

# Synopsis of China National Climate Change Assessment Report (II):

## Climate Change Impacts and Adaptation

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**Abstract:** Significant and various impacts of climate change have been observed in China, showing both positive and adverse effects, dominantly the latter, in different sectors and regions. It is very likely that future climate change would cause significant adverse impacts on the ecosystems, agriculture, water resources, and coastal zones in China. Adoption of adaptive measures to climate change can alleviate the adverse impacts, therefore such measures should be incorporated into the medium- and long-term national economic and social development plans. Because China has done relatively limited research on impact assessment and our understanding of climate change is incomplete, the current impact assessment methodologies used and results obtained contain many uncertainties. To reduce the uncertainties and develop effective and practical climate change adaptive measures in China, it is necessary to emphasize regional case studies on adaptive measures, enlarge the scope of climate change research, and strengthen the assessment of the impacts by extreme weather/climate events.

**Key words:** climate change in China; climate scenarios, impact assessment, adaptive measures, uncertainties

### Introduction

According to the Third Assessment Report of the Intergovernmental Panel on Climate

Change (IPCC), global average temperature has increased by  $0.6(\pm 0.2)^{\circ}\text{C}$  during the 20<sup>th</sup> century. In China<sup>[1]</sup>, the observed data show that the nation-wide mean surface temperature has markedly increased over the past 100 years and the change ranged between  $0.5\sim 0.8^{\circ}\text{C}$ <sup>[2]</sup>. Climate change characterized by warming will impact on various aspects of Chinese social and economic life.

Since the early 1990s, Chinese scientists have studied climate change impacts, vulnerability and adaptation strategies and obtained many good results<sup>[3-4]</sup>. Based on those study results, a National Assessment Report on Climate Change, commissioned by the Ministry of Science and Technology of China, the China Meteorology Administration, and the Chinese Academy of Sciences, has been prepared to summarize the current state of knowledge on the impacts of climate change, the country's vulnerability to climate change, possible adaptation strategies, and the related uncertainties.

This paper is a synopsis of Section II of the *China National Climate Change Assessment Report*, which is in the process of being published. We present in the paper the methodologies used for assessing climate change impacts in China, address climate change impact, adaptation, and vulnerability issues for major areas of vulnerability, e.g. agriculture, water resources, coastal

environment and ecosystems, and for different regions in China, discuss adaptive measures, and identify uncertainties and research areas critical for advancing the understanding of potential consequences of climate change and adaptation options.

## **2.1 Methods of climate change impact assessment**

The eco-systems that have received relatively little disturbance from human beings can be used as the reference pointer to assess the observed impacts of climate change. However, systems like agriculture, water resources and human health are influenced not only by climate change but also other factors, therefore it is rather difficult to single out the impacts of climate change. Nevertheless, the impacts that can already be observed should be taken as facts when conducting a regional or sector assessment. Despite the difficulty in quantifying climate change impacts, these facts are useful to manifest the impacts of climate change to some extent and offer a basis for assessing potential impacts of climate change in the future.

The future trends of global climate change will be greatly influenced by the development paths that human societies will take. Thus, to assess the potential impacts, vulnerability and adaptation associated with climate change, it is necessary to first establish scenarios of socioeconomic development, from which the scenarios of greenhouse gas (GHG) emissions can be derived. Then climate models could be used to forecast future climate changes to be caused by human activities. Two Chinese socioeconomic development modes, one assuming a higher rate and one lower rate, have been built taking into account the contribution of technology advancement to economy growth and the effect of population growth by the middle of this century.

There are three types of climate change scenarios used by Chinese scientists in the past : incremental increase scenario, equilibrium double CO<sub>2</sub> scenario, and transient GHG emissions scenario. The scenarios used in the study of climate change impact in China are Series IS92<sup>[5]</sup> and Series SRES designed by the International Panel on Climate Change (IPCC)<sup>[6]</sup>, while the climatic scenarios for the GCM include IPCC's HadCM2, ECHAM4, etc.

Generally, the grid of a GCM is at the level of hundreds of kilometers, which is too low a resolution for regional climate change assessment. Therefore, down scaling the grid, i.e. increasing the resolution, becomes necessary. The common ways of down scaling include interpolation, statistical method, and regional climate model (RCM). Interpolation was the main method used in the early years, whereby the GCM results were interpolated to the station level and, with the help of a weather generator, produced daily data needed for assessing potential climate change impacts.

