixed results for agriculture. While dry northern regions may face less precipitation, if they have access to water they will benefit from longer growing season and higher productivity (as well as from the fertilization effect of higher CO2 concentrations). But in warm regions of the country, further warming may exceed optimum temperatures for high value crops and lead to greater risk from pests. In general, many studies have suggested an inverted parabolic shape to the relationship between temperature and crop growth (Mendelsohn, 1999; McCarthy, 2001; Mendelsohn, 2001; Tor, 2002).

Policy framework for climate change adaptation

The government of China has moved in recent years to undertake comprehensive scientific and policy reviews and has developed a national strategic response to climate change. The National Development Reform Commission (the central economic planning and coordination ministry) has taken responsibility for coordinating national climate responses, and has assembled a multi-sectoral advisory National Leading Group on Climate Change, with representatives from 10 national ministries, including Science and Technology, Environment, Energy, Water Resources, Agriculture, and the Chinese Academies of Science and of Agricultural Sciences. This Leading Group contributed to drafting China's National Climate Change Programme, released by the National Development Reform Commission in June 2007. China's energy demand is expected to increase owing to accelerated industrialization and urbanization as well as rising standard of living. As its main source of energy is coal and industrial structure is very energy intensive, the country faces a huge challenge in tackling climate change. The National Development Reform Commission, MOST, NSFC and the national Leading Group will play a key role in setting priorities for state investment in scientific and technological innovation for mitigating and adapting to climate change, including capacity building for independent technological innovations in new and renewable energies, energy efficiency, carbon absorption and various adaptation measures. A series of policy measures has already been introduced to support economic adjustments, improve the mix of energy sources, raise energy efficiency, carry out afforestation and family planning, among other measures. National Development Reform Commission has also identified areas where climate change can be incorporated into other areas of policy and legislation, including the Agriculture Law, Forest Law and the Marine Environment

Protection Law. Following the leadership of National Development Reform Commission, most provinces have also established their own Leading Groups to address Climate Change, Energy Conservation and Emission Reduction.

Part of China's water resource management planning that also responds to climate change, the South-to-North water diversion project is the largest construction project in China's modern history. If all goes as planned, this massive construction scheme will be completed by 2050. It is planned to eventually divert 44.8 billion m^3 of water annually to the densely populated and drier north. When finished, the project will link China's four main rivers – the Yangtze, Huaihe, Yellow River and Haihe – and require the construction of three diversion routes, stretching south-to-north across the eastern, central and western parts of the country. The complete project is expected to cost $US 62bn – more than twice as much as the country's controversial Sanxia (Three Gorges) Dam. Studies of climate change impacts in the vulnerable N China plain suggest that if successful, the magnitude of the water transfers involved will far exceed potential climate impacts in drought years (Yin, 2002).

For the past several years, the Chinese government has consistently indicated that it treats climate change as a serious and urgent problem and will encourage all levels of government to achieve energy saving and emission reduction targets (cf. policy statements during the G8 summits of July 2005 and June 2007; Premier Wen Jiabao statements to State Council Executive Meeting, 11 July 2007). The National Medium- and Long-term Science and Technology Development Plan (2006-2020) has as a goal to create an innovation oriented economy with the emphasis on strengthening both indigenous innovation capacity and intellectual property protection, including various energy technologies.

Within this overall context of increasing political profile and public investment in climate change research, special funding for climate change adaptation in China has been announced in 2007. Some provinces have already invested in technologies and practices for cloud seeding (Sichuan, Tibet) and for rain harvesting (Xinjiang). In Ningxia province for example, the provincial Science and Technology Dept plans to invest in improved climate forecasting and studies of agricultural adaptation (changing crop choice and water-saving cultivation methods). The provincial Academy of Agricultural Sciences will also conduct research on agricultural adaptation, including improved crop varieties and studying factors to support ecological migration. The Agriculture Department will invest in more efficient irrigation technologies and subsidize greenhouse construction and rainwater storage cisterns. The Agriculture Dept will also promote new water-saving techniques and new crops through extension and awareness building services. The Provincial Office of Poverty Alleviation funds the resettlement of "ecological migrants" from drought affected southern parts of the province to central Ningxia, providing them with greenhouse or irrigated agricultural land. The Water Resources Department is introducing reforms to water allocation in the Yellow River, and decentralizing irrigation system management to user groups or association to improve efficiency of water use.

There has also been attention to coastal areas and disaster planning. The State Council issued the 11th Five Year Plan on National Comprehensive Disaster Mitigation in Aug. 5, 2007 (Data source: http://www.gov.cn/zwgk/2007-08/14/content_716626.htm). In this document, the central government emphasized that the response capacity to major disasters should be increased, especially in the urban agglomerations of Yangtze River Delta, Pearl River Delta, and Bohai Rim. The office of State Flood Control and Drought Relief Headquarters and the Ministry of Water Resources commissioned the National Plan of Flood Control (Quan Guo

Fang Hong Gui Hua) and the Storm Surge Protection Plan for China's Coastal Areas (Zhong Guo Yan Hai Di Qu Fang Feng Bao Chao Gui Hua)(Data source: http://www.mwr.gov.cn/ldxw/hsy/hdhxgbd/200801301019198a5376.aspx). These plans address the need for both engineering measures such as sea wall construction as well as biological protection such as reed and coastal forest restoration, and non-engineering measures such as improving forecasting and warning systems and insurance on flood control.

At the provincial level, Guangdong province has made the Guideline of Sea Wall Project Design (trial) (Guang Dong Sheng Hai Di Gong Cheng She Ji Dao Ze (Shi Xing) (Data Source: http://www.cws.net.cn/Journal/sljsjd/200503/01.pdf); Zhejiang province finished research on the Strategies of Protecting Against Devastating Typhoon (Zhe Jiang Sheng Fang Yu Chao Qiang Tai Feng de Zhan Lue Yan Jiu) (See http://www.zjwater.gov.cn/pages/document/46/document_939.htm). Now the Ministry of Water Resources is working on updating sea wall designing standards. And in the past few years, many investments have been implemented in coast areas, for example:

- Zhoushan municipality in Zhejiang implemented a 3-tier communication warning network for the fishing fleet to ensure a chain of warnings are passed along to fishermen to return to harbour in the event of a typhoon.
- Hangzhou installed weather observation stations at street level in order to improve the accuracy of weather forecast.
- The State Oceanic Administration has increased the number of stations to monitor the development of sea level.
- Shenzhen invested 85.05 million RMB to restore reed beds for coastal protection.
- Guangdong province has finished an assessment report on climate change impacts.

Though some kinds of adaptation on storm protection have been adopted, there are still large knowledge and action gaps on how to respond to and manage the uncertainties. For example, how to build the infrastructure based on projections on sea level rise? It is common that government and specialist base the standard of sea wall and reservoir on past experiences and stationary probability distributions of extreme events. So the standards are usually called 50-year, or 100-year standard. Now the governments and related institutions have realized this situation and will start the action of integrating the city planning and the standard of key infrastructure construction into the climate change context (Data source:http://gov.people.com.cn/GB/46728/104514/104515/6349701.html).

