AEA

Impacts of Climate Change on Chinese Agriculture – Phase II

Adaptation Framework and Strategy

Part 2: Application of the Adaptation Framework: A Case Study of Ningxia, Northwest China

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Project Background

The project *Impacts of Climate Change on Chinese Agriculture* (ICCCA) was funded by the UK Government's Department for Environment, Food and Rural Affairs (Defra – transferred to the Department of Energy and Climate Change, DECC, in October 2008) and Department for International Development (DFID), conducted in partnership with China's Ministry of Science and Technology (MOST).

Since 2001, the project has led the way in understanding how climate change can be expected to affect rural China.

The project was rolled out in two phases: Phase I (2001 to 2004) applied regional climate modelling to construct several possible future climate scenarios for China. These were subsequently fed into a suite of regional crop models adapted by the Institute of Environment and Sustainable Development in Agriculture (previously the Agrometeorology Institute) of the Chinese Academy of Agricultural Sciences (CAAS), in collaboration with UK climate-change researchers, to determine the potential impacts of climate change on crop yields in China up to 2100.

Building on Phase I, Phase II (2005 to 2008) refined and widened the national level analysis. CAAS also worked in collaboration with major regional implementers such as the Clean Development Mechanism Service Centre (Ningxia) and Meteorological Study Institute (Ningxia), and engaged a range of stakeholders to assess the impact of climate change on rural livelihoods. This led to the development of the first regional adaptation framework in China – for the northern province of Ningxia.

The key findings and approaches for the project are summarised in six pamphlets. These are:

- *Overall summary of results*
- *Understanding how China's climate may change in the future*
- *Modelling the impacts of climate change on cereal production in China*
- *Modelling the interaction of climate change - water availability and socio-economic scenarios on cereal production*
- *Rural livelihoods and vulnerability to climate hazards in Ningxia*
- *An adaptation framework and strategy for Ningxia*

The full technical reports from the project can be found at www.china-climate-adapt.org. These are:

- *National Level Study: The Impacts of Climate Change on Cereal Production in China*
- *Future Cereal Production in China: Modelling the Interaction of Climate Change,Water Availability and Socio-Economic Scenarios*
- *Climate and Livelihoods in Rural Ningxia*
- *Climate Change in Ningxia: Scenarios and Impacts. Technical Report.*
- *Adaptation Framework and Strategy:*
  - *Part 1 – A Framework for Adaptation*
  - *Part 2 – Application of the Adaptation Framework: A Case Study of Ningxia, Northwest China*
  - *Part 3 – An Adaptation Strategy for Agriculture in Ningxia, Northwest China*

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Project Team

The project team comprised the Institute of Environment and Sustainable Development in Agriculture of the Chinese Academy of Agricultural Sciences (CAAS), AEA Group, who managed the project and provided technical input, and Dr. Declan Conway of the University of East Anglia as Scientific Advisor. The project has benefited from the contribution of numerous partners and stakeholders in both China and the UK. Collaborative research links have been forged resulting in new insights into the scientific and policy challenges posed by climate change in China over the next century.

Acknowledgments

Key collaborators

China

- Chinese Ministry of Science and Technology
- National Development and Reform Commission
- China Meteorology Administration
- Chinese Ministry of Agriculture
- Chinese Academy of Social Sciences
- Ningxia Department of Science and Technology
- Ningxia Bureau of Meteorology
- Ningxia Agriculture and Livestock Department
- Office of Environmental Protection, Ningxia
- Office for Poverty Alleviation, Ningxia
- Clean Development Mechanism Centre, Ningxia

UK

- Cranfield University
- Environment Agency
- Met Office Hadley Centre
- The Tyndall Centre for Climate Change Research, University of East Anglia
- UK Climate Impacts Programme (UKCIP)
- University of Reading

Additionally, the following organisations have provided invaluable support:

- ADAS, UK
- Centre for Ecology and Hydrology, Natural Environment Research Council, UK
- Cranfield University at Silsoe, UK
- East Malling Research, UK
- Environmental Change Institute, Oxford University, UK
- Forestry Commission, UK
- Greater London Authority, UK
- Institute of Arable Crops Research, Rothamsted Research, UK
- Institute of Grassland and Environmental Research, UK
- John Innes Centre, UK
- JSC/CLIVAR Working Group on Coupled Modelling (WGCM), UK
- Programme for Climate Model Diagnosis and Intercomparison (PCMDI), USA
- School of Earth, Environmental and Geographical Sciences, University of Edinburgh, UK
- Unit for Landscape Modelling, Cambridge University, UK

www.china-climate-adapt.org

Executive Summary

ICCCA Phase II developed the first framework for adaptation to climate change in China. This is a generic and transferable tool to help decision-makers develop a comprehensive and strategic approach to adaptation policy which can inform action on the ground. Although local conditions will vary, the framework identifies a number of key actions that should be undertaken in the development of an adaptation strategy and represents a useful means for decision-makers to structure their approach to climate change impacts and adaptation. ICCCA successfully applied its framework to the agricultural sector in the autonomous region of Ningxia Hui (northwest China) to produce the first regional adaptation strategy in China but the generic framework should be applicable to different areas and sectors.

ICCCA's research on adaptation during Phase II is presented in three reports:

- ***Part 1: A Framework for Adaptation***. This part outlines the generic, transferable tool developed by ICCCA to help decision-makers to structure their thinking about adaptation and to start develop their own adaptation strategy.

- ***Part 2: Application of the Adaptation Framework: A Case Study of Ningxia, Northwest China***. This part illustrates the practical application of ICCCA's framework to generate prioritised adaptation options – the first step towards the development of an adaptation strategy. It covers the methodology, results and lessons learnt from applying the framework, as well as the outcomes from the exercise.

- ***Part 3: An Adaptation Strategy for Agriculture in Ningxia, Northwest China***. This part concentrates on the outcomes of applying the adaptation framework to the agricultural sector in Ningxia by presenting the adaptation strategy arrived at through application of the framework.

This report is **Part 2** of ICCCA's research on adaptation, and illustrates the practical application of ICCCA's framework to generate prioritised adaptation options for the agricultural sector in Ningxia, Northwest China. It covers the methodology, results and lessons learnt from applying the framework, as well as the actual outcomes from the exercise.

The framework, which consists of six stages, was applied as follows in Ningxia:

Stage 1: Assessing the climate risk. This stage involved characterising recent climatic variability in Ningxia and the regions subsequent vulnerability. Using a risk-based approach, the potential significance of future climate change in Ningxia was then considered. Four main climate risks to Ningxia were identified:

- Drought;
- Surprises/Extremes – including weather extremes such as increases in windstorms, heatwaves and agricultural pests and disease;
- Drying and high temperatures – leading to increases in soil moisture evaporation and exacerbation of ongoing desertification;
- Shifts in the river flow regime of the Yellow River.

Stage 2: Integrating regional development goals and adaptation goals. This stage relied on stakeholder consultation and policy documents to cross-reference development goals with assessments of climate risks. Ningxia has three main agricultural systems, each with distinct physical and economic features. The three agricultural systems roughly map onto three distinct geographic areas of Ningxia and have separate development priorities.

Stage 3: Identifying adaptation options. Different stakeholders have different perspectives and knowledge about adaptation options and whilst some are focussed on policy, others are more concerned on other issues, such as technical or behavioural responses. Adaptation options under three headings were explored: structural, non-structural and high level policy.

Stage 4: Prioritising options. ICCCA proposed three different tiered approaches to identifying and prioritising adaptation options:

1. An **approach for prioritising policy type options at regional government** level relying on insights and experience from local and regional experts and wider consultation;
2. A **risk-based approach** to identifying options at sector and sub-regional level;
3. **Multi-criteria analysis (MCA)** to prioritise particular activities at the organisational level with implementation in mind.

Adaptation priorities identified for Ningxia's agricultural sector on the basis of these approaches were:

1. Recommendations for cross-sectoral activities that could form useful entry points for integrating adaptation in regional level planning in Ningxia are as follows:

   - Move towards the establishment of a **cross-departmental group** on climate change adaptation within regional government. Consultation with government agencies clearly highlighted the cross-sectoral nature of climate risks and adaptation responses, demonstrating **a need for coordinated action on climate change**.[2]
   - **Mainstream adaptation into development and poverty alleviation processes**. Because of the close alignment at community and household level between adaptation (reducing vulnerability to climate change) and more generic individual and institutional aims for development, there exists **good potential to mainstream adaptation into development plans and poverty alleviation processes**.
   - **Raise awareness on climate change** trends, potential impacts and adaptation activities across the region.

2. Priorities from a **risk-based approach** to identifying options at sector and sub-regional level can be categorised as:

   - water-saving measures;
   - disaster prevention and reduction measures;
   - improvement of farmer's livelihoods;
   - establishment of climatic early warning system.

   These priorities fall under the responsibility of various government departments in Ningxia, including the Land and Resources Department, Ningxia's Meteorological Bureau, Yellow River Commission, Ningxia Water Resource Department, Ningxia's Department of Science and Technology, Ningxia's Department of Agriculture and Livestock, and Ningxia Development and Reform Commission.

Stage 5: Implementation and demonstration

To date, no specific practical measures have been taken on the ground in relation to adaptation in the agricultural sector in Ningxia. However, some actions have occurred on policy mainstreaming. For instance, the *Ningxia Eleventh-five Development Plan* mentions the need to strengthen climate change adaptation and the *Ningxia Climate Change Response Office* has been established.

Responsibility for developing the region's adaptation response lies primarily with the newly established *Ningxia Climate Change Response Office*. One of ICCCA's final activities is to present its findings at the Office's inception meeting and to help initiate a series of next steps towards mainstreaming adaptation in Ningxia.

Stage 6: Monitoring and evaluation

Monitoring and evaluation should be an important feature of policy responses to climate change. Monitoring is necessary to periodically assess whether changes are occurring in the regional/local climate or socio-economic systems and to evaluate whether actions taken are effective. At this stage, it is too

[2] Recognising the cross-institutional nature of climate change, Ningxia established a steering committee "Climate Change Response Office" in early 2008 to promote both adaptation and mitigation programmes.

early to provide any results of monitoring and evaluation in relation to the application of the ICCCA's adaptation framework in Ningxia.

This report ends with some conclusions and reflections based on the experience of applying the framework in Ningxia. These include:

- Adaptation should be seen as an ongoing process. There are no blueprints for mainstreaming. The local context is critical and considerable efforts need to be made to ensure that consultation with stakeholders informs the process;
- There is a need to raise awareness about climate change;
- Climate risks and adaptation priorities vary across (sub)regions and sectors;
- Any framework ought to be applied flexibly;
- There is a need for coordinated management across sectors;
- A good way of generating awareness and action on climate change is through reducing vulnerability to existing climate hazards. Consultation with stakeholders through all stages of the framework is critical for identifying appropriate adaptation measures.