Chinese scientists have researched into ways to improve the resolution of climate scenarios and apply the research outcomes in climate change impact assessment. The China National Climate Center employed the RegCM2 model to simulate the country's regional climate scenarios with doubling of CO<sub>2</sub> concentrations<sup>[7]</sup>. Since 2002, Chinese scientists has introduced PRECIS, an RCM model from the British Hadley Weather Center, into their studies<sup>[8]</sup>, and scaled down HadAM3H to a grid of 50km × 50km. Then they established China' SRES climate scenarios and applied them in the assessment of agriculture<sup>[9]</sup>, water resources<sup>[4]</sup> and natural ecosystems<sup>[10]</sup>. The statistical method for down scaling has seldom been used in China.

## **2. Climate Change Impact Assessment on**

## **Vulnerable Sectors and Regions**

### **2.1 Observed Impacts**

Since the 1950s, the rates of sea level rise along China's coastal line have been at 1.4mm ~ 3.2mm /year; marine ice condition on the surface of Bo Sea and Yellow Sea has decreased; glacier areas in northwest China have decreased by 21% since the little ice age; the permafrost in Tibet has gotten thinner by up to 25 meters; the water levels of some high plateau inland lakes have risen; and grassland production in Sichuan, Qinghai, and southern Gansu provinces have decreased. Since the 1980s, spring phenophases have advanced 2 ~ 4 days. In recent years, coral bleaching occurred in the coastal of Hainan and Guangxi provinces.

Drought-stricken areas have widened in northern China and flooding got more serious in southern China. Since the 1980s, agricultural production has become more unstable. In some places, droughts and heat waves have become more severe. Crop damage from spring frost has increased due to mild winters that lead to earlier onset of budding and flowering in winter wheat, trees and fruit, making them more vulnerable to cold. However, climate warming over the past two decades has caused winter wheat plantation in northeast China moved northward and extended westward. Certain varieties of maize that have a relatively long growth period and high yield have been grown more widely, resulting in increased output. Since the 1950s, the runoffs to six large rivers in China have all been observed to experiencing a decreasing trend, with the largest decrease occurred along the Haihe River. Some rivers in northern China faced intermittent flow. Every year over the past 15 years, more than 10 million hm<sup>2</sup> /year of areas

suffered from serious droughts, while large flooding events occurred along the Yangtze, Pearl, Songhua, Huai, and Yellow rivers as well as the Tai lake in the 1990s resulting in increasingly heavy losses. Climate Change and sea level rise have already affected China's coastal areas, where the economic losses from storm surges, flooding, heavy rain, drought and other serious climatic events were most significant. Yellow river delta, Yangtze delta and Zhujiang delta are more vulnerable to storm surge, coastal flooding, shoreline erosion, and losses of wetlands than other coastal places. Since the 1960s, forest area of Mount Qilian has decreased 16.5%, its forest belt has moved up by 400 meters, and forest coverage decreased 10%. In Sichuan Province, grass production and quality have decreased. The areas of wetland in southwest China, the Sanjiang (Three-River) Plain and Qinghai Province have also shrunk and their functions declined. Since the 1950s, the fluctuation cycle of mountain disasters in the Southwest has shortened, and the frequency of disaster events and the losses they caused have increased. Climate change has raised the possibility of disease incidence and transmission, greatly influencing the distribution and the potential danger of vector-borne infectious diseases. After a flood disaster, the incidents of infectious diarrhea diseases, such as plague, malaria, typhoid and paratyphoid, often increased. In the past 40 years, although the Qinghai-Tibet Plateau experienced a warming trend, the coverage of dry grassland has actually increased due to increased rainfalls.

### **2.2 Projection of Future Impacts**

According to China's national development plans, by 2050, per capita Gross Domestic Product (GDP) would hit \$10,000, the total population rise to 1.54~1.58 billion, and the total consumption of primary energy reach

3.9~4.9 billion tonnes of coal equivalent. This projection is very close to the IPCC SRES B2 scenario (mid-low emissions scenario), the pathway for regional sustainable development. Under B2 scenario, RCMs project that the average temperature for whole China would increase by 1.2 °C, 2.2 °C, 3.2 °C, and precipitation increase by 4%, 7%, and 10% in 2020s, 2050s, and 2080s, respectively. These changes, however, would not likely to alter the situation of water resources distribution in China characterized by abundance in the southern part and scarcity in the northern part.

### **2.2.1 Impacts on agriculture**

Climate change would decrease the stability of agricultural production causing larger variations in crop production. The most recent studies show that climate change will greatly influence China's agricultural output. By 2030, the overall crop productivity in China can decrease 5~10% if no action is taken. By the second half of the 21st century, climate change can cause yield reduction in rice, maize and wheat up to 37%. In the next 20~50 years, agricultural production may be seriously affected, compromising long-term food security in China.