In addition to government action, WWF China has organized a collaborative programme funded largely by HSBC Corporation with several relevant components focusing on the Yangtze River Basin. Their project will assess the vulnerability of Yangtze basin to climate change, with the objective of maintaining and restoring the ecosystem of the middle and lower reaches of the Yangtze River. It will include pilot demonstrations of water resource conservation and sustainable, climate-friendly agriculture, as well as construction of a network for protection of wetlands and fisheries habitat in the lower reaches of the Yangtze.

But most research issues have so far been framed in terms of scientific and technological issues around climate impacts and the agricultural, engineering or technical measures to address these. One of the most prominent climate change scientists in the agriculture field, Prof Lin Erda of the Chinese Academy of Agricultural Sciences has recently emphasized the need for more action oriented research, and enabling support for local, farmer led and context specific adaptation approaches (IISD Reporting Services 2007).

A detailed list of research projects relevant to climate change and adaptation is presented in the Appendix.

5. Specific Issues Raised in Consultations / Interviews

The four consultations provided opportunities for leading regional and national climate experts to present information from their own research as well as to share perspectives on adaptation issues. All four consultations have been reported separately so we will not repeat the information contained in the reports that have already been circulated (see Table 5 below). Rather, we will summarize the comments and suggestions made in the various consultations (and in separate interviews with key experts who were unable to attend the consultations) under the following subject headings: climate research in China; impacts of climate change; local responses to climate variability; and adaptation initiatives already underway.

TABLE 5 | **Consultation meetings held as part of scoping study - China**

Location	Date	Host Organization	No. of Participants	Report circulated
Beijing	Jan 10, 2008	CCAP	28	Yes
Yinchuan (Ningxia)	Mar 9, 2008	Ningxia Clean Development Mechanism service center	27	Yes
Hangzhou (Zhejiang)	May 5, 2008	Centre for Agriculture and Rural Devt, Zhejiang Univ	25	Yes
Beijing	May 29, 2008	CCAP	32	Yes

Climate Research in China

Climate research has attracted considerable attention in China because the country is so large and geographically diverse, and because its food self-sufficiency depends partly on climatic factors. Extreme climatic events (droughts, floods, typhoons) have long been a part of Chinese life, and as population and economic development have increased, the risks from these hazards, and the study devoted to reducing such risks, have all increased proportionately. China's meteorological service maintains an extensive network of monitoring stations, especially in the heavily populated and agriculturally productive eastern part of the country, and historical data sets are generally good for the last 50 years.

What those data sets show is that temperatures have been steadily rising in the latter part of the 20th century. This trend seems to be accelerating, with noticeably higher maximum temperatures in summer months in both the northwest and eastern coastal regions of the

country, for both rural and urban areas, in recent years. This documented evidence is consistent with global climate change observations.

A number of efforts have been made to downscale global climate models to the continental scale for east Asia. These have so far not been very satisfactory. The uncertainties in regional or sub-regional forecasts are particularly large for precipitation, as different models yield a fairly broad range of results, and conventional models in widespread use in China do not match historical data very well. While temperature trends and forecasts can therefore be undertaken with a reasonable degree of confidence, in the arid and semi-arid parts of China small variations in forecast precipitation can lead to large proportionate differences. Most models predict an increase in intensity of precipitation events, and greater seasonal variation.

Sea level rise has also been studied, but forecasts of future sea level rise have not attracted much attention. Partly this is due to the high uncertainties regarding storm intensities and storm surge elevations. There does not seem to be consistent evidence from Chinese researchers regarding trends in typhoon intensity (despite a string of severe storms in the past decade), although the frequency of typhoons in some regions (Zhejiang) seems to be increasing.

Some of the greatest uncertainties occur in the sparsely populated mountainous regions of southwest China and the Tibet-Qinghai plateau, where meteorological stations are much more widely dispersed and the influence of topography makes climate prediction more difficult. Despite their low population, these areas are strategically important because they comprise the upper watersheds of the country's largest river systems, which are heavily used for water supply, irrigation and transportation. There are also hundreds of large dams and reservoirs whose management will be affected by future hydrological regimes.

Impacts of Climate Change

Despite extensive research and good data sets for both climate and agriculture, there is still extensive scientific debate in China about basic issues related to forecast climate impacts. The areas of greatest consensus include temperature increases (higher max and min temperatures in most regions, particularly in summer months); precipitation intensity (higher and more intense rainfall in most areas, higher share of precipitation as rainfall in Tibet – Qinghai plateau, greatest rainfall increase in the already wet southern region). In the eastern part of Tibet, which feeds the major river systems of China and Southeast Asia, there is little doubt that glaciers and ice sheets are dissipating rapidly, leading to increased seasonal meltwater flows in the short term, but sharply declining meltwater flows by the middle of the century.

A crucial question is the impact of these changes on agricultural production. Various research studies have examined the productivity of agricultural crops under varying temperature and rainfall regimes, integrating these in simulation models of alternative future conditions in various regions. Other studies have chosen an economic approach, allowing for changing behaviour of farmers in response to climatic variation. Conclusions from these studies differ, but while there are likely to be substantial regional differences (some regions favoured, others disadvantaged) in climate impacts, there is consensus that

the key variable is access to water. In areas where supply of irrigation water is affected, production will very likely be impacted. Where irrigation water supply can be assured, climate impacts on agriculture will be minimal.

This is an important conclusion for the North China Plain. This is the most productive agricultural area in the country, but is likely to become warmer (extending growing season, enabling higher productivity) and drier. The pressure of water demand from Agricultural production in this area may be relieved by the construction of the South-North Water Transfer scheme (see section 4.3 above).

Climate impacts in the northwestern part of the country are likely to lead to reductions in water availability. Rainfall, which is typically higher in summer months, may increase on average, but it is highly uncertain whether this will result in greater surface runoff for irrigation, or even in higher soil moisture in rainfed areas, because temperatures will also increase. Rainfall intensity and variability may also increase, which would add to the risks of both rainfed and irrigated agriculture. Yet many government agencies in this region officially plan to expand irrigated agriculture, despite facing water shortages already.

Farmers in the northwest and in the Tibet-Qinghai plateau are already noticing changes in the growing season. In some cases this provides opportunity (e.g. extending northwards the area in Ningxia suitable for growing winter wheat, or enabling barley cultivation in areas of Qinghai that were previously too cold). In other cases, it has had an effect on pasture management practices, as animals need to be moved from degrading summer rangeland earlier, while winter pastures may not have fully recovered yet. And recurring droughts, together with inappropriate pasture allocation and use patterns, have weakened the livelihoods of pastoralists.

