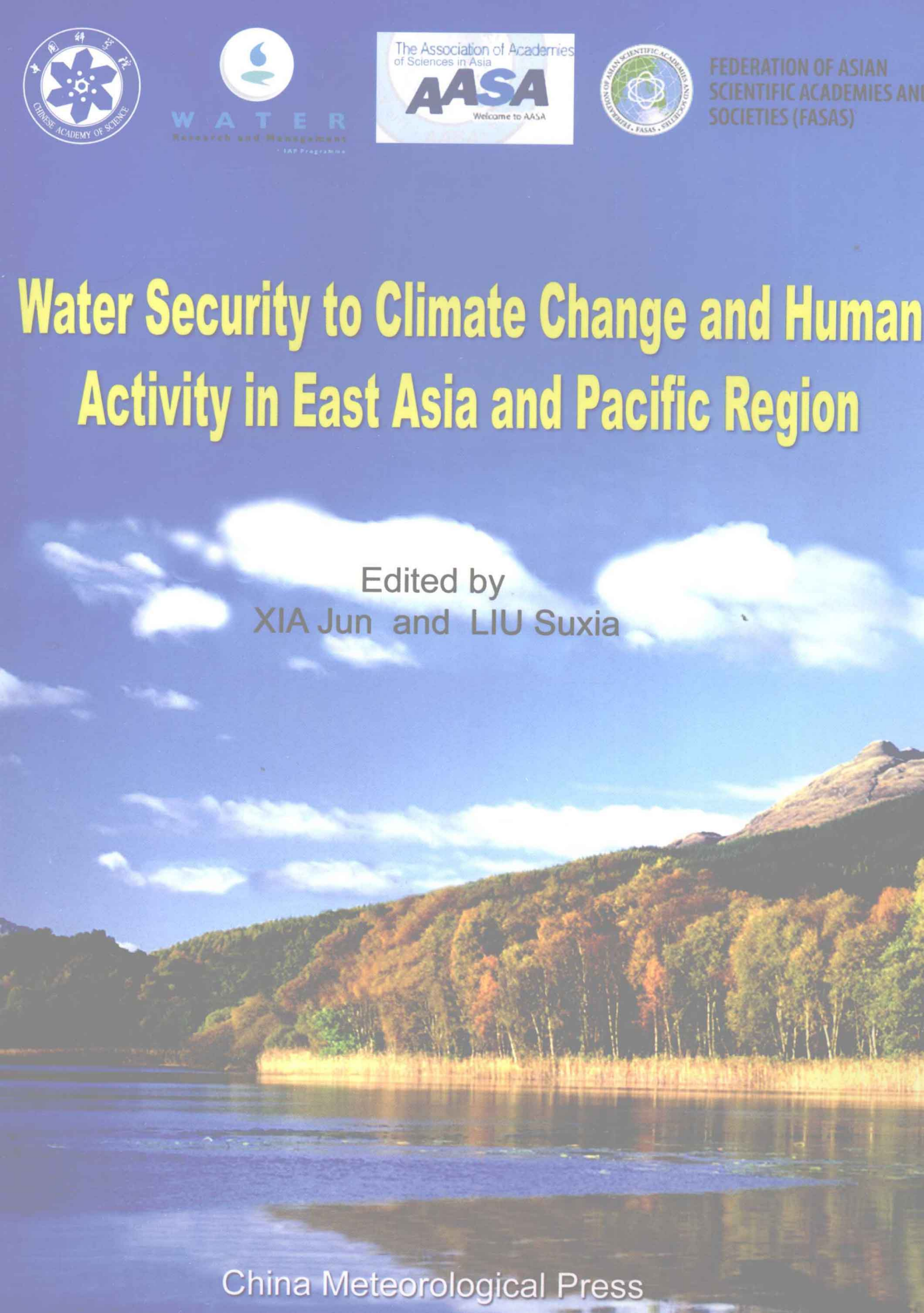

Water Security to Climate Change and Human Activity in East Asia and Pacific Region

Edited by
XIA Jun and LIU Suxia

China Meteorological Press

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Brief Introduction

This book addresses water security issue to climate change and human activity in East Asia and Pacific Region in the framework of Inter-Academy Panel (IAP) Water Programme. Three key issues, namely climate change and water resources, ecosystem and environmental flow, and water resources sustainable management, are introduced and researched by several case studies in East Asia and Pacific Region. This is also one of regional contributions of IAP water programme in 2006 Beijing Workshop.