Water demand for irrigation will grow in most regions of China due to increased evaporation and, in some regions, decreased precipitation as the climate gets warmer. Coupled with intensified water stress, this situation will significantly affect the costs of and investments in food production. The carrying capacity of grasslands and the number and distribution of grazing animals will undergo large changes as well.

### **2.2.2 Impacts on forests and other ecosystems**

Climate change would not have a significant impact on the geographical pattern of Net Primary Production of forests in China. However, through 2030, the productivity of forests may boost from 1%~10%, with the southeastern region realizing less increases and the northwestern region more. The structure and composition of forests in the Northeast would experience great changes, with defoliate and broadleaf trees becoming dominant species.

In semi-arid areas, desertification would gain more momentum. The upper limit of mountain grassland could move up by 380m ~ 600 m, while the areas would decrease in size. However, the productivity of the grassland could increase by 13% ~ 23%.

Regional warm and dry weather would lead to reduced wetland resources, loss of biodiversity, increased number of endangered species, and the conversion of large areas of swamp to meadow land in the San-Jiang (three-river) fluvial plain of China. Sea level rise would cause reduction in wetland area, degradation of wetland, and submergence/erosion of tidal flat land in the Yangtze River Delta.

In the coming 50 years, the spatial distribution of the permafrost in the Tibetan Plateau would undergo a rather significant transformation: 80% ~ 90% degradation of permafrost islands, deepened seasonal melting of permafrost, and the formation of melting interlayer and deeply buried permafrost. The areas of surface permafrost could reduce by 10% ~ 15% and the nether limit of permafrost on sunny slopes could rise by 150m ~ 250m.

Future climate change would accelerate the shrinking of inland lakes. The mountain and highland lakes that rely on inland glaciers for recharge, such as the lakes on Tibetan Plateau

and Pameer Plateau, could initially enlarge as a result of glacier melting, but eventually shrink as the glaciers are reduced over time.

### **2.2.3 Impacts on water resources**

Climate warming could decrease river runoffs in northern China and increase them in southern China. The annual average evaporation would increase in each watershed, with the Yellow River Basin and inland river basins possibly experiencing about 15% increase. Therefore, the probability of droughts and floods would increase, exacerbating the instability of water resources distribution and the gap between water demand and supply.

The volume of glaciers would change as the climate changes. We estimate that by 2050, the total area of China's western glaciers could reduce by 27.2%. Over the same period, glacier melting would increase water discharge, peaking the amount during 2030 ~ 2050 by annual increases of 20% ~ 30%.

### **2.2.4 Impacts on coastal environment**

The response of China's coastal regions to climate change and sea level rise would be different from that of Europe and America.. Storm surges, droughts and other extreme climate events are the main coastal disasters. Currently, the Yellow River Delta, the Yangtse River Delta and the Pearl River Delta are the most vulnerable coastal regions in China.

By 2030, the sea levels along Chinese coastal areas could rise by 0.01~0.16m, increasing the possibility of flooding and intensified storm surges. The disasters could increase coastal erosion, degrade coastal ecosystems such as wetlands, mangroves and coral reefs, and

exacerbate saltwater intrusion.

### **2.2.5 Impacts on other sectors**

Climate change could increase the frequency of heat waves and their intensity, resulting in higher mortality and morbidity of serious diseases. It would endanger human health by increasing the occurrence of diseases and the transmission of infectious diseases. Climate change would increase the degree and range of cardiovascular diseases, malaria, dengue fever and heatstroke.

Climate change may cause the melting of mountain snow and the rising of sea levels, so that mountain, coastal and island landscapes would change, affecting nature conservation areas and national forest parks characterized with excellent environmental quality and biodiversity. The impact of climate change could thus affect tourism and the safety of tourists.

Climate change would further challenge power supplies in China because of people's increasing reliance on air conditioners. The Qinghai-Tibet Railway and other large projects could also be adversely affected by the thaw of perennial frost, and/or rainfall changes.

### **2.2.6 Impacts on different regions**

Temperature increase would benefit agricultural production in northeast China, but some specific ecosystems (such as wetland and permafrost) will deteriorate or disappear as a result of climate warming and human activities. The structure of forest ecosystems will change as well. In north China, climate may continue to become obviously warmer and droughts intensify. As water demand would increase significantly, water shortage

would get worse. However, warmer winters will promote the development of protected agriculture in the region. In northwest China, while precipitation may increase, the region would remain water stressed. Our simulations indicate that water shortage in this region could reach about 20 billion m<sup>3</sup> /a between 2010~2030. The area of desertification will extend in the places where agriculture and livestock raising are overlapped and along the edge of oasis after 2050.