In coastal areas, there has been relatively little attention to the impacts of climate change. In southern China, where rainfall is expected to increase substantially, flooding is already a problem. Rivers are heavily managed, with many dams, flood control structures and engineered channels to control floods. In recent years, in the lower Yangtze, there has also been an effort to restore natural wetlands as flood retention areas. Yet in the densely populated deltas of the Pearl and Yangtze rivers, where there are high concentrations of manufacturing plants and transportation infrastructure, wetlands continue to be lost to reclamation and urban development. Every year these regions lose about 2% of their GDP in flood and storm damages, despite heavy investments in preventive infrastructure. The potential impact of sea level rise is substantial for coastal areas, however, relevant studies are scarce. More importantly, there appears relatively little study on the potential combined impacts of floods, sea level rise and storm surges in these areas, let alone the adaptation strategies in future.

There is recognition that climate change will bring health impacts as well: already the active area of dengue fever transmission has migrated northwards about 2 degrees of latitude, and waterborne diseases are becoming more frequent in wet southeast coastal areas.

In the rugged karst uplands of southwestern China, heavy rains, unstable slopes, poor soils and deforestation have combined to increase vulnerability to landslides, soil erosion, and flash floods. Recent climate variability has also demonstrated this region's vulnerability to drought, in part because of its geology (which does not retain water). With increasing

A small village in
Lijiang_Yannan province

variability and more intense rainfall, these problems are likely to increase. The mountainous terrain makes infrastructure such as roads and power transmission lines vulnerable to catastrophic slope failures, often cutting off settlements as a result of heavy storms.

In many areas of the country, climate change will impact on biodiversity. Despite a broad network of protected areas and conservation zones, the changing climate will lead to additional stress on valuable species, some of which may no longer be well adapted to the conditions inside protected areas, but cannot migrate outside these areas due to habitat disruption. This is an area that is receiving increased research attention in China. In some areas (e.g. Qinghai) warmer and wetter climate may lead to increased forest growth.

The demand for energy induced by climate change will increase. Projections show that the number of days with extreme high temperature in summer will increase, this will lead to more demand for electricity for cooling. E.g., in Jiangsu, the annual amount of electricity consumption grew by 6.9% during the ninth Five-Year Plan. If the average summer temperature increases by one degree, the electricity consumption of residents and urban system will respectively increase 0.32% and 0.41%, which will accelerate the current shortage of electricity (Liu *et al*. 2005).

Local Responses to Climate Variability

In coastal cities, where the population is high and incomes are rising rapidly, warmer summer weather has led to an increase in the demand for and use of air conditioning in residential buildings. The number of summer days with temperatures above 35° C every year has increased in recent years, and in some parts of Zhejiang province maximum temperatures have reached record highs over 40°. Despite this, temperature increases in these coastal areas are not expected to be as great as in the interior of the country.

In the dry northwest region, farmers have been encouraged to shift from rainfed agriculture to greenhouse production. The use of simple plastic greenhouse technology reduces evaporative losses from the soil, and permits the cultivation of high value vegetable crops, but these require intensive irrigation so water use actually increases.

There has been increased use of insurance policies provided by government or through mutual insurance associations. China Insurance Regulatory Commission has noticed the influence of climate change on the insurance industry. In 2007, they issued a notification to emphasize to take care of the effects of more frequent extreme meteorological events, and to call for more innovations in insurance product. In fact, Zhejiang province has launched a pilot project of integrated subsidized agricultural insurance in 2006, run by the non-commercial agricultural insurance company. The basic principle of this agricultural insurance

is to provide insurance for household losses. Different insurance are provided to different farmers. All farmers could buy insurance for breeding sows, milk cow and rapeseed and specialized farmers could buy insurance for rice, greenhouse vegetables, watermelon, oranges, forest, pig, chicken, duck, goose, and fish. Hazard coverage includes tropical cyclone, rainstorm, flood, frost damage, common insects and disease. There are compulsory and optional insurance coverage products. This insurance will cover all rural areas starting in 2008. To provide agricultural insurance to farmers is a good way to improve their resilience to disaster.

There have also been efforts towards better disaster preparedness and warning of floods or typhoons. The local government and meteorological bureaus make full use of advanced communication technology to help farmers and fishermen to prepare for meteorological disaster. For example, in Fujian the government uses "*quanqiu yan*", "*Xin Shitong*" and other communication products to warn, supervise and prepare efficiently the whole process of disaster (data source: http://www.szfj.gov.cn/Show.asp?NewsID=17093).

Climate Change Adaptation Measures

In most parts of China there has been relatively little consideration yet of formal adaptation strategies for climate change. This is starting to change as the national government has now established a formal Climate Change policy and has required the provinces to incorporate adaptation into their formal development planning. Nevertheless, research and planning for adaptation remain at a very early stage. Mitigation of climate change has received much more prominent attention and research investment, and low carbon development strategies, renewable energy technologies and energy efficiency investments are all increasing rapidly.

It was not surprising to observe that there was relatively little research attention to indigenous knowledge of climate variability, or assessment of the relevance of this knowledge for adaptation strategies.

Ningxia province is in some respects a leader in adaptation, due to the influence of the long-term DFID project on adaptation in the agricultural sector. For example, in Yanchi County, local governments chose to move villages in unfavourable circumstances, subsidized house building and provided every household either a greenhouse or irrigated agricultural land. Local officials said that the resettlement must be done simultaneously for the whole village. The farmers' old house would be completely destroyed to prevent them from going back and cultivating their fields.

There are new standards for seawalls and dikes in Zhejiang and other coastal provinces. The total length of the seawall in Zhejiang province is 2,132 km, which is responsible for protecting most of large and medium cities of Zhejiang. However, the capacity of seawall in Zhejiang province to resist storm surge is lower than what it should be. In the 1990s, more than 1200 died from 9417 typhoon. Meanwhile, some other losses occurred during the 9417 typhoon. For example, more than 90 thousand factories and enterprises had to stop production; more than 7000 km electricity and communication lines were damaged; more than 1000 km roads were ruined. Since 1998, the department of water resources in Zhejiang invested more than 5 billion RMB to construct 1400 km high standard sea wall, 1.5 billion RMB to consolidate the water reservoirs, and more than 12 billion RMB to set up the flood prevention system with 50-year flood standard in large and middle cities.

The government has promoted sedentarization programmes, encouraging pastoralists to shift to cultivated agriculture. Considering the degradation of grassland, Tibet, Xinjiang, and Ningxia, Inner Mongolia, Gansu and other provinces in which pastoralist live have started the sedentarization projects. The government subsidizes the pastoralists' house building, and encourage them to cultivate. Generally, the sedentarized pastoralist should provide fodder for their livestock rather than letting them graze on pasture.

There are still many barriers to adaptation, e.g. the lack of information, the lack of coordination between different government agencies or different levels of government, difficulty of interdisciplinary research; for example, during consultation in Ningxia, staff from Agricultural Bureau (extensionist) said that they could have done more to prevent greenhouse damage from snowstorms had they known and understood more about the weather forecasts. Participants to the final consultation in Beijing stressed due to climate change, the complication of dealing with disease control and preventing health issue in China this days becomes more challenging as it requires much more knowledge on areas other than traditional health sector. This would require multi-sector and multi-disciplinary collaboration and such exercises have not been common in the practices.