Please see *Part 3: An Adaptation Strategy for Agriculture in Ningxia, Northwest China* for details of the adaptation strategy designed for Ningxia through the application of ICCCA's adaptation framework.

Glossary

A2	An IPCC SRES emissions scenario (storyline) representing a very heterogeneous world with continuously increasing global population and regionally oriented economic growth that is more fragmented and slower than in other storylines.
Adaptation	Adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities, (IPCC AR4). Adaptation aims to ensure that people's livelihoods, public and private enterprises, assets, communities, infrastructure and the economy are resilient to the realities of a changing climate.
Adaptation Framework	A means of conceptualising and communicating the process of adaptation. Adaptation frameworks are a form of decision-support tool and are meant to make it easier for decision-makers to address impacts and adaptation within existing decision-making processes.
Adaptation Strategy	A policy tool outlining an integrated, internally consistent and comprehensive set of initiatives which seeks to adjust human and natural systems to a new or changing environment so as to minimise the harm from climate change, and capitalise on the opportunities it creates.
B2	An IPCC SRES emissions scenario (storyline) representing a heterogeneous world with local emphasis, which gives priority to the environment and implements clean and efficient technologies.
CDM	Clean Development Mechanism
Climate Models	A numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties (IPCC AR4).
CO_2	Carbon Dioxide
Consultation	A process whereby the public's and other stakeholders' input on matters affecting them is sought.
DECC	UK Government Department of Energy and Climate Change
DEFRA	UK Government Department for Environment, Food and Rural Affairs
DFID	UK Government Department for International Development
IPCC	Intergovernmental Panel on Climate Change
IPCC AR4	Intergovernmental Panel on Climate Change's Fourth Assessment Report (2007)
Low-regrets option	An option that has a low cost now but might provide considerable benefits in the future
MCA	Multi-Criteria Analysis
NDRC	National Development and Reform Commission
No-regrets option	An option whose benefits outweigh the costs irrespective of the magnitude of climate change
ORCHID	ORCHID: opportunities and Risks from Climate Change and Disasters. A climate risk screening methodology (Tanner et al 2007)
PRECIS	UK Meteorological Office Hadley Centre's high-resolution regional climate model
Risk-based approaches	An approach which takes into account possible outcomes of a situation giving each a weight determined by its probability of occurrence and the significance of its effects.

Stakeholder	Any person or entity with an interest that could be positively or negatively affected by a particular action or policy.
Scenarios	A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces (e.g. rate of technology, change, prices) and relationships (IPCC AR4).
Vulnerability	Mainly a function of the physical characteristics of a locality, local weather and climate (averages and extremes), the local socio-economic characteristics and the preparedness of the local community to respond both in the short and long-term. This preparedness is often termed 'adaptive capacity' which could be seen as the formal and informal factors that enable or hinder a community's response.
Win-Win option	An option that has multiple benefits, not just in terms of adaptation

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1 Introduction

ICCCA's research on adaptation aims to contribute to China's rapidly emerging engagement with adaptation. This report presents the methods and lessons learnt from applying an adaptation framework to develop an adaptation strategy for the agricultural sector in Ningxia. The assessment concentrates on short (5 to 10 years) and medium term (out to 2050) timescales, identified by stakeholders as critical for planning and decision-making.

This report is Part 2 of ICCCA's work on adaptation and illustrates how ICCCA's adaptation framework was applied to the agricultural sector in Ningxia province in Northwest China to generate prioritised adaptation options. Whilst this report can be read as a stand-alone document, it is supported by two other ICCCA Phase II reports on adaptation, namely:

- ***Part 1: A Framework for Adaptation***. This part outlines the generic, transferable tool developed by ICCCA to help decision-makers to structure their thinking about adaptation and to start develop their own adaptation strategy;

- ***Part 3: An Adaptation Strategy for Agriculture in Ningxia, Northwest China***. This part concentrates on the outcomes of applying the adaptation framework to the agricultural sector in Ningxia by presenting the adaptation strategy arrived at through application of the framework.

A further ICCCA Phase II report entitled *Climate Change in Ningxia: Scenarios and Impacts. Technical Report* (Lin Erda et al., 2008f) contains a detailed description of recent climate trends, future climate scenarios and impacts on crop yields for the region.

Part 2 is structured around the six main steps of the adaptation framework as it was applied in Ningxia. The report ends with a discussion of the main experiences and lessons learned from the process with a view to transferring experiences to other regions of China and elsewhere in the world.

1.1 What is adaptation?

Climate change will alter local weather conditions, including rainfall and temperature, and lead to changes in the frequency and severity of climate hazards, such as droughts. Some level of climate change is now inevitable and society and individuals will need to adapt to the changes which will occur, either to avoid negative impacts or to take advantage of new opportunities. *Adaptation aims to ensure that people's livelihoods, public and private enterprises, assets, communities, infrastructure and the economy are resilient to the realities of a changing climate.*

Adaptation should be seen as a process, not a one-off activity: a changing climate will require ongoing activities by institutions and individuals to adjust their behaviour either in anticipation of projected impacts or in response to events.

China recognises climate change as a major issue of international concern. Both the *17th National Congress of the Communist Party* and the *National Government Report* declared that adaptative capacity within China needs to be improved. China's *National Climate Change Programme*[3] recognises mitigation and adaptation as integral components of the strategy to cope with climate change: '*China will take practical measures to enhance its capacity to adapt to climate change via key projects for ecosystem protection, disaster prevention and reduction and other key infrastructure construction*'.

1.2 Background: Ningxia Hui Autonomous Region

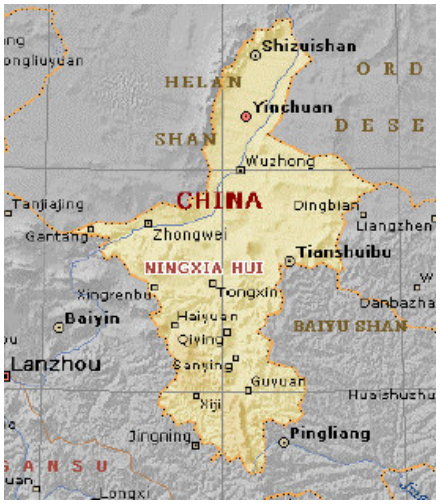
Ningxia is located in northwest China and is one of its five autonomous regions (Figure 1.1a, b, c). Ningxia is one of the poorest regions in China and is particularly exposed to extreme climatic events such as drought. The region's climate is dry and highly seasonal; annual mean temperature ranges from 5-9℃. Precipitation decreases from south to north: the mountainous area in the south receives annual precipitation totalling around 600mm; this decreases to only 100mm in the north, with an overall average of 262mm across the region. Winters are dry and very cold, summers are hot and receive most

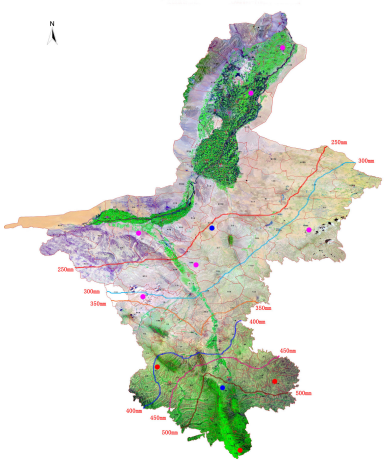
[3] China's *National Climate Change Programme*, prepared under the Auspices of the National Development and Reform Commission People's Republic of China. June 2007

of the precipitation (Figure 1.1c). Per capita water resources are only one tenth of the national average. The Yellow River is the main surface water source in the region.

The population is close to six million, with 65% in rural areas and 35% in urban. In 2004 the regional GDP was 46.0 billion RMB (1US$ = 7RMB) and GDP growth was around 11% per year. Primary industry accounts for 14% of GDP; secondary industry 52%; and tertiary industry 4%. Per capita GDP was 7,900 RMB (only 75% of the national average) and per capita annual income in rural areas only 79% of the national average. The population below the current national poverty levels in the mountainous areas of Ningxia decreased from 1.1 million in 1995 to 0.15 million in 2004.

Figure 1.1 Ningxia: location in China (a), main urban areas (b), and land cover (c): green is cultivated, red lines show annual precipitation).





Ningxia has three main types of agricultural production systems determined by factors such as topography, climate, traditional customs, and availability of water from the Yellow River:

- Southern mountainous area: rainfed cultivation in the more humid climate, but still fairly dry, with an average annual rainfall above 400mm. Potato is the major crop grown over a large area; cattle, sheep, pig and chicken are the major livestock;
- Central arid area: a mix of irrigation with some rainfed and extensive grazing. Average annual rainfall between 250-400mm. The dry conditions only allow corn, spring wheat, potato, and some cattle and sheep husbandry;
- Northern irrigation area: primarily irrigation with water diverted from the Yellow River. Averaged annual rainfall is less than 250mm. Intercropping is the major planting system. The main crops in this area are corn, spring wheat, paddy rice, and potato. Cattle, sheep, pig, and chicken are the major livestock.

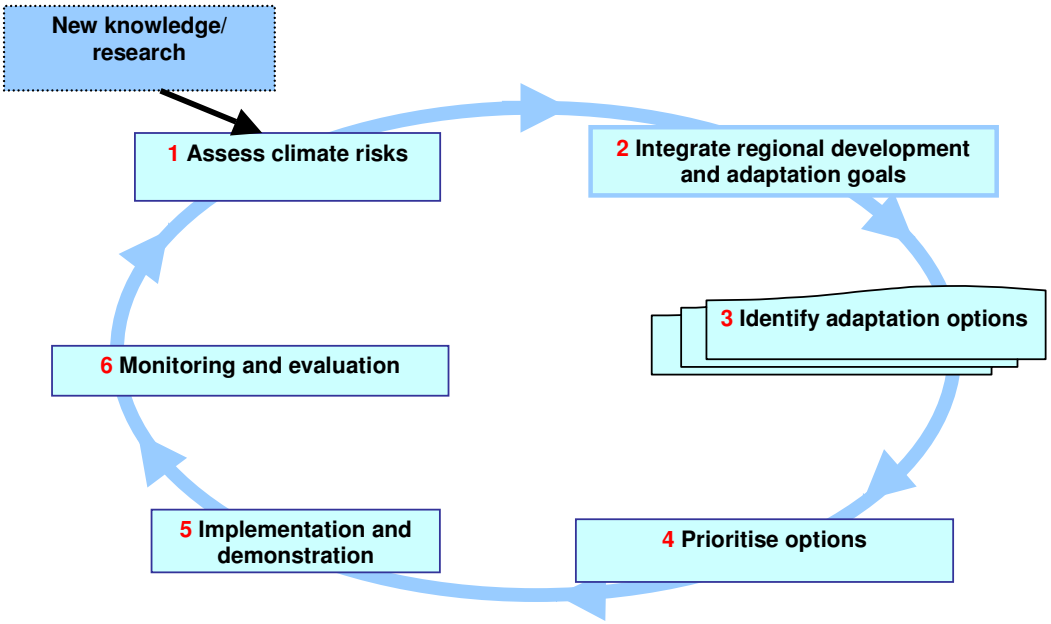
Ningxia was chosen as the focus of the project because it possesses three of the main agricultural production systems in China and because poverty levels (and possibly vulnerability) are high. Ningxia also experiences a range of extreme weather events and is the focus of significant development and investment. Each sub-region has specific vulnerabilities and risks related to climate change.

