China Country Water Resources Partnership Strategy (2013-2020)

THE WORLD BANK

WATER PARTNERSHIP PROGRAM

China Country Water Resources Partnership Strategy

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Acknowledgments

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Abbreviations and Acronyms

AAA	Analytical and Advisory Assistance
CPS	Country Partnership Strategy
CUW	Consumptive Use of Water
CWRAS	Country Water Resources Assistance Strategy
CWRPS	Country Water Resources Partnership Strategy
EC	Environment Carrying Capacity
EPB	Environmental Protection Bureau
ET	Evapotranspiration
FFWS	Flood Forecast and Warning System
GCC	Global Climate Change
GEF	Global Environmental Facility
GWP	Global Water Partnership
IRBM	Integrated River Basin Management
IWEM	Integrated Water and Environment Management
IWRM	Integrated Water Resources Management
KMS	Knowledge Management System
M&E	Monitoring and Evaluation
M&I	Municipal and Industrial
MCA	Ministry of Civil Affairs
MEP	Ministry of Environmental Protection
MLR	Ministry of Land and Resources
MOC	Ministry of Construction
MOF	Ministry of Finance
MWR	Ministry of Water Resources
NDRC	National Development and Reform Commission
RWS	Real Water Savings
SAP	Strategic Action Plans
SFA	State Forestry Administration

SIDD	Self-financing Irrigation and Drainage Districts
SNWT	South-North Water Transfer
WCP	Water Conservation Project
WPP	Water Partnership Program
WRMPP	Water Resources Management Policy Paper
WRT	Water Rights Transfer
WRSS	Water Resources Sector Strategy
WSC	Water Supply Company
WUA	Farmer Water User Association
WWDP	Wastewater Discharge Permit
WWPS	Water Withdrawal Permit System

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Executive Summary

Background

This report presents the outcome of the World Bank's analytical and advisory work to assess the status of water resources development and the key water issues and challenges facing the country. The Bank has also reviewed its history of cooperation with the Government of China in recent decades, and notes the remarkable achievements China has made in developing the water sector. The report proposes solutions for tackling the enormous challenges facing China in the sector. The central priority is to ensure sustainable utilization and management of water, land and related resources at the national, basin, regional and local levels.

Despite relatively poor endowments of land and water by international standards, China's economy has developed extremely rapidly over the last three decades, supporting 21% of the world's population with 9% of the world's arable land and only 6% of the world's water while simultaneously lifting some 400 million people out of poverty.

It is noted in the national water resources master plan recently completed by the Ministry of Water Resources (MWR) and the National Development and Reform Commission (NDRC) that China's water resources are under stress from the combined demands of agriculture, industrialization, urbanization, population increases and improving living standards. The impact is evident in regional falling water tables, inadequate flows to the environment, pollution, and so on.

In 2002, The World Bank, in consultation with the Ministry of Finance (MOF), MWR and other related ministries and agencies formulated the China Country Water Resources Assistance Strategy (CWRAS). That

document reviewed the major water resources challenges and related government priorities in China, and analyzed the general strategic themes and key issues. It was instrumental in laying the groundwork for a comprehensive Bank-supported water program in China.

With the Government of China now setting its agenda and priorities for water sector for the next decade, it is an opportune time for the Bank, to review and update the 2002 CWRAS to address current water-related issues, incorporating experience and lessons from various studies and projects in China and other countries.

Country Context

China has made very substantial progress in developing, and managing its water resources in the last three decades. Most major rivers are now effectively protected from floods; irrigation development has reduced the impact of droughts; China is the world leader in hydro-power capacity; huge areas have been preliminarily protected from water-induced soil erosion; food self-sufficiency has been achieved; and the coverage of water supply systems has increased. Some 400 million people have been lifted out of poverty – a unique achievement. However, the country's economic development is critically dependent on solutions to water-related problems. The following five strategic issues have been identified, which present the most significant barriers to China's economic growth and social development in the future:

- Risks of flooding;
- Water scarcity;
- Water pollution;
- Aquatic ecosystem degradation; and
- Under-improved management of water resources.

The priorities for the coming decade were set out by the Central Committee of Communist Party of China (CPC) and State Council in a policy statement in 2011 entitled "Decisions on Accelerating Water Reform and Development", specifying four strategic "big systems" to be established by 2020 to manage its water resources. The four big systems proposed by the Chinese Central Government are as follows:

- A system for flood protection and drought mitigation;
- A system for rational allocation and efficient use of water resources;
- A system for water resources conservation and river and lake health security; and
- A system for mechanism instrumental in scientific development of the water sector

These elements have provided a framework for identification of the components of the proposed partnership program.

China Country Water Resources Partnership Strategy

The World Bank is by now a trusted partner in China's efforts to address challenges in the water sector, as reflected in the title of this report. The approach recognizes important realities from both sides: from the Chinese perspective, it is now clear that the extensive approach to development – committing more and more resources and infrastructure to the water sector – must increasingly be replaced by an intensive strategy of making more productive use of the available resource; from the Bank's side, it is recognized that the scale of financial resources that it can commit are limited in relation to China's total program, so it is critical to identify areas of strong comparative advantage, with the potential for replication.

Each side is committed to address key water issues on the basis of the internationally recognized approach of Integrated Water Resources Management (IWRM), recognizing the interdependence of all water-related management and development activities within

the basin, the importance of water allocation based on economic efficiency and environmental protection and participation of users in the management process.

What distinguishes this new partnership strategy from the 2002 assistance report is that new developments and new situation in the water sector are reflected and specific areas of collaboration and support are identified now as part of a eight-year commitment from both sides. The shared perspective is that IWRM will underpin the cooperation strategy and guide the selection of actions and interventions to meet China's stated strategic goals and targets for the year 2020.

This Partnership Strategy commits the Bank and China to the elements and strategies to implement integrated water resources management and address emerging issues and problems in its journey towards China's stated strategic goals and targets for 2020. It is a plan for cooperation to be carried out by partners committed to the goal of enhancing water security of the nation – sustainable, green growth – based on Integrated Water Resources Management, while taking into consideration the specific conditions for water sector development in China.

This partnership strategy is aligned with the Bank's China Country Partnership Strategy (2013-2016), and is closely related to Strategic Theme One: Supporting Greener Growth, Outcome 1.5 for Demonstrating Sustainable Natural Resource Management Approaches - Implementing approaches of integrated water resources management at the river basin level, addressing multiple uses: water scarcity, flooding, pollution, water demands, economic instruments, and institutional aspects.

Applying the IWRM Approach

IWRM is a holistic approach confirmed in the 2002 Water Law of the People's Republic of China, integrating the regional management of water resources with river basin management within that of the broader socioeconomic and political frameworks.

Main difficulties normally experienced by countries implementing IWRM stem from an effort to carry out the principles simultaneously in one basin master plan, which made cooperation and coordination at all the levels excessively complicated. On the other hand, attempts to introduce IWRM at a local level often fail to produce significant results because what is assumed or planned at one level is often inconsistent with upstream availability or downstream commitments. Instead, a step-by-step approach is required, starting from resource availability at the basin level and progressively defining allocations, linkages, rights and responsibilities at lower levels. The process will be dynamic and must adjust to changes as earlier assumptions are refined. New information on the potential implications of interventions will flow upwards and downwards through the system, but the principle of tracing impacts on all users (including the environment) will continually guide the process.

Guiding Principles for Partnership Strategy

The Bank would support Integrated Water Resources Management (IWRM) at the river basin level, and further down to the administrative and water-user levels to address various water issues, particularly to facilitate a shift from current resources-intensive development patterns to more resources-efficient development patterns, maximizing the economic value of each drop of water while minimizing negative environment impacts, and contributing to the on-going sustainable, green and inclusive social and economic development in China. Success will

depend on a number of key factors, which are recognized by both partners:

- Political will and commitment;
- A clearly understanding of the available basin resources;
- Participation and coordination mechanisms, fostering information-sharing and exchange;
- Capacity development;
- Well-defined and enforceable legal frameworks and regulations;
- Water allocation plans;
- Adequate investment, financial stability and sustainable cost recovery; and,
- Comprehensive monitoring and evaluation.

Based on the agreed approach of IWRM at basin level, and further down to administrative level and water user level, and the guiding principles set out above, the following six are specific strategies to support establishment of the "four big systems" by 2020 recommended by the No.1 Document of the Central Committee of the Communist Party of China, which have jointly been identified as key strategic issues: (1) flood protection and mitigation; (2) addressing water scarcity; (3) prevention and control of water pollution; (4) protection and restoration of the ecological environment; (5) good governance through improving water resources management; and (6) climate change adaptation.

Strategy for Flood Protection and Mitigation

With flood protection largely completed on the major rivers, the Bank would support China to develop integrated flood risk management and mitigation for small and medium-sized river basins, in addition to construction of physical protection works, including cost effective structural and non-structural measures to mitigate flood disasters. The following nine key areas need to be considered in short to long-term action plans to implement the strategy:

- Inclusion of integrated flood risk management into national flood management regulations, policies and investment system;
- Development of risk management based strategy for small and medium-sized river basin flood protection;
- Prior assessment of flood risk and catastrophic vulnerability;
- Combination of structural and non-structural control measures;
- Strengthening management of small/rural dams and barrier lakes;
- Establishment of emergency response and coordination mechanism between local governments and communities;
- Calamity prevention and emergency preparedness; and
- Demonstration of flood risk transfer and insurance mechanisms.

Strategy for Water Scarcity

The rapid progress in rural agriculture, urbanization, industrial development, and improvements in living standards have so far been based on continually increasing water use – with some negative results noted. In the irrigation sector, the Bank would support China's efforts to promote high productivity agriculture and tap new types of water sources in areas of water scarcity. Two categories of water scarcity can be distinguished: (1) physical scarcity, where there are not sufficient water resources available to meet all water demands, including environmental flows; and (2) economic scarcity, where there is a lack of investment in water infrastructure.

- In areas of physical water scarcity, where surface and groundwater resources are already being overused, the Bank would support actions to reduce consumptive use of water – consumption or evapotranspiration (ET) management – in agriculture, while increasing the production per unit of water consumed. This is especially important where aquifers, which provide 40% of the water

to the north of China – are over-exploited. Infrastructural and managerial improvements to increase water use efficiency would be supported, provided water consumption is capped at sustainable levels;

- In areas of economic water scarcity, the Bank would support investment to increase the irrigated area through improved water use efficiencies. The consequent increase in water consumption would be justified by the increased agricultural production from the more abundant water resources in these areas;
- The potential to utilize flood waters and non-conventional water sources (e.g. sea water or brackish water, etc.) to augment scarce supplies would be explored wherever feasible.

Strategy for Prevention and Control of Water Pollution

The No. 1 Central Government Document of 2011 requires China to strictly control the total amount of pollutant discharges into rivers, lakes or other water bodies, which should not exceed the carrying capacity of recipient water body in order to meet the water function zone targets. Prevention and control of water pollution is a major task for the Chinese water and environment departments. The Bank would support implementation of the water pollution prevention and control strategy by enhancing cooperation as follows:

- A joint conference-based decision making system for integrated water and environment management be established and set out for close cooperation of the water and environment departments at each administrative level of government;
- Water and environment departments work closely to determine the amount of pollution discharge to a receiving river/lake based on the target environment carrying capacity (EC) and target evapotranspiration (ET) allocated from the river/lake basin agreed with all stakeholders;
- Enhancement of M&E systems for both water quantity and quality monitoring, and pollution discharge standards are strictly enforced by both water and environment departments; and, related policies and regulations on pollution control are revised to support good practice.

Strategy for Restoration of the Ecological Environment

The Bank would support a partnership strategy with government agencies to restore the ecological environment by releasing water from existing consumptive uses and ensuring eco-environmental flow in rivers and lakes. A consumption-based analytical approach would help to:

- Facilitate decision makers to prioritize water demands of the various economic activities;
- Allocate target water consumption caps from the river basin level to water user level as the basis to determine the allowable amount of water withdrawal; and
- Monitor the actual consumption and impacts on eco-system conditions and recommend actions to reduce water consumption for economic purposes with trade-offs to restore the ecological environment to target levels set at the river basin level.

Strategy for Water Governance

China's leadership is well aware of the deepening crisis, in the water sector. Document No. 1 of 2011, sets priorities in regard to water resources management, protection of waterways and lake beds from encroachment, and improvements to the funding of infrastructure operation and maintenance.

In particular regarding water resources management, the central government has decided to accelerate water reform and development

through the strict enforcement of the "Three Red Lines": (1) to control total amount of water use or withdrawal from rivers and groundwater aquifers without exceeding planned targets; (2) to increase water use efficiency and resolutely restrain waste of water; and (3) to strictly control the total amount of pollutant discharge into rivers, lakes or other water bodies, which should not exceed the carrying capacity of recipient water body in order to meet the water function zone targets.

The Bank would support the Government's efforts to improve water governance through application of a strengthened Water Withdrawal Permit System with the concept of consumption management supported by the latest developed remote sensing technology on consumption management. Other strategic issues related to the improved water resources management by implementing the three "red lines" supported by the Bank include:

- Change from the traditional intensive use of water to a sustainable or efficient approach, and a more balanced social/economic development and ecological environment protection for sustainability;
- Introduce the integrated approach on control of the amount water use based on the ET management together with control of the amount pollutant discharge based on the EC to enforce the strictest water resources management with "Three Red Lines" as indicated above; and
- Strengthen the monitoring and evaluation system with the latest RS-based ET measuring technology to monitor the consumptive use of water, particularly to monitor and evaluate agricultural consumptive use of water and water productivity as important performance indicators for irrigated agricultural water savings.

Strategy for Climate Change

Due to impacts of global climate change, China has experienced frequent extreme weather events in recent years, showing a tendency towards multiplicity, concurrency and repetition of floods and droughts. It is an arduous task to adapt to global climate change. The World Bank supports the Government effort to adapt to the impacts of the global climate change in the following ways:

- Incorporate climate change into the water resources planning process;
- Strengthen planning and construction of water infrastructure with more attention to non-structure measures, e.g. application of integrated flood risk management system for flood prevention;
- Preparation for more severe extreme events;
- Shift the energy structure towards clean generation and low carbon consumption, e.g. to promote more small hydropower and wind power generation; and,
- Conduct related in-depth studies, and most importantly their application on adapting to the impact of global climate change in China.

Applying Lessons Learned and Continued Cooperation

In more than 30-years of cooperation between the World Bank and China on a wide variety of projects involving elements of each of the partnership strategies listed above, a great deal of experience and knowledge about the changing conditions has been gained along with real trust in working together to respond to short-, medium- and long-term priorities.

The main activities of the past working partnership have been carried out in the areas of river basin management, water savings in irrigation, participatory irrigation management through development and operations of water user associations (WUAs), combating flooding and water-logging and controlling droughts,

water and soil erosion control, water pollution control, identifying impacts of climate change on water resources development and utilization. These activities were funded through the Bank's lending program in China (IBRD Loans) and through grant-funded technical assistance for projects and studies on water including the World Bank's Analytical and Advisory Assistance (AAA) studies and Water Partnership Program (WPP).

In the coming years, based on the strategies identified in this report, China will welcome Bank support through AAA and WPP to thematic studies (achieving water and food security under climate change; flood management; ecosystem protection; and the role of infrastructure development) as well as pilot and demonstration projects through the Bank's Lending Program in China in specific locations, and more generally to develop the capacity of Chinese specialists to implement and disseminate the innovations on which sustainable, green Integrated Water Resources Management at basin level will depend.

The World Bank stated in its 2010 review that "Like all enduring partnerships, the China – World Bank partnership has evolved over the years… We have learned a great deal from the way China has fine-tuned and scaled up successful projects and adapted new ideas." The new partnership strategy set out in this paper is designed to help China adapt, successfully and sustainably into the future.

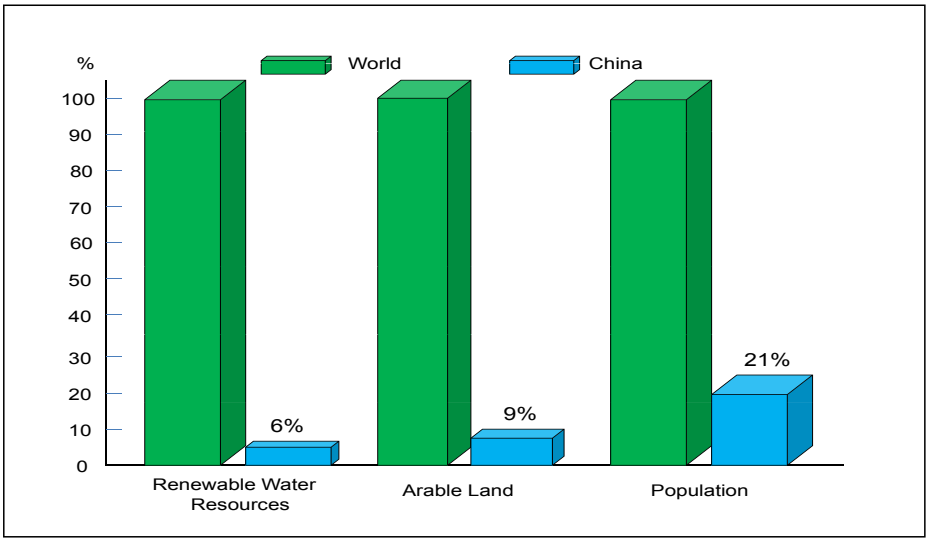
Chapter I – Introduction

1.1 Background

1. In preparation of this report, the World Bank has analyzed the context of water resources development in China and the key water issues and challenges facing the country. The Bank has also reviewed its history of the cooperation with the government of China in the area of water resources over the past decades, noting the remarkable achievements China has made in water sector development. The report was prepared as a joint effort of the World Bank and the Government of China to provide solutions for tackling the enormous challenges facing China in the water sector and to ensure sustainable utilization of water resources at the national, basin, regional and local levels.

2. Over the last six decades, exceptional progress has been made in the water resources sector. Nearly 30,000 km of river dikes and over 87,800 reservoirs have been constructed; effective flood control systems have been preliminarily established in major river basins; water supply systems now serve 400 million people in rural areas; erosion has been controlled in an area of over 1.068 million km^2; and hydropower capacity has increased to a total of 171,720 MW. Considerable progress has also been made in irrigation development, and China is now able to support 21% of the world population with only 9% of the world's cultivated land and 6% of the world's water resources, as shown in Figure 1-1. From this it becomes clear that the water sector is essential for ensuring China's development, and that the exploitation and management of China's water resources must be made sustainable.

Figure 1-1: China's Water Resources, Arable Land and Population in the World



3. China has a huge population and a rapidly developing economy. While poverty alleviation has reached an estimated 400 million people – a unique economic and social achievement – further rapid development will be needed to continue this process and support the ongoing urbanization. Industrialization will also continue at a high rate, but with more attention is paid to environmental sustainability. Water resources management will need to ensure a reliable water supply, provide food security through irrigation and agriculture, protect people and properties from floods, and protect the ecological environment. During the coming decades, China will need to make a huge effort to meet these challenges, because the negative impacts of over-exploitation and pollution are already evident.

4. From this it becomes clear that a healthy water sector is fundamental to ensuring China's continued development, and that the exploitation and management of China's water resources must be made sustainable. The World Bank is mindful of development trends and lessons in addressing water issues in China, as in other countries. The Bank also disseminates successful experiences internationally, believing that the challenge of water resources management is a common issue confronted by humans and governments, requiring strong cooperation among all stakeholders.

5. This report coincides with China's planning cycle for economic and social development. The government recently concluded implementation of its 11th five-year plan (2006-2010) for water resources management. Based on an assessment of achievements, it will prepare and initiate the 12th five-year plan (2011-2015) on water resources. It is thus an opportune time for the Bank, together with the Government of China, to review and update the basis for cooperation, which was last agreed in 2002.

6. At that time, the World Bank, in consultation with the Ministry of Finance (MOF), MWR and other related ministries and agencies such as the Ministry of Environmental Protection (MEP) and Ministry of Housing and Urban-Rural Development (MOHUD), formulated the China Country Water Resources Assistance Strategy (CWRAS). The Strategy was based on a review

of the major water resources challenges and related government priorities, and an analysis of the general strategic themes and key issues. It was instrumental in laying the groundwork for one of the best and most comprehensive Bank-supported water programs in the world. Over the past ten years, the World Bank has financed a number of projects and promoted water sector capacity building through its assistance strategy, introducing international experience and technology. The results of these efforts have been summarized in a recent publication for the 30th anniversary of the cooperation between China and the World Bank (1980-2010) entitled "Sharing Knowledge on Development and Promoting Harmony and Progress".

1.2 Existing Strategies and Principles

7. The 2002 CWRAS was developed cooperatively between the World Bank, the relevant Chinese authorities and other partners. It reflected water resources conditions in China at that time, and drew on relevant international experience. The strategy was also based on the Bank's 1993 Water Resources Management Policy Paper (WRMPP), which was updated in 2002.

8. In 2005 the World Bank published its Water Resources Sector Strategy (WRSS) which incorporates updated international experience in water resources development and management. The main messages of the strategy are:

- Water management and development are central to sustainable growth and poverty reduction and therefore of central importance to the mission of the World Bank;
- The main challenge is the implementation of integrated water resources management – in particular to coordinate water sector initiatives across all relevant sectors – based on a "pragmatic but principled" approach that promotes principles of efficiency, equity and sustainability. To be a more effective partner, the Bank must be prepared to back reformers and to pay more explicit attention to the political economy of reform in the context of existing institutional arrangements.
- The Bank's water assistance must be tailored to a country's circumstance and be consistent with the overarching Country Assistance Strategies and Poverty Reduction Strategy papers.