6. Analysis and Identification of Key Research Themes

Strategic Issues for Adaptation Research

Climate research has attracted considerable attention in China, in part because of the strategic importance of food production and the historical exposure of large rural and urban populations to extreme events (droughts, floods, typhoons). There is reasonable consensus on the broad nature of future climate change in different regions of the country under various global emission scenarios, but high uncertainty as to how these trends will be expressed locally. A great deal of research has dealt with impacts on agricultural production, particularly in the highly productive North China Plain and floodplain regions of the south. There are divergent views about the implications of climate change on overall national grain production (partly reflecting different methodological approaches to this assessment), but the principal agricultural areas of China are unlikely to be severely affected: they are also reasonably prosperous, dynamic and well served by infrastructure and agricultural inputs. In the northern plains, where water constrains agricultural productivity, the future effects of the South-North water transfer scheme, already committed by the national government, will far outweigh the impacts of climate change on water supply in drought years. For these reasons, from the perspective of vulnerability and adaptation challenges, other regions of the country are of greater interest.

Scientific research capacity in China is strong. Most research attention continues to be devoted to assessing the *effects* of climate change, including issues of data collection (which remains weak in many mountainous and remote areas of the country), modelling and climate forecasting. These are important areas for continuing research effort, particularly when results can be better linked to decision-making through user oriented information products. There is also growing attention to the impacts of forecast changes on ecosystems and biodiversity, and to assessment of aggregate costs of climate change impacts and adaptation. However, adaptation as a specific domain of research effort in China is a new concept.

For example, so far there has been limited research attention to the process of decision-making and response to anticipated or observed climate variability, especially at the micro level (households, communities, local government). Nor has there yet been much interdisciplinary adaptation research that integrates analytical perspectives across social and natural sciences. While there is a great deal of experimental research on agricultural technologies and techniques, there is limited long-term assessment of farmer behaviour, particularly as economic factors change (relative factor prices, resource availability, accessibility and markets).

In response to the information collected through the literature review and in consultations and interviews (see sections 4 and 5 above), as well as the conceptual framework shared by the other regions of Asia covered in this study, we identify a small number of priority research themes in this section of the report. These themes mostly respond to areas identified by the team or by our informants as "gaps" in knowledge, where additional applied and interdisciplinary research could inform better practice.

These themes were selected based on the climate trends and knowledge gaps identified in consultations, but with a particular focus on the following criteria:

- The impacts on poor and especially vulnerable people: this criterion was set by DFID and IDRC, and gives the research a clear "developmental" focus by emphasizing that research investments should benefit poor and vulnerable social groups.
- Geographic contexts of high climate impact: initial investigations suggested four zones of particular interest due to the confluence of relatively high climate impacts and relatively poor or vulnerable people. These geographical contexts of vulnerability led to the selection of sites for consultations and field interviews, and therefore strongly influenced the identification of adaptation issues. These issues should have high relevance in these geographical areas, but will also provide valuable insight for adaptation elsewhere.
- Research themes not already well covered by existing programmes: China has an extensive national research programme and there are a number of well funded donor research programmes approaching adaptation issues already. We have tried to identify issues that are not already well covered by existing research investments.
- Relevant to autonomous and planned adaptation (see conceptual framework in summary report): Most thinking about adaptation in China so far has focused on planned adaptation, which requires good modelling and impact assessment, as well as dealing with the inevitable uncertainties. Many of the areas we recommend for research attention will support planned adaptation, but they are particularly relevant for autonomous adaptation. The actions of many separate households or local governments will be crucial in overall climate adaptation. These actors are not responding only to climate, but to a broad range of social and economic factors. We have tried to select research themes that will help to broaden the range of choices they face, and to build local capacities for response, in the face of greater climate stress.

The significance and rational, relevant research issues and knowledge gaps, as well as the linkages between the geographical areas "hotspots" and vulnerable people and the identified major research themes are summarized in Table 6.

TABLE 6: **China Summary of Climate Adaptation Research Themes by Regions of High Vulnerability and Climate Impact**

	Arid Northwest China	**Tibet-Qinghai Plateau**	**Karst Plateau**	**Densely populated coastal conurbations**
Vulnerable social groups	Rainfed agriculture farmers Irrigation farmers (if water supply threatened) Pastoralists	Pastoralists	Mixed farmers Small urban settlements	Peri-urban migrants
Nature of climate impacts	Higher temp Greater precipitation variability Reduced surface water supply Some cultivated land may return to pasture	Higher temp Higher proportion of precip as rain Changing pasture management	Higher temp and precip Higher frequency and intensity of storms Landslides, flash floods	Sea level rise Floods Typhoons Storm surge
Research Themes and Issues by region				
Local Natural Resource Management	Water management (already well-funded and studied) Rangeland management	Rangeland management	Soil and water conservation (well studied already)	Limited applicability in urban areas
Local Disaster Risk Reduction and Resilience	Risk of floods may increase with storm intensity and variability		Frequent local disasters lead to infrastructure failure: potential design, planning or organizational reforms might increase resilience	Providing better access to housing for non-registered migrants Infrastructure design for extreme events and sea level rise Disaster risk reduction and multiple hazards in high density areas
Migration	Outmigration from high-risk rainfed areas to irrigated areas; from rural areas to cities; from region to east coast - factors likely to facilitate employment, remittances, resettlement	Historical seasonal migrations of pastoralists may be affected by sedentarization and pasture change	Outmigration to large urban centres	In-migration from rural areas: how to build skills, speed adjustment, improve services and welfare benefits for vulnerable groups
Organizational and governance strategies	Mechanisms to promote cross-sectoral and cross-disciplinary coordination Improved downward accountability of local governments to increase responsiveness to specific local conditions Flexible and ad hoc collaboration in program delivery to improve effectiveness and responsiveness to local context Local consultation mechanisms Integration of local and indigenous knowledge in adaptation options			

Research Themes

We identified four domains of adaptation research that would seem to be relevant for China. These are thematic entry points, in the sense that they provide a way to frame and link research across different disciplines and at different scales to provide insight for adaptation strategies that can respond to emerging needs of Chinese people who are vulnerable to climate change.

Local management of natural resources:

The proximate impacts of climate change are already being felt in areas of China where people depend on local ecosystems for their livelihoods. In Ningxia, for example, longer growing seasons and other changes on climate have led to a northward shift of winter wheat cultivation and increased potato production. These changes will have direct implications for how natural resources are managed. The challenges faced by farmers and other resource users will be manifest differently in different locations. In some areas, water scarcity will be the main focus as the frequency of drought events increases, or as higher summer temperatures and increased water demand lead to reduced irrigation water volumes. Land management practices will have to change in areas of steep slopes as the intensity of rainstorms increases. As carbon sequestration acquires commercial value through global capital flows from a post-2012 UNFCCC framework, this will also affect land and resource management strategies in new ways.