1.3 The adaptation framework

Part 1: A Framework for Adaptation explains the structure of ICCCA's proposed framework to tackle adaptation policy. This tool is intended as a useful way for decision-makers to structure their thinking about adaptation and to start to develop their own adaptation strategies..There are a number of similar frameworks available in both the public and academic spheres that attempt to provide guidance for decision-makers on how to adapt. The ICCCA framework has drawn from some of these, e.g. UKCIP's

Adaptation Wizard[4] and the OECD's report *Stocktaking of progress on integrating adaptation to climate change into development co-operation activities* (Gigli and Agrawala, 2007).[5] The ICCCA framework was developed with considerable input from stakeholder organisations, and has been further refined for use in Ningxia.

Figure 1.2 ICCCA's adaptation framework.



The process identifies a number of key stages and the associated resources necessary for the development of an adaptation strategy. Chapter 2 describes in detail each of the six stages in Figure 1.2 above:

Stage 1: Assessing the climate risk:
- a) Identifying current vulnerability
- b) Estimating future vulnerability
- c) Prioritising risks

Stage 2: Integrating regional development goals and adaptation goals

Stage 3: Identifying adaptation options

Stage 4: Prioritising options

Stage 5: Implementing and demonstrating

Stage 6: Monitoring and evaluation

The application of the framework should be viewed as an ongoing process in which individuals and institutions engage continuously with changing climate risks. For instance, new research or knowledge may require the adaptation strategy to be refined or developed. Different stages of the process may also require different skills and capabilities, and different types of stakeholders may also need to be involved. Box 1.1 highlights some key features of the methods relevant to developing an adaptation strategy.

[4] http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=147&Itemid=297 [last accessed on 20 October 2008]
[5] See also "Climate adaptation: Risk, uncertainty and decision-making" (Willows &. Connell, 2003); "Objective setting for climate change adaptation policy" (various, 2005; available from http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=482&Itemid=480).

A fundamental component of the work involves consultation with different stakeholders to synthesise their experiences (across scientists, decision-makers, local communities) and the outcome should enhance linkages between science and policy, and policy and practice. **Adaptation requires a careful process of consultation**. This is necessary both to understand existing vulnerability (and significance of climate risks) and to ensure that potential responses fit with ongoing activities, are practical and realistic and economically sensible.

For this study we have used a combination of interviews with experts and organisations, surveys with rural communities. We also held several large workshops to collect information, present results and seek feedback from a range of stakeholders. Reports on this work include the following:

- *Scoping Study Report* May 2006
- *Application of a tailored ORCHID methodology in Ningxia* May 2007
- *Ningxia Workshop Report* December 2007
- *Climate and Livelihoods in Rural Ningxia: Final Report* March 2008

Note that the exact form and details of the consultation need to be designed to fit each region or sector according to the overall objectives of the exercise, budget, time constraints and other relevant considerations.

Box 1.1 Overview of methods used for developing an adaptation strategy

Describing and assessing future climate risks

- Results from climate models (projections or scenarios);
- Impacts assessments, using models (e.g. crop simulation models) and expert judgement;
- Understanding of current vulnerability or exposure to climate variability and extremes, using mainly interviews and surveys
- Risk assessments, using a combination of model results and expert judgement to assess the **likelihood of a particular event/outcome occurring** together with the **potential significance in terms of physical or socio-economic impact**.

Identifying responses

- Discussion with stakeholders to highlight potential options
- Multi-criteria assessment to rank different options (important to consider non-climate considerations and the current decision-making processes)
- Presentation and discussion of results with stakeholders

2 Case Study: Applying ICCCA's adaptation framework to Ningxia's agricultural sector

2.1 Stage 1: assessing climate risks

The first stage of the framework assessed the main climate-related risks to rural communities and key stakeholder institutions in Ningxia. The methods used in this stage of the process included documenting the characteristics and impacts of current climate variability and extreme events and defining the range of future climate change in the region based on the use of computer climate models. This stage comprised a number of activities outlined in Sections 2.1.1- 2.1.3, as follows.

2.1.1 Characterising recent climate variability and trends and their impacts

This activity entailed reviewing recent climate variability and trends within the region. The main source of information on recent climate variability was meteorological observations for Ningxia; data from roughly 23 stations distributed throughout the region, with records dating back to the early 1950s, were analysed. These provided an overview of the presence and magnitude of trends or changes in temperature, precipitation and other climatic elements. The detailed results are presented in the ICCCA technical report entitled *Climate Change in Ningxia: Scenarios and Impacts*.

Figure 2.1 Seasonal and annual temperature series for the whole of Ningxia, 1961-2007.

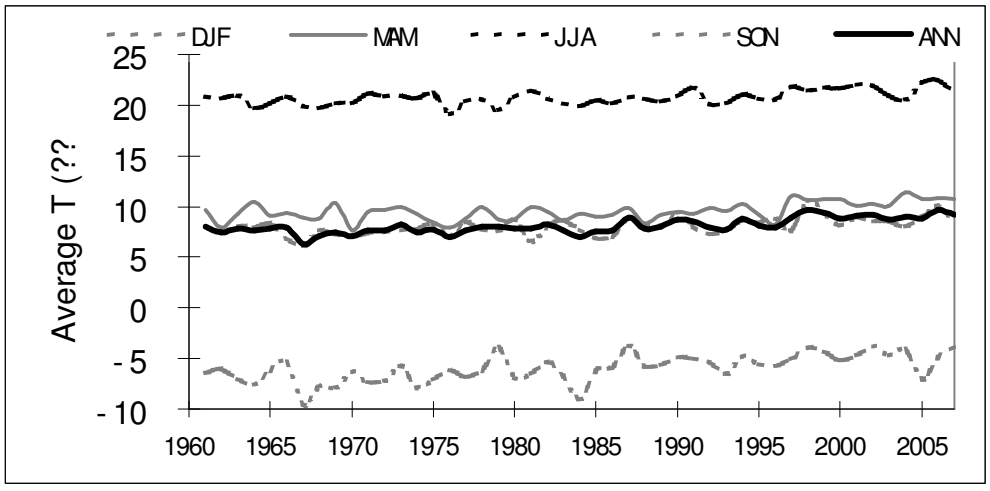


Figure 2.1 and Figure 2.2 respectively chart long term annual values for temperature and precipitation in Ningxia. The mean annual temperature of Ningxia was fairly stable from the early 1950s to the 1980s. It then developed a modest positive trend. Temperatures in winter months show an increasing trend (roughly 0.5℃/decade) which is more pronounced in the most recent decades, with a range of 0.6-1.2℃/decade during 1991 to 2007. Precipitation records since 1961show little evidence of a trend either annually or seasonally. However this hides the fact that a marked feature of recent climate in Ningxia has been a major drought, with three very dry years from 2004-2006.

Figure 2.2 Seasonal and annual precipitation series for the whole of Ningxia, 1961-2007 (DJF not shown as precipitation was below 10 mm).

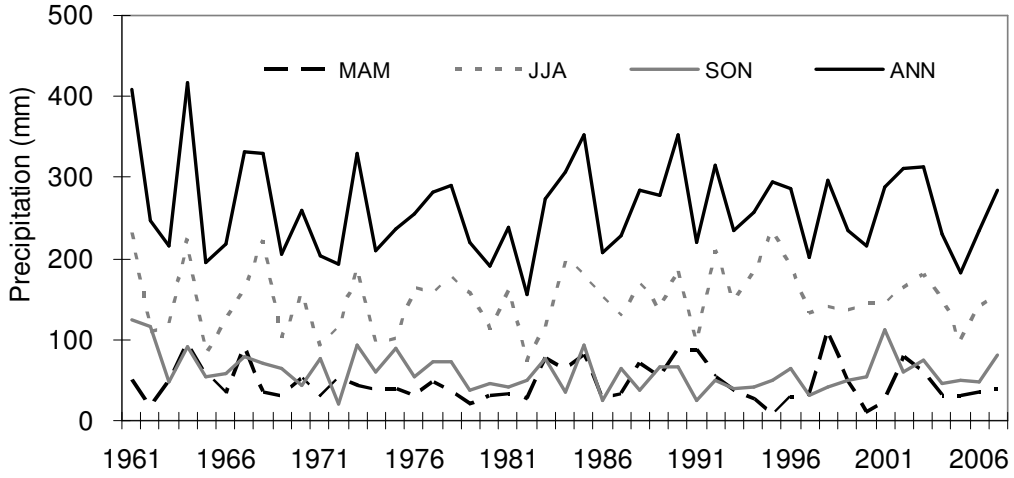


Table 2.1 summarises the key aspects of recent climate variability for a range of climatic elements based on observations and their local impacts based on consultation with regional experts and local communities.

Table 2.1 Recent climate variability and extremes, and their impacts in Ningxia.

Climate factor/event	Evidence of local impacts[6]
Recent warming: Minimum and maximum temperatures have warmed, particularly since the 1980s	• Positive impacts include northward migration of winter wheat, increased harvest time, an increase in frost-free days, and a decrease in cold and frost disasters. • Negative impacts involve more plant disease and insects; conventional field technology lost positive effects; more fertilizer and more irrigation needed; field material investment increase.
Rainfall: long-term variability has been fairly modest and is similar across the whole region. [Some larger monthly and sub-regional trends]	• In all three agro-ecosystems surveyed drought is the most recognised meteorological disaster, especially in the middle arid area and southern rainfed mountainous area. • Most respondents in the middle arid area believe that it has become increasingly difficult to acquire drinking water. • Decline in ground water levels and greater difficulty in pumping water.
Major drought 2004 to 2006: Rainfall lowest on record in some areas	• Local experiences suggest an increase in frequency and intensity of droughts with negative impacts on livelihoods[7] in some parts of Ningxia. • Some areas have experienced crop failures, resulting in significant economic impacts, especially in the central and southern areas. • Some farmers, who depend on rainwater collection cellars, had to buy water at great expense during the drought period.
Extreme weather hazards such as hail, frost, sandstorm and hot dry winds: show no clear recent trends	• During 1994 to 2006 meteorological hazards caused economic losses of RMB 940 million. Since 2000, such losses have gone up to RMB 1.27 billion. • Community surveys highlight significant negative effects of these events on livelihoods.
Recent decline in Yellow River flows	• Annual Yellow River flow was 30.5×10^9 m^3 from 1956 to 1980; 29.6×10^9 m^3 (1956 to 2000) and 24×10^9 m^3 (1995 to 2005)

[6] Gathered through survey, dialogue and workshops with local stakeholders.
[7] Observations do not show this clearly. Differences may be due to how people perceive and experience drought and changing vulnerability.