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Preface

At the beginning of the 21th Century there is a water crisis in East Asia. About one-third of its population is living under moderate or severe water stress, lacking access to adequate supply of safe water and adequate sanitation. Water pollution is continuing to cause millions of preventable deaths every year, especially among children. This is a consequence of a long history of excessive and inadequate use, pollution and contamination, and increasing demand. Besides, climate change also, to a certain degree, makes this situation even worse. The increasing economic development produced a rising demand for freshwater in very large quantities. In the next 20 years the rate of development will continue to grow. How to mitigate the increasing water crisis is a scientific, technological and managerial challenge.

One of the efficient ways to pose this challenge is to establish international cooperation led by international organizations, as the water crisis is international. Launched in 1993, Inter-Academy Panel (IAP) is such a global network of the world's science academies, aimed at the regional improvement of existing programmes on water conservation, wastewater treatment, control of eutrophication and contamination, as well as the development of strong scientific and technical capacities. Its Water Program is one of the four themes in its 2004—2006 science agenda.

With the Vice Director of Chinese Academy of Sciences (CAS), Prof. Chen Zhu being the Vice Chair of IAP, Chinese Academy of Sciences has been paid special attention to water crisis problems in China and the world. As one of the sessions' convenors, Prof. XIA Jun, Leading Professor on Hydrology and Water Resources, Director, Key Lab. of Water Cycle and Related Land Surface Processes, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences attended the Preparatory Meeting for the Regional Workshops of the IAP Water Programme at Adriatico Guest House, Trieste, Italy, May 28th and 29th of 2005.

To speed up the work of IAP Water Programme in East Asia, auspice by Bureau of International Cooperation, CAS and International Academy Panel, an international regional workshop, entitled International East Asia Regional Workshop of Inter-Academy Panel (IAP) on the Water Security to Climate Change and Human Activity, was held in Beijing, 12—13 June 2006 to disseminate the methodology, experience and knowledge gained in the East Asia countries to researchers and the relevant government agencies to each other and elsewhere, so that all can benefit from the specific findings and methodology in dealing with water crisis. The workshop processed scientific exchange by oral presentation, and two days and half-day water resources management cruise at Three-Gorge Dam to give up to 20 participants a demonstration and hands-on experience of the

technology to deal with water crisis. All participants were invited, including personnel from government environmental protection agencies and researchers from China and overseas. The total number of attendees is fifty

Goals of the Workshop is to exchange information and experience among participants in the western Pacific Region on the present state-of-the-art for key water security problems, promote international research cooperation and regional networks, and inoculate international East Asia Water program in the nearest future.

Topics involve the following aspects, given by:

(a) Water cycle characteristics and water resources vulnerability to climate change and human activity in the Asia-Pacific region;

(b) Science role and facing challenges in front of domains of water security problem in the Asia-Pacific region;

(c) Synthesis and interdisciplinary approaches on natural science, social science, economics applied to solve water security problem in the Asia-Pacific region;

(d) Case studies in the Asia-Pacific region to close the gap between water management requirement and water science development to support water sustainable use and management.

This workshop was sponsored by Chinese Academy of Sciences, Inter-Academy Panel—Water Program (IAP-WP), Federation of Asian Scientific Academies and Societies (FASAS), and the Association of Academies of Sciences in Asia(AASA).