Box 1: **Challenges of Grassland Management in the face of Climate Change**

National policy provides for allocation of grasslands to households on a contract basis, to provide incentives for fencing and conservation of vulnerable lands. But in many parts of the northwest, farmers are too poor to pay their share of subsidized fence costs, so pasture is essentially treated as open access, or managed (weakly) at the commune level. The current structure of both private and collective tenure systems seems ineffective. Research is needed to identify new institutions for grassland tenure and management (Data source: From Interviews in Yanchi, Ningxia).

On the Tibet-Qinghai plateau, sedentarization programs encourage traditional nomadic pastoralists to cultivate barley as a food grain instead of herding livestock. But without animal dung as a source of fuel for drying and cooking their grain, farmers are driven to using low quality grass and plant roots as fuel, destroying the sensitive high-altitude grasslands. Climate change will further stress this unique ecosystem (Data Source: From Beijing consultation).

Many areas of natural resource management already receive research attention. We refer to agricultural research above. Water resource management is another example of a domain that will become more important in many areas of the country, but is already receiving considerable research attention. In these cases, future research investments should consider the relevance of climate change in their planning and execution. However, one example of local resource management that does not now receive much research attention, but is likely to grow in importance, is rangeland management for livestock production.

In both the arid northwest and the Tibet-Qinghai plateau, agricultural intensification is problematic as a long-term livelihood strategy. For example, northwest China receives large subsidies from national poverty alleviation programmes, many of which are currently invested in the expansion of irrigated agricultural production (now 40% of cultivated area). Surface and groundwater extraction already exceed safe limits and climate change will only exacerbate water scarcity. There is already a substantial research community engaged in improving the resource use efficiency of irrigated agriculture, but the area suitable for these kinds of systems will be reduced by future water availability. Meanwhile, many areas of rangeland are experiencing severe degradation, and various conservation programmes and incentive schemes have been launched to reduce grazing pressure, with limited success (see Box 1). In order to minimize further degradation and desertification, innovative rangeland management practices will be essential.

Pastoralists are the poorest and most vulnerable social groups in these regions, and have traditionally relied on culturally-embedded ecological knowledge that is no longer reliable. Current management strategies (sedentarization, enclosure, ecological migration) may exacerbate social conflict and local economic disparity, and yet fail to address the increasing risk exposure of livestock production in a variable climate. At the same time, there may be opportunities for both biodiversity conservation and carbon sequestration in actively grazed rangelands. These issues will become more serious under more frequent droughts, as irrigated agriculture fails and more area becomes suitable only for pasture land.

Key knowledge gaps revolve around options for fodder and pasture management, alternative livelihoods and asset diversification in a relatively unproductive agro-ecosystem that is isolated from markets and infrastructure. Increased risk of forage vulnerability poses special concerns for a livestock based economy, where it can take many years to re-build productive herds. Another issue is how to re-build knowledge systems when traditional pastoral-ecological knowledge based on a stable climate becomes less reliable. The research issues in this domain go beyond questions of animal husbandry, health and natural science to include social issues of benefit sharing and household roles, as well as institutional issues of resource tenure and local governance in the face of changing environmental, economic and policy conditions.

Local disaster risk reduction and resilience

In the karst uplands, and in peri-urban coastal areas, poor people are vulnerable to further impoverishment as a result of increasing frequency of extreme climatic events, such as heavy rainstorms, floods, typhoons and storm surges. Essential infrastructure and new construction are built to current standards for extreme hydrological or storm events, but as climate changes those standards become outdated. Yet there is little critical assessment of the trends in wetland degradation or lowland vulnerability to sea level, storm surges and flooding.

Current approaches to disaster management and infrastructure engineering may be less appropriate when climate becomes more variable. The issues may be not simply engineering standards, but the whole approach to engineering (e.g. safe fail designs instead of failsafe). Institutional mechanisms for local risk reduction, disaster preparation and limited self-reliance in some domains may prove to be more resilient than very costly high standard infrastructure that cannot be feasibly protected from extreme events. In low-lying areas this may include planning for floods by designing retention basins and minimizing flow barriers, rather than building dikes. Innovative engineering and infrastructure construction approaches need to be balanced with new approaches to risk assessment and organizational, institutional and social communication methods (awareness building, warning measures, hazard specific responses, credit and strategic reserve facilities for recovery). Some of these innovations are emerging already, but there is need for research on how they can be better integrated at the local level to address diverse and context specific conditions.

One of the biggest challenges is how to manage uncertainty. There are a lot of uncertainties on climate change, such as climate change models. While the prediction of local or regional climate futures remains inherently uncertain, decision-makers must proceed with planning and action on the basis of available information and estimates. With such uncertainties lay ahead, responding to climate change and managing disasters and building resilience can be more sophisticated and need new knowledge.

Migration

Long-standing regulatory controls over residential registration to control the rate of urban growth in the prosperous eastern part of the country have increased the cost to migrants of relocation. However, benefits from participation in China's urban economic boom have exceeded these costs, and there is growing recognition at the policy level of the economic value of the labour force provided by rural-urban migrants in eastern cities. Yet because they lack official registration, and the social welfare protection it brings (health insurance, pension, unemployment benefits and subsidized housing), migrants are particularly vulnerable in urban areas.

The size of this 'floating' or unregistered population is very large. In Shanghai, over six million people, more than one third of the population, are unregistered residents. Despite living for many years in the cities, this population is viewed as temporary. Remittances from this population form a key part of rural incomes. In Guangdong province, the value of remittances outside the province is more than 130 billion RMB in 2007 (Data sources: http://nc.people.com.cn/GB/61156/61919/6816167.html). The government already recognizes the need for ecological migration and subsidizes local and regional relocation (both voluntary and involuntary) from ecologically fragile zones. Relocation is identified through international experience as a common autonomous adaptation to climate variability and extremes (Moench, M and A. Dixit, eds. 2004). Migration is a complicated socio-economic decision, simultaneously creating a new form of individual vulnerability and yet offering the prospect of reducing household vulnerability. Gender and ethnicity are factors in determining how migration plays out in both source and destination areas. The process creates social issues at both ends, and can be mediated by many types of information and communication strategies as well as by transportation and communication infrastructure. There are many potential areas of research and of policy intervention in order to improve the social and economic effectiveness of migration and to foster climate adaptation in both rural and urban areas.

Box 2: **Helping to Find Off-Farm Employment**

In Ningxia, programs at both the provincial and county level help farmers to find off-farm employment. The provincial Dept of Civil Affairs provides financial support for counties to offer one-year vocational and technical skills training for senior middle school graduates. The county level also supports placement information and short-term job-related training for temporary employment. Climate change is likely to increase stress on marginal farmers, leading to higher rates of migration. The factors that affect such migration, and those which lead to economically and socially successful outcomes, need further research (Data sources: From Ningxia consultation).