9. Both China and the World Bank share a commitment to the three "Dublin Guiding Principles to IWRM[1]" adopted by the international community as a basis for future water sector development:

- The ecological principle: water should be managed comprehensively (not through independent actions of water-using sectors) with the river basin as the development and management unit, with special attention paid to the environment; because development and utilization of water resources relates to water use for multi-sector economic development, the resources should be managed in an integrated manner. More attention should be paid to environmental protection in planning and executing water resources development and improving management between different areas in a river basin;
- The institutional principle: Water resources management is best done when all stakeholders participate, including the state (national and local governments and respective agencies), the private sector (water users), and civil society (public and environmental concerns). Actual water management should take place at the lowest levels possible in accordance with basin and local plans, and specifically involve participation by women; and

[1] The Dublin Guiding Principles to IWRM are based on the Dublin Principles, so called as they were adopted from the 1992 International Conference on Water and the Environment in Dublin.

- The instrument principle: water is a scarce natural resource and an economic good whose management requires greater use of incentives and economic principles to improve its allocation and enhance equity.

This partnership strategy is aligned with the Bank's China Country Partnership Strategy (2013-2016), and is closely related to Strategic Theme One: Supporting Greener Growth, Outcome 1.5 for Demonstrating Sustainable Natural Resource Management Approaches - Implementing approaches of integrated water resources management at the river basin level, addressing multiple uses: water scarcity, flooding, pollution, water demands, economic instruments, and institutional aspects.

1.3 Focus Areas of a New Partnership Strategy

10. On December 31, 2010 The Central Committee of Communist Party of China and the State Council issued its most influential document No. 1 entitled "Decisions on Accelerating Water Reform and Development" with a focus on the key water resources issues and targets to be achieved within the next 10 years.

11. In particular this document identified four strategic elements to be basically established by 2020: (i) a system for flood control and drought mitigation; (ii) a system for rational allocation and efficient utilization of water resources; (iii) a system for protection of water resources and restoration of ecological environment; and (iv) a system for governance of water resources. Each of these elements is entirely consistent with the principles of IWRM as summarized above.

12. As a long-term partner, trusted by the Chinese Government, the World Bank has, in close collaboration with Chinese officials, revisited the 2002 CWRAS to identify new priorities and relevant strategies in light of recent changes in the country, reflect a re-examination of the challenges facing the water sector and the necessary focus areas for development, and emphasize the special water resources "partnership" relationship that has developed between China and the World Bank.

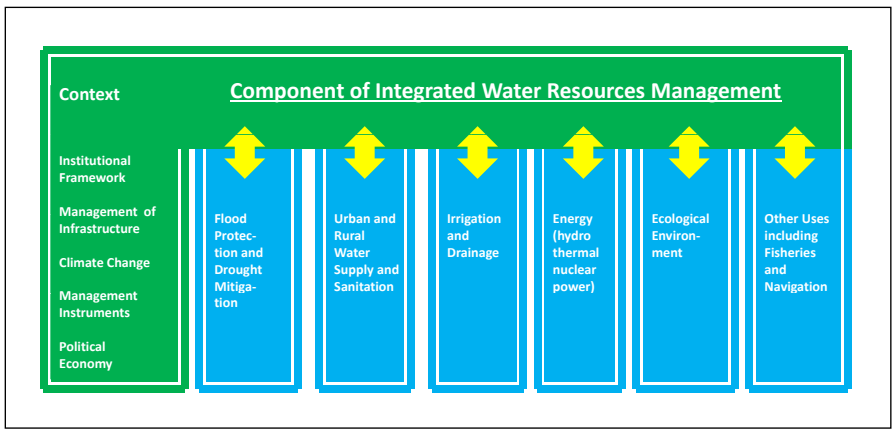
13. This report – the China Country Water Resources Partnership Strategy (CWRPS) – provides strategic direction for activities at the water-sector level in the short and long term that are consistent with the basin level strategies. The basin-level perspective enables better linkages to the needs of specific geographic and sectoral areas. This new Partnership Strategy also recognizes the potential for phenomena such as climate change to affect the hydrological cycle, with consequent implications at the local level.

14. In summary, this report aims to define a program of cooperation that will:

- Help the Bank to have a deeper understanding of the development and management conditions in the water sectors of China, and adjust its cooperation strategy and strategic directions so that the assistance to the water sectors will be more fruitful;
- Help the government to address the key problems and challenges confronting the water sectors; and
- Help other developing countries in the world in water sector development with various challenges on water issues by drawing on experience and lessons gained in water resources planning and management in China.

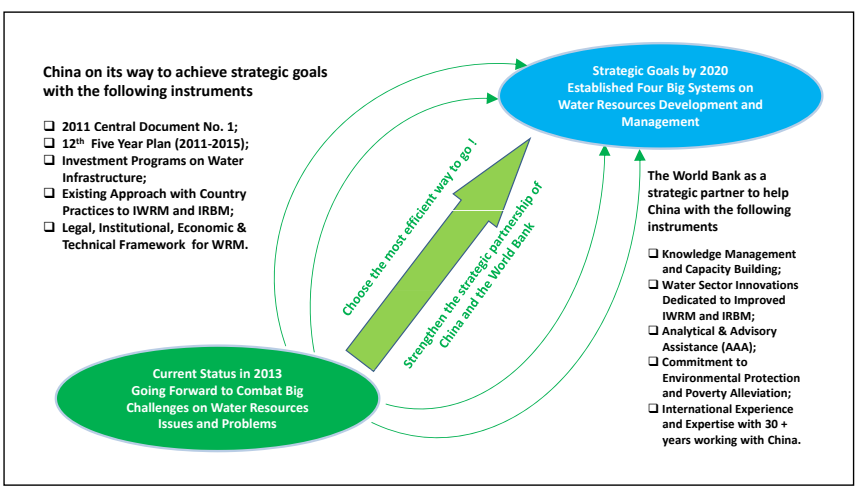
15. Figure 1-2 illustrates the sub-sectoral elements proposed for the partnership, in the context of the basin-level institutional framework, management of infrastructure, climate change adaptation, management instruments, and the political economy of water management and reform. In line with the proposed strategies, integrated strategic directions are proposed and coordinated with initiatives or innovations for each of the key water-related activities (shown in blue) such as flood prevention and drought

Figure 1-2: Context and Components of Integrated Water Resources Management
From the River-Basin Level to the Water-Sector Level



relief, water supply and sanitation, irrigation and drainage, hydro-power development, ecological environment, and other activities. By using this model, the Bank acknowledges China's long commitment to integrated water resources management and in particular with combined river basin management and local administration as set out in the 2002 Water Law of the People's Republic of China.

Figure 1-3: Road Map for Achieving Strategic Goals
Through China-World Bank Water Resources Partnership Strategy



[1] The strategic goals set in 2011Central Document No. 1: China will establish four big systems by 2020 to manage its water resources: (a) a system for flood protection and drought mitigation; (b) a system for rational allocation and efficient utilization of water resources; (c) A system for water resources conservation and river and lake health security; and (d) a system for mechanism instrumental in scientific development of the water sector.

1.4 Road Map for Achieving Strategic Goals

16. What distinguishes this Partnership Strategy from the 2002 assistance report is an agreed "road map" (See Figure 1-3) of areas for collaboration and associated specific activities, committing the Bank and China to address emerging issues and problems in over the next decade as determined by China's stated strategic goals[1] and targets. This road map is a plan for cooperation to be carried out by partners committed to the goal of enhancing water security of the nation, using an internationally recognized approach for integrated water resources management, taking into consideration the specific conditions for water sector development in China.

17. From the Chinese side, the Road Map is guided by the 2011 CPC Central Committee and the State Council statement on water policy for the coming decade, the 12th Five Year Plan in the context of existing legal, technical and economic conditions – including China's commitment to integrated water resources management at the basin level. The World Bank brings innovations based on international experience, capacity building in relevant areas, and a commitment to environmental protection and poverty alleviation. The Bank believes that with joint efforts, cooperation and collaboration will strengthen and accelerate China's current rate of progress.

18. The following chapters describe in more detail the strategic issues, country context, coperation between China and World Bank, and partnership strategies in the water sector. In the final chapter, specific proposals for actions within the Partnership are identified.

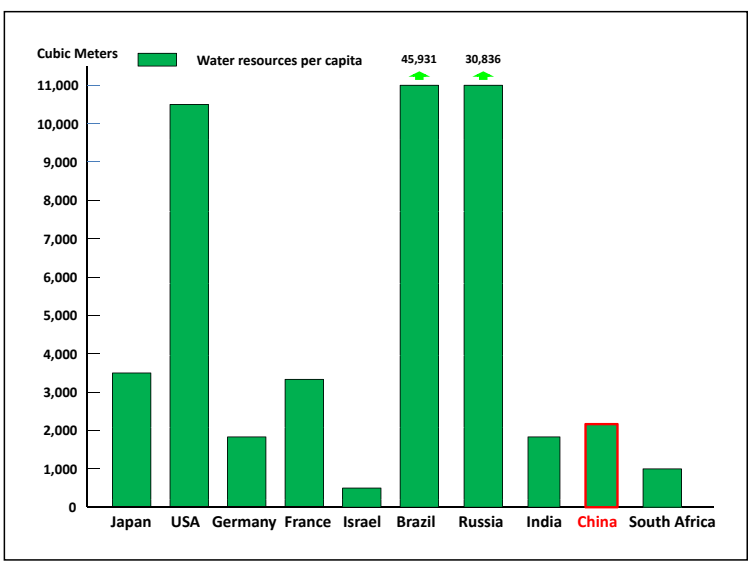
Chapter II - China's Water Resources and Strategic Issues

2.1 Water Resources Overview

Relative water availability

19. The availability of water resources per capita in China is less than one third of the global average. Each year, the amount of renewable water resources in China is around 2,841 billion m^3. With a population of 1.34 billion, the per capita share is only 2,120 m^3, which is low compared to more water-rich countries like Brazil, Russia, the United States, Japan, and France (see Figure 2-1).

Figure 2-1: Comparison of Water Resources Per Capita in Selected Countries



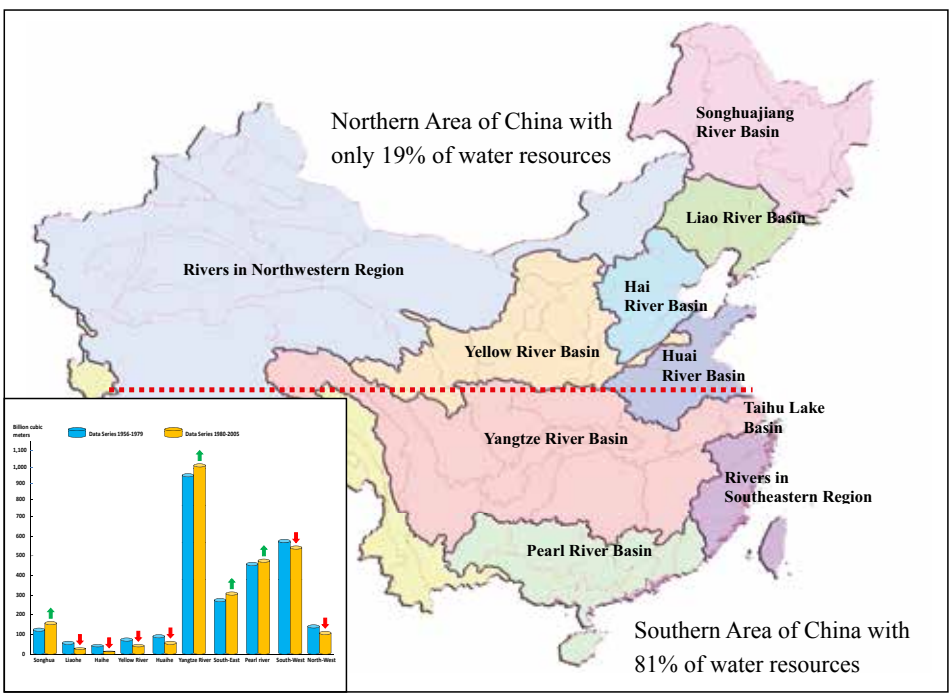
Temporal distribution

20. About 60 to 80% of the total precipitation is concentrated in the rainy season. Water availability varies dramatically intra- and inter-annually. In the north, for example, the annual runoff in a very wet year can be up to six to ten times higher than the runoff in a very dry year. The occurrence of dry years is particularly frequent in the north, where the flow in many rivers may be below average for three to eight years in succession, while in the south below average flow sequences rarely exceed four years.

Spatial distribution

21. Physical and per capita availability of water varies sharply between the north and south. Some 81% of China's water resources are concentrated to the south of the Yangtze River (see Figure 2-2), where 60% of the population live. The north, where most major grain production areas are located, only has access to about 19% of water resources, the per capita availability is only about 900 m^3 per year, far below the national average, and below the internationally accepted level for water stress.

Figure 2-2: Water Distribution between North and South China



2.2 Trends and the Impact of Climate Change

Changes in water availability in China's major river basins

22. According to the results of recent water resources assessment, there has been a significant change in regional distribution of water resources over the last two decades in China. Comparing the hydrological series of 1980-2005 with those of 1956-1979, the four water resource regions of the Yellow River, Huai River, Hai River and Liao River in the north show a reduction of 6% in average precipitation, 21% in river runoff and 13% in total water resources. Of the four, Hai River region sees a decrease of 11% in precipitation, 45% in river runoff and 28% in total water resources. There is a dramatic difference between the south and the north where there are much less water resources (as indicated in Fig. 2-3).

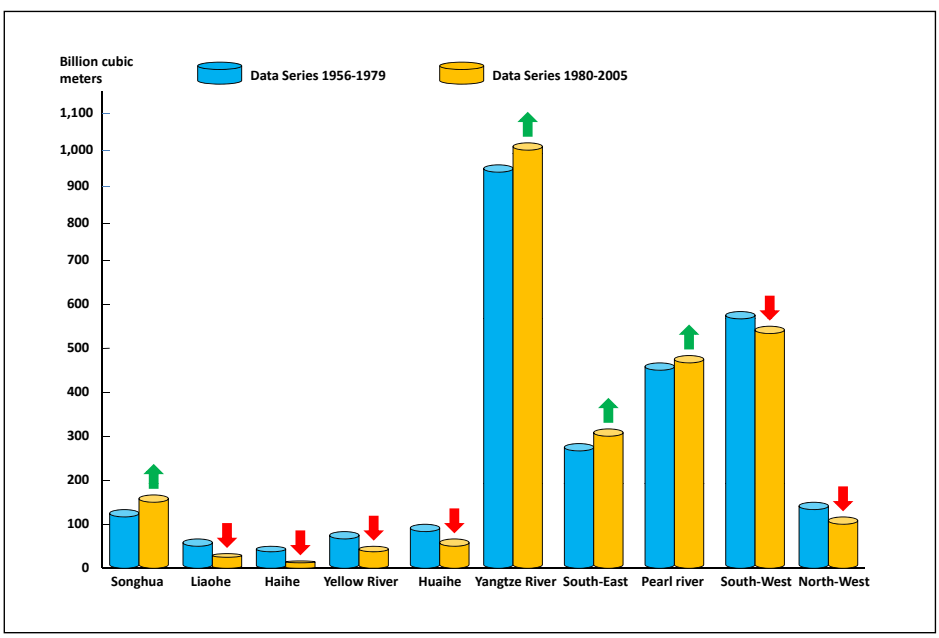
Projected water availability trends

23. With global climate change, extreme weather events happen more often. It is likely that there will be more frequent, intense and uncertain calamities such as flood, typhoon and drought so on. But China's capacity for adaptation to natural calamities is clearly insufficient and its economic and social development is still facing serious threats of flood and drought.

2.3 Strategic Issues for China's Water Resources

24. China's natural hydrological situation combined with impacts of climate change all contribute to variability in the availability of water across the country, between years, and even between seasons. Combined with growing water demands to support China's social and economic development, this is causing many complex water problems.

Figure 2-3: Impact of Climate Change on Water Availability in China's Major River Basins



25. The following four strategic issues present the most significant barriers to China's growth and development: (a) risks of flooding; (b) water scarcity; and water security for food security; (c) water pollution, and ecosystem degradation; and (d) under-improved water resources management. Further information on each of the above issues is presented below.

Strategic Issue 1: Risks of Flooding

26. Following the substantial improvement of flood prevention systems along China's main rivers, the relative number of flood disasters along small and medium-size rivers – where flood-protection infrastructure and management are still inadequate – has been growing. Each year, flooding along smaller rivers results in a severe loss of life and property. This flooding will increase with the impact of climate change.

27. More than 90% of the flood-related disasters over the last 10 years were in small towns and cities, and in rural areas, and in most cases were caused by landslides and flash-floods. In 2010 alone, such events resulted in 2,690 deaths and left 1,170 missing in an extraordinary flood and debris flows occurred in Zhouqu of Gansu Province. In total, the floods in 2010 affected 140 million people and 7 million hectares of agricultural areas across 28 provinces and regions. The direct economic losses are estimated at about US$ 40 billion.

28. Factors that contribute to these flood-related disasters are the low standards for flood control for medium and small rivers, the fact that more than 48 thousand small-sized reservoirs need structural improvements, and the large number of unsafe gates in dykes and dams. The capacity to monitor and avert mud-rock flow, landslides, flash floods and other calamities is also seriously inadequate, as are the drainage systems in areas prone to water-logging, and the protection against storm surges along the coast.

29. Priority areas to be addressed include:

- Policies to ensure availability of investment, particularly in non-structural measures and increased funding improve flood management along medium and small rivers;
- Land use planning: urbanization is proceeding at an unprecedented rate, often at the expense of floodways, which are increasingly being used for settlements and other human activities. The challenge is to coordinate flood control and disaster mitigation with economic development, especially in smaller towns, where planning and enforcement are weakest;
- Introducing cost effective standards for flood control based on systematic risk assessment, and upgrading poorly maintained, ageing infrastructure. Again, the focus would be small and medium rivers;
- Risk assessment and related mitigation measures for the large number of small dams that were designed with very low standards or are maintained. Of the 87,800 dams in China, 90% are small with storage capacity of less than 10 million m^3.
- More effective management of small and medium rivers: irrational earth extraction, human barriers and obstructions of the water flow, garbage contaminating and clogging the drainage system and rivers, and land reclamation for farm and town development in floodplains and stream are common, violating river management regulations, reducing water flow and increasing flood risk;
- Flood control plans for vulnerable, mostly small cities: of the 639 cities in China which are required to prepare flood control strategies, 567 are small and medium cities located along tributaries of major rivers or medium and small rivers. Many are vulnerable to flood risk and priority should be given to their needs, based on a comprehensive river basin approach;
- Improved flood risk awareness. A major problem faced in the current flood control and disaster mitigation endeavors is the

poor flood risk awareness of most of people. Flood risk awareness of some governments, of stakeholders and of the general public is generally not strong, reflected by lack of understanding of flood risk and vulnerabilities and wrong assumptions about effectiveness of flood control works, which has resulted in inadequate flood disaster preparedness and response, delaying and hampering full economic recovery;

- Improvements to real-time flood warning systems: in many small town and rural areas, the impact of floods on vulnerable people and costs of each event could be reduced by improved information and quicker response for smaller events in remote areas;
- Introduction of a unified approach to applying both structural and non-structural measures for flood management, including engineering measures, land use planning, small watershed management, flash flood management and urban flood management. Basin wide planning is required, but, smaller and medium-sized rivers are a priority for implementation of works;
- Integration of potential impacts of climate change and land use on flood management planning: substantial information is available on the type and pace of changes that may be expected and the consequence to intensified rainfall and flooding.

Strategic Issue 2: Water Scarcity

30. Shortage in Cities: There has been serious water scarcity in the semi-arid and arid north and west part of China. In those areas, water resources are naturally scarce, and the region's social and economic development currently depends on over-exploitation of surface and groundwater resources, which has a negative effect on water quality and leads to a general degradation of the environment. Water scarcity in the northern areas is also likely to be exacerbated by climate change.

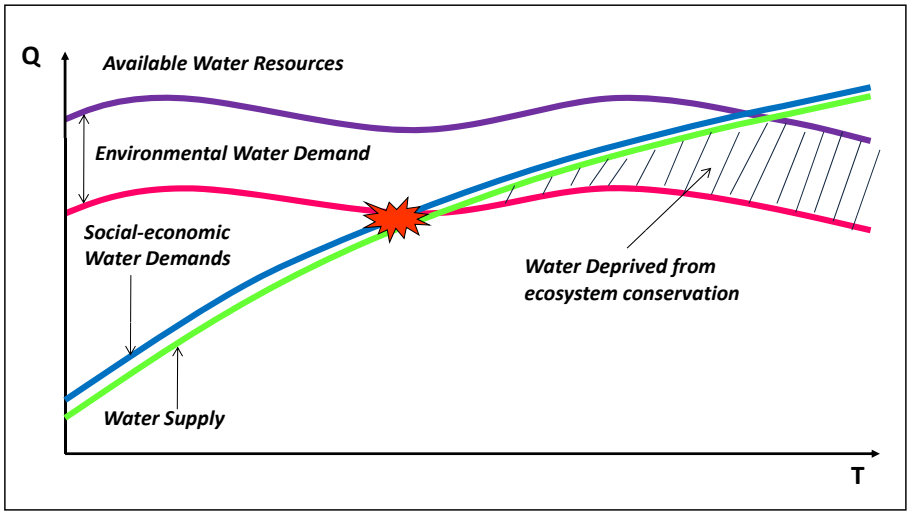
31. Over the last 30 years, in China's northern areas the weather has generally become drier. In the north, the surface humidity index has been relatively low for 28 years in a row. Every year an average of 15.3 million hectare (230 million mu) of farmland suffers from drought calamity, and nearly two thirds of the cities in China are short of water to various degrees.

32. Nearly half of China's population lives in water-shortage areas in the north. The north is also where most of the country's maize, wheat and vegetables are grown, and where the capital and other mega-cities. Water is even scarcer in the arid lands in the northwest. While rich in mineral resources, the area lacks sufficient water resources to meet current water demands. The economic development of these regions partially depends on the over-development and utilization of surface and groundwater resources.