2.1.2 Characterising vulnerability and adaptive capacity in Ningxia

This activity comprised several tasks:

- collecting background socio-economic data for Ningxia;
- surveying rural communities across Ningxia to identify the main climate hazards, how people were affected by them, how they responded, and how institutions can and could support this process;
- identifying the main institutional stakeholders, namely those institutions with responsibilities that may be affected by climate change or those which may have a role in responding to climate change;
- gathering information on economic impacts of extreme weather events and discussions with a range of institutional stakeholders to identify how they were affected by climate variability and how they responded.

To get a better understanding of the risks from climate change that Ningxia might face in the future and the region's capacity to respond appropriately, the project first undertook a scoping study to determine the degree to which the region is currently affected by climate. This covered climatic observations, background socio-economic conditions and some preliminary consultation with rural communities and government officials. This information is available in two ICCCA reports: *Scoping Study Report* (available upon request) (see Section 2 therein) and *Climate and rural livelihoods in rural Ningxia* (Yue et al., 2008g).

To characterise socio-economic impacts, the project relied on information from Ningxia's Meteorological Bureau on the economic effects of extreme weather events and on discussions with experts and officials. Surveys with local communities showed that recent climate variability has affected many aspects of farmers' livelihoods. Further, analysis of the key factors affecting farmers' income revealed that hazards (mainly meteorological ones) and diseases were important factors affecting incomes. Box 2.1 highlights some of the main results from the survey of rural communities in Ningxia.

Ningxia Hui Autonomous Regional Government has responsibility for the regional political, economic and cultural development plan, for management and implementation activities. It comprises more than 30 separate institutions, including the Ningxia Development and Reform Commission, Ningxia Financial Department, Ningxia Agricultural and Livestock Department, Water Resource Department and Meteorological Bureau. Many of these organisations' responsibilities or activities may be impacted by climate change. ICCCA's analysis was based on:

a) interviews with members of the main stakeholder organisations in Ningxia; and

b) secondary material such as national level reports and websites.

Table 2.2 lists the organisations and their level of exposure to climate change. Levels of exposure have been categorised into macro-management (organisations with responsibility for cross-sectoral and long-term planning), direct and indirect exposure.

Table 2.2 Key stakeholder institutions in relation to adaptation in Ningxia

Macro-management	Direct exposure to Climate Change	Indirect exposure to Climate Change
Development and Reform Commission	Agriculture and Livestock Department	Office of Poverty Alleviation and Development
Financial Department	Water Resource Department	Environmental Protection Administration
Science and Technology Department	Meteorology Administration and Resources Department	Construction Department
		Health Department
		Transportation Department

Box 2.1: Rural livelihoods and vulnerability to climate hazards in Ningxia (Li Yue et al., 2008g)

ICCCA carried out a survey of households at nine selected sites in three different agro-ecosystems in Ningxia –the northern irrigation area, middle arid area, and southern rainfed mountainous area. The analysis included the effects of climate on accessibility to drinking and irrigation water, grain production, crop composition and sowing areas, and income. Opportunities for and barriers to farmers' adaptation and the role of local government in facilitating this process was also considered.

Key findings from the survey are as follows:

Adaptation is an ongoing and dynamic process: the perennially dry climate and limited availability of soil moisture undermines agricultural production in the region. This is greatly exacerbated by periodic reductions in moisture, related to the occurrence of droughts. Farmers use a wide range of measures to retain and enhance soil moisture and to maintain agricultural production in this harsh environment.

Drought is the most important climate hazard: drought was the most recognised meteorological disaster in all three areas, but especially in the middle arid area and southern rainfed mountainous area.

Vulnerability was differentiated across Ningxia: farmers in the three different agro-ecosystems showed differing levels of vulnerability to climate variability. This was higher in the middle arid and southern rainfed mountainous areas, because of farmers' greater exposure to climatic hazards and their higher reliance on farming activities for their income.

Adaptation needs to align closely with rural development initiatives: farmers and institutions in Ningxia have adopted a range of adaptation measures to cope with the region's dry climate and its variability. However, these may not be sufficient to deal with future climate change.

Because of the close alignment at the community and household level between adaptation (reducing vulnerability to climate change) and more generic individual and institutional aims for development, there exists good potential to mainstream adaptation into development plans and poverty alleviation processes, and local and regional expertise is essential to inform good decision-making.

Selection was made on the basis of discussion with regional experts, Ningxia Clean Development Mechanism (CDM), the Environmental Protection Service Centre and the Ningxia Bureau of Meteorology. The results of these discussions are presented in full in the ICCCA report *Scoping Study Report* and the *Ningxia Workshop Report*.

Some of the key findings are as follows:

- The effects of climate variability are not only related to the agriculture and water resource sectors, but also to a broader range of institutions responsible for strategic regional development including poverty reduction and resettlement programmes;
- Institutions have implemented a range of actions and policies to respond to climate variability. Some of these policies and activities have been implemented by more than one institution – there may be opportunities for greater coordination between organisations and programmes;
- Many current activities are likely to be appropriate adaptations. However, this issue requires further analysis and more detailed consideration of the range of future climate and socio-economic scenarios for Ningxia.

2.1.3 Assessing the significance of future climate change impacts on crop yields in Ningxia using a risk-based approach

This activity used a modified ORCHID methodology, and comprised the following tasks:
- preparation of high-resolution climate change scenarios for Ningxia using the PRECIS regional climate model;
- modelling of the impacts of climate change on crop yields.

High-resolution future climate scenarios

In order to inform stakeholders about the potential risks that climate change represents to their assets and activities, ICCCA provided estimates about the projected rate and magnitude of future climate change over the short and medium term. ICCCA also provided an indication of confidence levels associated with projections of future change.

The future climate was described using computer generated 'scenarios'. Scenarios are projections of future climate. As such, they entail large uncertainties. For Ningxia, most climate models show

increases in precipitation although the magnitude of change varies from one model to another. This suggests reasonably high confidence in the direction of change even if there can be less confidence for individual scenarios.

Table 2.3 shows the overall changes in major climatic elements and levels of confidence in the projections for China based on recent results from the IPCC AR4 (IPCC, 2007).

ICCCA used the PRECIS regional climate model to provide high-resolution climate change scenarios for Ningxia. Changes in Ningxia include shifts in the average conditions (such as warmer average temperatures) as well as changes in the frequency and severity of more extreme weather events (e.g. heatwaves, rainstorms). The latter are likely to cause greater socio-economic impacts.

Table 2.3 Climate variables and associated confidence levels, ranked in decreasing order of confidence (adapted and updated from IPCC, 2001 with new results and IPCC 2007).

Climate variable	Confidence	Changes in China
Atmospheric CO_2 concentration	High	As IPCC SRES A2 and B2 emissions[8]
Global-mean sea-level		See IPCC AR4
Global-mean temperature		See IPCC AR4
Regional seasonal temperature		China warms by: 2020s A2 1.3°C, B1 1.2°C 2050s A2 2.4°C, B1 1.9°C (Average of 17 climate models) Warming is most rapid in the north and west and slowest in the south
Regional temperature extremes		Higher maximum temperatures, longer growing season (based on temperature)
Regional precipitation	Medium-high confidence	Across China precipitation generally shows increases of up to 10% by the 2080s
Regional seasonal precipitation		Precipitation tends to increase in the west, north and north-east, slight decreases in the south and east
Precipitation extremes	Medium confidence	Daily extreme precipitation amounts likely to increase
Regional potential evapotranspiration		Higher temperatures are likely to lead to higher rates of evaporation and, assuming other influences remain unchanged, higher rates of surface water evaporation and higher soil moisture deficits.
Changes in climatic variability (e.g. cyclones and storm surges)	Low confidence	See IPCC AR4
Climate surprises (e.g. disintegration of the West Antarctic Ice Sheet)	Very low or Unknown	See IPCC AR4 (examples for China include rapid glacial melt in the west, rapid changes to permafrost)

Table 2.4 shows the changes in temperature and precipitation for three periods in the future, based on the regional climate model PRECIS.

[8] See Glossary for further details of A2 and B2 emissions scenarios.

Table 2.4 Changes in future annual maximum and minimum temperature and precipitation projected by PRECIS, averaged across Ningxia (changes are relative to the average values during the baseline period 1961-1990).

	T_{max} (℃)		T_{min} (℃)		Precipitation (%)	
	B2	A2	B2	A2	B2	A2
2011-2040	1.6	1.8	1.6	1.8	+3	+5
2041-2070	2.6	3.6	2.7	3.7	+4	+8
2071-2100	3.5	6.0	3.7	6.4	+6	+12

Table 2.5 lists the main changes in climate and their potential impacts across Ningxia in summary form, highlighting the key socio-economic effects and an assessment of the level of confidence in the potential impacts based on expert judgement. Further details can be found in the ICCCA report *Climate Change in Ningxia: Scenarios and Impacts* (Lin Erda et al., 2008f).

Table 2.5 Future key risks in Ningxia and associated confidence levels

Main climate risks	Details of the risks	Main effects, short and long term	Confidence level
Drought	**Drought frequency and intensity**	Drought already ranked as most significant hazard by farmers, and is associated with very high economic losses.	Low confidence: the balance between evaporation and increases in rainfall will be critical (more climate research needed).
	Rainfall trends: moderate increase overall (drier in summer, wetter in spring); 2020s B2: +3% 2020s A2: +5% 2050s B2: +4% 2050s A2: +8%	Moderate impacts on water availability and soil moisture. Impacts will depend on seasonal timing of changes.	Medium-high confidence. All models show increase in rainfall but seasonal changes less clear.
Surprises and extreme events	**Extreme events**: frost, hail, sand and windstorms, extreme rainfall	Higher rainfall intensities could lead to increase in mountain floods. Warmer temperatures reduce impacts of hail and frost.	Medium confidence for increase in variability and extremes, detail unclear.
Drying/high temperatures	**Max temperatures increase by**: 2020s B2: 1.6℃ 2020s A2: 1.8℃ 2050s B2: 2.6℃ 2050s A2: 3.6℃	Mixed effects: benefits from longer growing season; negative impacts resulting from faster crop maturation. Extreme temperatures may have negative impacts on yield. Change in frequency and distribution of pests and disease.	High confidence in warming: all models show fairly similar rates of warming. Medium confidence in secondary impacts (CO_2 fertilisation critical).
Changes in Yellow River flows	2020: modest increase 2050: modest increase	The balance between upstream higher evaporation and increases in rainfall will be critical. Will be affected by other non-climate factors.	Flow regime highly likely to change, low confidence in the detail of the changes.