Practical and flexible organizational strategies for government

Climate impacts and adaptation actions are inevitably local in nature, but local adaptation can be enabled by government actions and socio-economic networks at multiple scales. Research could help to identify and describe these enabling actions and the types of government institutions to best address them. Government structures, budgets and programmes are normally administered sectorally, for example, in vertically articulated "silos" that are not well integrated or coordinated. In these structures in China, accountability is almost entirely upwards to the centre. As a result, even when significant government resources are devoted to ecosystem management and climate adaptation, local implementation is often uncoordinated and unresponsive to contextual priorities (see Box 3 for an example from Ningxia). Effective climate adaptation will recognize and support the initiative of local actors. This suggests that policies and programmes be flexible enough to be implemented differently in different places, and that oversight mechanisms encourage accountability and transparency of decision-making both upward and downward.

There is also a need for greater flexibility in responding to emerging and unpredictable local issues without necessarily creating new government organizations. For example, climate vulnerability of poor migrants in peri-urban coastal areas is not only a function of geographic exposure, but also their insecure livelihoods and lack of access to social welfare benefits. In high density urban areas, all of these factors combine to create public health risks as well. To address climate adaptation issues for this group will require innovative and coordinated responses not only between local government agencies with different sectoral responsibilities, but also with national level ministries. Some kind of flexible task force or "ad hoc" local coordinating committee will be needed. Similar types of issues will emerge in rural areas as well. The mechanisms for combining budgets and technical resources from different agencies to tackle such emerging adaptation issues need to be better researched.

One of the issues raised in consultations and interviews was that while the impacts of adaptation will be local, and will require local governments to take actions, they currently have limited awareness of the issues. Even when there is some concern about climate, they may lack appropriate information in a form that they can readily incorporate into decision-making. There are also few practical planning or analytical tools that local practitioners could use to assess and implement adaptation strategies. This includes tools for economic analysis of adaptation options.

In the long term, climate change will demand better institutions for adaptive management; i.e. a willingness to take management decisions for complex systems in the face of uncertainty and risk, but to view interventions as learning opportunities, examine outcomes critically and share lessons (see below). Research can help to develop such institutions suited to Chinese conditions.

Box 3: **Poverty Reduction Programs and Climate Maladaptation in Ningxia**

State subsidies for greenhouse construction in Ningxia are intended to reduce poverty by encouraging farmers to grow high value vegetable crops. While the greenhouses reduce evaporative losses from the soil, the crops themselves use more water than traditional grain production. In the south mountains of Yanchi County, local agricultural technicians were aware that there was insufficient local water supply to sustain greenhouse production but the program criteria were too rigid to allow them to use the funds for other poverty reduction strategies. Senior government officials ignored the technicians' advice and farmers received subsidies for greenhouses, which then failed, losing both the State and farmer investments (Data source: From interviews with local government officials in Yanchi).

Knowledge systems

In all of these research themes, a pervasive challenge is the way that knowledge and learning are structured in China's expert driven society. Adaptation will require local learning as part of adaptive management. Technological innovations are likely to require local modification for effective climate adaptation. Ecosystem response to new techniques will inevitably vary depending on dynamic local conditions (including climatic factors, but also pollution and intensification of resource use). Experts will not be able to predict how specific techniques will perform in diverse and dynamic contexts. Surprise will be the rule, rather than the exception. Under these conditions, new approaches to shared learning and expertise will be needed. These approaches will recognize the value of diversity, rather than uniformity, in local and regional response strategies to foster resilience. They will address plural sources of knowledge and evidence. Most of all, these new approaches will have to build practical local strategies for experimentation, local and scientific assessment, and systematic sharing of learning.

With high uncertainty about ecological changes linked to climate and resource exploitation, together with urgent livelihood needs, there is not enough time for comprehensive research

and analysis of long-term options. Yet innovation will be essential. New ways must be found to support local initiative and creativity in combination with scientific expertise and knowledge of good practice. Relevant issues could include the reform of agricultural extension systems, strengthening regional expertise and capacity in both government and research, the role of private enterprises in responding to innovation incentives, and how best to connect local adaptation opportunities to national and global resource flows (such as market incentives for carbon sequestration).

There is no shortage of innovation and local initiative in China, but local access to scientific knowledge, as well as systems of adaptive management and shared learning are not well developed even in coastal areas where capacity and resources are plentiful. In poorer and more remote areas research capacity is relatively weak even at the level of provincial academies, never mind the county (local) government. Part of the issue is providing better local access to national scientific knowledge networks, and part of the issue is translating scientific and technical innovations into practical and locally relevant formats that can be easily accessed by practitioners. Reforms of the agricultural extension system could contribute to building these more responsive local knowledge and learning systems. Another way to approach this would be to build participatory research capacity among provincial academies, who can then engage with both national-level interdisciplinary scientific support, and county level implementing agencies, as appropriate to test adaptive management interventions.

Although the four themes identified above are meant to be cross-cutting, there are differences in nature. The following are major features when these themes are compared.

- Some of these themes are sectoral (e.g. NRM, disaster prevention and management) and others cross sectoral boundaries (e.g. migration, governance), but all are in key ways interdisciplinary. For example, although natural resources management is meant to be local and can be sectoral, it does go beyond the boundary of natural sciences when resource tenure, institutions and systems are concerned.

- Some of the themes do show strong needs of certain engineering expertise, such as building sea walls, constructions, etc. However, certain types of social sciences approach should be integrated and they approve to be useful in these different areas. Role of participatory methods in social sciences in gaining both new insights as well as engagement of actors at multiple levels is one of the examples.

- One cross-cutting issue which plays out significantly among all the themes is governance. Whether to address natural resource management, disaster management and prevention, or migration, governance at community as well as at national levels play significant role in setting the institutions and boundaries under which all the stakeholders making their responses and adaptation actions.

Audiences for research results: in some cases, there are national policy implications, but often the key will be local government practices and how best to support awareness and innovation at this level.

7. Key actors in Climate Change Research in China:

Many efforts have been made by governments and institutions to increase understanding about the climate change, mostly focused on agriculture, water resources and meteorology because of the impacts of extreme events, the lack of water in many areas of China and the pressure of supplying food for 1.3 billion people. Also, many environmental and ecological research groups have shifted or re-oriented their research focus onto CO_2 emission, low carbon growth (eg. biofuel) and carbon trade or other related studies. In addition, government policies favouring mitigation are now increasingly being incorporated into local and regional development plans.

The China Meteorological Administration and Chinese Academy of Sciences collaborated on a broad inter-disciplinary "First National Climate Change Assessment" in 2006, documenting available scientific knowledge and summarizing research to date. There are also many funding support efforts by MOST and China's National Science Foundation to improve the understanding of Climate Change. For example, the projects number 863 and 973 on the forecast of climate change, future ecosystem change, disaster planning and extreme event forecasting, climate change adaptation strategy and support techniques. Special funding was announced in the report on Climate Change Adaptation in China (2007), in order to better prepare planned adaptation strategies after detailed studies on the effect of climate change on agriculture, water resource, coastal area and fishery, biodiversity, etc. The report announced Chinese government support for demonstration sites on climate change adaptation in several climate vulnerable regions.