33. As a result of the over-exploitation and utilization of groundwater resources, more than 160 groundwater-overdraft areas have identified, covering a total area of 190 thousand km^2. Each year, groundwater withdrawals are estimated to exceed recharge by 22 billion m^3. In the Hai river basin – home to both Beijing and Tianjin – shallow water tables have dropped by up to 50 meters and deep ones by up to 90. Some groundwater aquifers are fully dewatered.

34. The over-exploitation of these ground and surface water resources has decreased their long-term carrying capacity for economic and social development. Many rivers and lakes have dried up, wetlands have shrunk, groundwater levels have declined, and the water cycle system has partly been damaged. Over-exploitation of water resources in the semi-arid and arid areas has not been controlled. The economic growth in these basins or regions is already at the expense of ecological sustainability and eventually will threaten economic development as shown in Figure 2-4.

Figure 2-4: Impact on the Environment of Increasing Demand for Water



35. Food Security: Water Scarcity has become an issue for food security with increasing impact of climate change in China. Inadequate irrigation infrastructure and agricultural extension systems in the main grain producing areas[1] are affecting grain production. Every year, about 13% of the irrigated area suffers from severe water scarcity as a result of dry weather events and drought. The percentage may gradually increase with impact of climate change in the future.

36. China's total irrigated area accounts for 48% of total arable land. About 40% of the large-scale irrigation systems and 50% of the medium and small-scale irrigation systems are not fully functional because of their age, and poor operation and maintenance. Moreover, some on-farm systems are incomplete and therefore unable to deliver water to the designated area. This has resulted in many land areas with an insufficient water supply for irrigation and consequently low agricultural yields.

37. About 52% of China's arable land is rain-fed. As the risks of long-term droughts are increasing due to climate change, grain production could be reduced not only in the semi-arid north, but also in the water-abundant southwest. In recent years, the extraordinary droughts occurred many times in this region and other recent large drought events have shown that drought in the southwest are now a regular threat.

38. The response system to drought emergencies is not complete. Recent droughts have exposed several problems that hinder an effective response: (a) a lack of irrigation systems, (b) insufficient water reserves, (c) incomplete systems and mechanisms for drought emergency management, and (d) a particularly weak capacity to respond to persistent and severe droughts.

[1] China has thirteen major grain production areas, namely Henan, Hebei, Sichuan, Anhui, Heilongjiang, Jilin, Liaoning, Hubei, Hunan, Jiangsu, Jiangxi, Inner Mongolia and Shandong and other areas.

39. Inadequate infrastructure and infrastructure management has weakened the protection of the main grain production areas against flood and water-logging events. With global climate change leading to more extreme flood and drought events and an increase in the frequency, intensity and uncertainty of flood and water-logging events, typhoons and other calamities, China's capacity in the field of agriculture for natural disaster mitigation needs improvement. Flood and water logging calamities will continue to pose a serious threat to the country's grain production.

40. The other key issues related to water scarcity are:

- The average water productivity in the irrigated areas is only about 1.0 kg/m^3, compared to 1.5-2.0 kg/m^3 in other countries.
- Inefficient use of water and a frequent wasting of water resources. Even though current production methods and technical conditions limit water conservation efforts, many opportunities remain to save water in industries, domestic use, and irrigated agriculture by linking water withdrawal to consumptive water use needs.
- Consumptive use of water in cities and towns when wastewater is reused for agriculture has resulted in more serious water scarcity in downstream regions and areas.
- Little appreciation for the economic value of water resources. Efforts should be made to ensure that water is valued as a resource and only used for products with relatively higher values.

Strategic Issue 3: Water Pollution and Ecosystem Degradation

41. China's rapid social and economic development is resulting in increased water pollution, water-loss and soil-erosion, and a degradation of the ecological environment. Water pollution is now one of the biggest environmental challenges in China. Water quality in rivers and lakes nationwide has deteriorated. In some rivers and reaches, water resource functions have been degraded or lost, threatening the entire water ecosystem. According to official data, almost 50% of existing water function zones does not meet national water quality standards.

42. China's water systems will continue to be under immense pressure as a result of the pollution from outdated production processes. While the government is heavily focused on energy conservation and emission reduction, investment in environmental protection facilities such as in-factory waste treatment equipment and wastewater treatment plants, can put a tremendous burden on local enterprises and even lead to unemployment and other social problems. Consequently, dealing with industrial and domestic wastewater will require long-term attention. Moreover, domestic pollution from cities and towns, point-source pollution from industrial enterprises, and diffuse (non-point source) pollution from agricultural development in the vast rural areas will continue to grow and together form one of the greatest threats to water safety. Water quality is now at the core of China's water-related challenges, perhaps posing an even greater threat to development than the water scarcity and flooding risks discussed above.

43. Water-related soil erosion is also a growing cause of environmental degradation. One third of all lands have already seen water-related soil erosion, with about 1.61 million km^2 of land affected by water erosion and about 1.95 million km^2 by both wind and water erosion. Although improvements at the watershed level, such as the return of farmland to forest and other water conservation measures adopted by the government, have yielded some positive results, the intensive use of farmland, mining, construction, and other economic activities continue to contribute to soil erosion and a wasting of water resources through non-beneficial evapotranspiration. Many areas are at risk and

slope farmlands, erosion ravines, hill collapse areas, and stone desertification areas urgently need to be improved prevent further erosion.

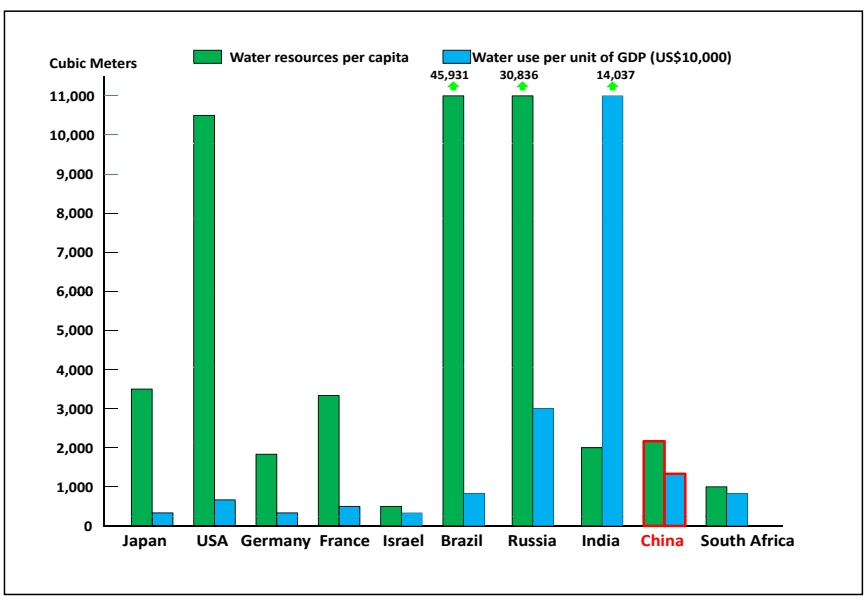
Strategic Issue 4: Improving Water Resources Management

44. The current, "resources-intensive" approach to water resources management, which depends on ever greater consumption of water, needs to be replaced by a sustainable, "resources-efficient" approach in order to support more balanced social and economic development while protecting the ecological environment.

45. China's limited water resources will require careful water resources planning. Figure 2-5 shows that while China's per capita water resources are much lower than those in Japan, the United States, Germany, France, or Brazil, its water use per unit of GDP is much higher.

46. Table 2-1 illustrates China's pattern of water use compared to other countries with similar income levels[1].

Figure 2-5: Water Availability and Per Capita GDP – Selected Countries



[1] Data sources: The figures for China are based on the national database for 2008; and for other countries from the "International Statistical Yearbook 2009"; and FAO database on water resources; and Amount of water use does not represent consumptive use of water. For the same amount of water use or withdrawal, consumptive use of water varies with water use efficiencies, particularly for irrigated agricultural water use.

Table 2-1: Water Use and GDP Data by Country and Income Group

County		Water Resources Per Capita (m^3)	GDP Per Capita (US$)	Water Use Per Capita(m^3)	Water Use for Agriculture (%)	Water Use Per Unit of GDP US$10,000 ($m^3$)	Water Use Per Unit of Added Industrial Value US$10,000($m^3$)	Daily Water Use Per Capita(Liter)
High Incomes	Japan	3,373	36,612	693	62	189	104	374
	U.S.	10,491	33,575	1,647	41	491	935	573
	Netherlands	5,651	23,915	493	34	206	496	187
	Germany	1,867	23,037	571	20	248	554	193
	U.K.	2,475	24,286	161	3	66	177	285
	France	3,409	22,189	668	10	301	980	287
	Canada	92,692	23,154	1,469	22	635	1,313	355
	Italy	3,290	18,901	765	45	405	523	381
	Australia	25,097	20,664	1,219	75	590	220	492
	Israel	281	19,100	289	56	151	27	298
	Spain	2,682	14,031	860	68	613	389	317
	South Korea	1,474	10,822	393	48	363	146	384
	Group Average	9,337	27,292	1,003	42	367	588	395
Medium Incomes	Argentina	21,625	7,550	776	74	1,027	352	357
	Mexico	4,492	5,715	769	77	1,345	264	366
	Brazil	45,931	3,596	331	62	920	594	183
	Malaysia	23,910	3,722	372	62	999	415	172
	South Africa	1,073	2,853	268	63	941	179	229
	Turkey	3,051	3,810	599	75	1,572	487	250
	China	2,100	3,300	445	64	1,340	890	131
	Thailand	6,648	1,989	1,412	95	7,099	416	270
	Russia	30,836	1,777	525	18	2,953	4,949	210
	Egypt	830	1,446	990	86	6,844	1,212	108
	Kazakhstan	7,366	1,225	2,342	82	19,109	7,811	163
	Group Average	8,893	1,807	521	68	2,884	1,611	166
Low Incomes	Philippines	6,026	955	359	74	3,755	1,098	126
	Ukraine	2,915	652	781	53	1,1981	11,667	260
	Pakistan	1,500	493	1,126	96	22,869	2,017	60
	India	1,753	425	597	86	14,037	2,919	132
	Vietnam	10,941	383	877	68	22,885	14,957	186
	Group Average	2,521	467	661	85	14,162	3,880	134
Overall Average		7,200	9,200	630	70%	1,000	840	200

47. Improving water management to meet the challenges of flood and water-logging, water scarcity, drought and pollution will have a number of dimensions and components. At the government level, sound water management must be based on long term as well as real-time information about the resource, shared among sectors, administrative units and users. Laws and regulations governing the sector must be consistent, complementary, and enforced. Further, institutional arrangement must promote cooperation and information sharing across sectors and administrative units. Among other benefits, this will facilitate appropriate reuse of water across sectors.

48. Within agriculture in water scarce areas – the dominant water consumer – careful attention needs to be paid to the impact of new technologies that allow farmers to irrigate larger areas with the same level of withdrawals, often increasing consumption at the expense of other users. The charges for irrigation services should reflect costs, and the funds available to operating agencies (from public sources, farmers, and potentially the private sector) must be stable and reliable – so that short term O&M as well as long term upgrading and rehabilitation works can be planned and the irrigation service made sustainable. Agriculture will generally have to reduce water consumption – to release water to the environment as well as other economic sectors – and this will require involvement of farmers in aspects of project design, implementation and O&M. Controlling the over-exploitation of ground and surface resources can be facilitated by information about water consumption rather than just water withdrawals.

49. In sum, China's water sector needs to support rapid urbanization and industrialization and guarantee water availability and better services. The country's capacity for water resources management, however, is insufficient. The ongoing and fundamental transformation of China's economic development pattern will present a big challenge to water resources management and improving water security.

2.4 Main Issues in China's Major River Basins

50. As indicated by the National Water Law (2002), China has adopted a mixed water management system which allows both river basin management and administrative or regional management for its water resources. Integrated Water Resources Management (IWRM) at the river basin level, and further down to administrative and water user levels is to be tested in local conditions under the current National Water Law in China. The ongoing reform and innovation in river basin management, however, is not yet complete and more reforms are necessary before attaining the level of the IWRM with principles recognized and set forth internationally (Section 1.2). Agency and inter-agency responsibilities for water resources administration and management are both horizontally and vertically divided, with responsibilities distributed among central ministries and among provinces, cities and counties. As a result, reaching the planned objectives at the river basin level – such as an allocation of water resources for economic activities, ending over-exploitation of water resources, protecting ecosystems, and establishing flood warning and forecasting systems – is difficult. China can take advantage of international good practices, adapted to and building on local conditions for institutional reform.

51. The large variation in geographic features and economic and social development across river basins implies that water resource management, assessments and evaluations would be best addressed separately for each of the country's ten major river basins. Table 2-2 summarizes the main issues and impacts of climate change on water resources for each of China's ten major river basins[1]. More detailed issues and proposed strategies for each area are given in Annex 4.

Table 2-2: Main Issues by River Basin

No.	Basin	Mainstream Issues/Problems
1	Songhuajiang River Basin	▪ Low standards for flood control; ▪ Both physical and economic water scarcities in local areas; ▪ Water and soil erosion in black soil regions.
2	Liaohe River Basin	▪ Both physical and economic water scarcities; ▪ Over utilization of water resources; ▪ Serious water pollution.
3	Haihe River Basin	▪ Serious physical water scarcity; ▪ Serious Groundwater overexploitation; ▪ Serious water pollution; ▪ Ecosystem degradation.
4	Yellow River Basin	▪ Both physical and economic water scarcities; ▪ Water and soil erosion at the middle-river reaches; ▪ High flood risk because of low water flow and high sediments; ▪ Serious water pollution in local areas.
5	Huaihe River Basin	▪ Frequent flood and drought disasters; ▪ Complicated tasks related to improvements of rivers and lakes; ▪ Serious water pollution.
6	Yangtze River Basin	▪ High risk of flooding; ▪ Difficult tasks for improvements of rivers and lakes; ▪ Serious water and soil erosion at the upper river reaches; ▪ Serious water pollution in part of river reaches and lakes;
7	Pearl River Basin	▪ Serious water pollution in the delta areas; ▪ Disasters from sea storm surge and river flooding; ▪ Sea water intrusion along coastal areas; ▪ Serious rock desertification at the upper reach of the Xijiang River.
8	South-East River Basin	▪ Serious disasters by sea surge storm; ▪ High flood risks for small and middle rivers flowing directly to the sea; ▪ Serious water pollution in some areas.
9	South-West River Basin	▪ Insufficient water infrastructure; ▪ Economic water scarcity; ▪ Serious disasters from mountain flood and debris flows.
10	North-West River Basin	▪ Physical water scarcity; ▪ Over utilization of water resources; ▪ Fragile ecosystems.

[1] Data source: Study reports (see references) on impact of climate change on China's big river basins.

Chapter III - Country Context of Water Sector Development

52. Lao Zi's "Tao Te Ching," the famous ancient Chinese philosophical classic, mentions that "water embodies supreme virtues, as it nourishes countless lives on the earth without contending for anything." For thousands of years water has been a symbol for the moral character of the human being. Since the times of Ta You, an ancient Chinese water engineer who lived more than 4,000 years ago, generations of Chinese rulers have regarded the tranquility of rivers as a key governance issue.

3.1 Development Progress in China's Water Sector

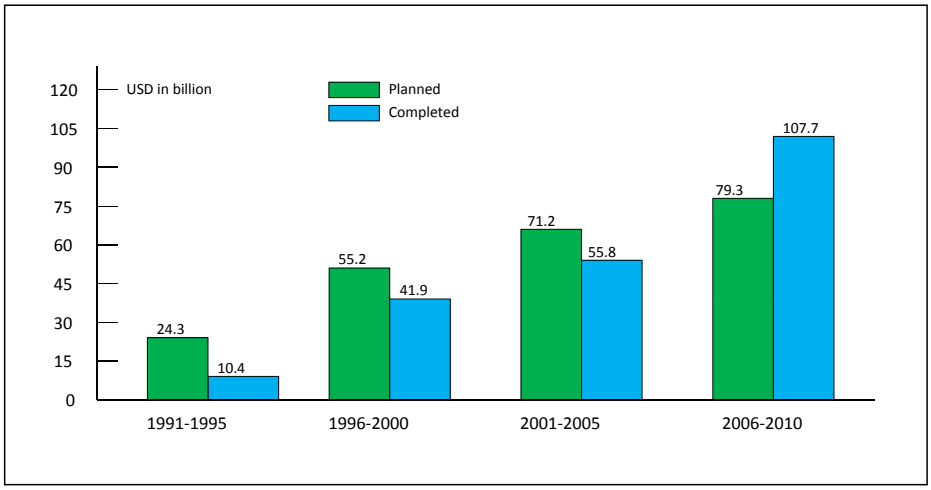
53. The Government of China attaches great importance to the challenges of developing and managing the nation's water resources. Droughts and floods are key constraints to China's social and economic development. The country has constantly intensified its investment programs[1] in water resources development and utilization, in particularly over the past 20 years as shown in Figure 3-1. At the same time, increasing attention has been paid to the management of water resources. A brief summary of about 60 key water projects is given in Annex 5.

Flood Prevention and Water-logging Control

54. Extensive infrastructure has been built to regulate floods in China's major rivers and lakes. By the end of 2010, the total number of (completed) reservoirs had increased to 87,800, with a total storage capacity of 716.2 billion m^3. In addition, nearly 300 thousand km of embankments and dykes for flood control and 44,000 water gates (including 500 big ones) were constructed.

[1] The investments in tap-water-supply networks and sewerage system in the urban or township proper areas were not included in the Programs, which were made from Provincial Governments and Central Government via Ministry of Housing and Urban-Rural Development.

Figure 3-1: Investment Completed in Water Resources Development (1991-2010)



55. Great progress has also been made with the rehabilitation of dams and reservoirs. During the 11th five-year plan period, more than 7,000 unsafe dams were reinforced. In the 12th five-year plan period, all the dams that are currently unsafe will basically be reinforced.

56. Substantial successes have also been achieved in flood prevention. From 1949 to 2009, the total direct economic benefit from flood control was US$595.5 billion and the average annual loss of people's lives from flooding was reduced from 8,976 in the 1950s to around 1,507 in early 2000s. About 170 million hectares of arable land was protected from flooding, leading to a reduction in annual losses of over 10 million tons of grain production.

57. Despite these successes, China still faces enormous challenges that nearly every year flood and water-logging events occur. Many places on the middle and lower reaches of the Yangtze, Huai, Songhuajiang and Pearl River basins are extremely prone to water-logging.

Drinking Water Supply and Quality

58. Drinking water services have expanded substantially over the last two decades, supporting social and economic development in the country. Many large, middle and small-scale water diversion and supply projects have been constructed, improving the supply to in rural areas. By the end of 2010, the annual water supply capacity supported by water works in China had reached over 700 billion m^3, which basically ensures the urban and rural water supply in a medium drought year. Since the 1980s, the government has accelerated its efforts to supply drinking water for the rural poor. By the end of 2010, about 1 million rural water supply works were built in rural areas, currently delivering drinking water to 400 million rural poor.

59. China also increasingly pays attention to the quality of drinking water. In the 11th five-year plan period, the central and local governments invested an additional US$15 billion to provide a safe drinking water supply for the rural poor. By the end of 2010, China provided safe drinking water for 300 million rural people, already substantially exceeding the United Nation's Millennium Development Goal for

2015. According to current government plans, problems related to drinking water safety will be completely resolved by 2015.

Irrigation and Drought Mitigation

60. Irrigation plays a critical role in grain production in China. The irrigated area[1] reached 60.3 million hectares (905 million mu) by 2010, accounting for 48% of the total arable land in China, producing about 75% of the total grain and 90% of the total cash crops in China. There currently are about 460 large-scale irrigation districts (over 20,000 hectares) with an irrigated area of some 17.5 million hectares, accounting for 29% of the total irrigated area.

61. The development of irrigation districts, water works supplementation and water-saving technique transformation in China has focused on increasing irrigation efficiency and minimizing losses. Over the past 30 years the effectively irrigated area has increased by about 8 million hectares (170 million mu) and grain production by 78%, while the total water supplied to irrigation has remained much the same. Nominally, losses have reduced from 65% to 50% by the end of 2010. However, more careful analysis of the National Irrigated Agricultural Water Saving Program is required, because some "losses" actually return to the ground as recharge to aquifers or runoff to rivers. Groundwater is increasingly overexploited, as much as 22 billion m^3 per year, with some of the overdraft areas located in areas falling under the national water saving program.

62. Despite successes, challenges remain: droughts are becoming increasingly serious – in 2006 a catastrophic drought took place in Chongqing Municipality and in the eastern part of Sichuan Province; in 2007, there was a widespread summer drought; in 2009, a spring drought occurred in some parts of China; and in 2010, another drought affected the southwestern region.

Water-Soil Erosion Control

63. Good progress has also been achieved in water-soil erosion control, which has played a key role in flash flood control and poverty alleviation in China's mountain and rural areas. By the end of 2010, the total improved water-soil erosion areas exceeded 1.068 million km^2. With soil and water conservation measures taken, an average of more than 1.5 billion tons of soil will be prevented from being eroded each year, increasing the total water storage to over 25 billion m^3 , and increasing grain production by 18 million tons, which has benefited over 100 million people and relieved 50 million people from poverty. About 62 large demonstration areas have been established in selected focal areas to demonstrate and extend the program benefits to other water-soil erosion areas.

64. Although watershed-level improvements, the return of farmland to forests, and other water conservation measures adopted by the government have yielded positive results, conflict between population and farmland continues. Mining, construction, and other factors continue to cause soil and water losses. In the near future, 24 million hectares of slope farmland, 442 thousand ravines caused by erosion, and many areas with either stone desertification or with hills about to collapse as a result of erosion urgently need to be improved.