The workshop was well organized by Key Lab. of Water Cycle and Related Land Surface Processes Institute of Geographic Sciences and Natural Resources Research (IGSNRR), CAS; Center for Water Resources Research, CAS, and the Asia Scientific Network Office of Global Water System Project (ASNO-GWSP). There are eight different national representatives of IAP from East Asia and Pacific Regional, i. e, Korea, Japan, Philippine, Malaysia, Thailand, Australia, New Zealand, P. R. China and more than 40 participants to attend this Workshop, including Representative of IAP Water Programme from Brazilian Academy of Sciences. They include: Myongji University, Korea; University of Melbourne, Australia; University of Waikato, New Zealand; National Hydraulic Research Institute of Malaysia; Philippine Council for Aquatic and Marine; Hokkaido University, and Chuo University, Japan; four Institutes related to Water issue, Chinese Academy of Sciences; three Universities from Ministry of Education, China, such as Beijing Normal University, Peking University etc, and two Institutes from Ministry of Water Resources, P. R. China, such as China Institute of Water Resources and Hydropower Research etc. On behalf of IAP organization committee, we thank all participants for your contribution to the workshop.

As my summary, major themes and discussion in the workshop involved four themes, given by

(1) ***Water System and Modeling***: Watershed Model Integration in the Heihe River Basin, Progresses and Prospects (LI Xin); Estimation of spatial-temporal distribution of the depth to shallow groundwater table in China (XIE Zhenghui) ;Numerical Modeling of Groundwater Supply for Cities along Yellow River(Guomin LI); Recent Development in Hydrology (Tadashi YAMADA)

(2) ***Climate Chang Impact***: Vulnerability of Chinese farmers to water shortage: choosing social institutions for water management (WEBBER, Michael John); Plausible impact of climate change on air temperature and precipitation in the Tibetan Plateau (XU Zongxue)

(3) ***Ecosystem and Environmental Flow***: Meeting Productive and Environmental Water Needs in Broken River Catchment (LANGFORD John); Use of Laundry Wastewater for Aquaculture: A Philippine Experience (Academia Brasileira de Ciências); Development of Sustainable Sanitation System and its Implementation to Asian Countries: Interdisciplinary Research Project (Naoyuki Funamizu)

(4) ***Water Security and Management***: Water Security in North China and Countermeasure to Climate Change and Human Activity (XIA Jun);Closing Gap Between Water Management Requirement and Water Science Research — Korea Experience (Jungho Sonu);Rapid Changes of Urban Land—use and Flood Warning System (CHEN Qiuwen); Integrated Water Resources Management In Malaysia-Challenges And Responses (AHMAD JAMALLUDDIN SHAABAN); Estimation of water use efficiency in North China Plain and some suggestions to water-saving agriculture (MO Xingguo);Water policy and management (JIA Shaofeng).

Finally, total nineteen papers were selected as this workshop proceeding for publication in China Meteorological Press. We would like to express my deep appreciations to the Inter-Academy of Panel Water Programme, Chinese Academy of Sciences, and Brazil Academy of Sciences, and FASAS, AASA, and peoples from the East Asia and Pacific region for their support of this activity.

XIA Jun and LIU Suxia

March 11, 2007 in Beijing, China

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Proposal and Actions for Water Programme in New IAP Study on Sustainable Water Resources in China

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1 Critical Water Problem in World

Water resource is not only regional but also a global big issue. As we enter the 21st Century, a global water crisis threatens the security, stability and environmental sustainability of all nations, particularly those in the developing world. It was shown from World Water Resources Assessment Programme(UNESCO, 2006), UN, that one third of humanity lives in countries where water is scarce, and 1 billion people lack access to clean water .

Today's water crisis takes many forms and threatens aspects as,

—Drinking water: Due to lack of effective management and infrastructure, one fifth of people in the world lack access to clean drinking water, and 40% humanity is lack of basic sanitation.

—Human health: Due to bad water quality and poverty, 3.1 million people in the world die from disease, in which 90% are children less than 5 years old.