Expert assessment of future climate projections was combined with detailed local knowledge of Ningxia's sub-regions to identify four main areas of climate risks important to Ningxia according to

likelihood, confidence in projection and significance of impact (based on stakeholder views and expert judgement[9]). These were:

- **Drought:** Drought was widely identified as a key concern by individual and institutional stakeholders in Ningxia due to the significance of its current impacts and threat of greater impacts in the future;
- **Surprises/Extremes:** These include weather extremes such as windstorms and heatwaves as well as agricultural pests and disease. Although very hard to predict, these were identified by stakeholders as being of high importance due to the significance of their current and potential impacts;
- **Drying/high temperatures:** this refers to a regional scale gradual drying of the landscape related to increases in soil moisture evaporation (due to higher temperatures) leading to stress on natural and farmed vegetation leading to enhanced desertification. The latter is already a major problem in Ningxia. Drying and higher temperatures was deemed a key climate risk given the high confidence that warming will continue in the future;
- **Shifts in the river flow regime of the Yellow River:** Upstream changes in precipitation and evaporation are likely to lead to changes in downstream flows available to Ningxia given Ningxia's dependence on Yellow River water for irrigation, domestic and industrial use.

Modelling the impacts of future climate change

The amount of modelling that goes into producing estimates of future climate change and impacts is determined by:

- *Time and resource availability* – modelling can be data, time and resource intensive;
- *Purpose of the assessment* – there needs to be a balance between detail and the need for pragmatic decision-making. Some situations may require detailed estimates of climate change and impacts (e.g. siting of a reservoir) but in many cases a broad-level assessment of potential risks may be sufficient to guide decision-making.

Consultation with stakeholders is a useful way of eliciting and making judgments on what is an appropriate balance between detail and practical needs of institutions and individuals.

For this study, the Ningxia Meteorological Bureau undertook preliminary modelling of climate impacts on four of the main crops grown in Ningxia using crop models. The methods and results are presented in the ICCCA report entitled *Climate Change in Ningxia: Scenarios and Impacts* (Lin Erda et al., 2008f). A summary of impacts on crop yield for different periods in the future is given in Table 2.6. These changes include the combined effects of warmer temperatures and increased concentrations of atmospheric CO_2. Crop yields show mixed responses: modest increases in rice yield, large increases in maize yield in the short-term changing to modest decreases beyond the 2050s, and modest to large decreases in spring wheat yields.

Table 2.6 Future climate change and crop production in Ningxia

Crop type	2020s	2050s	2080s
Rice (irrigated)	A2: +7%; B2: +4%	A2: +10%; B2 +9%	A2: +9%; B2: +9%
Maize (irrigated)	A2: +18%;B2: +21%	A2: +1%; B2 +4%	A2: -7%; B2: -5%
Spring Wheat (irrigated)	A2: -3%; B2 -3%	A2: -9%; B2 -7%	A2: -18%; B2: -11%

Higher concentrations of CO_2 due to continued emissions of greenhouse gases at a local level also have a potentially significant affect on crop yields. Overall the effects are likely to be beneficial for crop yields but the precise detail of the effects remain highly uncertain because different crops show different responses, the positive effects may decrease over time and interactions with other confounding factors (e.g. surface ozone) make predictions very difficult.

In order to assess impacts, projections of socio-economic development in Ningxia are necessary. These are encapsulated in socio-economic scenarios (SES). SES are projections of potential futures based on

[9] See stakeholder workshop details: http://www.china-climate-adapt.org/en/chapter.php/action

a clear storyline that is often interpreted in a number of quantified terms or indicators. SES can provide a context for future climate change impacts and guide the development of plausible adaptation strategies. ICCCA developed SES for Ningxia for the period up to 2050 by downscaling regional projections of GDP and population from the IPCC storylines underpinning the A2 and B2 SRES emissions scenarios. By choosing these storylines, ICCCA ensured consistency with the emissions scenarios that were used to obtain climate change scenarios with PRECIS. Recent national and provincial level statistics on agricultural land use and water use were used to generate projections of agricultural land use change and future water demand by sector.

Assessing the risks of climate change for Ningxia's sub-regions

Risk-based approaches combine an assessment of the likelihood of a particular event or outcome occurring with the magnitude of the event in terms of physical or socio-economic impact. The aim is to generate information on climate change risks that can be readily be considered by decision-makers for planning and investment. The method involves some expert judgment because it is not known with certainty how the future frequency and intensity of extreme events will change and neither what their precise impacts will be. It also means that decision-makers need to explicitly acknowledge their appetite for risk as this will determine the range of potential actions. Climate models combined with expert judgement provide a reasonable basis to make preliminary risk assessments. Discussion with stakeholders during this stage helped to identify potential impacts and assess their significance, overall as well as for specific organisations.

The three sub-regions of Ningxia were analysed separately because they possess very different agricultural production systems. The approach combined a simple ranking from High to Medium to Low for three aspects of climate risk: L = likelihood of change occurring in the future; I = Potential significance of the impacts; and C = Confidence in the direction and detail of future change. By combining these indices, the overall level of risk priority was assessed. Table 2.7 and Table 2.8 presents the results of this analysis.

Table 2.7 Climate risk prioritisation by sub-region.[10]

	Drought			Surprises / Extremes			Drying / high temperatures			Changes in Yellow River flows		
	L	I	C	L	I	C	L	I	C	L	I	C
North	M	M	M	M	M	L	M	H	H	M	H	L
Central	M	H	M	M	H	L	M	H	H	M	M	L
South	M	H	M	M	H	L	M	M	H	M	L	L

Table 2.8 Summary of climate risk prioritisation by sub-region.

	Drought	Surprises / Extremes	Drying / high temperatures	Changes in Yellow River flows
North	M	M	H	H
Central	H	M	H	M
South	H	H	M	L
All Ningxia	H	M	M	H

For ICCCA's study in Ningxia, the first stage of this process involved a significant amount of work and resources. Developing a baseline assessment of climate, socio-economic conditions and a subsequent risk assessment may take a considerable amount of time and effort. There is a trade-off between the level of detail required by decision-makers and the time and funding available to develop climate risk assessments. A minimum amount of information about the detail of future climate risks is necessary to enable decision-makers to start thinking about adaptation and situate impacts within their own particular context. In some cases a tiered approach may be appropriate such that a broad-level initial screening of risks across management or programme responsibilities and objectives is enough for most situations.

[10] L=Likelihood; I= Impact; C=Confidence. Colour coding is as follows: Red – High risk, Brown – Medium risk, and Green – Low risk.

This raises the prospect for nationally produced information on climate risks which could be made available to different stakeholders, possibly based on information available through the IPCC AR4 (2007). Where management or programme responsibilities and objectives are found to have significant levels of risks associated with climate change then a follow-up, more detailed assessment of risks and opportunities could be performed.

2.2 Stage 2: integrating regional development and adaptation goals

Each sector or region has its own mid-to-long term development plans, many aspects of which may be affected by climate change. By cross-referencing development goals with assessments of climate risks, the threat of climate change affecting the delivery of development targets can be identified and integrated within regional development priorities. Such analysis is critical for developing core adaptation targets, i.e. **adaptation ought to be firmly rooted in current institutional management objectives and processes.**

In Ningxia the process was to identify key development objectives, consider how these might be affected by the climate risks identified in Stage 1 and then identify the objectives for adaptation.

2.2.1 Ningxia's five-year agricultural development plan (2006 to 2010)[11]

Ningxia set up a regional five-year plan to promote economic and social development. The plan comprises the following goals in agricultural development:

- **Ensuring grain production levels**:
  - Stabilise grain sowing area and adjust planting system;
  - Develop grain production system with high quality yield and effectiveness;
  - Use technology improvements to increase average yield by 275 kg (a 15.5% increase as compared with the last five year period);
  - Aim to maintain the wheat, rice and maize sowing areas in the northern irrigated area;
  - Move and concentrate rice area in most suitable irrigation areas;
  - In southern and central Ningxia, ensure stable grain production by expanding maize and potato planting.

- **Developing specialised agricultural industries**:
  Ningxia intends to gradually develop regional specialised agricultural industry and greenhouse agriculture. Specific targets have been defined (e.g. for vegetables, greenhouse agriculture and gravel covered watermelon).

- **Strengthening water conservation and developing water infrastructure**:
  Water use efficiency in the irrigated area is to be increased, and further water infrastructure developed. Accessibility to drinking water in central Ningxia is to be guaranteed, especially during droughts. Water harvest facilities to meet agricultural water demand are to be built in the southern mountainous area.

- **Restoring ecosystems**:
  Water and soil erosion control programmes will be put in place to restore forests previously converted into farmland in the southern mountainous areas. Biological measures will be used to enhance water use efficiency and increase crops' resistance to natural disaster. Infrastructure will be built. Population pressure on the environment will be reduced through the implementation of relocation programmes. In the middle arid sandstorm-stricken area, ecological protection will be enhanced and grass breeding increased. A programme to prevent land salinization in the irrigated area will be implemented.

[11] Agriculture and Rural Economic Eleventh–Five Year Development Plan in Ningxia Hui Autonomous Region (2006-2010), Ningxia Administration Council, 2006

- **Enhancing public welfare and social services in rural areas**:
  Efforts will be made to guarantee drinking water safety, ensure energy supply, and strengthen education investment in rural areas. Capacity development will be put in place for farmers to retrain and find employment in other sectors. Road and communications links to remote areas will be improved.

2.2.2 Sub-regional development priorities

Ningxia has three kinds of agricultural systems, each with specific physical and economic features. Based on Ningxia's agricultural development goals, ICCCA identified the development priorities for each area taking into consideration production patterns and farmers sources of income.

Northern irrigated area: this area is mostly irrigated by water from the Yellow River, and produces more than half of Ningxia's commercial grain. Major crops are maize, spring wheat, rice and vegetables. The following development objectives were identified based on regional development plans:

- Improve water use efficiency by promoting water conservation, infrastructure construction and developing water saving agriculture;
- Capitalise on natural resources and promote commodity products such as high quality grain, wolfberry, mutton and beef products, vegetables and grapes;
- Promote agricultural industry development, improve agricultural product processing, and establish modern agriculture zone.