Hydro-Power Development

65. Hydro-power generation has been a priority area for the development of clean energy. By the end of 2010, the installed storage capacity of

[1] China reports the "effective" irrigated area, as the physical area actually irrigated, thus excluding incomplete or dysfunctional parts of projects, and only counting once any areas that are irrigated more than once in the year. Thus a project designed to serve 100 ha, but actually irrigating 80 ha in one season and 50 ha in a second season would be recorded as 80 ha of effective irrigation.

hydro-power has increased to 230 million KW, ranking first in the world[1].

66. Substantial progress has also been achieved in small hydro-power development in rural areas, greatly benefitting the rural poor and helping alleviate poverty. By the end of 2010, the total installed capacity of rural small hydropower works reached 59,000 MW with an annual power production of 204.4 billion kWh, accounting for 26% of the total hydro-power capacity. About 99.6% of rural farmer households currently have access to electricity.

Development of Water Information Technology

67. Application of modern information technology has played an important role in flood prevention and drought relief in China. The country-wide flood prevention and drought relief command system is currently being established and will consist of 280 single units to cover the key target areas all over the country. So far, the 39 units have been located in the Ministry of Water Resources, river basin management authorities, and provincial water bureaus on a dedicated information network with video conference facilities. An additional 125 units for the collection of real time data and information are now under construction.

68. By the end of 2010, China had established 37,436 hydrological stations with a total number of 65,464 staff working on the hydrological services. In addition, various internet-based computer networks have been installed to support information sharing and acquisition in the field of office administration, flood and drought warning and forecasting, surface and groundwater resources monitoring, water-soil erosion monitoring, management of large-scale irrigation districts, and public water information.

Improved Water Resources Management

69. Since 1978, when economic development was defined as a central task, the Government of China has paid increasing attention to water resources management. The period has seen exceptional economic growth in all sectors, which has manifested itself in increased competition for water, industrial pollution, urbanization, and consequent degradation of ecosystems. Increased prevalence of droughts and floods, probably related to climate change, has further complicated the situation. The milestones and key historical events of the improved water resources management in China are as follows:

- 1979-1984: The first country-wide water resources assessment was carried out to determine the status of water resources development and utilization;
- 1985: The State Council decided to establish the National Coordinating Group for Water Resources Management; 1987: The Program for Water Resources Allocation of the Yellow River was issued and implemented, which formed the early concept and approach for water resources management in China;
- 1988: China's first "Water Law of the People's Republic of China" was promulgated and implemented, which, among other features, established the institutional and administrative frameworks for water resources management in the country;
- 1993: China's first "Water Withdrawal Permit System" was issued and implemented, which allowed collection of water resources fees and established review and approval procedures for use of China's water resources;
- 1996-2000 (the 9th Five-Year Plan period): The Ministry of Water Resources (MWR) put forth the new concept of water resources management and implemented it across the

[1] See "China Statistics Yearbook"

country, thereby acknowledging and acting on "the need for change from the traditional approach [of continuous expansion of infrastructure] to a modern and sustainable development approach [setting priorities for allocation of the available supply] for water resources development and utilization";

- 2001-2005 (the 10th Five-Year Plan period): China's first "Water Law of the People's Republic of China" from 1988 was updated and promulgated in 2002 and for the first time proposed that China performs "the approach for river basin management combined with administrative boundary management" for its water resources. Following this 2002 law, a proposal from MWR to build "a nation-wide water-saving oriented society" was approved and implemented;
- 2006-2010 (the 11th Five-Year Plan Period): The Government of China pushed forward the development of "a resources-efficient and environmentally friendly society," requiring further water savings, the monitoring and evaluation indicators of which include: (a) the amount of water use per unit of GDP or increased industrial output value and (b) the total amount of water use for a given river basin or a local government administrative areas.

70. The Government of China has treated water as a strategic national resource for economic development as well as for maintaining an ecosystem balance. The water sector is to support rapid social and economic development through sustainable utilization of water resources. A series of major transformations have taken place in the ideology of water resources management, reflected in the following principles:

- Human beings should deal with nature in a harmonious manner instead of placing infinite demands on the nature;
- Water resources are basic natural resources and strategic economic resources. They are controlling elements of the eco-environment and an important part of national security;
- Water resources are important to ensuring and improving the livelihood of the people and play an important role in facilitating poverty reduction and increasing public welfare;
- Implementing the strictest water resources management system will become necessary, including establishing the three "red lines" for water resources management, namely strictly implementing a control on the total amount of water use; continuously increasing water use efficiency; and strictly controlling the total amount of pollutant discharge into rivers;
- Implementing a shift from flood control to flood management is necessary, including giving equal attention to both the storage and discharge of flood water and offering flood waters a way out;
- Structural measures are combined with non-structural measures with importance attached to the effects of management;
- Development of a water saving society is deeply promoted to make sure that water saving technology and measures are implemented on a full scale;
- Importance is attached to the role of market mechanism[1] in water resources allocation to increase the efficiency of water resources utilization through water pricing mechanism, water right trading, and other activities;
- Emphasis is placed on integrated water resources management with attention paid both to water development, utilization and management and to water allocation, saving and protection;
- Integrated basin management is promoted to strengthen coordination and cooperation between different government departments, water use organizations and stakeholders.

[1] It is important to note that water is a national asset, so that water rights will be defined as rights of an individual or entity to use water rather than ownership rights.

71. In accordance with the Water Law of the People's Republic of China, China has developed and implemented a series of important master plans and specialized plans. These plans are prepared and implemented at the national and local government and river basin levels with coordination and cooperation among the water authorities at the respective levels. The main progresses by the end of 2010 in this regard are that (a) the first National Water Resources Master Plan was approved by the State Council in December 2010 (see Box 3-1); (b) the water resources master plans at the river basin level for China's seven largest river basins (the Yangtze, Yellow, Huai, Hai, Songliao, Pearl and Tai Lake) have been reviewed and technically approved by Ministry of Water Resources (MWR); and (c) the specialized flood control plans for the seven largest river basins in China have been approved by the State Council.

Box 3-1: The Latest National Water Resources Master Plan for China
(Approved by the State Council in December 2010)

The National Water Resources Master Plan is a national strategic water resources plan specified by the National Water Law that serves as an important basis for water resources development, utilization, improvement, allocation, saving, protection and management. The Master Plan was developed in two stages: the first stage was to carry out a water resources survey and evaluation, and the second stage was to prepare the water resources master plan with the "bottom-up" and "topdown" approach through coordinated back-forth-planning activities at the three levels of the national, river basin and provincial government.

The Master Plan evaluated available water resources and their development and utilization; studied and formulated the overall allocation of the available water resources at the national, basin and regional levels; determined the targets by 2030 for water resources development, utilization, conservation and protection at the river basin and regional levels; and proposed the implementation plan with the strictest water resources management.

The implementation of the Master Plan will improve the level of water conservation and protection, and upgrade the supporting capacity of the water sector for social and economic development and ecological environment protection. This means that the current extensive mode of water utilization will be changed and the government may put forward policies (such as those related to rational water resources allocation, water rights and water marketing) to promote water conservation, while the water price will possibly go up in the future. Meanwhile, the government will speed up the construction of the eastern and middle routes, and the preparatory work of the western route of the South-North Water Transfer Project to effectively resolve the water scarcity issue in the northern regions of China.

The Master Plan confirms the following medium- and long-term targets to be achieved by the water sector in China by 2020 and 2030, respectively:

- The amount of water use per unit of GDP (RMB 10,000) will be reduced to 105 m^3 or less by 2020, which is 30% of reduction from the 2010 number. It will then be further reduced by 40% of 2020 number by 2030.
- The amount of water use per unit of increased industrial value (RMB 10,000) will be reduced to 63 m^3 or less by 2020, which is 30% of reduction from the 2010 number, the then it will be further reduced by 40% of 2020 number by 2030;.
- The total amount of water use in China will be limited to 670 billion m^3 by 2020, and 700 billion m3 by 2030 respectively.

Governmental Organizations for Water Management

72. The Water Law of the People's Republic of China provides that "the State exercises a system of river basin management combined with administrative boundary management of its water resources; and MWR is the administrative department of water under the State Council, which mandates it to be in charge of the unified administration and supervision of water resources throughout the country." The Law also provides that "the other water-related administrative departments under the State Council are responsible for water resources development, utilization, saving, and protection in accordance with the division of their responsibilities" assigned by the State Council.

Box 3-2: Governmental Organizations for Water Management

Water administration and management organizations in China are set up in accordance with the principle of line agencies combined with administrative boundary divisions. There are four levels of water administration departments from the central to the local levels. The Ministry of Water Resources (MWR), as a member department of the State Council, is the water administrative department under the State Council. Under it there are seven river basin management agencies including the river basin commissions for Yangtze, Yellow, Huai, Hai, Pearl, Songliao and Taihu river basins. There are three levels of local governmental water administration departments, i.e. water resources/affairs departments/bureaus at the provincial level, water resources/affairs bureaus at the prefecture level and water resources/affairs bureaus at the county level, as the water administrative departments of the corresponding administrative areas.

Agencies and organizations are also set up at the provincial, prefecture and county levels respectively under the other water-related departments under the State Council. The Ministry of Land and Resources is responsible for the work concerning groundwater reconnaissance and surveys; the Ministry of Housing and Urban-Rural Development is responsible for the work concerning water public utilities in urban areas; The Ministry of Environmental Protection is responsible for the work concerning water pollution prevention and control; the State Forestry Administration is responsible for the work concerning wetland ecology; and the National Energy Administration is responsible for the work related to large-scale hydro-energy project development.

The National Flood Control and Drought Relief Headquarters are set up at the central level in the State Council. A Vice-Premier acts as its chief. Its routine working body sits inside the MWR. In the important river basins determined by the State, a basin flood control and drought relief headquarters or a flood control headquarters are set up, the working bodies of which are located in the respective river basin management agency. At various levels of local governments, there are flood controls and drought relief headquarters or flood control headquarters set up in the respective level of governments. The National Development and Reform Commission (NDRC) and MWR are responsible for construction of water infrastructure for flood control and drought relief works.

Key Laws and Regulations on Water

73. Since 1978, when the Government of China strengthened its water affairs management by legislation, a system of water-related laws and regulations has been established.[1] This system includes at least 5 laws, 17 administrative regulations, 53 ministerial rules, and more than 800 local laws and government regulations. It's expected that these laws and regulations serve as the legal basis to ensure that water is being managed to promote sustainable social and economic development and ecological environment protection. To ensure results, increasing attention has also been paid to enforcement of these water-related laws and regulations. The major water-related laws and regulations are listed in Table 3-1, below.

Table 3-1: Main Water-Related Laws and Regulations

Name of the Law/Regulations	Promulgated by
Water Law of the P. R. C. (2002)	Order of the President of the P. R. C. No.74
Flood Prevention Law of P. R. C. (1997)	Order of the President of the P. R. C. No.88
Water Pollution Control Law of the P. R.C. (2008)	Order of the President of the P. R. C. No.87
Water and Soil Conservation Law of the P. R. C. (2010)	Order of the President of the P. R. C. No.39
Fishery Law of the P. R. C. (2004)	Order of the President of the P. R. C. No.25
Regulations for Flood Prevention of P. R. C. (2005)	State Council Decree No.441
Regulations for Administration of Water Withdrawal Permission and Water Resources Fee Collection (2006)	State Council Decree No.460
Regulations for Drought Relief of the P. R. C. (2009)	State Council Decree No.552
Hydrological Regulations of the P. R. C. (2007)	State Council Decree No.496
Regulations for Water Allocation of the Yellow River (2006)	State Council Decree No.472
Regulations for Land Acquisition, Compensation and Resettlement Concerning Construction of Large and Medium-Scale Water and Hydropower Projects (2006)	State Council Decree No.471
Regulations for Administration and Management of Sand Extraction from the Yangtze River	State Council Decree No.320
Detailed Rules for Implementation of the Water Pollution Control Law of the P. R. C. (2000)	State Council Decree No.284
Regulations for Urban Water Supply (1994)	State Council Decree No.158
Regulations for Implementation of the Water and Soil Conservation Law of the P. R. C. (1993)	State Council Decree No.120
Regulations for Reservoir and Dam Safety Management (1991)	State Council Decree No.78
Regulations for River Course Management (1991)	State Council Decree No.3
Measures for Administration of Water Project Construction Plan Consent Letter System (for trial implementation) (2007)	MWR Regulation No.31
Measures for Administration of Water Withdrawal Permission (2008)	MWR Regulation No.34
Provisions for Supervision of Water Project Construction (2006)	MWR Regulation No.28
Measures for Administration of Rectification within a Specified Time Limit (for trial implementation) (2009)	MEP Regulation No.6
Measures for Administration of Key Water Pollutants Discharge Permits in Hai River Basin and Taihu Lake Basin (for trial implementation) (2001)	MEP Regulation No.11
Measures for Administration of Municipal Water Discharge Permission (2006)	MOC Regulation No. 152

[1] The "Rule of Law" principle was adopted in Constitutional changes of 1999.

Adaptation to Global Climate Change

74. China attaches great importance to global climate change and has formulated a National Plan for Climate Change Adaptation and promulgated a series of policies and measures about climate change adaptation. Water is the most important resource that is directly affected by climate change. Due to its impact, the temporal and spatial distribution of water resources in China has become more uneven in the past decade. Extreme weather events (torrential rains, high-temperature droughts, super typhoons) are becoming more and more frequent and stronger; meanwhile, floods and droughts are becoming more sudden and unpredictable.

75. Climate change adaptation and mitigation measures mainly include : (a) enhancing integrated water resources management to protect and recover eco-systems with rational water resources allocation; (b) research on climate change impacts on the water cycle; (c) inducing artificial rainfall; (d) recycling industrial wastewater; (e) using improved irrigation and agronomic technologies for irrigated agricultural water savings; (f) improving rain-fed farming; (g) developing hydropower production in the western and other areas in China; (h) strengthening monitoring of typhoon, rainstorm and flood with increased flood protection and calamity mitigation capacity; and (i) controlling groundwater exploitation and preventing sea water intrusion and land subsidence.

76. Based on the above-mentioned measures, the following priority measures are proposed to continue to adapt to climate change:

- Improvements to the flood control and disaster relief system;
- Strengthening construction of water supply works in response to drought emergencies;
- Strengthening development of flood and drought emergency response mechanism;
- Enforcement of integrated water resources management;
- Optimization of water resources allocation and regulation; and
- Development of water-saving oriented society.

3.2 China's Strategic Goals and Targets for 2020

77. The No. 1 Central Government Document and the Central Government Water Conference of 2011 clearly defined the guiding ideologies, objectives and basic principles of water resources development and set down a series of new policies and measures for water resources management and its improvement, providing a grand blueprint. In June 2012, the State Council approved the "Master Plan for Water Resources Development (2011-2020)" prepared jointly by National Development and Reform Commission, Ministry of Water Resources and Ministry of Housing and Urban-Rural Development, which further specifies the direction and priority areas of development for the 2011-2020 period.

Decisions for Accelerating Water Sector Reform and Development

78. Position for Water Sector Development in the new situation. Water resources are an element indispensable for modern agricultural development, a cornerstone irreplaceable in economic and social development and a support inseparable from eco-environmental improvement, being very important in terms of public service, basic needs and strategic purpose. Accelerating water sector reform and development concerns not only rural and agricultural development but also the overall economic and social development; it is related to not only flood protection security, water supply security and food security but also economic security, ecological security and national security. It is necessary to put water sector development higher on the agenda of the national undertakings

and those of the Communist Party of China, with focus on accelerating on-farm water works construction and promoting the leapfrog development of the water sector.

Priority areas for water sector development

79. In accordance with the requirements of the No.1 Central Government Document of 2011, water resources development will be regarded as a priority area in the national infrastructure development, on-farm water works construction will be considered as a key task in rural infrastructure development and strict water resources management will be adopted as a strategic measure for accelerating the transformation of the economic development pattern. Emphasis will be placed on scientific water management in accordance with the law, with stress laid on strengthening weak links, to intensify people's wellbeing-oriented water resources development, keep deepening water sector reform, speed up development of water-saving society and promote sustainable water resources development so as to blaze a path of development with Chinese characteristics featuring modernized water resources development.

80. Investment for water sector development: Governments at central and local levels will invest more in water resources related activities over the period from 2011 to 2020 and double the average 2010 annual investment on water. Given about a US$30.4 billion of government investment in 2010 for water, this means that about US$608 billion in total will be available for the water sector over 10 years until 2020. In addition, financial sources for water-related activities will become more stable. The government will levy 10 percent tax on rural land transfer payments to build agricultural water resource infrastructure. The availability of the funds for water resources development will be improved, and the sources of the funds will be diversified and increased.

Strategic Goal and Targets

81. The Decisions of the Central Committee of the Communist Party of China and the State Council on Accelerating Water Sector Reform and Development requires that the current significant lagging situation in water sector development should be fundamentally changed within 5 to10 years. The four big systems are to be basically established by 2020: (a) a system for flood and drought calamity mitigation; (b) a system for rational allocation and efficient use of water resources; (c) a system for water resources conservation and river and lake health security; and (d) a system or mechanism instrumental in scientific development of the water sector.

82. The System for Flood Control and Drought Mitigation: A comprehensive flood control and calamity mitigation system will be basically established on major rivers with combined structural and non-structural measures. (a) standards of the master plan will be met by dikes on mainstreams and important tributaries of major rivers and important reaches of independent sea-entering and in-land rivers and important sea walls; (b) national flood control standards will be met by important flood protection cities; (c) flood control capacity for important reaches of key medium and small rivers will be significantly increased; (d) a monitoring, forecast and early-warning system for flash flood and geological calamity prevention areas will be basically established; (e) drainage capacity in key low-lying areas will exceed one in five year frequency standard; (f) a drought relief and calamity mitigation system will be preliminarily established to comprehensively strengthen emergency backup water supply works for important cities and substantially increase drought mitigation capacity for drought-prone area and main grains production areas.

83. The System for Rational Allocation and Efficient Use of Water Resources: (a) safe drinking water supply will be ensured extensively for a rural population of about 300 million (including state-owned farms) and rural school teachers and students; (b) percentage of rural population that benefits from concentrated water supply will be increased to around 80%; (c) an additional water supply capacity of about 40 billion m^3/year will be built, including that of approximately 26 billion m^3/year for urban areas; (d) water use for GDP/104 Yuan will be reduced to less than 105m^3 and water use for industrial value added/104 Yuan will be reduced to less than 63m^3; (e) effective irrigated area will be increased by 40 million mu; (f) high efficient irrigation area will be increased by 50 million mu and efficiently irrigated forage land through water saving will be intensified; (g) the capacity for water resources control will be comprehensively increased with on-farm irrigation water use coefficient raised to 0.53.

Box 3-3: Outlines of No. 1 Central Government Document of 2011
Decisions on Accelerating Water Sector Reform and Development in China

1. The strategic position of water sector development
   - The new situation facing the water sector
   - The position and role of the water sector
2. The guiding principle, objectives, and basic rules of water reform and development
   - Guidelines
   - Objectives and tasks
   - Basic principles
3. Improvements in priority areas
   - Improve irrigated agricultural water facilities
   - Speed up medium- and small-river improvements and small-reservoir reinforcements
   - Combat water shortages from lack of engineering facilities
   - Enhance emergency response capacity to floods and droughts.
   - Continue necessary construction for drinking water safety in rural areas
4. Increased and accelerated construction of necessary water infrastructure
   - Continue to improve flood prevention in big rivers
   - Strengthen construction of water allocation and transfer works
   - Improve water-soil conservation and water ecology protection
   - Rationally develop hydro-power resources
   - Strengthen hydro meteorological and technical support
5. Establishment of a mechanism for a stable and increased investment in water sector
   - Increase public finance and investment into the water sector
   - Strengthen financing support for the construction of water infrastructures
   - Widely absorb social funds to invest into the water sector
6. Application of the strictest water resources management system
   - a Establish a total volume control system on water use (note: these systems have not been established)
   - Establish a water use efficiency control system
   - Establish a restricted acceptance system on pollution in water function zones
   - Establish a responsibility and accountability system for water resources management.
7. Continued innovative improvement in water-sector institutional system and mechanisms
   - Improve institutional systems for water resources management
   - Carry out reforms on water infrastructure operations and maintenance system
   - Improve grass-roots water service system
   - Move forward with water pricing reform
8. Strengthening of the leadership for water-sector
   - Clarify and put in place the responsibilities of party committees and governments at the various levels
   - Promote law-based water management
   - Strengthen managerial or technical capacity of water staff
   - Mobilize social forces to concern and support water work

Note: The full text of the document is given in Annex 1

84. The System for Water Resources Conservation and River and Lake Health Security. (a) important rivers, lakes and reservoirs nationwide will be improved so as to meet 60% of the main water quality standards in relation to their function zones and concentrated drinking water supply works will also increase percentage of water quality standards compliance; (b) 85% of municipal sewage will be treated and more than 20% of wastewater will be recycled in cities where water is physically scarce or water is short due to poor quality; (c) another 250 thousand km^2 of soil and water erosion areas will be comprehensively improved; (d) environmental water use will be increased in eco-environmentally fragile areas and on key rivers and lakes so that the eco-environment will be rehabilitated to a certain degree; (e) groundwater overexploitation will be preliminarily improved in serious overdraft areas.

85. The system for mechanism instrumental in scientific development of the water sector (a) the strictest water resources management system will be implemented (Box 3-4); (b) the national water right system will basically be established so that the water allocation plan for major rivers will be completed and the institutional reform for integrated basin management will make significant progress; (c) major breakthroughs will be made in investment in water resources and their financing so that the system for water works construction and management will be further improved and a virtuous-circle mechanism for water works operation will basically come into being; (d) a complete system of water-related laws and regulations will be established and management of rivers and lakes will be substantially improved; (e) the capacity for scientific research and innovation in water resources development will be greatly enhanced, with information technology further improved.

Main Tasks

86. Stress will be laid on strengthening on-farm water works construction: (a) large and medium-sized irrigation districts extension, supplementation and water-saving technique transformation; (b) reconstruction of drainage pumping stations for large-sized irrigation districts; (c) more area of effective irrigated farmland; (d) construction of small-sized on-farm water works; (e) water saving intensification in agriculture.