—Disasters: 90% natural disasters result from water and related unsuitable land use. It is the example that East Africa recently suffered seriously drought. Area of Chad lake had reduced 90%.

—Food security: Conflict between water supply and demand in agriculture is further increased as global food demand will increase 55%. Water use in agriculture occupies 70% of total water resources and lower water use efficiency.

—Urbanization: Growth rate of urban population will reach to 2/3 in 2030, that results in significant growth of water demand.

—Ecosystem: Degradation of freshwater ecosystems and species are rapidly. One-fifth freshwater fish will be close to die out.

(1)Water Crisis in Africa, particular countries of Southern Sahara. It was reported by UNDP in 2006 that water shortage is the big issue in Africa continent:

—There are 4.1 billion people facing to drinking water shortage, in which 11% population is in Africa.

—The 2/3 Africa cities in 2025 will face water crisis.

—Agricultural water use in Africa occupies 85% water resources, in which 60% irrigation water could not be efficiently used.

(2)China is a developing country with a variety of climate and much stress from its population and economic development, water resources become as the most important issue associated with regional and global sustainability. For instance, North China is the case to show how serious water security in both water shortage and water quality, and related eco-system degradation in recent 30 years. These include drying-up of rivers, decline in groundwater levels, degradation of lakes and wetlands, and water pollution. It is shown that 4,000 km of the lower reaches of the Haihe River—some 40% of its length—has experienced zero flows and, as result, parts of this river have become an ephemeral stream. The area of wetland within the Basin has decreased from 10000 km^2 at the beginning of 1950s to 1000 km^2 at present. Over-extraction of groundwater occurs beneath 70% of the North China Plain, with the total groundwater over-extraction estimated at 90 billion m^3. Understanding causes of this un-health water cycle and integrated water resources management will be key issues in this important region in China. Basically, big challenges on sustainable water resources focus on impact of climate change and human activities on water resources. For example, there are today some 45000 large dams operating in the world, 22000 of these dams are in China. Climate change and land use and cover change have significant changed land hydrological processes. For the Haihe River Basin of North China, it was shown that the amount of surface water resources had reduced 40% related 20 years ago case in the same precipitation condition. Impact of human activity and climate change on water cycle and social-economics and eco-system still have much unknown science problems, that becomes to key limited factor for China new water security policy, namely Building Society of Saving Water to change environment. New challenges in the 21st century in sustainable water resources in China will focus on:

(a)Understanding water cycle process under a changing environment, i. e. climate change and human activity;

(b)Quantifying water security linked with social-economic and environment issues to support the sustainable management of water resources.

(3)Critical global water problems:

—Drinking water issue (Surface water and ground water)

—Agricultural water issue

—Urban water issue (including water recycling etc.)

—Eco-water issue (river, lake, wetland, land and coast eco-system etc.)

From point of review for scale issue: Global and regional water system. Considered aspect will focus on water quality and water quantity.

The most need countries for IAP study could be from developing and under developing countries, particularly in Africa countries, Asia countries and others.

2 Role of New IAP Study on Sustainable Water Resources in China should be Addressed as Following Two Points

(1) Leading role in front domains of water problem challenges in the future by its interdisciplinary advantages on natural science, social science, economics etc.

(2) Closing the gap between water management requirement and water science development to support water sustainable use and management, particular for developing world like China and other counties.

So, it is should be discussed IAP how to play role in national water policy such as evaluation of national water resources security, developing trend analysis, water resources demand prediction, and making decision support of national or regional water policy.

3 Proposal for Water Programme and Actions of New IAP Study on Sustainable Water Resources in China

China is a large developing country with different climate zones and significant impact of climate change and human activity. Chinese Academy of Sciences has more than 15 independent Institutes, such as Institute of Geographical Sciences and Natural Resources Research (IGSNRR) etc., involve water issue in different aspects. Center for Water Resources Research, Chinese Academy of Sciences (CWRR-CAS), is such the network to link those research groups and teams in CAS system, and linked with national and international cooperation bodies on water resources. Thus, proposal for new IAP study on sustainable water resources in China will suggested as follows:

(1) Developing the water cycle observation programme related to the earth observation system in China, and Global Water System Project (GWSP) in Asia region. By integrated multiple-scale observations, such as RS, land surface experiment stations and network that already built in CAS system and related Ministries in China and international bodies, strengthening capacity building to understand time-space change and variation of water resources to change environment.