The central arid zone: This is an arid belt experiencing almost constant drought/dry conditions. In parts it features irrigation sustained with water from the Yellow River, and husbandry. The development for this area include:

- Ecological environmental management: Continued implementation of the national *Grain for Green* policy to replace farmland with forest and grass. Restore degraded land. Protect natural pasture vegetation and restrict livestock grazing. Develop eco-buildings and protection to ensure healthy environment development;
- Livestock development: Improve water use efficiency and resolve human and animal drinking water accessibility. Guarantee drinking water safety. Vigorously develop sheep raising, promote livestock industry with high quality forage grass and higher levels of local processing of agricultural products. Expand specialised agriculture by increasing potato and watermelon planting. Develop ecological agriculture system with e.g. liquorice, lemon strip, red date.

Southern rainfed agriculture area: the southern part consists of ravines of the Loess Plateau and hills. This part is dominated by rainfed agriculture. It is the poorest area in Ningxia. Major crops are spring wheat, winter wheat, potato, maize and minor grain crops. Farmers rely on agriculture for most of their income. In light of the area's physical and economic features, its development objectives are:

- Ecological environmental management: Take full advantage of the higher precipitation in Liupan Mountain to restore the ecological environment and improve ecological production. Measures involve water conservation forests, reforestation, afforestation of barren hills, protection of natural forests and watershed management;
- Develop specialised agriculture: Improve well irrigation facilities and sustainable use of water resources to ensure water supply for agriculture. Promote husbandry and fodder development. Plant more potatoes, fruit, corn and Chinese medicinal herbs;
- Strengthen skills training for farmers: enlarge the service market, speed up rural labour diversification and promote eco-tourism.

2.2.3 Sub-regional adaptation objectives

Using the sub-regional development strategies and consultation with local experts and policy-makers, sub-regional adaptive objectives were identified[12] and are listed in Figure 2.1. The northern irrigated area places more emphasis on high quality agricultural products. It is the major agricultural production

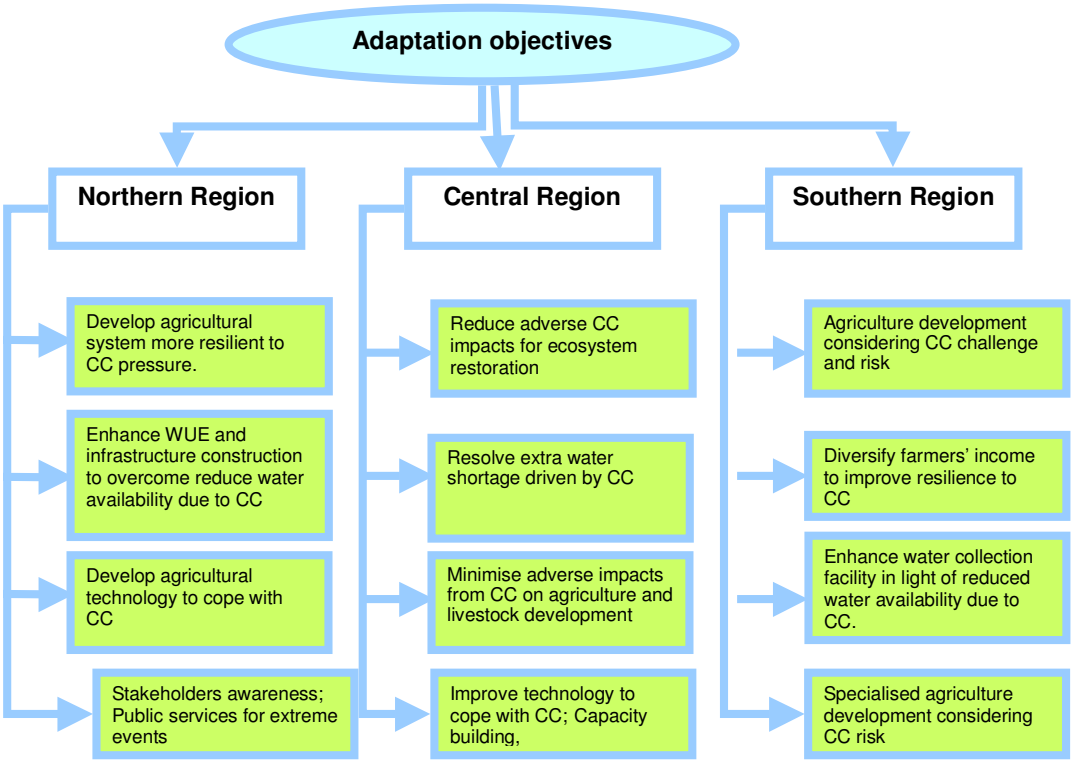
[12] Agriculture and Rural Economic Eleventh–Five Year Development Plan in Ningxia Hui Autonomous Region (2006-2010), Ningxia Administration Council, 2006.

area in the region. In light of the negative impacts from climate change on agriculture, major adaptation goals here are to improve the production of crops, ensure a stable and sustainable development of agricultural produce and enhance the income of farmers.

In the central region, which is dominated by hybrid belts of agriculture and animal husbandry, adaptation objectives seek to develop a more rationalised production mode for animal husbandry and to enhance farmers' ability to cope with climatic hazards by preserving their incomes.

In the southern part, where agricultural production is mainly rainfed, the major adaptation objectives aim at poverty alleviation, ecological restoration, and enhanced capacity to handle climatic risks.

Figure 2.1 Adaptation objectives for the three main sub-regions of Ningxia. [CC = climate change].



2.3 Stage 3: identifying adaptation options

Different stakeholders have different perspectives and knowledge about adaptation options. For instance, while some are focused on policy, others are more concerned about technical responses. After consultation, possible adaptation options were divided into three types: a) strategic and planning (how does policy get made and implemented); b) structural and technical; and c) non-structural. For a full list of adaptation actions identified for agriculture by different stakeholders, including more detailed examples of each type of adaptation, see Table 2.9 below.

Table 2.9 A typology and full range of adaptation options in agriculture in Ningxia identified through stakeholder consultation.

Strategic and Planning
Regional development plans and strategies (i.e. the eleventh-five year plan)
Department plans and options for addressing disasters
Improving enforcement and regulation of existing guidelines (e.g. *Grain to Green* policy)

Structural
Investment in new agricultural technology and agricultural extension services:
Practical agriculture technique training
Technology dissemination for dry land farming system
Crop management practices:
Technologies to reduce climate risk for agricultural systems (e.g. new varieties)
Adjustment of agriculture planting structure
Reducing spring wheat areas
Increasing potato and mulching maize areas
Decrease rice area and instead with fruit and melon
Two harvests in one year
Vintage wine development
Shrink summer grain area but increase autumn's
Shifting spring sowing to summer
Slope field shift to terrace
Reduced tillage
Development of stock raising sector
Water saving techniques:
Promotion of water saving methods in agriculture
Drought resistant varieties
Deep ploughing
Soil moisture retention techniques (gravel mulching, film and straw)
More effective irrigation regime and water use efficiency for rice
Yellow River Extension Project: from north to the middle arid region of Ningxia. (Big willow Water Conservancy Project)
Drip and sprinkler irrigation
Water cellar and reservoir
Poverty alleviation programmes:
Subsidize farmers who return crop land to grass or forestry
Village resettlement
Export of labour
Help and support agricultural leading factory development
Capacity building in farming communities
One million farmers training: government invest 10 million Yuan to help farmers get qualified certification for off-farm job;
Countryside labour migration— government encourage and help 100 thousands farmer to look for temporal job in city (three month each year).
Other:
Technology or projects for agricultural development (e.g. ecological system protection)
Weather modification programmes: hail defence and artificial rainfall stimulation
Develop climate friendly techniques
Methane project in rural area: reduce fire-wood consumption and GHG emissions
Solar energy utilisation (for cooking or house warming)
Non-Structural
Raising awareness about climate change issues
Strengthening appropriate programmes for vulnerability reduction (e.g. livelihood diversification)
Research, monitoring and data collection (e.g. improve knowledge of existing risk and vulnerability, economic costs of climate hazards)
Education, training, and dissemination about climate change risks (experts and communities)
Introducing / strengthening early warning systems
Weather forecasting

Build capacity to respond to climate hazards at individual and institutional level

2.4 Stage 4: prioritising adaptation options

2.4.1 Three approaches to prioritising adaptation options

Due to the wide range of potential options available (many of which may already be in place for reasons other than climate change), various approaches may be used to help prioritise responses, depending, *inter alia*, upon the level of perceived risk, local/regional development and management priorities already in existence. ICCCA proposed three different tiered approaches to identifying and prioritising adaptation options:

1. An **approach for prioritising policy type options at regional government** level relying on insights and experience from local and regional experts and wider consultation;
2. A **risk-based approach** to identifying options at sector and sub-regional level;
3. **Multi-criteria analysis (MCA)** to prioritise particular activities at the level of organisations with a focus on implementation.

1. An approach for prioritising policy type options at regional government level

By using insights and experience from local/regional experts and processes of consultation, ICCCA identified a set of three high-level responses relevant to the whole of Ningxia and across different sectors. These measures were considered very much as the first steps towards building capacity for regional government level responses to climate risks. Such measures are likely to be relevant in other regions and sectors and could provide suitable entry-points for national level capacity building and support measures elsewhere in China. The measures were arrived at through expert judgement, cumulative experience and discussion with stakeholders, and emerged as a result of applying the adaptation framework in Ningxia.

The recommendations are for cross-sectoral activities that could form useful entry points for integrating adaptation in regional planning in Ningxia:

- Move towards the **establishment of a cross-departmental group on climate change adaptation within regional government**. Consultation with government agencies clearly highlighted the cross-sectoral nature of climate risks and adaptation responses, demonstrating a need for coordinated action on climate change. Adaptation to climate change is a cross-sectoral and inter-institutional issue. More efficient and cost-effective implementation of adaptation activities could be achieved through integrated planning and streamlining of adaptation activities through an integrated office for climate change. Such an office could align and coordinate with the National Leading Group for Climate Change to better execute and implement the national guidelines for climate change. In addition, the cross-departmental group will foster collaboration opportunities in the area of climate change and help to clarify different agencies' terms of reference in relation to adapting to climate change, improving coordination and management activities[13].