87. Efforts will be focused on strengthening weak links in flood prevention: A flood and drought calamity mitigation system will be basically established to increase the flood control and drought relief capacity of key cities and flood protection areas: (a) improvement of major rivers and lakes; (b) improvement of medium and small rivers and reinforcement of unsafe reservoirs; (c) construction of priority flood retention and storage areas; (d) prevention of flash floods and geological disasters; (e) non-structural measures for flood control.

88. Capacity for urban and rural water supply security will be greatly increased: (a) construction of water resources allocation works; (b) construction of key water source works; (c) construction of river, lake and reservoir water system connection works; (d) capacity building for water supply security for cities and towns; (e) construction of rural safe drinking water works; (f) utilization of non-conventional water sources.

89. Establishment of aquatic ecology safeguard system will be accelerated: (a) protection of drinking water source areas; (b) groundwater protection and rehabilitation; (c) hydrological and water resources monitoring; (d) soil and water erosion improvement in key areas; (e) construction of small hydropower works; (f) construction of water works for schistosomiasis prevention.

90. Water sector reform and management. (a) reform in water resources management system; (b) reform for integrated river basin management system; (c) reform in the investment and financing system for water resources development and in the management system for water works construction; (d) reform in water works management system; (e) water pricing reform; (f) establishment of ecological compensation mechanism; (g) implementation of the strictest water resources management system; (h) strengthening supervision and management of rivers and lakes and soil erosion; (i) strengthening management of calamity prevention and mitigation water works; (j) establishment of a sound and complete system of water-related laws and regulations and water planning; (k) establishment and improvement of a system for scientific research and innovation in water resources development; (l) deepening scientific researches on major water issues; (m) intensifying application and extension of water scientific research results; (n) promoting development of water information technology; (o) acceleration of water technical staff capacity building; (p) strengthening international scientific cooperation and exchange.

Box 3-4: The Strictest Water Resources Management System Implemented in China

The core of the strictest water resources management system is to implement the "three red lines" established for water resources management:

- The first red line is to control total amount of water use or withdrawal from rivers and groundwater aquifers without exceeding planned targets. For areas where total water withdrawal has reached or exceeded the target, review and approval for additional water withdrawal should be suspended; and for areas where total water withdrawal is close to the target, review and approval of additional water withdrawal should be restricted;
- The second red line is to increase water use efficiency to resolutely restrain waste of water. A regional and sector water use efficiency examination and appraisal system will be established to accelerate the process of water saving society development; and
- The third red line is to strictly control the total amount of pollutant discharge into rivers, lakes or other water bodies, which should be determined by the assimilative capacity in water bodies to be consistent with the water function zone targets. The results of the pollution control and prevention should serve as the reference basis for the performance of responsible government officials at all levels.

In accordance with the "12th Five-Year Plan", the main targets to be achieved through the implementation of the strictest water resources management system include:

- The total amount of water use for whole country should be controlled within 635 billion m^3 by 2015;
- Water use per 10 thousand Yuan industrial value adding will be over 30% less by 2015;
- Irrigation water use coefficient should be increased to more than 0.53 by 2015;
- More than 60% of main rivers and lakes will meet the targets set for water function zones by 2015;
- A complete system for water resources management, supervision and administration should basically be established by 2020 to ensure that (a) water resources is rationally allocated; (b) water saving society pattern basically comes into existence; (c) water use efficiency and benefits are significantly increased; (d) quality of drinking water sources in urban and rural areas and water ecology in key areas are improved; (e) groundwater overdraft is effectively controlled; and the capacity for guaranteeing water use for economic and social development is significantly enhanced.

Chapter IV - Cooperation between China and World Bank

4.1 Review of Past Cooperation

91. In the document of the 30-years of cooperation (1980-2010) between China and the World Bank, it was pointed out by the Chinese Government that "the World Bank's financial resources have supported China's capital needs for domestic construction[1]. Together with the financial resources on projects, the Bank has also transferred expertise through internationally advanced technology and management techniques, trained a vast number of project managers and professionals, and introduced new ideas and innovation in many sectors".

92. The World Bank also indicated in the document that "Like all enduring partnerships, the China – World Bank partnership has evolved over the years. At first, the Bank was able to share experiences with 'China in a wide range of areas: how to appraise and implement priority projects; how to encourage innovation and introduced new technologies; how to develop the institutions and policy instruments needed for good economic management. Later on, the learning became more mutual as China's success with reform, growth, and overcoming poverty gathered pace. We have learned a great deal from the way China has fine-tuned and scaled up successful projects and adapted new ideas."

[1] The Bank has contributed US$50.41 billion in supporting 349 projects as of June 30, 2012.

Table 4-1: The World Bank Loan-Financed Irrigation and Water Projects

No.	Name of World Bank Project	World Bank Credit /Loan ($M)	Board Approval /Closing Dates
1	North China Plain Agriculture	160	06/15/82–12/31/87
2	Xinjiang Agricultural Development	70	03/03/87–12/31/94
3	Northern Irrigation	103	03/22/88–12/31/97
4	Shaanxi Agricultural Development	106	03/28/89–07/31/97
5	Shandong Agricultural Development	109	05/16/89–06/30/95
6	Jiangxi Agricultural Development	60	02/27/90–12/31/94
7	Hebei Agricultural Development	150	06/14/90–06/30/98
8	Henan Agricultural Development	110	05/14/91–12/31/98
9	Irrigated Agriculture Intensification	335	06/04/91–03/31/98
10	Tarim Basin I	125	08/29/91–06/30/97
11	Guangdong Agriculture Development	162	11/05/91–12/31/98
12	Sichuan Agricultural Development	147	07/07/92–04/30/00
13	Taihu Basin Flood Control	200	02/23/93–12/31/01
14	Xiaolangdi Multipurpose Dam	460	04/14/94–12/31/00
15	Loess Plateau Watershed Rehabilitation	150	05/26/94–12/31/05
16	Yangtze Basin Water Resources Development	210	04/25/95–12/31/05
17	Gansu Hexi Corridor	150	05/30/96–12/31/06
18	Heilongjiang Agricultural Development	120	05/13/97–06/30/04
19	Wanjiazhai Water Transfer	400	06/03/97–06/30/07
20	Xiaolangdi Multipurpose II	430	06/24/97–12/31/03
21	Tarim Basin II	150	06/09/98–12/31/04
22	Irrigated Agriculture Intensification II	300	06/18/98–06/30/05
23	Anning Valley Agricultural Development	120	01/21/99–12/31/06
24	Guanzhong Irrigation Improvement	100	05/25/99-06/30/06
25	Second Loess Plateau Watershed Rehabilitation	150	05/25/99–06/30/05
26	Yangtze Dike Strengthening	210	06/27/00–06/30/08
27	Water Conservation	74	12/18/00–06/30/06
28	Jiangxi Integrated Agricultural Modernization	100	11/20/03–06/30/10
29	Irrigated Agriculture Intensification III	200	10/11/05–12/31/10
30	Changjiang and Peal River Watershed Rehabilitation	100	06/27/06–06/30/12
31	Xining Flood and Watershed Management	100	06/02/09–12/31/14
32	Huai River Basin Flood Management and Drainage Improvement	200	07/06/10-12/31/16
33	Xinjiang Turpan Water Conservation	100	06/17/10–03/31/17
34	Water Conservation II	80	05/10/12-06/30/17
35	Sichuan Wudu Irrigated Agricultural Development Project	100	02/28/12-12/31/17
Total amount of financing from World Bank		5,841	--

93. Since the first loan in 1982 supporting a rural water supply project, the World Bank's cumulative lending to China in the water sector has been close to about US$ 5,841 million for a total of about 35 projects accounting for about 12% of the total Bank financing in China as of June 30, 2012, as shown in Table 4-1. Reflecting a growing Government emphasis on better water resources management, the Bank has over the last 30 years complemented investment in water-related infrastructure with increasing attention to water policy, planning, management, and conservation issues.

94. In 2002, the Bank prepared the China Country Water Resources Assistance Strategy. The strategy, supported by the Ministry of Water Resources and other related ministries, described the key development issues and the Bank's assistance in the form of investment programs in the water sector to enhance integrated water resources planning and management. In addition, the Bank also carried out various Analytical and Advisory Assistance (AAA) studies for China's water sector.

95. Table 4-2 below lists the project activities funded by the GEF together with the World Bank's Analytical and Advisory Assistance (AAA) studies and Water Partnership Program (WPP) studies responded to the key challenges and opportunities related to water resources in China, in line with the Bank's China Country Water Resources Assistance Strategy. These activities included the Strategic Framework for Climate Change and Development, the Hydropower Business Plan, and China Country Water Resources Assistance Strategy and updated China Country Water Resources Partnership Strategy (2013-2020). Several of these activities have contributed to experiences that will be further pursued under this new partnership strategy.

Table 4-2: The Grant-Funded Projects and Studies on Water in China

No.	Name of Project and Studies	Grant Funds($ '000)	Completion Dates
1	The China Country Water Resources Assistance Strategy (CWRAS)	100	12/31/01-12/31/02
2	Addressing China's Water Scarcity	250	07/01/08-06/30/09
3	Study on National Water Rights Administration System	50	07/01/08-06/30/09
4	Study on Economic Value of Water and Its Policy Intervention in the Hai Basin	60	07/01/08-06/30/09
5	Policy Note on Integrated Flood Risk Management – Key Lesson Learned and Recommendations for China	60	06/28/10-08/28/10
6	Revision of National Guidelines on Dam Safety Management	130	07/01/10-06/30/11
7	Study on ET-based Water Rights System and Its Compensation Mechanisms	80	07/01/10-06/30/11
8	Review and Update of National Design Codes in Relation to Urban Water Supply and Drainage	130	07/01/10-06/30/11
9	Study on Water Pricing for WUA Sustainability in China	80	07/01/10-06/30/11
10	Study on Rural Wastewater Management	80	07/01/10-06/30/11
11	GEF Hai Basin Integrated Water and Environment Management Project	17,000	09/22/04-06/30/11
12	China Country Water Resources Partnership Strategy	130	07/01/10-12/31/11
	Total Amount of Grant Funds	18,150	--

96. The outcomes of the grant-funded technical projects and studies include an improved framework for addressing the challenges of water demands for social and economic development and environmental and ecological protection; a high-level policy dialogue with the Ministry of Water Resources and improved focus for future lending projects; an improved understanding of the development impacts of climate change on China's 10 big river basins; crucial technical assistance to a number of Bank projects in China; improved reservoir and dam safety management guidelines, including a better understanding of risks; implementation of international good practices in watershed management; establishment of a new water rights system by a local government; and improvements in transparency and enabling of performance monitoring at water supply and wastewater utilities.

97. The overall objective of the Bank's assistance has been to ensure sustainable use of water resources to support both social and economic development and ecological environment protection in China. The highlights of the Bank supported projects and studies are as follows:

4.2 Flood Protection and Drought Mitigation

98. To combat flooding and water-logging and control droughts, efforts have focused on application of an approach that includes not only structural measures but also non-structural measures. The non-structural measures included flood warning and disaster assessment systems; flood detention management; conjunctive use of surface and groundwater; and establishment of WUAs or Farmer Drainage and Irrigation Associations (FDIAs). This application of non-structural measures has proven to be very effective in maximizing the benefits of the flood control infrastructures and maintaining O&M for both main and on-farm drainage and irrigation systems. The major World Bank funded projects in this area included the completed Yangtze Dike Strengthening Project, and the ongoing Huai River Basin Flood Management and Drainage Improvement Project, Xining Flood Management and Watershed Improvement Project, and Jiangxi Wuxikou Integrated Flood Management Project. Through preparation and implementation of these projects, the international experience and best practices in flood risk management based on integrated structural and non-structural measures (See Box 4-1) has been initiated and introduced.

4.3 Irrigated Agricultural Water Savings

99. World Baank programs supported investment on increase of water use efficiencies in order to provide water to crops in a right amout of water at right time. However, in the areas where water resources have been over-exploited and environment has been degradated, the Bank has also supported an innovative concept of consumption management in agricultural irrigation by increasing water productivity through providing farmers with incentives to implement engineering, agronomic and management measures that would maintain or increase their incomes while reducing total water consumption. The new concept (see Box 4-2) – based on the idea that true water savings require a reduction of consumptive use or evapotranspiration or ET[1], which requires that the actual ET with a water saving project should not exceed the ET without the project.

[1] ET is a term that is used for the consumptive use of water in agriculture. It describes the sum of the amount of water that is evaporated and transpired into atmosphere. Evaporation accounts for the movement of water from the ground surfaces to the atmosphere, including from the soil, canopy interception, and water bodies. Transpiration accounts for the movement of the water from plant leaves to the atmosphere.

Box 4-1: Selected International Experience and Lessons on Integrated Flood Risk Management

1. **Inclusion of integrated flood risk management into national regulations, policies and investments for flood prevention**
   It is very important that sectoral investments, especially by the Government, integrate preventive risk reduction measures. A recent brief by the World Bank's Independent Evaluation Group has shown that disaster vulnerability warrants serious consideration on solely financial grounds, especially since 60 percent of the World Bank investments in infrastructure, rural development, and environment are at risk to flooding. The United States Federal Emergency Management Agency (FEMA) estimates that 1 dollar invested in mitigation measures generates an estimated US$4 on average in future benefits.
2. **Development and implementation of a risk-based national flood management strategy at the river basin level**
   In The Netherlands, the approach based on comparing cost of flood infrastructure investments, cost of nonstructural measures and cost of socio-economic impacts of flood disasters, shows that flood risk management investments can be considerably reduced. It is often referred to as learning to "live with floods" instead of "fighting floods". Climate change impacts need to be considered in the definition of land use plans and actualization of floodplains. Climate considerations however need to be meaningful at regional and local levels, which mean a hierarchy of areas that are most vulnerable to these impacts needs to be developed.
3. **Prior assessment of flood risk and vulnerability**
   A very useful approach is to use satellite maps that provide vital information required by the decision makers at different phases in the flood disaster cycle i.e. pre flood (preparedness), during flood (relief and rescue operations) and post flood (mitigation measures). Disseminating disaster maps can help reduce risks and become a mechanism for local community participation in flood disaster management. The United States' HAZUS Flood Model is an example of a powerful tool in the hands of communities, allowing proactive analysis and mitigation at the national and local level. The HAZUS Flood Model is based on an integrated set of flood hazard analysis algorithms, using national elevation and other hydrologic and hydraulic datasets.
4. **Balance between structural and non-structural control measures**
   Investing in non-structural measures are often less costly and provide many additional benefits. For example, the city of Curitiba, Brazil, instead of investing in massive infrastructure decided to implement floodplain regulations and tax incentives for protection of green space and restricted land occupation in flood prone areas of the city. It created retention ponds, parks and recreational areas along the main river that are widely used by the population.
5. **Strengthening management of small /rural dams and Barrier Lake**
   The Bank has extensive experience with risk analysis to guide the design and operation of dams, as well as the monitoring system. A specific Bank Operational Policy ensures that Safety of Dams is properly integrated into Bank investment and can be shared with the Government.
6. **Institutional emergency coordination at the local government and community level**
   One of the key lessons of the Bank's disaster-related projects is that successful projects strongly involve the affected communities. In the Philippines, for example, Albay province is frequently hit by major disasters such as typhoons, floods, landslides and earthquakes. To more effectively respond to the disasters, the province created the Albay Public Safety & Emergency Management Office (APSEMO) in 1995. APSEMO helped mainstream and institutionalize disaster risk reduction strategies into local government plans and programs. As a result, disaster prevention, preparedness and response are well coordinated, and casualties have been reduced considerably.
7. **Emergency preparedness and response**
   In São Paulo State, Brazil, a Civil Defense Preparedness Plan (CDPP) was developed to protect population living in a mountainous region undergoing rapid urbanization and vulnerable to flashflood and mudslide as a result of excessive rainfall. The CDPP uses meteorological and geological data as well as trained field observers to declare emergency situations and evacuate people at risk. It includes a significant public education component and has been highly successful in reducing numbers of deaths due to landslides.
8. **Risk transfer and insurance mechanisms**
   Many innovative schemes utilize parametric, or index-based, approaches which are transparent and simple and do not require the assessment of damages in order to pay an insurance claim because the contract is defined against a weather proxy or index, such as rainfall, sunlight or temperature. If a chosen weather proxy exceeds a certain threshold, a payment is triggered. Some developed countries have used crop index based insurance, such as the United States of America and Canada.

Box 4-2: New Concept on Irrigated Agriculture Water Savings

Experiences and lessons from China and other countries suggest that limiting the use or drawing of water, or increasing water-use efficiency may increase rather than reduce the consumptive use of water, particularly in water-scarce areas.

Over the past two decades, China has spent huge funds in rural areas to introduce irrigation water savings programs. The programs focus on reinstating irrigation and drainage systems and promoting various watersaving technologies to increase effective irrigated areas by raising the level of water use efficiency. But statistics show that over the past 30 years the effective irrigated area has increased by about 8 million hectares, while the total use or drawing of water has remained much the same and the annual over-exploitation of groundwater has reached up to 22 billion cubic meters. As a result, the ecosystem in these areas has degraded further.

Saving water under the traditional concept is to reduce supply and application losses, for example by lining canals, using pipes and installing sprinkler or drip irrigation. This reduces water that is "lost" when measured at point of diversion to point of delivery and field "losses", which many water officials consider water available for expanding irrigated areas or transferring to domestic or industrial uses. But this water is not totally lost nor are the savings "real"; most of the water that "escapes" returns to the water system through runoff or percolation and can be reused again. But this "lost water" has a cost when measured and paid for as well when energy is used to divert, deliver and apply it.

As a special report on water in the Economist (May 20, 2010) said, "In truth, though, such water is not all lost: much of it returns to the aquifers below, from where it can be pumped up again. There is a cost to this, in energy and therefore cash, but not in water. The only water truly lost in a hydrologic system is through evapotranspiration (ET), since no one can make further use of it once it is in the atmosphere." If genuine savings are to be made, measures should be taken to cut non-beneficial ET or reduce ET (for example, by reducing irrigated areas or producing food with less transpiration). Growing more crops over a wider irrigated area or increasing of cropping intensity in the same area raises the level of ET.

In many water-scarce areas in the world that are similar to North China, policies aimed at reducing the use or drawing of water have actually increased groundwater depletion. This has happened in the Upper Rio Grande basin shared by the United States and Mexico, where measures designed to make irrigation more efficient have increased crop yields upstream, which in turn have raised the level of ET and left less water to replenish aquifers. Such facts increase the attractiveness of demand management that is being tried in China. In irrigation projects that cover several parts of arid and semi-arid areas, including Water Conservation Project, GEF Hai Basin Integrated Water and Environment Management Project and the Xinjiang Turpan Water Conservation Project, the World Bank has been promoting water conservation with focus on reducing consumptive use of water or ET.

As part of the Water Conservation Project, farmers have formed water-users' associations to plan and operate irrigation services. But the objective is specifically to reduce consumptive use of water or ET and simultaneously increase the farmers' incomes (for example, by using integrated engineering and agricultural and management measures such as crop pattern adjustments) without further depleting the groundwater table. The objective is also to increase the yield and value of production per unit of ET and stay within the fixed consumption quota.

According to project monitoring data, the farmers' per capita income increased by 193 percent and water productivity rose by 82 percent, while consumptive use of water or ET over the irrigated areas fell by 27 percent by the end of the Water Conservation Project (2000-2006), which was financed by the World Bank and implemented by the Ministry of Water Resources. The project shows that the main strategic goal of combating water scarcity is to find better ways to reduce the consumptive use of water or ET, and increase farmers' incomes in addition to many other good measures.

4.4 Enhanced Water Withdrawal Permit System

100. The new concept strengthened and enriched the current water withdrawal permit system (see Box 4-3 below) and strictly controlled consumptive use of water at the farm level in the Bank's project areas. Consumption management avoids the overdraft of groundwater that may typically result from increasing basic irrigation efficiency – which typically leads to increases in the crops area and parallel increases in water consumption (ET). The major Bank-funded projects using the consumption management approach included the completed Water Conservation Project and IAIL II Project (both with a World Bank IEG rating of highly satisfactory), and the ongoing projects IAIL III, Water Conservation II, and the Xinjiang Turpan Water Conservation Project, which employ as a

Box 4-3: New Concept on Improving Existing Water Withdrawal Permit System

The Existing Water Withdrawal Permit System

The conventional water withdrawal permit system in China and other parts of the world is based on control of water withdrawal amount. In China water users are issued permits which specify the amount of water that can be withdrawn from a surface or groundwater source. It is becoming increasingly clear that permits which use "withdrawals" as the only measure of water may not be effective in controlling the overuse of water. This is because, given a particular withdrawal amount, if a farmer switches to a modern irrigation technology with a higher irrigation efficiency, it is likely that the water consumption (ET) is higher than before with the lower irrigation efficiency. It is important to keep in mind that the amount of water withdrawn from a local water source can be divided into two parts: the amount of water consumptively used (ET), and the amount of water that returns (or is recycled) via runoff or deep percolation to the local water system. When water rights are based (only) on the amount of water that can be withdrawn, there is a built in incentive to consume as much of it as possible, and to minimize the amount of return flows. Thus, a water rights system based solely on withdrawal amounts can result in increased depletion of water resources.

Let's assume a farmer has been issued a permit by the water bureau allowing the withdrawal of 10,000 cubic meters (m^3) from an aquifer. The farmer grows 1 hectare of wheat with an irrigation efficiency of 40%, and thus applies 4,000 m^3 (consumptive use) to the crop. If the farmer adopts an improved irrigation technology with an irrigation efficiency of 80%, and leaves everything else unchanged, the necessary withdrawal would be reduced to 5,000 m^3. But with a permit over 10,000 m^3, the farmer has several options, including irrigating an additional hectare of wheat, or switching from wheat to a higher-value crop that requires the application of higher amounts of irrigation water. The farmer could also sell the apparently 'saved' withdrawal amount to a neighboring farmer. No matter which option the farmer chooses, the resulting ET amount will increase substantially (double in case the farmer decides to irrigate an additional hectare of wheat), and the return flows to the aquifer concomitantly decrease. A continuous decrease in deep percolation can significantly contribute to groundwater overdraft and ecosystem degradation.