(2) Supporting a number of key international cooperation projects of new IAP study on sustainable water resources in China.

3.1 Integrated study on multiple—scale water cycle system in China

Purpose of this project is to develop multiple-scale distributed hydrologic and water resources models to climate change and human activity, quantify interaction relationship of water for climate, water for ecosystem, water for society etc, build the integrated water cycle system to assess quantify impact of climate change and human activity on water security, to prove decision support to regional water resources sustainable use in case study

or regional study and whole China.

3.2 Decision support system of sustainable water uses in the process of globalization

The goal of this project is to establish decision support system facilitating the sustainable use of water at national and regional levels, to evaluate alternatives for promoting the sustainable development of China's socio-economy, food and water security in the process of globalization. The contents include: re-innovating some key technologies and exploring the relationship between regional socio-economic development and water supply and demand; developing an equilibrium modeling system of supply and demand of regional economy in China; establishing comprehensive simulation systems of water cycling, water supply and demand; linking all the models established into a unified decision support system of sustainable uses of water at national and regional levels.

3.3 Impact of water projects on water security and environmental restoration

It is a big issue, that river pollution and related eco-system degradation due to regional economic development and water project construction, in China. This project is to make use of water science knowledge to develop modeling tool to assess impact of water project on change of flow regime and related water quality and eco-system. Some of case studies in Huaihe River and Yangzte River in China are suggested. The project will focus on causes on change of water quality and quantity and river eco-restoration by water projects management and pollution control. Major contents include: (a) Observations for water cycle and related ecosystem change due to building water project and reservoir operation in river system; (b) Distributed modeling system to integrated major interaction and impacts due to building dam on physics, biology, chemistry and others; (c) Integrated assessment and operation system to evaluate the positive and negative benefits on economic, social and ecological aspects under the different change scenarios, and provide the best operation scheme for ecosystem restoration in health water cycle.

4 Proposal for Water Programme New IAP Study on Water Sustainability in Asia Region and Globe

4.1 Proposal for new IAP study on water sustainability

1) Concept of global water system (GWS): We are moving rapidly toward a fully global-scale and regional-scale pictures of a changing hydrosphere, the anthropogenic contributions to this change, and its consequences, water system could be defined as such water cycle and interaction system which linked three basic components among physical component, biological and biogeochemical component and human component (Fig. 1, C. Vörösmarty, 2005).

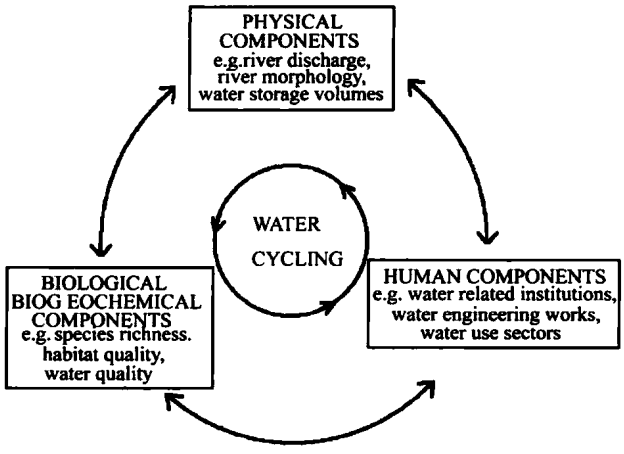

Fig. 1 Water system related to water cycle and major three components

Mission of GWS issue: To understand the ways in which the humans influence dynamics of the global/local water system and to inform decision makers on how environmental and socioe-conomic consequences of these impacts can be mitigated.