However, special attention should be paid to two key national organizations in China if research is to have any systematic impact on policies. The National Development Reform Commission has formal responsibility for the Leading Group on Climate Change, and oversees all climate policy development. While it is not responsible for research or scientific policy, it sets national priorities for climate responses and is one of the very few agencies that can ensure both the collaboration of powerful but independent State ministries, as well as the widespread implementation of new planning procedures, practices or standards. Their support and engagement in adaptation research will be very important in providing links to implementation.

The other crucial policy agency is the Ministry of Science and Technology. This is a key research funding and priority setting agency. They oversee national research programmes, select research institutes to lead and participate in long-term research projects, and direct the broad priorities for provincial research strategies throughout the country. Our identification of research issues is interdisciplinary, and not specifically focused on

technologies, but this makes it even more important to engage with MoST, which recognizes the weaknesses of interdisciplinary research in China.

Some other research institutions also play important role in climate research, for example, the Chinese Academy of Sciences, the Chinese Agricultural Academy of Sciences and Universities, and the China Meteorological Administration. Up to now, most research has focused on the impact of climate change on agricultural, ecological, water resources sectors. Studies on the impact of sea level rise have been initiated but remain very limited. The published paper provided the preliminary analysis of the impact of sea level rising on the coastal areas, particularly focusing on the Yangtze River Delta and the Pearl River Delta (Shi *et al*. 2000; Huang and Fan 2000; Huang, Zhang and Fan, 2001; Deng and Fan, 2002; Dong and Zhou, 2005; Li *et al*, 2006). The researchers on this issue are mainly from the Nanjing Institute of Geography and Limnology, CAS, such as Guishan Yang, Jiwen Zhu, Zixiu Ji and Zixun Jiang. In addition, the School of Geographic & Oceanographic Sciences of Nanjing University and the State Key Laboratory of Marine Geology of Tongji University, Guangzhou Institute of Geography are also contributing to this. At the same time, local research institutes/governments are also involved such as the Monitoring Station of Ningbo Geological Environment, the Zhejiang Department of Water Resources. The research about typhoon is relatively numerous. The main researchers are from meteorological department of governments (e.g. China Meteorological Administration, Beijing Climate Centre, Shanghai Typhoon Institute of CMA, Nanjing University of Information Science and Technology). But most of them are from the view of meteorology and physics. Only few researches paid attention to the economic impact of typhoon. The vulnerability assessment to climate change/natural disaster is desperately lacking. Several literatures we could find were still staying in the theoretical stage. Interdisciplinary cooperation should be suggested in future research.

Although many efforts are paid to the research on the impact of climate change, most of researchers agreed that there remain great uncertainties in this field. At the same time, although adaptation is an important component of response to climate change, its relative researches have not got enough attention. This kind of research could follow a bottom-up approach.

While much of the scientific research strength in China is at the national level, the adaptation research themes we address play out at multiple levels. It will be particularly important in implementing these research themes to pay attention to the articulation of leading capacity at the national level with provincial level experts who will have to be involved in designing and monitoring innovations locally, as well as with local governments who will be responsible for implementing many of them. Only through new processes of shared learning, involving all of these actors, will lessons from adaptation research become implemented into local practice and governance. A brief summary of research organizations and projects follows (Table 7), with a more detailed listing attached as Appendix 1.

TABLE 7: A brief summary of funding/research organizations and projects on climate change and adaptation

Funding/Research organizations	Research issues	Year
National Development Reform Commission	China's national climate change adaptation programme	2007
MOST	A series of national programmes of S&D and basic research on climate change and adaptation (8th to 11th five year plan)	
Australian Greenhouse Office, Department of the Environment and Heritage and Office of the National Coordination Committee for Climate Change, National Development and Reform Commission	Australia-China Bilateral Cooperation on Climate Change	2003-2005
National Natural Science Foundation in China (NSFC)	NSFC initiated a series of Programmes on climate change and its regional response	2002-2017
Laboratory for Climate Studies, China Meteorological Administration	Study on the eco-hydrological processes and its response to environmental changes at watershed scale in arid and semi-arid area of northwest China	2005
China Meteorological Administration (CMA)	The impact of climate change on human health	2008
Chinese Academy of Meteorological Sciences	Research on theories and methods of monitoring and predicting of heavy rainfall in South China	2004
National Climate Centre, China Meteorological Administration	First National Climate Change Assessment	2006
Beijing Climate Centre of China Meteorological Administration	Research on short-term climate prediction system in China	1996-2000
National Centre for Disaster Mitigation ; Institute of Atmospheric Physics, CAS	Global Natural Disaster and Disaster Reduction	2005
Institute of Atmospheric Physics, CAS	The Impacts of Climate change and adaptations in Inner Mongolia	2007
Institute of Geographical Sciences and Resource Research, CAS	Framework: Evaluation and Management of adaptation to the impacts of climate change on water resources	2008
IGSNRR, CAS	Carbon cycle and Driving Mechanism in Chinese Terrestrial ecosystem	2002
Institute of Atmospheric Physics, CAS	Ocean-Atmosphere Interaction over the Joining Area of Asia and Indian-Pacific Ocean and Its Impact on the short term Climate Variation in China	2007-2011
Institute of Tibetan Plateau Research, CAS	Responses of environmental changes on the Tibetan Plateau and adaptations under the global change	2005
Institute of Atmospheric Physics, CAS	Aridification over Northern China and Human Adaptation	2006
Institute of Rock and Soil Mechanics, CAS; China University of Mining&Technology	Basic research on the safety of major engineering projects in hazardous environments	2002

Institute of Geology and Geophysics, CAS	The dynamics and trends of environmental evolution in arid and semi-arid areas in the past 150 000 years	1998
The Chinese Academy of Agricultural Sciences (Erda Lin)	Impact of Climate Change on Chinese Agriculture—Phase I Overall Assessment	2001-2004
Institute of Environment and Sustainable Development in Agriculture	The climate change impacts on agriculture and regional CCA ability development	2005-2007
Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences	Investigating the Impacts of Climate Change on Chinese Agriculture and building regional capacity in climate change	2005
Beijing Normal University	Study on the process and mechanism of human adaptation to climate change	2003
Beijing Normal University	Spatial changes of land coverage in the past 300 years in northeast China	2006
Beijing Normal University	The recovery and impact of historically environmental change events	2002
Renmin university of China	Strategies to cope with climate change	2002
Renmin university of China	China-UK cooperation project: how to improve the CCA ability of provincial government	2002
the State Environmental Protection Administration, Energy Research Institute, Chinese Academy of Agricultural Sciences, Chinese Meteorological Administration and Tsinghua University, CIDA	Canada-China Climate Change Cooperation Project	2002
National Meteorological Bureau; Nanjing University; Cold and Arid Regions Environmental and Engineering Research Institute;	Climate change impacts on west China and evaluation of vulnerability and adaptation	2004
Chinese Academy of Forestry	Simulation of primary productivity pattern and its response to climate change in Tibetan Plateau	2003
Climate Change Cooperation Projects between China & the UK	Investigating the Impacts of Climate Change on Agriculture and climate change adaptation methods in Ningxia	2005
DFID and DEFRA, Chinese Government (concept)	“Strengthening Adaptation to Climate Change in China: Science communication and Integration of Adaptation with Provincial Planning and Management”	New initiative