The Strengthened Water Withdrawal Permit System

An alternative design of a water rights system based on ET amounts would be much more effective in controlling the overuse of water. Water rights in an ET-based system are formulated and recorded with three components: (a) the amount that may be withdrawn; (b) the amount that may be consumed (or ET for irrigation); and (c) the amount that must be returned to the local water system, and meets national water quality standards for wastewater and sewerage discharges. Such a formulation complicates water rights administration, because at least two of the three components need to be measured and controlled. (Under the conventional system, the focus is only on one component, withdrawals.) However, in recent years remote sensing has been increasingly used to estimate actual ET, and allows the measurement of the consumptive use component. This helps to assess whether actual consumptive use (actual ET) is less than the target consumptive use (target ET, as specified in an ET-based water right). ET can now be measured in an area of 30x30 meters with acceptable accuracy, particularly in arid regions. In conclusion, ET measurements enriched the current water withdrawal permit system which can function much better in controlling consumptive use of water, particularly in physical water scarcity regions or areas.

local mechanism the formation of farmer Water User Associations (WUAs) to facilitate improved productivity, gender equality and poverty reduction while reducing the burden on the government of water distribution.

4.5 Water/Soil Erosion Control

101. World Bank supported water and soil erosion control has focused on the application of best principle approaches and strategies of watershed development in the region and areas where agricultural production is constrained by lack of irrigation, soil erosion, and limited soil fertility due to low organic matter. Special attention has been paid to the loess plateau region in the north-west of China. Livelihoods in these environmentally fragile areas are precarious and lack of food security and lack of access to drinking water are still common problems. The Bank's completed

Box 4-4: Watershed Management in Loess Plateau Pays Off

Starting Points

Home to over 50 million people, the Loess Plateau in China's Northwest takes its name from the dry powdery wind-blown soil. Centuries of overuse and overgrazing led the region to be one of the worst eroded places on earth and poverty was widespread in the region. Uncontrolled grazing, subsistence farming, fuel wood gathering and cultivation of crops on slopeshad left huge areas of the Plateau devastated. Frequent droughts and flooding caused crops on slopes to fail.

Watershed Management Effort

In early 1990s, the Chinese government started a massive effort to restore the heavily degraded Loess Plateau through one of the world's largest erosion control and water/soil conservation programs with the goal of returning this poor part of China to an area of sustainable agricultural production. With support from the World Bank, two projects to rehabilitate and restore the eco-system of the Loess Plateau were carried out, spreading over a decade. More recently, a DFID funded project assisted in deepening community participation and gathering lessons. The government, working closely with local communities, scientists, local governments and donors, introduced more efficient and sustainable use of land and water, reduced soil erosion and sediment flow into the river. These efforts have paid off and turned out to be the largest and most successful water and soil conservancy efforts in the world.

Highlights

- Political commitment for change
- Public participation, including detailed land use plans prepared in close consultations with villages
- Implementation of the government's policy for land tenure and land use zoning

Visible Results on the Ground:

- Poverty Alleviation - more than 2.5 million people in four poorest provinces of China – Shanxi, Shaanxi, Gansu, and Inner Mongolia Autonomous Region – were lifted out of poverty. Through the introduction of sustainable farming practices, annual farmer incomes more than doubled from US$70 to US$200 per person, employment diversified and the degraded environment was revitalized.
- Agricultural Production - sediment control transformed previously unproductive land into valuable crop land. With terracing, agricultural production has changed from generating a narrow range of food and low-value grain commodities to high-value products. Per capita grain output increased from 365 kg to 591 kg per year. The diversification of agriculture and livestock production has brought about new on-farm and off-farm employment, which rose from 70 to 87 percent.
- River Flows - the flow of sediment from the Plateau into the mighty Yellow River has been reduced by more than 100 million tons each year. Better sediment control has reduced flooding with a network of small dams storing water for towns and agriculture when rainfall is low.
- Vegetation Cover - the restoration effort encouraged natural regeneration of grasslands, tree and shrub cover on previously cultivated slope-lands. Perennial vegetation cover increased from 17 to 34 percent.

Conclusion:

Implementation of Loess Plateau Watershed Management and Rehabilitation has convinced policy makers, planners and local communities that land conservation is compatible with sustainable and productive agriculture, and that they are mutually reinforcing.

Source: http://go.worldbank.org/RGXNXF4A00

Loess Plateau Rehabilitation Project (World Bank IEG rating: highly satisfactory) has provided a best practice to address this issue. The other major Bank-funded projects using this approach included the Loess Plateau Rehabilitation II Project (see Box 4-4), the Yangtze and Pearl River Basin Water Erosion Control Project, and the Xining Flood Management and Watershed Improvement Project.

4.6 Participatory Irrigation Management

102. World Bank projects have also focused on the application of a realistic and sequenced approach for participatory irrigation management. Based on the CDD concept, the approach suggests the physical and financial responsibility for the operation and maintenance (O&M) of on-farm works within a lateral canal system should be fully covered by Farmer Water User Associations (WUAs), while the O&M for the main canal system will continue to be managed by the government water supply institutes. The approach helped to implement the government's reform policies and process aimed at increasing efficiency and quality of the services provided to the WUAs. About 50,000 WUAs have been established in China since the first WUA was established in 1994 with the Bank funded Yangtze River Basin Water Resources Project. The participatory irrigation management approach has been disseminated by the DFID-funded and Bank-managed Pro-poor Rural Water Reform Project and has been widely applied in Bank-funded and government internal funded irrigation or water projects. It has received strong supported from the central and local governments.

4.7 Water Pollution Control

103. Water pollution control in World Bank supported projects has focused on the application of a basin-wide approach on total pollution control and allocation of the pollution control targets from the basin level to the administrative level for enforcement. The targets were derived based on the target environment carrying capacity (EC) and target evapotranspiration (ET) in a given river basin or a sub-river basin. The pollution control targets were enforced jointly by water and environment departments at the central, provincial and county levels in accordance with the cooperation mechanisms established and data sharing agreements signed by both water and environment departments. In addition to building wastewater treatment plans and sewer systems, the Bank financed projects also focused on the control of the increasing non-point water pollution sources in rural areas, which in many areas are responsible for over 50% of the total pollution loads. The approach focused on improvements in the legal framework and institutional capacities at both the government level and the farm level and greatly contributed to a reduction in non-point pollution loads to rivers or lakes. The major World Bank funded projects in this area include the GEF supported Hai Basin Integrated Water and Environment Management Project, the GEF Huai Basin Marine Pollution Reduction Project, and many urban environment protection projects.

4.8 Impact of Climate Change

104. World Bank supported projects and studies have used the integrated river-basin approach to identify the impact of climate change on water resources development and utilization in China. The basin-level perspective enabled the study to define strategies at the river basin level and link those to water users at lower levels. The study was also able to address global and local change issues, as climate change impacts are realized through the response of the hydrological cycle, with direct impacts on the basin. The studied identified several strategies at the river basin level for dealing with the impact of climate change, which were then implemented by the different water-use sectors within the provinces in the river basin. This approach has been used in the design of the GEF Hai Basin Integrated Water and Environment Management Project, the IAIL III Project, and the Xinjiang Turpan Water Conservation Project and related studies.

4.9 Integrated Water Resources Management

105. Integrated Water Resources Management (IWRM) is defined by the Global Water Partnership (GWP) as "a process that promotes the coordinated development and the management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems". China is implementing IWRM as the basis for developing and managing its water resources in accordance with the "Dublin Guiding Principles to IWRM" as indicated in Section 1.2 of this strategy paper.

106. The river basin approach focuses on implementing IWRM principles through better coordination amongst operating and water management entities within a river basin, with a focus on allocating and delivering reliable water-dependent services in an equitable manner. It is a holistic approach that seeks to integrate the management of the physical environment within that of the broader socioeconomic and political framework.

107. The process is sequential, because the allocation at each level below the basin (administrative unit, project, WUA, etc) is determined by the higher level. The first allocation may be between provinces, if a river crosses provincial boundaries, then within the province, allocation is among (for example) urban, industrial and agricultural users while reserving appropriate supplies for ecological and downstream obligations. At the lowest level, an individual farmer allocates water to the crops he has planted – but just as at every other level, if water is short, priorities must be set between competing demands within the allocation.

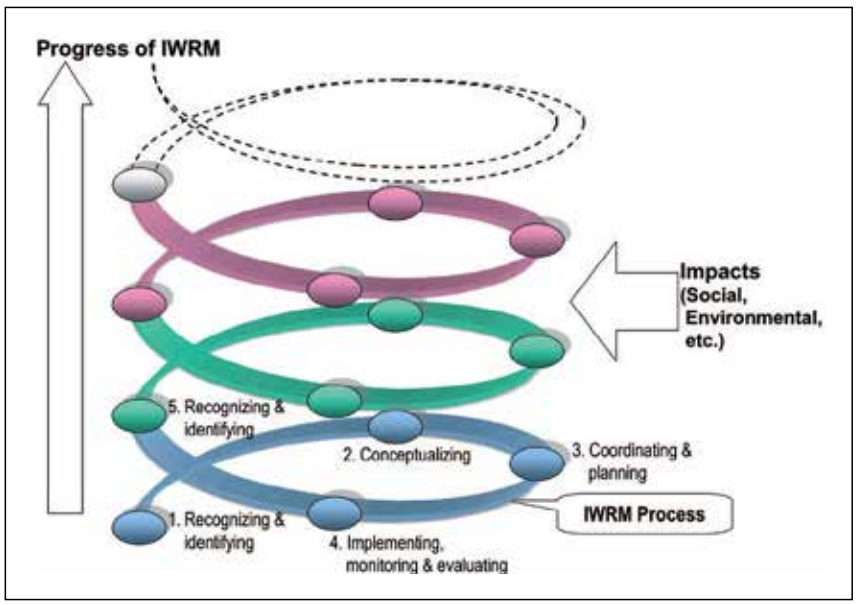
108. It can be seen as an open-ended dynamic process that evolves in a spiral manner over time as one moves towards more coordinated water resources management. As shown in Figure 4-1 on IWRM spiral and process at the river basin level[1], each spiral process involves the four stages as follows, which creates a new and adapted IWRM framework or scheme in the basin, forming the beginning of the next stage of the spiral. One turn of the spiral may take a long time:

- Recognizing/identifying pressing issues or needs;
- Conceptualizing the problem itself and locating possible solutions;
- Coordinating and planning among stakeholders to reach an agreement; and
- Implementing/monitoring/evaluating the plan and its outcome.

109. Stakeholder Consultation: Water resource systems are directly and indirectly affected by the interaction of numerous human related drivers of economic, social, and demographic functions, including climate change as an uncertain driver. The management of water-related disasters such as floods and droughts, including appropriate risk management, should not be considered in isolation but should comprise an essential part of IWRM. Food security, gender, health, environment, industry and many other objectives are all closely related to and affected by sound water resources management. Hence, the need for a more integrated approach to water management involving all stakeholders at every step and level of the spiral process became increasingly central to successful planning.

[1] Cited from IWRM Guidelines at the River Basin Level from United Nations. Many past failures at IWRM implementation occurred for lack of the reiterative spiral that enables a dynamic adjustment and adaptation to changing conditions at the basin and administrative levels.

Figure 4-1: Implementation Spiral for Integrated Water Resources Management



110. Cooperation among Water Use Sectors: The principles and concepts of IWRM have been widely recognized, but the implementation of IWRM has not always progressed satisfactorily in many basins perhaps partly because it has been perceived as a static instead of a dynamic process and partly due to the disparate perspectives held by the various water sectors concerned, all working with their interests in mind and failing to recognize the need for greater interaction and cooperation. Implementation of IWRM means proposing a plan to individual sectors, which respects their needs, respects the needs of other users, and most importantly is consistent with the available water supply. In conditions of water scarcity and over-use, as currently found in China, it is in essence a balancing act of advantages and compromises. Practitioners would need to think how individual water-related sectors can respond to scarcity, recognizing inter-dependencies between sectors. Ultimately, the technical judgments of the practitioners provide the basis for the political decisions that will be required to balance consumption with available supplies.

Advantages of IWRM at the River Basin level

111. IWRM at the river basin level leads to better water resources management through more integrated institutional framework. The foundation for this process is a clear, transparent and openly available set of assumptions and data about how much water is actually (or expected to be) available, and the agreed allocation plan between users. This goal must always be kept in mind wherever positioned in the IWRM spiral. The spiral evolutionary model reflects progressive positive changes in historical water resources development and management at the river basin level and offers the following advantages:

- It allows IWRM actions to be started at any point of the evolutionary process and make changes with back and forth feedback from the river basin level to water user level – always reflecting the current plan or a proposed change in terms of the resulting water allocations and pattern of use and consumption at the basin level;

- It builds capacity on IWRM over time at all administrative levels including the national, river basin authority and city and county levels;
- It promotes cooperation and coordination with all different water-related sectors and stakeholders with the approach on carrying out top-town / bottom-up activities, and horizontal and vertical integration[1];
- It promotes the pursuit of better solutions that adapt to changing circumstances and values, particularly with the increasing water demand for rapid social and economic development;
- It facilitates consensus building and stakeholder ownership at each "turn of the spiral", which leads to a higher level of spiral process;
- It illustrates IWRM as an incremental, step-by step process, and therefore provides a practical framework for looking ahead and planning for successive "turns of the spiral"; and
- It provides a foundation for progress towards adaptation to climate change. Climate change impacts are realized through the response of the hydrological cycle, in terms of quality and quantity, with direct impacts on the river basin. It may increase in the number and severity of floods and droughts over current seasonal patterns and ultimately determine when, where, and how much water is available.

National Experience Relevant to IWRM in Bank Projects

112. As indicated in Section 2.3 on strategic issues on water scarcity, China's rapid social and economic development is resulting in increased degradation of ecological environment due to water scarcity and soil-erosion, particularly in the physical water scarcity areas, mostly located in the northern part of China (Figure 2-2). In these areas, there is not enough water or it is impossible to meet the increasing water demands from various economic activities. The real challenge therefore is not to simply answer a question of "how to supply" with ample water but a question of "how to allocate" with an order of priorities and trade-offs or balance between water demands for economic activities and ecosystem restoration within a river basin. This can be only achieved through the Integrated Water and Environment Management (IWEM)[2].

113. Already a number of Bank-supported projects and collaborative activities have generated significant experience. Bank support in the area of river basin management has included application of a new approach on IWEM to balance water use for economic activities with the protection of the ecological environment, supported by the latest remote-sensing technology to monitor and measure consumptive

[1] Top-down activities include establishing laws, policies, regulations, standards and water allocations for IWRM at the national and river basin levels; Bottom-up activities include working with local government and stakeholder levels (government officials, villages and individual water users) in the planning and implementation of IWRM actions; Horizontal integration includes cross-sectoral cooperation and coordination of IWRM actions at each level of the government administration; and Vertical integration includes direct linking and constant interaction of the IWRM actions at the national and river basin level and local government and stakeholder levels. At the interface between each level, the water allocation plan is defined as the basis for the service to be provided to the lower level user.

[2] Integrated Water and Environment Management (IWEM) has the same definition as IWRM. Both refer to "Integrated Water Resources Management at the river basin level and furtehr down to administrative and water user levels". Given China has two separate government authorities to be responsible for water resources management and environment protection, respectively, the IWEM is used to explicitly show that IWRM is carried out jointly by water resources department and environment department.

use of water or evapotranspiration (ET), and modeling technologies to determine environment carrying capacity (EC). The approach supported China's Water Law on integrated water resources management at both river basin and administrative levels. There has been a number of the Bank or GEF-funded projects which has used this innovative and integrated approach. A brief description of the new approach is given in Box 4-5.

114. The most significant to date has been the GEF-funded project in the Hai basin which embodies the general principles of IWEM at the basin level, and were jointly implemented by the Ministry of Water Resources, Ministry of Environment Protection and Beijing, Tianjin and Hebei Province, which is summarized in Box 4-6.

115. Another Bank-funded project in the Turpan Basin fully adopted this new approach with the water balance analysis at the river basin level, which is illustrated in Box 4-7.

Box 4-5: A New Approach on ET/EC-based Integrated Water and Environment Management For Sustainable and Inclusive Social and Economic Development

How much water is available to consume for various economic activities in urban and rural areas without adverse impacts on ecosystems in a river basin, and how to ensure the actual consumptive use of water does not exceed the amount of water available to consume in a sustainable manner, and what actions should be taken to have more balanced social and economic development and ecosystem preservation in a river basin?

The answers to these questions are coming to you from this new approach on ET/EC-based integrated water and environment management (IWEM) supported by the cutting-edge remote sensing technologies to derive the target ET, and modeling technologies to derive target EC in the studied river basin.

Remote-Sensing technology measures ET, i.e. the actual consumptive use of water in ecological, environmental, agricultural and urban areas. Relying on the data obtained with the technology, a more reliable water balance analysis shall be made at the river basin level, together with the supplemented consumptive use data available from the industrial and domestic uses through field surveys. Based on the result of the analysis, the target ET (or the allowed or maximum consumptive uses of water) for various economic development activities by different water-use sectors shall be worked out under the prerequisite that water resources are allocated to ensure necessary environment flows and eliminate groundwater overdraft for green and sustainable growth in the river basin.

Modeling technologies are used to determine EC for a river basin, which can be aggregated from the rivers and lakes within the river basin. EC has nothing to do with pollution discharges, but highly related to target ET for various economic activities. Given the fixed average amount of water available in the river basin, the higher the target ET, the lower the target EC, this is because the higher target ET makes less environment flows in a river or less inflows to a lake or more groundwater net withdrawal in the river basin. The target ET and target EC are interrelated to each other and need to be worked out together through their interactions at the river basin level. ET determines how much water "disappears" through consumption and therefore how much water is left, which would help us to decide with trade-offs how much of that left would need to be maintained for environment and how much (the maximum) could be consumed by economic activities. EC determines the environment carrying capacity of the water that is left for environment, which would help us to control emissions of pollution discharges.

This new approach on ET/EC-based IWEM will be prepared and carried out jointly by water and environment departments and other related government agencies and stakeholders with participatory approach. The major steps are as follows:

- A river basin shall be taken as a unit to find out target ET and target EC, which are highly related to each other and shall be negotiated and agreed by all related government agencies and stakeholders through a platform called "Joint Conference Decision Making System" established for the river basin;
- Given the target ET and target EC are agreed at the river basin level with participatory approach, they shall be allocated to each of the administrative units in the river basin;
- The water and environment departments of an administrative unit in the river basin shall jointly prepare an IWEM Plan under the constraints of target ET and target EC allocated from the river basin level in consultation with other stakeholders (e.g. other government agencies, and representatives of water users and polluters);
- The administrative unit, among others, shall implement and enforce the IWEM Plan to ensure that the actual ET is less than the ET allocated, and the actual pollution discharge is less than the EC allocated from the river basin level to the administrative unit;
- On-line monitoring of actual ET against target ET (by remote sensing technology) and actual pollution discharges against target EC (by water quality monitoring stations) shall be in place to report on the regular basis to leaders of the related administrative units in the river basin where actual ET and pollution discharges exceed the targets, in order for these administrative units to take actions for improvements in time;
- For the administrative unit where its actual ET and EC exceed the ET and EC targets shall take actions to convert the current resources-intensive production mode to a resources-efficient one which leads to produce the same or higher quality products with much less water consumption and much less water pollution discharges for the purpose of green growth and sustainability; and
- The existing laws, regulations, rules and regulatory system shall be enriched and supplemented as necessary to facilitate the implementation of the above steps.

The approach has been tested or partially tested by a number of water resources and environment projects financed by the World Bank in China and could be applied in any arid or semi-arid areas or regions to effectively control the over exploitation of water resources and abusive emission of water pollution in a river basin to maintain green growth and sustainability of its urban and rural areas within the basin.

Box 4-6: Hai Basin Project – IWRM in Practice

1. Implemented Agencies:

- Ministry of Water Resources
- Ministry of Environment Protection
- Provinces or Municipalities of Beijing, Tianjin and Hebei

2. Project Objectives:

The overall objective is to catalyze an integrated approach to water resource management and pollution control in the Hai Basin in order to improve the Bohai Sea environment.

3. Project Innovations:

- Institutional mechanisms for cooperation among government departments in different sectors rather than the traditional sectoral line management and top down (command and control) direction. A joint decision making conference system was established and tested at the Hai Basin, a sub-basin, and municipal and county levels;
- A basin-wide knowledge management (KM) system (including application of remote sensing ET measuring technology) located at the Hai Basin Commission and local governments which included decentralized knowledge hubs at the lower levels, and made it technically possible to share and allocate data at both basin and county levels by local governments and water use sectors within the basin;
- A new concept of real water savings which targeted a reduction in consumptive use or ET rather than just increases in irrigation efficiency alone which normally leads to increases in consumptive use of water through increased effective irrigation areas;
- Public participation: During project implementation, the outcome was achieved by establishing Water Users Associations (WUAs) and by promoting Community Driven Development (CDD) that farmers' income increased greatly while consumptive use of water was reduced; and
- The development and implementation of sub-basin and county-level Integrated Water and Environmental Plans (IWEMPs) based on the ET and EC targets to return surface and groundwater use and pollution discharge to sustainable levels consistent with the project's goals, ET quotas or targets, and EC quotas or targets for water and environmental function zones.