In eastern China, the 1/100 frequency of flood occurrence in one hundred years would increase. In the central part of China, temperature increase will not be obvious, but droughts and floods would come in turn more frequent. Future climate change would decrease the yield of double-harvest rice, especially of the late-season rice in central China.

In the southwest, the strength, scale, scope and frequency of land disasters are expected to increase over time resulting in more severe losses. The southern part of China is susceptible to sea level rise, estimated to be between 0.60 m~0.74 m by 2100. The rise would have more adverse influence to low-lying and damp areas in the Pearl River Delta than to other places. The border lines of mangrove areas would move northward and the scope of coral bleaching would expand.

### **3. Adaptation measures to climate change**

Developing rational adaptation measures and enhancing the capacity to adapt will play an important role in minimizing the adverse impacts of climate change and promoting sustainable development in China. The pertinent adaptation measures for main sectors should include:

#### *Agriculture*

- a) strengthening agricultural infrastructure;
- b) breeding stress-resistant crop varieties;
- c) developing new agricultural technologies including biotechnology;
- d) promoting large scale plantation of superior crop varieties in suitable areas;
- e) adopting special techniques to increase and stabilize crop yields in order to enhance the agriculture sector's resistance to disasters;

#### *Flood and drought control*

- a) strengthening hydrological infrastructure to enhance the capacity of flood and drought control, water supply, and emergency response;
- b) incorporating the potential impacts of climate change on water resources as limiting factors in construction projects;

#### *Forestry*

- a) continuing reforestation efforts;
- b) enhancing the abilities of tree species to adapt to environmental changes;
- c) strengthening nature reserves management;
- d) preventing and controlling forest fires, forest diseases and insects;

#### *Grassland management and animal husbandry*

- a) taking into account climate change in determining grazing capacity of pastures;
- b) halting over-grazing and avoiding prairie degradation;
- c) stopping and reversing the trend of desertification to enhance the resistance of livestock production to climate change;

#### *Coast protection*

- a) raising the design standards of facilities for tide prevention;
- b) enforcing tide prevention facilities in the coastal areas;

### *Climate forecast*

- a) improving the forecast of climate hazards;
- b) establishing forecast, monitoring and control systems in order to enlarge the coverage of epidemic supervision area.

Regional adaptive measurements may include the following. In northeast China, climate warming provides advantageous conditions to move winter wheat cultivation areas northward and enlarge rice paddies as suitable. In north China, adaptation could involve establishing water saving systems, preventing and managing desertification, and promoting regional social and economic sustainable development. In northwest China, work should focus on reasonable allocation of water resources, development of water saving agriculture, protection and improvement of ecosystems and the environment, and enhancement of adaptive capacity in agriculture in dry-land areas. In central China, capacities should be built on control and reduction of droughts, floods and other disasters, on better water retention and drainage, and on monitoring and prevention of schistosome disease. In southwest China, adaptation to climate change involves strengthening prevention and early-warning systems for landslides, speeding up and improving water and soil conservation, and protecting the prairies in Tibet. In the coastal areas of eastern and southern China, the protection level of storm stopping levees should be raised based on sea level rise predictions, and the ability to monitor and give early warnings on typhoon and storm surge be strengthened. Since adaptive measurements can help alleviate negative impacts of climate change, it is important to progressively incorporate them into national medium and long term development plans and strategies.

It is necessary to develop a dedicated

monitoring system to examine the impacts of climate change and to establish a science and technology system to research into adaptive strategies. Building multi-disciplinary research and management teams in China at advanced international levels is critical for enhancing the analytical and decision-making abilities to respond and adapt to climate change.

## **4 Uncertainties in Climate Change Impact Assessment and Ways of Improvement**

There are many uncertainties in the current impact assessment methodologies and results due to limited scientific research conducted in China on climate change. Because many models take climatic and non-climatic scenarios (including socio-economic assumptions) as input parameters when assessing climate change related impacts, vulnerability and adaptation needs, a high level of uncertainty originates from the assumptions of scenarios. Main uncertainties come from the incompleteness of climate models and the uncertainty of future GHG emissions that can be reduced only if we are able to accurately project non-climatic scenarios of socio-economic, environmental and land use changes, and technology advancement in the next several decades to one century.