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ANNEX I:

Table of prior and ongoing research projects (e.g. 973 program)

Year	Chief Scientist	Principal Organization	Sponsors	Project Title	Covered regions	Main Contents/Results	Links
2002	Ji Zou	Renmin university of China		Strategies to cope with climate change	China		
2002	Ji Zou	Renmin university of China	Climate change challenge fund, UK	China-UK cooperation project: how to improve the CCA ability of provincial government	China		
2003	Ji Zou	Renmin university of China	Climate change challenge fund, UK	UK-China climate change	China		
2001-2004	Erda Lin	CAAS	DEFRA, DFID	Impact of Climate Change on Chinese Agriculture—Phase I Overall Assessment	China	A set of climate change scenarios for China are developed, and their likely impact on crops during the 21st century was examined.	http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=5398
2005-	Erda Lin	CAAS	DEFRA, DFID	Impact of Climate Change on Chinese Agriculture—Phase II Case Study	Ningxia	Further emphasis on determining impacts of climate change, and developing suitable regional adaptation policies to address these.	
2002			Canadian International Development Agency	Canada-China Climate Change Cooperation Project		Awareness and outreach; National communications; Impacts and Adaptations; Clean Development Mechanism	http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=5397
2003				Australia-China Bilateral Cooperation on Climate Change		Cooperation and Research (Policy study, impacts and adaptation, National communication); Technology cooperation; Capacity building and public awareness	http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=5396
2005-2007		Institute of Environment and Sustainable Development in Agriculture	British Council	The climate change impacts on agriculture and regional CCA ability development	Inner Mongolia; Zhejiang	to broadcast the CC research findings, training work in Inner Mongolia and Zhejiang province, to enhance the regional sensibility of CC and CCA abilities	
2004	Guodong Cheng	National Meteorological Bureau; Nanjing University; Cold and Arid Regions Enviromental and Engineering Research Institute; et al.	AIACC	Climate change impacts on west China and evaluation of vulnerability and adaptation	Western China	To develop a series of indicators to evaluate the impacts, vulnerability and adaptation	

1996-2000		Beijing Climate Centre of China Meteorological Administration		Research on short-term climate prediction system in China		http://bcc.cma.gov.cn/Website/index.php?ChannelID=4
2005	Hongmei Xu	CMA	NSFC	Study on the ecohydrological processes and its response to environmental changes at watershed scale in arid and semi-arid area of north-west China		http://bcc.cma.gov.cn/Website/index.php?ChannelID=39&WCHID=4 (The URL links to a lot of researches on climate change conducted by CMA.)
2005		National Center for Disaster Mitigation ; Institute of Atmospheric Physics, CAS	IAP	Global Natural Disaster and Disaster Reduction		http://www.iap.ac.cn/english/iap/international_projects.htm
2007	Hongbing Fu	Institute of Atmospheric Physics, CAS	ADAM	The Impacts of Climate change and adaptations in Inner Mongolia	Inner Mongolia	
2008	Jun Xia	IGSNRR,CAS	NDRC, DFID	Framework: Evaluation and Management of adaptation to the impacts of climate change on water resources	Huai River valley; Hai River Valley; Shiyang River valley, et al.	
20072011	Guoxiong Wu	Institute of Atmospheric Physics, CAS	Key project of Chinese National Programs for Fundamental Research and Development (973 program), Ministry of Science and Technology	Ocean-Atmosphere Interaction over the Joining Area of Asia and Indian-Pacific Ocean and Its Impact on the short-term Climate Variation in China		http://mahasri.cr.chiba-u.ac.jp/meetings/1stIMASSC/RegionalNEA/LiJianping(BingWang).ppt#278,29,??? 29

2005-?	Tandong Yao	Institute of Tibetan Plateau Research, CAS	Key project of Chinese National Programs for Fundamental Research and Development (973 program), Ministry of Science and Technology	Responses of environmental changes on the Tibetan Plateau and adaptations under the global change	Tibetan Plateau	It is consisted of six sub-projects. Where, one is 'Adaptation to environmental changes on Tibetan Plateau' which is presided by Yili Zhang(IGSNRR, CAS).	http://www.973.gov.cn/English/ReadItem.aspx?itemid=355
2006	Hongbing Fu	Institute of Atmospheric Physics, CAS	Key project of Chinese National Programs for Fundamental Research and Development (973 program), Ministry of Science and Technology	Aridification over Northern China and Human Adaptation		(1) Land surface and atmospheric processes in arid/semi arid regions and their interactions with human activity; (2) Evolution, transition, or abrupt change of aridification and its predictability; (3) Impacts of aridification and its transition on food, water and land security, and corresponding adaptation measures; (4) Development of Asia regional model of the earth system and its application on aridification prediction, impact assessment and adaptation	http://www.973.gov.cn/English/ReadItem.aspx?itemid=354
2004	Renhe Zhang	Chinese Academy of Meteorological Sciences	Key project of Chinese National Programs for Fundamental Research and Development (973 program), Ministry of Science and Technology	Research on theories and methods of monitoring and predicting of heavy rainfall in South China		study on structure and mechanism of heavy rainfall; effects of long-term dynamic processes on heavy rainfall; climate environment of forming heavy rainfall; basic theoretical problems of heavy rainfall prediction; study on remote sensing of monitoring heavy rainfall; development of heavy rainfall prediction model with meso-scale; experiment and study of meso-scale heavy rainfall observation system.	http://www.973.gov.cn/English/ReadItem.aspx?itemid=495

2002	Xiating Feng; Heping Xie	Institute of Rock and Soil Mechanics, CAS; China University of Mining&Technology	Key project of Chinese National Programs for Fundamental Research and Development (973 program), Ministry of Science and Technology	Basic research on the safety of major engineering projects in hazardous environments			http://www.973.gov.cn/English/ReadItem.aspx?itemid=302
20032005	Xiuqi Fang	Beijing Normal University	NSFC	Study on the process and mechanism of human adaptation to climate change			
20062008	Xiuqi Fang	Beijing Normal University	NSFC	Spatial changes of land coverage in the past 300 years in northeast China	northeast		
20022005	Xiuqi Fang	Beijing Normal University	Innovation Fund of CAS	The recovery and impact of historically environmental change events			
20032005	Zhihua Guo	Chinese Academy of Forestry	NSFC	Simulation of primary productivity pattern and its response to climate change in Tibetan Plateau			http://mrp.nsfc.gov.cn/?mn=project&mo=homei&mv=P2&pid=448
2008	Xiaofeng Xu	CMA	NSFC	The impact of climate change on human health			
1998	Dongsheng Liu	Institute of Geology and Geophysics, CAS	NSFC	The dynamics and trends of environmental evolution in arid and semi-arid areas in the past 150 000 years			
20022017	Not available		NSFC	NSFC initiated a series of Programs on climate change and its regional response			http://mrp.nsfc.gov.cn/?mn=project&mo=profile&pid=486