- **Raise awareness on climate change** trends, potential impacts and adaptation activities across the region. The consultation clearly demonstrated a lack of awareness of risks, levels of confidence in future impacts and in the identification and design of appropriate measures of response. Ningxia is the first region in China to integrate climate change in its Eleventh Five-year regional development plan. It has a track record as a pioneer in taking actions against climate change in China, and its achievements and practical experience may serve as valuable examples and references for other

[13] In 2008, recognising the cross-institutional nature of climate change, Ningxia established a steering committee *Climate Change Response Office* to promote both adaptation and mitigation programmes. The committee is to act as a counter-part to the National Leading Group for Climate Change of the National Development and Reform Commission (NDRC). The Ningxia steering committee's primary mission is to organise and implement programmes from the State Council to address climate change. Ningxia's governor is the leader of the committee and more than 20 department general directors and five mayors act as key members in the group.

provinces. The media in all its forms should be capitalised on to promote awareness on climate change, potential impacts and adaptation options on the understanding that better public awareness will lead to conscious adaptation and mitigation activities by the public and the sustainable development of the region;

- **Mainstream adaptation into development and poverty alleviation processes.** Because of the close alignment at community and household level between adaptation (reducing vulnerability to climate change) and more generic individual and institutional aims for development, there exists **good potential to mainstream adaptation into development plans and poverty alleviation processes**. Local and regional expertise is essential to inform good decision-making.

2. A risk-based approach to identifying options at sector and sub-regional level

For this approach the four main prioritised risks related to climate change across Ningxia were reviewed against the main agricultural activities and development goals in each of its three sub-regions. Using a combination of local expert knowledge and the team's judgement, various adaptation options were identified that could be used to address the risks. The organisations with responsibility for implanting the responses are highlighted in the final column of Table 2.10. This approach does not attempt to prioritise specific actions but more to provide local and provincial decision-makers with insights into which measures are appropriate to particular risks. This information can then be used in combination with other considerations important to the whole process of management and investment decisions, some of which are included in the Multi-Criteria Assessment in the next section.

Table 2.10 Examples of priority adaptations by sub-region.

Risk/ opportunity	Risk priority	Possible adaptations for supporting agricultural production	Responsible organisations
North			
Drought	M	Improvements in early warning (seasonal forecasting) Improvements in intra-regional (and sectoral) allocation of water (review irrigation policies) during drought – responsive mode for management Provide training and support for agricultural technology instruction to reduce economic losses	Yellow River Commission Ningxia Water Resource Dept. Dept Science and Technology Dept. Agriculture and Livestock
Surprises / Extreme events	M	Improvements in early warning (weather forecasting), skill and dissemination Improve weather modification technology	Ningxia Met. Bureau
Drying / desiccation of landscape	H	Periodic review of anti-desertification strategies in view of recent trends Monitoring of soil moisture conditions, revise policies as appropriate	Land and Resources Dept.
Change in Yellow River flows	H	Improvements in intra-regional (and sectoral) allocation of water (review irrigation policies) – respond to emerging trends (wetting/drying) Long-term promotion of water saving in agriculture (demand management)	Yellow River Commission Ningxia Water Resource Dept. Dept Science and Technology

Central			
Drought	H	Ensuring reliability of supply from Yellow River during drought Review emergency relief procedures (compensation, water supply) Improve early warning of drought/other extremes Strategic review of long-term feasibility for agricultural livelihoods in increasingly marginal areas	Ningxia Water Resource Dept. Department for Agriculture and Livestock Ningxia Development and Reform Commission
Surprises / Extreme events	M	As for Northern sub-region Establish public aid system both short term and long-term	Ningxia Met. Bureau
Drying / desiccation of landscape	H	Monitoring and review of grazing conditions and policies Monitoring and review of sustainability of land management policies, e.g. Grain for Green Increase support for water harvesting saving technologies	Department for Agriculture and Livestock Ningxia Development and Reform Commission
Change in Yellow River flows	M	Ensuring long-term reliability of Yellow River supply (across different scales of use)	Ningxia Water Resource Department
South			
Drought	H	As for Central sub-region except YR allocation	As for Central sub-region
Surprises / Extreme events	H	As for Northern sub-region Periodic review of flash flood frequency and damages, review potential for forecasting and early warning	Ningxia Water Resource Deptartment
Drying / desiccation of landscape	M	Improve WUE both agriculture and ecosystem through water conservancy programme and technologies Lang use change according to soil moister	Ningxia Water Resource Dept. Ningxia Department for Agriculture and Livestock

3. Multi-criteria analysis to prioritise specific activities by organisation

There is general agreement that decision-makers need policy-relevant indicators to assess the effectiveness of adaptation actions. ICCCA used a Multi-Criteria Analysis (MCA) approach as a means of assessing different options. MCA enjoys wide application as different weightings (coefficients) can be set for different stakeholders to provide a comparable means of ranking alternative options according to different preferences. This was developed from the ORCHID methodology (*ORCHID: Opportunities and Risks from Climate Change and Disasters*) developed by Tanner et al. (2007).

The criteria chosen for the MCA in Ningxia were generalised to be applicable in different institutional contexts and the project drew on the ORCHID methodology.

A total of eight criteria were used to reflect adaptation effectiveness and practical feasibility. Each criterion was scored on a 1-4 scale. The 1-4 scale was favoured for offering a good compromise between conflicting needs, namely on the one hand the need to distinguish between different options (the wider the range, the better) and, on the other, the need to avoid giving the impression that the scoring is highly precise, and extended discussions over particular scores (the narrower the range, the better). The range is sufficient to encourage participants to choose between negative and positive scores. The individual indices and marking criteria based on specific adaptation measures are listed in Table 2.11.

Several government agencies were invited to rate these criteria, including Ningxia's Science and Technology Department, the Water Conservation Department, and the Agriculture and Livestock Department. They were first requested to select and rate the two options that in their opinion constituted the most effective option.

Generally, the MCA and scoring system worked well in that they were not too complex, and permitted an active debate on adaptation effectiveness. The methodology can easily generate the priority order of different technologies for one or several departments. Note that the value of the mark serves only as a

reference, not the ultimate decision-making indicator. ***In fact, it is the process of going through the discussion that generates the most useful insights as this enables stakeholders to learn about the climate risks, and the adaptation experts to learn about the other relevant considerations in an institution's decision-making.***

Table 2.11 Multi-Criteria Analysis: Criteria and scoring system for specific adaptation options (based on Tanner et al., 2007).

Criteria	Rating
Win-win options: Does the option address current climate variability *and* future climate change?	1 = uncertainty 2= based only current 3= both current and short term (3-5 years) 4 = medium to long-term (more than 5 years)
Existing risk management: Is the option consistent with existing risk management activities?	1= no 2= consistent in short term (extreme event) 3= consistent in long term (average change) 4= both short and long term
Cost effectiveness: Can costs and benefits of the option be easily determined?	1= very difficult 2= difficult 3= easy 4= very easy
Adaptive flexibility: Does the option focus on narrow range of future scenarios, or allow flexibility of response?	1= no, irreversible 2= limit flexible 3= flexible 4= very flexible and easy
Unintended impacts: Potential negative spin-off impacts beyond targeted activity?	1= adverse impact 2= uncertain 3= no impacts 4= beneficial impact
Practical considerations: Is the option practical and feasible for the implementer?	1= unfeasible, impossible 2= more problematic 3= relatively simple 4= more easily
Knowledge level: How much certainty is there in predicting a particular change in hazard and its impact?	1= uncertainty (less 10%) 2= low certainty (10%~20%) 3= medium certainty (about 50%) 4= high certainty (more than 80%)
Policy coherence: Does the option reflect local and national disaster risk reduction / adaptation plans or studies?	1= only the long-term or only the medium-term needs 2= long and medium term needs 3= short term needs 4= both above all
Total score	

2.5 Worked example: prioritising adaptation options in Ningxia's Agriculture and Livestock Department

Table 2.12 below lists the main adaptation options identified by the Agriculture and Livestock Department during the discussion. This table was used to guide more discussion in relation to

prioritising specific actions using the MCA method outlined above. Each department was invited to select two potentially feasible options to test the MCA method. In order to reflect different views within the department, at least eight people were involved in the evaluation process. Every participant was given an opportunity to assign scores depending on their own understanding and views and an average mark and final score was then computed.

Table 2.12 Main types of adaptation actions identified by Ningxia's Agriculture and Livestock Department.

Strategic and Planning
Eleventh five-year plan for agriculture
Structural
Adjustments in planting structure
Reducing spring wheat areas
Increasing potato and mulching maize areas
Decreasing rice area and replacing rice with fruit and melon
Bi-annual harvests
Vintage wine development
Winter wheat northward migration
Shrink summer grain area but increase autumn grain area
Develop husbandry
Promote water saving methods in agriculture
drought resistant varieties
deep ploughing
soil moisture retention techniques
shifting spring sowing to summer
more effective irrigation on rice
Mountain enclosures and grazing restrictions
Develop greenhouse agriculture
Methane project in rural area: reduce fire-wood consumption and GHG emissions
Utilise solar energy (e.g. for cooking and house warming)
Slope field shift to terrace
Water saving infrastructure and facilities(dripping irrigation and sprinkle irrigation)
Mulching techniques (gravel mulching, film and straw)
Non-Structural
Government funds for capacity building
Training programme: government to invest 10 million Yuan to help one million farmers get professional qualifications;
Techniques to supprt household programme: new varieties are delivered to the field, key agricultural techniques are transferred
Countryside labour migration programme: government to encourage and help 100,000 farmers to look for temporary work in cities during the low season (three months a year).
Clean energy utilisation (e.g. solar energy)

Some criteria were deemed ambiguous and were therefore revised to make scoring easier. The results showed that cost-effectiveness was the most important criterion for evaluating potential adaptation options for the Agriculture and Livestock Department. There are several methods to calculate the final score of each option based on metrics. Table 2.13 below shows the results of running the MCA for two specific adaptation technologies. The method can help experts to identify priority options for implementation.