4. Project Outputs:

- Cooperation mechanisms and agreements prepared and updated at each administrative level including data sharing agreements signed at each administrative level;
- Eight strategic studies completed and used at the river basin level including: (i) Policy and Legal Framework and Institutional Arrangements; (ii) Bohai Sea Linkage (Pollution Status and Control); (iii) Countermeasures for the Protection and Measurement of the Water Ecological System; (iv) Water Savings and High Efficiency Water Utilization; (v) Administration of Water Rights and Well Permits, and Sustainable Groundwater Exploitation; (vi) Wastewater Reuse; (vii) Water Pollution Planning and Management; and (viii) Rationalization of Beijing Water Resources;
- Two strategic action plans (SAPs) were prepared and implemented at Hai Basin and ZWN Sub-basin;
- Seventeen integrated water and environment plans (IWEMPs) were prepared and implemented in 16 counties and Tianjin Municipality in the Hai River Basin;
- Various thematic studies were carried out to support IWEMPs and SAPs;
- Four demonstration projects were implemented;
- Knowledge Management (KM) Systems installed at MEP (for ZWN Sub-basin), Hai Basin Commission, Tianjin, Beijing and 16 counties in the Hai Basin;
- Two ET application centers were established in Hai Basin Commission and Beijing Water Affairs Bureau;
- M&E System and MIS were established during project implementation; and
- Four international workshops were held during the project implementation with workshop proceedings.

5. Project Outcomes and Scaling up:

The project has successfully demonstrated integrated water and environment management for Hai River Basin and for Bohai Sea ecological improvement with outcomes in substantially reduction of groundwater overdraft and pollution discharges to Bohai Sea. In addition, the project also demonstrated that the cooperation among different government departments would work for the same objectives. The government is keen to scale this up across the whole Hai Basin as well as across other river basins flowing into the Bohai Sea. Further illustration of scaling up is evident from inclusion of project approaches in national policy and master plans. In the Master Plan of Water Resources in Hai Basin (2011 - 2020) recently approved by the State Council, the project approach on ET management with remote sensing technology has been included as a new tool to control consumptive use of water resources in the Hai Basin.

Box 4-7: Example Water Balance Calculation – Turpan Basin, Xinjiang of China

The objective of water consumption balance analysis at the river basin level is to determine the target ET for irrigated agriculture (the biggest water consumer), taking into consideration the consumptive use targets for urban uses and ecological restoration (e.g. annual reduction of groundwater overdraft). A water balance at the river basin level refers to the balance between actual consumptive use and expected consumptive use for urban, irrigated agriculture, and ecosystem restoration as planned for a target year in the future. Based on the result of water balance, decisions would be made on a number of future projects through consultation with stakeholders in the river basin. The basin-wide target ET for irrigated agriculture would then be allocated from the river basin level to each of the irrigated areas managed by a farm or a village/WUA. With a careful design of integrated measures (engineering, agronomic, and irrigation management) to be taken to achieve real water savings, the proposed projects at the field level would ensure that the expected ET for the irrigated area managed by the farm or village/WUA is less than the target ET allocated from the river basin level. During project implementation, the impact of the project on ET would be closely monitored by remote sensing technology to ensure that the actual ET is less than the target ET allocated, or recommendations for improvements would be made to that farm or village/WUA.

The target ET for irrigated agriculture at the basin level can be derived as follows:

Water balance at the basin level: $P+I-O-WC_{URB}-ET_{ECO}-ET_{AGR}=\Delta G$

With: WC_{URB}=Target $WC_{URB}+\Delta WC_{URB}$ ET_{ECO}=Target $ET_{ECO}+\Delta ET_{ECO}$ ET_{AGR}=Target $ET_{AGR}+\Delta ET_{AGR}$

Thus: Target ET_{AGR}=P+I-O-Target WC_{URB}-Target $ET_{ECO}-\Delta WC_{URB}-\Delta ET_{ECO}-\Delta ET_{AGR}-\Delta G$

Objective: Actual $ET_{AGR} \leq$ Target ET_{AGR}

Items in Water Balance Equation	Water Items	Baseline Year			Project Completion Year 2015					
		Area	mm	Amount	Area	mm	Amount	Change to Baseline		
		Hectare		million	Hectare		million	mm	million	%
Available Water Resources	1. Precipitation	1,916,744	14.95	286.59	1,916,744	14.95	286.59			
	2. Water inflow			874.00			874.00			
	3. Groundwater base flow			41.00			41.00			
	Total Available			1201.59			1201.59			
Water Consumption	1. Ecological ET	484,188	85.10	412.04	484,188		412.04			
	1.2 Natural ET	481,238	84.34	405.88						
	2. Water Surface ET	14,013	240.45	33.69	14,197		29.48		-4.21	-13
	2.1 Man-made ET	963	293.68	2.83	1,147		5.20		2.38	84
	2.2 Natural ET	13,050	236.52	30.87	13,050		24.28		-6.59	-21
	3. Agricultural ET	114,206	542.49	619.56	114,206	484.95	553.84	-57.54	-65.72	-11
	3.1 Crop ET	94,271	630.62	594.50	85,942	603.76	518.89	-27.27	-76.02	
	3.2 Non crop ET	19,935	125.72	25.06	28,264	123.68	34.96	0.00	10.31	
	4. Unused Land ET	1,304,338	25.80	336.57	1,304,338		336.57		0.00	0
	5. Industries			15.42			43.61		28.19	183
	6. Domestic Use			7.03			11.35		4.32	62
	Total Consumption			1,424.30			1,386.89		-37.41	-3
Outflow				7.86			7.86		0.00	0
Change in Groundwater Storage				-230.57			-193.16		37.41	-16

Chapter V - Partnership Strategy for Sustainable and Green Growth

116. As set out in chapters II and III, China has made tremendous progress in its water sector development, which includes construction of water infrastructure, strengthening water management, and formulation of national water master plans and river basin master plans. Chapter IV has highlighted the already extensive and successful history of collaboration between the World Bank and the Government of China.

117. In Section 3.2, the principles set by the central government that will guide future development of water resources in China were listed. The first of these – that human beings should deal with nature in a harmonious manner instead of placing infinite demands on the nature – is perhaps the most important perspective that will influence the partnership strategy.

118. The unprecedented economic growth in recent decades has been based on continuous expansion of infrastructure and resource use, not least in the water sector. The depletion of aquifers and rivers, and pollution of waterways show that this process has in some cases exceeded safe limits. The relationship with nature is no longer "harmonious" and the future strategy must reflect this by finding ways to reduce demands on, and damage to natural resources while minimizing the negative impacts on the economy.

119. Integrated Water Resources Management provides an agreed framework to guide this process, starting at the river basin level and explicitly tracing impacts of human interventions and natural events across sectors and locations. Already a number of Bank-supported projects and collaborative activities have generated significant and relevant experience (as described in Chapter IV), on which the Partnership Strategy is based.

120. Activities have been formulated in support of China's ongoing program of water resources development and management. That program is vast in comparison with the resources that the Bank can commit, so that benefits to both sides are maximized by identifying those areas where the Bank can bring specific experience or expertise that would not otherwise be readily available. Thereafter, the potential to multiply the impact of successful interventions across the wider context is enormous.

121. The elements of the strategy relate to flood control, water scarcity, pollution, restoration of the ecology, improved resource management, and climate change. Each element contributes to one or more of the major "systems" (detailed in Section 3.1) that China proposes to put in place in the coming decade, namely:

- A system for flood protection and drought mitigation;
- A system for rational allocation and efficient use of water resources;
- A system for water resources conservation and river and lake health security; and
- A system for mechanism instrumental in scientific development of the water sector

122. Each of these is required to underpin the introduction of IWRM or IWEM in major river basins by 2020. Following the description of the broad elements of the partnership strategy, more specific activities that are expected to contribute to the implementation of the components are summarized.

5.1 Guiding Principles of Partnership Strategy

The Bank supports Integrated Water Resources Management (IWRM) at the river basin level, and further down to the administrative and water-user levels to address various water issues, particularly to facilitate a shift from current resources-intensive development patterns to more resources-efficient development patterns, maximizing the economic value of each drop of water while minimizing negative environment impacts, and contributing to the on-going sustainable, green and inclusive social and economic development in China (Section 4.9 and Boxes 4-1 through 4-7).

123. One of the keys for water sector to support sustainable social and economic development and green growth is to find better ways to live with nature and trade off water demands for economic activities and ecosystem protection. To establish the major "systems" by 2020 given the limited natural resources, China would need to take initiative with innovations on how to better live with flood and drought; how to make water resources allocations for more balanced economic development and environment protection, and how to practice "sustainable development" and "green growth" with the latest international knowledge from both natural and social sciences as a driver available for improved water resources management. More detailed points to support the guiding principle are as follows:

- The importance of water resources for the development and management at the basin level has been recognized at national, regional, and local levels. Implementation will require political will, and long-term commitment from both sides. It is especially needed where changes in legal and institutional structures, or to address controversies and conflicts among stakeholders.
- All related water using sectors within the river basin should contribute to preparation, revisions and implementation of the Master Plan at the river basin level that reflects the individual sector plans.
- Cooperation mechanisms or agreements on integrated water resources management among water using sectors, including initial sharing of general basin-wide data and information, and further sharing of more specific information, based on clear

agreements among stakeholders.

- Capacity development and training to build understanding and consensus on the new approaches and analysis will be essential.
- The existing laws and regulations that apply to water-related activities must be reviewed to determine how existing legislation can be adapted to accommodate sustainability with regard to water resources management;
- Master plans should reflect individual sector plans based on consumptive use and related water rights to facilitate ecological restoration and the most appropriate utilization of a basin's resource.
- IWRM or IWEM implementation needs financial sustainability — including the promotion of cost recovery. The decisions recently made by Government of China would greatly improve the current situation on financial difficulties for water infrastructure construction, financial stability and sustainable cost recovery.
- Monitoring and evaluation (M&E) are essential to identify the need to adjust management strategies. Upgraded technologies (e.g. application of remote sensing technologies on measuring actual water consumption, and other latest technologies in the world) are vital. More attention and efforts should be put on outcome indicators focusing on impact assessment.

5.2 Partnership Strategy for Flood Protection and Mitigation

The Bank would support China to further build on integrated flood risk management strategy at the small and medium-sized river basin levels, taking into account the risk and vulnerabilities of the entire systems and designing most cost effective measures to protect or response to flood disasters while incorporating locally acceptable and adequate techniques and approaches (Section 4.2, Box 4-1 and Annex 3).

124. China has a real opportunity to strengthen its flood risk management and protect human lives as well as properties and infrastructure by adopting risk management and cost effective strategies that focus less on controlling floods and integrate the concept of living with floods, protecting key assets, and minimizing losses. In this regard, the following eight key areas need to be considered:

- Inclusion of integrated flood risk management into national regulations, policies and investments for flood prevention: Integrate structural and non-structural measures into government financed investment programs, adopting early risk identification (for instance by applying a quick and simple risk-screening tool) and following up throughout the design process if necessary. Independent review or incorporation of flood risk expertise in identifying investment programs has also proven to be very cost effective;
- Development and implementation of a risk-based national flood management strategy at the river basin level: Risk management should be informed by systematic hazard and risk exposure and vulnerability mapping in order to develop possible economic loss scenarios. The systems approach allows the definition of resilience and resistance strategies for flood risk management. Resistance strategies aim at flood prevention, while resilience strategies aim at minimizing flood impacts and enhancing the recovery from those impacts;
- Prior assessment of flood risk and vulnerability: A comprehensive understanding, analysis and assessment of flood risks and vulnerabilities will be carried out that will guide river basin flood disaster risk management strategies, urban development, including appropriate urban drainage standards and land use plans;
- Balance between structural and non-structural control measures: Since structural risk mitigation cannot alone suffice for effective flood risk management and is a costly option, an integrated flood risk management strategy

should be able to balance between disaster risk reduction and preparedness measures, by defining minimum or optimal levels of acceptable risk;

- Strengthening management of small /rural dams and Barrier Lake: Safety of small/rural dams is critical because of their vast number, lack of proper designs, poorly maintained, operated and monitored. Chinese government has made achievement to ensure safety of small dams with structural measures, but it needs to continue improving management of these dams;
- Institutional emergency coordination at the local government and community level: Establish coordination principles for flood disaster response and recovery focused on the role of local authorities, communities and other locally relevant stakeholders;
- Emergency preparedness and response: Flood forecasts are just a small piece in the early warning chain. In case of flash floods such systems play a very crucial role in saving lives. A successful early warning system depends not only on forecasts but has to connect many specialties and organizations, including engineering, social sciences, government, news media, and the public; and
- Insurance mechanisms: Insurance mechanisms should be designed in a way that they encourage beneficiaries to avoid occupation of high-risk areas, comply with building standards and further implement flood-proofing and other mitigation measures. Insurance and other kinds of disaster risk management measures can facilitate public-private partnerships for dealing with extreme weather related calamities and play a critical role in disaster recovery and reconstruction.

5.3 Partnership Strategy for Water Scarcity

125. With China's rapid social and economic development since 1970s, many parts of the country are experiencing growing water scarcity, and hence water insecurity. Two major different types of water scarcity can be distinguished: (a) physical scarcity occurs when there are not sufficient water resources available to meet all water demands, including environmental flows. Most of these areas are located in the northern part of China with relatively less water resources; and (b) economic scarcity occurs when there is a lack of investment in water infrastructure or a lack of human, institutional and/or financial capacity to satisfy the demand for water.

A. Economic Water Scarcity Areas

In river basins or the areas where there are relatively abundant water resources, and water scarcity occurs when there is a lack of investment in water infrastructure. The Bank would provide support to promote high productivity irrigation through increasing water use efficiencies and beneficial consumptive use of water (Section 4.3).

126. In areas with economic water scarcity, engineering measures should be taken to expand the existing irrigated area or make water available to more users. In the case of irrigated agriculture, improving irrigation infrastructure combined with agronomic measures and participatory irrigation management measures should be promoted to increase production and farmer incomes. It should be noted that the total consumptive use of water, as a result of investment on high productivity irrigation, would normally increase because of increased irrigated areas or cropping index or intensity. But the increased water consumption can be justified by the increased agricultural production and abundant water resources in these areas.

B. Physical Water Scarcity Areas

In river basins or local areas where surface and groundwater resources are insufficient and already overused, the Bank would support consumption management, increasing the economic value per unit of consumptive use of water through high productivity irrigation, or directly reducing

consumptive use of water with alternative economic activities leading to sustainable development and ecosystem restoration (Sections 4.3 and 4.4, and Boxes 4-2 and 4-3).

127. In areas with physical scarcity, the focus should be on increasing the economic value per unit of consumed water (i.e. value of production per unit of consumptive use). In the case of irrigated agriculture, the goal should be to reduce consumptive use of water while still trying to increase farmer incomes. Investment in these areas should not increase total consumptive use of water.

128. Based on the above strategies, the increase of grain production capacity would need to be achieved mostly through newly developed irrigated areas and expanded existing irrigated areas in economic water scarcity areas. In the physical water scarcity areas, there will be a potential to increase water productivity, but there would be little opportunity to increase or expand irrigated areas because it would lead to further deterioration to the ecological environment. In general, the situation on physical water scarcity may not be able to change in the future in the northern part of China even after the completion of the eastern and middle routes of on-going "South-North" Water Transfer Works. The above analysis suggests that the biggest challenge on water scarcity for China is to combat physical water scarcity in semi-arid or arid river basins located in northern area of China where water resources have been overexploited by economic activities and ecosystems have been deteriorating. The issue of water scarcity will need to be addressed together with the issue of ecosystem degradation with trade-offs on water demands for all economic activities. In the south, pollution is the main threat to water availability for agriculture.

5.4 Partnership Strategy for Control of Water Pollution

A. The World Bank would provide support to perform Integrated Water and Environment Management (IWEM) to control the actual water pollution discharges based on the target ET and target EC with experience and lessons learned from Bank-supported projects jointly prepared, successfully implemented and completed by water and environment departments (Sections 4.7 and 4.9, and Boxes 4-5 and 4-6).

129. The policy statements of No. 1 Central Government Document of 2011 requires that China to "strictly control the total amount of pollutant discharges into rivers, lakes or other water bodies, which should not exceed the carrying capacity of recipient water body in order to meet the water function zone targets." This is a major challenge given the current division of responsibilities between water and environment departments for pollution control. The Bank would support a partnership strategy on water pollution control through enhanced cooperation as follows:

- A joint conference-based decision making system for integrated water and environment management be established and set out for close cooperation of the water and environment departments at each administrative level of government;
- Water and environment departments work closely to determine the amount of pollution discharge to a receiving river/lake based on the target environment carrying capacity (EC) and target evapotranspiration (ET) allocated from the river/lake basin agreed with all stakeholders;
- Enhancement of M&E systems for both water quantity and quality monitoring, and pollution discharge standards are strictly enforced; and, related policies and regulations on pollution control are revised to support good practice.

B. The World Bank would provide support to mainstream the integrated water and environment management approach in physical water scarcity and pollution areas (Sections 4.7 and 4.9, and Boxes 4-5 through 4-6).

130. The IWEM include the following key and important aspects:

- The mainstreaming of IWEM, at all levels, and with river basin as the unit of water resources and environmental management;
- The determination and integration of target ET (Evapotranspiration) and target EC (Environment Carrying Capacity) levels at the river basin level;
- The formulation of development plans for a basin or region's urbanization, population and production patterns in accordance with the constraints of target ET and target EC;
- The establishment of multi-stakeholder platforms for debate and joint decision-making among water users;
- The utilization of mechanisms for allocating water resources (Target ET) that are linked to the water productivity and pollution emission levels of sectors and users, along with environmental carrying capacity (Target EC);
- The establishment of a pollution discharge permit system at the river basin level, and incorporating "pollution discharge permit trading"; which should be linked and supported by the existing water withdrawal permit system supported by "ET-based water rights trading";
- The institution of stronger cooperation and coordination between relevant government departments and other stakeholders;
- On-line monitoring of actual ET against target ET and actual pollution discharges against target EC, as well as other indicators;
- The supplement of existing laws, regulations and regulartory system on water scarcity and pollution issues to ensure implementation of IWEM at all levels.

5.5 Partnership Strategy for Restoration of Ecological Environment

The World Bank would support integrated small-watershed managemen to support the sustainable development pattern. The Bank would also support the Integrated Water and Environment Management (IWEM) to protect or restore the ecological environment in river basins or regions with physical water scarcity (Sections 4.5 and 4.9, and Boxes 4-4 through 4-6).

131. The new approach would help to (a) facilitate decision makers to prioritize water demands and to control of water pollution from various economic activities and from the need for protection or restoration of ecosystems; (b) allocate target consumption from the river basin level to water user level as the basis to determine the amount of water withdrawal; and (c) monitor the actual consumption and recommend actions to be taken for the actual consumption to be less than the target consumption allocated at the river basin level.

132. To allocate water with an order of priorities based on the above approach, it is necessary to start with a water consumption analysis at the river basin level to find out the actual consumptive use of water within the Basin, and then propose a target amount of water available to be consumed by the economic activities for each of administrative areas within the river basin. The target consumptive use of water for economic activities requires trade-offs and coordination involving consultation with all stakeholders including local governments, big water users and farmers.

133. Human interventions have proved to be very successful to speed up the restoration of the ecological systems, particularly in loess plateau region in north-west part of China, where growth of forest vegetation and irrigated agriculture are constrained by lack of water, soil erosion and limited soil fertility due to low

organic matter. This proved to be successful in China's loess plateau projects in that land conservation is compatible with sustainable and productive agriculture and that they are mutually reinforcing (Box 4-4).

5.6 Partnership Strategy for Improving Water Resources Management

A. The Bank would support the Government (a) to changeover from the traditional or extensive mode to a sustainable or refined mode for water resources management in order to support a more balanced social /economic development and ecological environment protection for sustainability; (b) to introduce the consumption management concept to strengthen the existing water resources management system; (c) to introduce the latest knowledge and technologies in the world as tools to facilitate consumption-based management; and (d) to strengthen the monitoring and evaluation system and O&M with relevant performance indicators to facilitate IWRM or IWEM (Sections 4.1 through 4.9, and Boxes 4-1 through 4-7).

134. The Central Committee of Communist Party of China and the State Council's 2011 policy statement set out management priorities in three areas – physical water resource management, management of rivers and lakes to prevent encroachment, and infrastructural management primarily to ensure adequate resources for operation and maintenance (O&M).

135. Regarding the physical resource, the policy requires enforcement of the "Three Red Lines" as follows:

- To restrict the total amount of water use or withdrawal from rivers and groundwater aquifers to planned targets. For areas where total water withdrawal has reached or exceeded the target, the approval of additional water withdrawals should be suspended; and for areas where total water withdrawal is close to the target, review and approval of additional water withdrawal should be restricted;
- To increase water productivity and restrict waste. A regional and sector water productivity review and appraisal system will be established to accelerate the development of a water saving society; and
- To strictly control total pollutant discharge into rivers, lakes or other water bodies, and hence protect the capacity of recipient water body to meet its designated water function.

136. These measures are aimed at limiting the total water consumption to sustainable levels, increasing water productivity, and reducing pollution loads. Enforcing these measures will be challenging, however the government has stated that leaders at various levels will be held accountable. The Bank's partnership strategy on improving water resources management should center on how to effectively implement a strict water resources management system consistent with the "Three Red Lines". Controlling consumptive use of water in irrigated agricultural areas is the main challenge.

137. Under the current water withdrawal permit system, if water management improves, or hi-tech irrigation is adopted, the usual outcome is that the farmer is able to increase the irrigated area or increase the yield of crops while still withdrawing the same quantity of water. However, either of these outcomes – expanded area or higher yield – increases the volume water that is consumed through ET; that is a higher proportion of water withdrawn consumed. Return flows to rivers and aquifers will decrease, and sustainability is worsened. This outcome has been observed in some areas of country – as irrigation techniques have been upgraded, related production increased have been based primarily on additional water consumption per unit of water withdrawn, exacerbating physical un-sustainability and ecological degradation. This has been particularly significant in physical scarcity areas in the semi-arid and arid regions of China.