The uncertainties of impact assessment models come from four main sources: 1) limited understanding of climate change's impacts on various ecosystems and the interaction among them; 2) not all factors considered in the impact assessment models; 3) the impacts of climate change on trade, employment, and socio-economic development are seldom considered in impact assessment models; and 4) insufficient consideration to the effects of adaptation measures on lessening the vulnerability to climate change.

An effective way of reducing the uncertainties is to construct climate change scenarios under

various GHGs emission scenarios. To counter the “scientific uncertainty”, various models and climate change scenarios should be employed in the impact assessment.

To reduce the uncertainties, it is also necessary to improve the understanding of the response mechanisms of ecosystems to climate change, including to collect data of long-term changes in plant/animal communities and species, to investigate different ecosystems in different areas, to better control confounding factors during the experiments, and to distinguish the effects of climatic factors from non-climatic ones.

We should strive to develop integrated models for impact assessment and improve the projection of non-climatic factors. More consideration should be given to technology advancement, policies, major construction projects, and adaptive measures in the impact assessments, so as to improve the accuracy of the assessments for different sectors/areas, especially for agriculture and human health. While assessing the impacts of climate change under different scenarios, the interaction and intervention among various disciplines should be emphasized.

Given China’s vast territory and diverse climatic conditions, regional case studies are necessary for the assessment of climate change impacts and adaptation needs. Existing impact assessment efforts in China have mainly concentrated on agriculture, water resources, ecosystems, and coastal environments. Not many studies have looked at the potential impacts of climate change on human health, transportation, eco-tourism, major civil projects, residential buildings, and marine ecosystems. Since climate change would very likely do its damage through extreme weather/climate events, studying the occurrence of extreme climate events and their consequences is essential and should be enhanced.

**Acknowledgements:** This paper is a translation of a Chinese version synopsis from Section II of China National Climate Change Report. The authors thank all the authors of Section II not listed in front of this paper, they are Jiang Jinhe, Li Yu-e, Yang Xiu, Zhang Jianyun, Li Congxian, Zhao Zongqun, Wu Jianguo, Yan Changrong, Wang Shourong, Liu Yunfen, Du Bilan, Zhao

Chengyi, Qin Baofang, Liu Chunzhen, Huang Chaoying, Zhang Xiaoquan, due to space limitation. Our thanks also go to Zhang Jin, Zhu Jieping, and Fu Ping for their contributions to the Chinese version.

## References:

- [1] Houghton J T, Ding Y H, Griggs D G, et al. *Climate Change 2001: The Scientific Basis*[M]. Cambridge, UK: Cambridge Univ. Press, 2001.
- [2] Ding Yihui, Ren Guoyu, Shi Guangyu et al., National Assessment Report of Climate Change(I): Climate Change in China and its future trend, *Advances in Climate Change Research*, 2006, 2(1): 1-8
- [3] CHEN Yiyu, DING Yongjian, SHE Zhixiang, LIN Erda, et al., Measures to adapt and mitigate the effects of climate and environment changes, Assessment of Climate and Environment Changes in China (II), Science Press 2005, Beijing.
- [4] People’s Republic of China, Initial National Communication on Climate Change, Chapter 3: Climate Change Impact and Adaptation, 23-35, China Planning Press, ISBN 7-80177-374-8, 11, 2004
- [5] Leggett, J., W.J. Pepper and R.J. Swart, 1992. Emissions scenarios for IPCC: an update. In Climate change 1992: the supplementary report to the IPCC scientific assessment. J.T. Houghton, B.A. Callander and S.K. Varney (eds.), Cambridge University Press, Cambridge.
- [6] Nakićenović N, Alcamo G, Davis G de Vries, et al. Special Report on Emissions Scenarios[R]. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2000, 599pp
- [7] Gao X J, Zhao Z C, Ding Y H, et al. Climate change due to greenhouse effects in China as simulated by a regional climate model. *Advances in Atmospheric Sciences*, 2001, 18(6): 1224~1230
- [8] Xu Yinlong, Huang Xiaoying, Zhang Yong et al., Statistical Analyses of Climate Change Scenarios over China in the 21<sup>st</sup> Century, *Advances in Climate Change Research*, 2005, 1(2): 80~83
- [9] Xiong Wei, Lin Erda, Ji Hui, Xu Yinlong, A Study of the Threshold of Climate change Impact on Food Production in China, *Advances in Climate Change Research*, 2005, 1(2): 84~87
- [10] Wu Shaohong, Yin Yunhe, Zhao Huixia et al., Recognition of Ecosystem Response to Climate Change Impact, *Advances in Climate Change Research*, 2005, 1(3): 115~118