2) Proposal for new IAP study on sustainable water resources in the global and regional case studies will be suggested as follows:

A. Developing the evaluating project to assess and address the potential impact of climate change on the development projects and programmes of various organisations in representative regions/ developing countries and global scale.

Major area: Health water cycle and sustainable water management on drinking water (surface water and ground water), agricultural water, urban water, eco-water.

Study areas: Representative regions (such as Asia, Europe, Africa) and countries (e. g. China, India, Chad, South Africa etc.), and global scale.

The purpose is to develop a screening tool in terms of scientists study on water and related issue, to identify climate change impacts, and evaluate options for, and costs of, climate-proofing' development investments. Such a tool will become decision support part of the financial, social and environmental screening processes that are applied to development projects and water security issues.

B. Supporting a number of key international cooperation projects of new IAP study on global sustainable water resources, e. g. Global observation programme and information network of water system related to representative region (Asia and Africa etc.) and global water system. Integrated multiple-scale observations by remote sensing, land surface experiments network that already built in CAS system and international cooperation to understand time-space change and variation of water resources to change environment.

C. Organizing international workshop/symposium on new IAP study on sustainable water resources in China. Topics could be discussed and given by

(a) Water cycle and water resources vulnerability

(b) Impact of climate change and human activity on sustainable water resource

(c)Synthesis approaches of water high efficiency use
(d)Eco-hydrology and related eco-sustainability
(c)Integrated water allocation and management.

Acknowledgments This study were supported by the Knowledge Innovation Key Project of the Chinese Academy of Sciences (KZCX2-YW-126), and the Special Fund of Ministry of Science and Technology, China (2006DFA21890).

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I. CLIMATE CHANGE AND WATER RESOURCES

Variation of Temperature and Precipitation Extremes in the Yangtze River Basin from 1960 to 2004

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Abstract The present study is an analysis of the observed trends of temperature and precipitation extremes over the Yangtze River from 1960 to 2004 on the basis of the daily data from 147 meteorological stations. The intention is to identify whether or not the frequency and intensity of extreme events has increased with climatic warming background. Sen's method is performed to detect trends of extremes and statistical significance is assessed using the Mann-Kendall test.

Trend test reveals that the annual and seasonal mean maximum and minimum temperature trend is characterized by a positive trend and the strongest trend is found in the winter mean minimum in the Yangtze River. However, the observed significant trend on the upper Yangtze River reaches is less than that found on the mid-lower Yangtze River reaches and the mean maximum is much less than that of the mean minimum. Intensity of extreme minimum temperature is on the raising and frequency of extreme minimum temperature is on the declining significantly when averaged over the upper and the mid-lower Yangtze River, but emphasised in the western upper reaches and eastern mid-lower reaches. While, insignificant increasing trends for intensity of extreme maximum temperature over the most of the Yangtze River Basin, weak positive trends over the upper reaches and slight negative trends over the mid-lower reaches for frequency of extreme maximum temperature are observed.

The monsoon climate implies that precipitation amount peak in summer as does the occurrence of heavy precipitation events. The trend test has revealed a significant trend in summer precipitation, significant positive trends for intensity of extreme heavy precipitation over the mid-lower reaches. And obvious increasing trend at 90% confident level is also observed for frequency of extreme heavy precipitation over the mid-lower reaches. Drought intensity decreased over the upper reaches, but increased over the mid-lower reaches. While, drought frequency increased significantly both over the upper reaches and the mid-lower reaches. Aggravation of drought situation is obvious at the southeastern upper reaches, southeastern and northeastern mid-lower reaches in autumn season.

Key words: Variation of temperature; precipitation extremes; Yangtze River

1 Introduction

Extreme climatic and weather events are one of the most deadly and costly natural disaster in the world. Shifting of the frequency and intensity of the extreme events has more far-reaching impact on the nature and human society than do changes of the mean