Table 2.13 Example of use of multi-criteria: assessment table for Ningxia's Agriculture and Livestock Department

Rank	Criteria and Indicator	Decrease summer but increase autumn grain area		Film Mulching	
		Score	Comments	Score	Comments
3	Win-win options	4	Meet needs of agriculture and economic development. Autumn grain crops grow in the rainfall season.	3	Not good in the long-term as it will pollute the environment.
6	Adaptive effect	4	Relatively higher adaptive capacity to short and medium climate change.	2	Helpful only for the short term.
1	Cost effectiveness	3	Autumn grain production usually higher than summer grain, and then with good profit.	4	Easy to determine through film cost and production profit.
8	Adaptive flexibility	3	In different years, could take various measures autumn grain area and decrease summer's.	4	Simple when mulching is not suitable or good to crops, it could remove away.
5	Unintended impacts	4	Summer grain decrease can affect farmer food, but autumn grain increase will increase livestock income. Net impact is positive.	2	Adverse effect on nearby environment, as film is not bio-degradable
2	Practical considerations	3	Acceptable to farmers as autumn grain planting normally generates more profit than summer grain planting.	4	Easily accepted and implemented by farmers; easy to disseminate.
7	Knowledge level	3	The measures have been taken for several years, mainly because it has good benefit. To some extent it is consistent with current climate, albeit consistency with future climate is less certain.	3	Depending on farmer experience; future conditions are uncertain.
4	Policy Coherence	3	Meets the needs for local economic development.	3	Partly consistent with policy. Increases agricultural production at the expense of the environment.
	Total score	27		25	

2.6 Stage 5: implementation and demonstration

Climate change is still a new concept for decision-makers in Ningxia and local people tend to lack both a scientific understanding of the issue and a longer-term perspective on management and decision-making that could incorporate climate change. To date, no specific practical measures have been undertaken on the ground specifically in relation to adaptation in the agriculture sector although spontaneous adaptation has occurred. However there have been a number of actions at a policy level and climate change is starting to be 'mainstreamed' into existing policy. For instance, the *Ningxia Eleventh-five Development Plan* explicitly mentions the need to strengthen climate change adaptation.

Drivers for further action on adaptation lie primarily with the newly established *Ningxia Climate Change Response Office*. The Ningxia Climate Change Response Office will hold an inception meeting in October 2008 where a series of next steps towards mainstreaming adaptation in Ningxia will be discussed.

Where adaptation options rely on new techniques, it is likely these will need to be trailed, both to demonstrate and evaluate their potential to decision-makers and stakeholders. The most suitable route

for such measures will be through existing research and development capacity (e.g. through MOST) and delivery systems supported by the Ministry of Agriculture, Ningxia's Agriculture and Livestock Department and other relevant agencies. There will also be a role for the rapidly growing private sector to enhance these processes of change either through response to emerging trends and extreme events or through opportunistic anticipation of longer-term changes.

Until more distinct signals of climate change emerge (e.g. through increased warming, more frequent or clearer signals emerge in precipitation patterns), adaptation is most likely to be pursued through existing strategies to cope with existing climatic hazards and raising agricultural productivity. Box 2.2 outlines some ongoing measures to cope with current drought and high temperature. Some of these could be improved and applied in future to cope with a warmer climate and extreme weather.

Box 2.2: Examples of existing technologies being implemented or demonstrated in Ningxia that could represent potential win-win adaptations

- **Adjustment of agriculture planting structure**

In view of the ongoing warming, Ningxia has enhanced multiple cropping methods; adopting measures like planting single harvest rice and multiple cropping of grass in autumn fallows. These measures enhance agricultural returns while promoting the development of animal husbandry.

- **Winter wheat northward migration**

Since the 1990s and because of climatic warming, Ningxia has been exploring ways of shifting winter wheat northwards. Currently, winter wheat in the region is planted only from 39 degrees of northern latitude whereas previously it was from 35 degrees, making its successful migration from the southern mountainous areas to the northern area irrigated by water from the Yellow River.

- **Mountain enclosures and grazing restrictions**

Ningxia's agricultural production used to be roughly half cultivation and half livestock raising area, with natural grassland of 2.67 million ha. Desertification and pasture degradation is likely to have been aggravated by recent climatic warming. In 2001, the region implemented a mountain closing and grazing restriction plan. Areas where annual rainfall is below 100mm are recommended to plant grass and current manual grassland has reached 4.67 million ha.

- **Mulching techniques（gravel mulching, film and straw）**

Drip irrigation technologies, mulching and drought resistant varieties that can effectively prompt water saving in agriculture have been promoted. For instance, gravel covering watermelon fields can decrease wind and water erosion and reduce evaporation, preserving good performance and profits.

Implementation may only be possible after the capacity to take action has been developed. This includes the issue of awareness, but also technical competence and the development of new approaches to working; for example in partnership across institutional boundaries. Implementation may also require additional investment in resources, both for the 'action' itself and for any changes in staffing that may be required.

2.7 Stage 6: monitoring and evaluation

Monitoring and evaluation is an important feature of policy responses to climate change. As noted above, adaptation should be seen as a process not a one-off activity. Monitoring is necessary for three reasons:

- To detect any changes in the regional/local climate and any impacts on the biophysical and/or socio-economic systems. Such changes may indicate a need to expand or re-design existing monitoring and reporting systems and/or call for improvements in monitoring capacity of, e.g. rural vulnerability, infrastructure damage. Early detection of signals allows adaptation responses to be adjusted as necessary;
- To assess the effectiveness of the adaptation actions taken;
- To detect any changes in institutional or socio-economic conditions that may enable or constrain the effectiveness of adaptation actions.

In principle, the effectiveness of the adaptation actions should be monitored through existing means and methods, as the aim is to embed adaptation within existing institutional strategies, policies and plans. In instances where monitoring of current objectives is non-existent, poorly implemented or not widely communicated, then the issue of how to monitor adaptation needs to be addressed separately. In some cases it may be worthwhile setting up an independent, cross- departmental monitoring mechanism of the adaptation strategy as a whole. The information elicited through monitoring and evaluation mechanisms ought to be used to review and update the adaptation actions in place, in consultation with stakeholders where necessary.

It is too early in the application of the ICCCA framework in Ningxia to provide any results of monitoring and evaluation in relation to this project.

3 Concluding remarks and lessons learnt

The aim of this work was to raise awareness and develop a practical means to take forward the adaptation agenda in Ningxia. The process of developing and applying a framework for adaptation has been an extremely useful two-way learning experience for the research team and the regional institutions involved. There has been considerable capacity development as a result of this joint venture and there have been concrete developments within Ningxia. It is important to note that adaptation in China, as in the UK and elsewhere, is a relatively new issue and institutions are still grappling with the challenge of mainstreaming emerging climate risks into their existing management systems.

The main findings and experiences outlined in this report should be viewed in light of the lessons learnt by the project team:

- **adaptation is an ongoing process;**
- **there are no blueprints for mainstreaming;**
- **local context is critical and considerable efforts need to be made to ensure that consultation with stakeholders informs the process.**

The application of ICCCA's framework for adaptation to Ningxia's agricultural sector has highlighted several critical lessons and insights that may be relevant to adaptation in China more generally, and indeed elsewhere:

- **There is a need to raise awareness about climate change**. Climate change is still a new concept in Ningxia and China and local people lack scientific understanding of the nature of the risks and processes to identify appropriate responses;

- **Having a broad framework in which to situate and guide the project was felt to be extremely helpful** and provided clarity and direction to discussions with stakeholders. Buy-in to the project was helped by having stakeholders contribute to the development of the framework;

- **Any framework ought to be applied flexibly**. Stakeholders will have different requirements when it comes to mainstreaming climate risks into their activities. They will also have different levels of exposure and vulnerability, and their capacity to implement a risk assessment and design appropriate responses will vary from one instance to the next. This requires some flexibility in the application of the adaptation framework. For instance, it may be necessary to adjust the methods or level of detail at each stage, or even omit some stages altogether. As a further example, the MCA is useful for prioritising options but its application can be complex and resource intensive. Criteria can be redefined and adjusted according to the features of each specific situation;

- **There is a need for coordinated management across sectors**. An effective adaptation response may require new forms/ways of working across institutional and sectoral boundaries. The adaptation objectives in one policy or geographical area could be detrimental to another. Water management in Ningxia is one area in which this is particularly evident. Water management cuts across many sectoral and administrative boundaries. Allocation decisions are made from the Yellow River Basin level down to sub-regional organisation levels. Water use decisions affect not only the agricultural sector, but they also impinge upon other sectors, e.g. the urban and power sectors. Planning must ensure that all agencies charged with water use are involved in decisions on water use;

- **Climate risks and adaptation priorities vary across (sub)regions and sectors**. Different sub-regions in Ningxia have different priorities when it comes to adaptation actions. Ideally adaptation policies should integrate across climate risks and sub-regional management and development objectives and be situated within existing mechanism for devising and implementing policy;

- **A good 'entry point' for discussions on adaptation in the long-term is through reducing vulnerability to existing climate hazards**. Over the short term, strengthening existing programmes to maintain and increase agricultural productivity are priorities for action. As far as dealing with longer term risks associated with climate change is concerned, there is a strong case for raising awareness and building capacity to introduce methods for adopting longer term strategic planning, e.g. in water management and investment in agricultural technology and rural livelihoods. In some

cases, such as where clear signals in precipitation patterns are yet to emerge, a 'wait and see' response may be appropriate;

- **Consultation with stakeholders through all stages of the framework is critical for encouraging engagement with the process;**

- **Transferring the lessons from the experiences in Ningxia**. Adaptation frameworks or strategies will be implemented gradually at regional level. China's government is giving increasing importance to building adaptive capacity; however, as adaptation is a new concept for many stakeholders, implementation will remain a challenge.

The aim of this report is to contribute to this process of engagement with adaptation agendas at provincial level in China.

For more detailed information of the outcome of applying ICCCA's framework for adaptation to Ningxia's agricultural sector, please see ICCCA's report *Part 3: An Adaptation Strategy for Agriculture in Ningxia, Northwest China*.

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Annex 1

Contribution of various stakeholder organisations and officers to ICCCA's adaptation research.

Organisation	Activities			
	Scoping study interviews (6-10 November 2005)	MCA dialogues (10-13 May 2007)	Workshop on an adaptation framework for Ningxia (23/24 October 2007)	Adaptation report consulting process (16-18 June 2008)
Ningxia Development and Reforming Commission	√	√	√	√
Science and Technology Department	√	√	√	√
Agriculture and Livestock Department	√	√	√	√
Water Resource Department	√	√	√	
Meteorology Administration	√	√	√	√
Office of Poverty Alleviation and Development	√	√	√	√
Ningxia Forestry Department		√		
Ningxia Agriculture Academy	√	√		
Ningxia Academy Of Social Science	√	√	√	
Ningxia Agriculture Technology Dissemination Center	√	√	√	√

We thank all the above organisations for participating and contributing to ICCCA's consultations to identify and prioritise adaptation options for Ningxia's agricultural sector.

Annex 2

Questions and issues covered in interviews with stakeholder organisations.

- What is the level of awareness of recent changes in climate in Ningxia?
- How have institutions' activities or responsibilities been affected by recent climate variability?
- Has the institution implemented measures to reduce the effects of climate variability/extremes or help farmers and others to recover from them?
- How and approximately when have any such measures been implemented and how much investment was involved?
- How is the institution (and farmers in Ningxia) likely to be affected by climate change in the future (climate change during the next 20-30 years was presented as being likely to include increases in extremes, like flood and drought, higher temperatures and higher evaporation)?
- Given the potential changes, what kinds of measures could the institution implement that would be helpful to reduce the impacts of possible future climate change?

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