138. Improving irrigation – lining channels, better scheduling, and on-farm technology – has various benefits, including reduced pumping costs, less leaching of nutrients, lower pollution loads, etc. But physical water savings are usually minor, and indeed often consumption increases so that careful consumption based analysis is required to understand the impact of such improvements in the context of water scarcity.

B. The Bank would support the Government to introduce strict water resources management to control, monitor and evaluate the actual consumptive use of water in physical water scarce areas through application of a strengthened Water Withdrawal Permit System based on water-consumption management / monitoring supported by the latest developed remote sensing technology. Funding systems for O&M would also be strengthened (Sections 4.3 and 4.4, and Boxes 4-2, 4-3 and 4-7).

139. Compared with the current practice of the traditional water withdrawal permit system, one key difference of the current water withdrawal permit system and strengthened one is that the allowable water withdrawal must be determined through an analysis of water consumption balance. The principles of the strengthened water withdrawal permit system for a consumption-based water rights system include:

- Project evaluation based on a water consumption balance analysis must be prepared at the field level in an administrative area to ensure that the actual consumptive use after the project intervention is less than the actual consumption without the intervention and consistent with the target consumption at the basin level (Box 4-7);
- For surface water, the withdrawal rights need to be specified in entitlement (initial water rights, based on average annual flows) and water allocation amount (based on actual annual availability and priorities among users);
- Water withdrawals would be measured and controlled, and water allocations must be enforced. This is a major administrative undertaking that needs to be supported with adequate government financial resources;
- Using remote sensing techniques, the distribution of annual ET would be measured and reported, providing the basis for re-assessment of allocations and identification of high consumption/low productivity users;
- Water markets should be considered at an appropriate time to facilitate water reallocations from low- to higher-value uses, and supported by an adequate water rights administration system designed to assess and limit potential third party impacts of any transfers;
- Efforts should be undertaken to increase water productivity in irrigated agriculture, in order to protect farm income levels;
- Appropriate compensation policies and mechanisms should be designed and established for farmers who are willing to give up their water rights in order to return water to the ecological environment.

140. In support of the above partnership strategy, the Bank would provide technical assistance to resolve the following specific issues:

- Water and related laws, decrees and regulations, as described in Table 3-1, should be fully enforced and interpreted through the consumption management concept and approaches introduced through this strategy paper;
- Institutional arrangements for information and data sharing among different water-related government departments would be enhanced; and
- Where practicable, and particularly in groundwater areas, volumetric water charges should be designed to encourage productive use of water through rising block tariffs.

141. In support of the Government's Policy on infrastructural management, the World Bank would support strengthened cost recovery:

- Cost recovery of irrigation infrastructure systems would be carried out in two stages: (a) the cost for O&M should be fully covered by WUAs for on-farm irrigation systems (laterals, sub-lateral and farm ditches) within their management areas; and (b) the cost for main irrigation infrastructure systems would be covered by water users plus government subsidies; and
- Stakeholders including farmers and lower-level water users should fully participate in the process of project planning, design, construction and O&M activities, and their ownership and responsibility for the projects constructed should be strengthened.

142. Stable and adequate financing mechanisms to provide for sustainable maintenance of the infrastructure for water development should be ensured, based on government and beneficiary contributions. Private sector involvement in the water sector should be mobilized with incentives provided;

5.7 Partnership Strategy for Climate Change Adaptation

The World Bank would support the Government to adapt to the impacts of the global climate change in the following areas (Sections 4.8 and 4.9, and Boxes 4-5 through 4-6):

- To accelerate the shift from water supply management to demand management, e.g. application of consumption-based integrated water resources management at the river basin level with more attention to ecological protection and restoration and adjustments to infrastructure operations;
- To incorporate climate change into the water resources planning process, e.g. preparation of water resources planning guidelines including revision of engineering design standards in response to climate change;
- To strengthen planning and construction of water infrastructure with more attention to non-structure measures, e.g. application of integrated flood risk management system for flood prevention;
- To review design standards and assess their suitability for anticipated climate change scenarios;
- To shift the energy structure to one with clean and low carbon consumption, e.g. to promote more small hydropower and wind power generation to replace thermal power generation; and
- To conduct more related studies, and most importantly their application on mitigating and adapting the impact of global climate change in China.

143. The Chinese Government attaches great importance to the issues of climate change and water resources, operates "China's National Climate Change Program", strongly advocates the cause of sustainable development, actively promotes policies and actions on climate change adaptation and mitigation, and addresses the impacts of climate change on water sector. The proposed partnership strategy on climate change adaptation between the Chinese Government and World Bank is detailed in Annex 4.

Chapter VI – Agenda for Cooperation between China and World Bank

144. Based on the experience of cooperation with China, the World Bank would continue towards becoming "the most important strategic development partner" with China, including promotion of China's water sector development. The priority areas of the World Bank for water sector development will be in line with the guiding principles of partnership strategy as indicated in Chapter V, consistent with its objectives of poverty reduction, addressing resources and environment challenges, and promoting green, sustainable development.

145. The priority areas proposed for water sector development with the World Bank take account of the long-term priorities for the coming decade (2011-2020) set out in 2011 in a policy statement of the Central Government of China entitled "Decisions on Accelerating Water Reform and Development", and short-term priorities for the coming five years set out in China's "12th Five-year Water Program (2011-2015)" and the key areas in accordance with the relevant water sector master plans approved by the State Council. The World Bank would support these priority areas through its "Analytical and Advisory Activities (AAA)" Program and Loan financed projects or specially designed assistance to conduct studies and provide advice and recommendations on newly emerging problems.

146. The process would establish a long-term strategic partnership between the World Bank and China's Ministry of Water Resources (MWR) in line with the agreed partnership strategies.

6.1 Major Foundational Studies with World Bank's Future TA Program

147. Water security is closely linked with sustainable development of economy, society and human ecosystem. With the exacerbation of global resource crisis, water security has become an important component of national security and shares an equally important strategic position with national defense security, economic security and financial security.

148. To address China's need for a step-change in its approach to development of its water resources, it is planned to utilize the comparative advantages of the World Bank and international cooperation to keep track of the latest international developments under the theme of sustainable development and green growth as indicated in the mainstream partnership strategy above. These basic studies include the following:

Strategic study on water security in China

- Water security for food security
- Assessment on adequacy of irrigation infrastructure
- Inter-basin water transfer
- Development of water conservation society
- Irrigated agricultural water savings - increase water productivity
- Strategic use of groundwater

Sustainable water resources utilization

- Impact of human activities and climate change on availability of water resources and its trend prediction in China;
- Allocation of water resources with trade-offs with a focus on ecological environment protection and restoration in physical water scarcity areas in China;
- Rational utilization of flood water and wastewater as well as other waters as resources to combat challenges of water scarcity in China.

Flood control and drought relief and calamity mitigation

- Shifting national strategies integrated flood risk management for flood control and calamity mitigation;
- Flood emergency response and management for dam failure;
- Modernization of national flood control and water allotment system;
- Dynamic monitoring and early warning of drought in a region or vast area;
- Strategy for orderly development of flood retention plains and zones;

Environmental protection and ecosystem protection in river basins

- Water resources conservation and ecological restoration or rehabilitation for rivers and lakes in China;
- Technologies for protection of both water quantity and quality in river basins;
- Water environmental protection and ecological improvements in western region development in China;
- Ecological compensation on large-scale flood control and hydropower projects;
- Development of regional monitoring network for water resources and environment observation; and
- Development of platform for knowledge exchange and demonstration of ecological restoration and rehabilitation

6.2 Infrastructure Construction with World Bank's Future Loan Projects

149. Like many other developing countries, at the same time that the GDP and financial revenues are rapidly growing, China attaches great importance to infrastructure construction. During the period of the 11th Five-year Plan, the investment which has been put in water infrastructure construction was much more than any other five-year plan periods in the

history. During the 12th Five-year Plan period, the priority actions of the World Bank for infrastructure construction would be based on the partnership strategy and fundamental studies.

Flood Protection and Water Supply Security

150. It is expected that the Bank would introduce international experience in technical design of the infrastructures in flood protection and water supply, incorporating flood risk management and water resources allocation so as to maximize the economic benefits of the investments. The Bank will continue to assist China in developing and improving its infrastructure network system on flood protection and basin and regional water resources allocation.

Exploitation of New Water Sources

151. Development and utilization of non-conventional water sources, especially in northern China where water is short, is one of the measures for increasing water supply and improving the water cycle. Non-conventional water sources normally include rainwater harvest, cloud seeding, and reuse of treated wastewater, flood water use, sea water desalination, and brackish water exploitation. In these areas, the Bank has gained rich experience and advanced technology through relevant activities carried out in other countries of Africa and Asia, so it can provide good advice to China on non-conventional water sources development and utilization. The Bank can also help China use flood water, and recycled water for groundwater injection.

Irrigated Agricultural Water Savings

152. The World Bank has financed a number of projects concerning water saving in irrigated agriculture. It will continue to support and help China in improving agricultural irrigation works and irrigation water use, as one of its priority action plans. In future, it would expand pilot areas and disseminate relevant successful experience including monitoring and reduction of consumptive use of water with remote sensing technology and increase of water productivity in physical water scarcity areas. The Bank can also help China in carrying out irrigation scheduling or deficit irrigation, and other relevant work in dry and semi-dry areas.

Water Pollution Prevention and Ecological Environment Improvements

153. The Bank can provide assistance in design, construction, management and operation of wastewater treatment and management, so as to improve the financial returns to wastewater treatment plants, meet the standards in pollutant discharge, and promote water reuse and recycling. Pollution from farming, animal and poultry culturing, and rural domestic wastewater would need to be controlled. The Bank can finance projects or pilot projects to explore prevention of ecological environment and non-point pollution sources and introduce new technology and management mechanism in the light of local conditions so that the ecological environment of rivers and lakes that suffer from heavy non-point pollution sources will be restored and rehabilitated.

Small Hydropower Development in Rural Areas

154. Hydropower will be developed for clean energy use, to cut down emission of carbon dioxide and other pollutants. The Bank would continue to cooperate with the government of China in investing in construction of micro hydropower stations, as green energy, to reduce carbon emission. This will also help to raising the living standards of the people in poverty-stricken areas and improving the eco-environment.

6.3 Water Resources Management with World Bank's Future Loan Projects

Water Sector Management and Reform

155. The World Bank has accumulated rich experience from projects and activities implemented in almost all the large river basins in China. Priority cooperation in water sector management and reform would include:

- Carry out pilot studies to explore the model of consumption-based integrated water resources management;
- Establish an effective consultation platform for extensive participation of different stakeholders including government departments and water users;
- Make clear the responsibilities of different managers and their relationship with water resources interests between the upper and lower reaches;
- Conduct water resources assessment with new approach analyze their availability and demand;
- Establish systems and mechanisms for data and information sharing among different government departments and agencies as well as institutes;
- Establish mechanism for water dispute resolution and control instruments;
- Capacity building and legislation.

156. In addition, the World Bank would actively introduce international experience in water infrastructure construction and management to facilitate reform in some key areas of China's water sector, including:

- Introduce and extend good models for water infrastructure construction, operation and management to expand channels of investment sources, through market operations, in water energy development, municipal water supply and drainage, and so on;
- Accelerate establishment of a virtuous-circle water works operation and management mechanism to increase the life and efficiency of water infrastructures;
- Establish and improve China's water rights system and allocate water through the market to increase water resources efficiency and benefits;
- Make analysis of water supply costs and set water prices reasonably, so as to save and protect water resources by using the economic leverage.

157. The World Bank would also strengthen cooperation with China in the social management and public service of water sector and actively encourage the general public to participate in water resources management in the form of administration affairs transparency, business transparency, network services, WUAs, voluntary organizations and so on, in order to enhance the public's right to information on water regime (quantity and quality) and enhance social interaction and supervision. It will also assist in carrying out scientific knowledge dissemination and education to raise people's awareness of potential water problems and social morality of rational water use and train citizens to improve their self-protection and self-help capabilities in the event of extreme events.

Capacity Building and Staff Development

158. The Chinese Government proposes to develop talented staff for the water sector, increase investments in talented staff projects, promote coordinated development of various talented staff teams and establish systems for developing highly professional and skilled staff including leading officials and civil servants at various levels. More efforts shall be made to implement key talented people projects, advance large-scale staff training activities, and organize rotating training for 10,000 directors of county and city water bureaus and 10,000 heads of township water management stations.

With it rich experience in staff training, the Bank can help China implement more effective staff training and promote the application of advanced international experience in China.

159. Enhancing water sector technological innovation capacity is an important support for China to achieve a step-change in water sector development. China will deepen water sector scientific-technical system reform, and create water sector scientific-technical research and technology development system, with strong support for technological extension services and technological management system. The Bank is well positioned to introduce into China cutting-edge international institutional, systems and management experience as well as outstanding results in the field of technological innovation and promote cooperation between China and technologically advanced countries.

6.4 Short-term Focal Areas of Cooperation and Demonstration

Integrated River Basin Management

160. The Chinese Government has decided to increase investments in reversing the situation of lagging infrastructure development, but many issues/problems still exist with integrated basin management in China. The World Bank would play an important role in addressing these issues/problems.

- A key feature of China's present water resources management system is excessive fragmentation of roles and responsibilities, which has led to increased administrative costs of inter-departmental/agency coordination and declined effectiveness of water resources management. The World Bank has repeatedly stressed the importance of integrated river basin management when providing water resources management assistance, especially institutional issues relating to integrated river basin management, and has recommended creating a national-level integrated water management agency.
- Integrated river basin management requires information – digital platforms integrating real-time information on flows, diversions, rainfall, cropping patterns, groundwater levels, etc, which can be shared across agencies. China urgently needs to carry out studies and activities in the following areas: joint regulation of river basin water, ecological regulation of water resources, early warning and emergency preparedness management technology systems, most strict water resources management systems and associated policies, guidelines and technical specifications governing integrated river basin planning, river basin water resource and water environment monitoring system and information platform development, and river basin ecological compensation policies and mechanisms, among others.
- The World Bank and MWR would work together to select river basins with difficult management issues/problems and develop demonstration areas for integrated management, introduce advanced experience and techniques of developed countries and carry out studies on new models for integrated river basin management relevant to Chinese conditions.

Water Allocation System in Regions with Severe Water Shortages

161. In northern China, water conflicts between upstream and downstream, right and left banks and agriculture and industry have become increasingly severe and have seriously constrained socioeconomic development and eco-environmental protection. Establishing and improving water resource allocation systems in areas with severe water conflicts is of great significance. China is actively exploring how to enhance integrated water resource allocation capacity through connecting river and lake systems; creating an integrated river, lake and

reservoir water network system involving rural and urban areas which ensures smooth water diversion and drainage, appropriate water storage and detention and water control and regulation; and optimizing the layout of river and lake systems and enhancing coordination between river and lake system layout and socioeconomic layout. The World Bank can build on China's new needs to select important tributaries of the Yellow River, Hai River and other major rivers and establish demonstration areas, and to promote advanced international experience and techniques in establishing water resource allocation system and water resources management.

Management of Ecologically Fragile Rivers

162. With close attention from the Chinese Government for the management of ecologically fragile rivers, integrated management has been implemented for the Tarim River, Hei River and Shiyang River with successful preliminary results achieved. The World Bank can strengthen cooperation with the Chinese Government in this area and conduct studies and demonstrations on the following through selecting typical ecologically fragile rivers and establishing demonstration areas: maintaining "healthy" environmental flow of rivers and water bodies, impacts of large water projects on hydrology, water resources and ecological environment, water and soil conservation, comprehensive technological system for ecological restoration and poverty reduction, quantitative assessment of ecological water demand and allocation of water for ecological use, monitoring, evaluation and early warning of regional drought/flood disasters and emergency management, as well as agencies and methods for integrated river basin management.

Water Conservation

163. Irrigation efficiency is low with the coefficient of effective irrigation water use standing at 0.5. The Chinese Government is developing "agricultural sector efficient water saving" plans and intends to achieve the following within about ten years: improving agricultural water use and management, creating region-specific, modern, water saving irrigation and development models, extensively promoting water saving irrigation technologies, significantly increasing the coefficient of effective irrigation water use, increasingly improving agricultural irrigation modernization level and steadily enhancing agricultural productivity.

164. The World Bank has conducted studies on consumption-based agricultural water saving in the GEF Hai Basin Integrated Water and Environment Management Project and Turpan Water Conservation Project. These studies have achieved good results and proposed a consumption-based water resources management concept building on progress in remote sensing and GIS technologies, which would help China enhance the level of agricultural water saving and adopt better methods to allocate and manage water rights. According to China's plans for implementing large-scale efficient agricultural water saving, the World Bank will select typical irrigation districts to establish demonstration areas for agricultural water saving and promote the concept and techniques of consumption-based management.

Policy and Strategic Countermeasures

165. China has achieved significant progress in studies on policies and strategic countermeasures for water resources development, utilization and management, but major improvements need to be achieved in enforcement of such policies and countermeasures. The World Bank can strengthen cooperation with China on public participation and water resources

management, plan implementation, irrigation district management and water pricing reform and select typical irrigation districts to set up demonstration areas for studies and enforcement of policies and countermeasures, thereby contributing to enhancing China's capacity in developing and enforcing water-related policies and strategic countermeasures.

Integrated Flood Risk Management

166. China has achieved remarkable results in managing its major rivers and has effectively lowered damages of flood disasters. China's experience in this area is worthy to be promoted to the world. However, China needs to improve its flood risk control measures, especially non-engineering measures. The World Bank will provide to China advanced international flood risk control techniques and explore to develop flood risk control techniques and models of Chinese characteristics through establishing demonstration areas in regions with high flood risks.

167. Reservoir dam construction in China has reached advanced world level with respect to planning, designing, damming and so on. Yet, there are some gaps in dam safety management technology. Although China has achieved certain results in scientific research through international exchange since the beginning of 1990s, currently dam risk management in the country is still in its initial stage, with many problems with risk analysis technology being unsolved. Now, some developed countries have established systems for dam risk management, which has already been put into practical application. The World Bank can provide assistance in introducing advanced technology of dam risk management from developed countries and support China in establishing its dam risk management system by breaking technical bottlenecks and improving its relevant policies and regulations.

Addressing Climate Change

168. The impacts of global climate change on water resources have been widely recognized. China is prone to flood and drought disasters and impacts of extreme weather events on China are increasingly emerging. The World Bank is committed to conducting studies on adaptation countermeasures for water resources and river basin management under the context of climate change, such as those on impacts of global warming on water resources, water cycle and flood and drought disasters and on vulnerability and adaptation of river basin ecosystem to climate change, as well as on corresponding countermeasures and policies. In addition, the World Bank will select regions sensitive to climate change to establish demonstration areas and guide local people to take active measures to address impacts of climate change on water resources.

169. The World Bank would assist China in formulating guidelines for a water-resources plan to respond to climate change, and establish an assessment system for climate change impacts on water resources.

Ecological Compensation in River Basins

170. Protecting ecosystems in the upstream of river basins is an important approach to maintaining healthy river water cycle and providing necessary ecological compensation to water source sites in river basins is a consensus reached in the international community. China's central and local governments are increasingly interested in adopting ecological compensation mechanisms in the form of government financial transfers to protect ecosystems in the upstream of river basins. Nevertheless, this approach relies heavily on public financial transfers (mainly from the central finance) and lacks direct linkages between ecological service providers and beneficiaries. Internationally, some countries have successfully adopted market-

oriented ecological compensation methods (paid ecosystem services). In comparison with government financed supported ecological compensation mechanisms adopted in China, paid ecosystem services provide another method which is more market oriented and places more emphasis on self-financing. The World Bank can introduce these advanced concepts and methods to serve China.

Groundwater Management

171. China's groundwater resources amount to 821.8 billion m3. Groundwater development and utilization have played an extremely important role in ensuring water use for socioeconomic development. At present, groundwater use across the country amounts to over 100 billion m^3, or one-sixth of the country's total water use, which is mainly distributed in regions such as Huang-Huai-Hai Plain (also known as North China Plain), Guanzhong Basin and inland rivers in northwestern China. Due to irrational development and utilization of groundwater resources, groundwater has been severely over-withdrawn in some regions of China with widespread overdraft in northern China. So far, there have been over 160 groundwater overdraft zones in China with a total area amounting to 19 km^2 and annual average overdraft exceeding 20 billion m^3. As a result, environmental and geological problems have occurred in some regions, such as land subsidence and seawater intrusion.

172. The Chinese Government has taken a series of measures to effectively protect and rationally develop and utilize groundwater resources and MWR has prepared groundwater development, utilization and protection plan to make overall arrangements for future development, utilization, conservation and protection of groundwater resources. According to the plan, groundwater withdrawal would be moderately increased in areas with groundwater development potential and withdrawal would be gradually reduced in groundwater overdraft zones to eventually achieve balanced withdrawal and replenishment of groundwater resources and promote sustainable utilization of groundwater resources.

173. Given the current status of and problems with groundwater development and utilization, main tasks for groundwater management in the upcoming period are to strictly control withdrawal, upgrade management of overdraft zones and preserve and protect groundwater resources. MWR has completed the preparation of Program for Control and Reduction of Groundwater Withdrawal in Water-receiving Areas under Phase I of Middle Route South-North Water Transfer Project. According to the program, water from the South-North Water Transfer Project will be used to replace groundwater in some areas of North China Plain and groundwater withdrawal will be reduced to control and maintain a rational groundwater table. In other areas with alternative water sources, it is also necessary to gradually control and reduce groundwater withdrawal, establish emergency and strategic reserves and enhance the capacity of groundwater in combating emergency drought. In areas with appropriate conditions, it is necessary to replenish and preserve groundwater through establishing groundwater reservoirs and using rainwater, floodwater and recycled water for recharge purposes.

174. The Chinese Government has decided to enforce the "most strict water resources management system", including strictly controlling total amount of groundwater withdrawal, i.e. defining annual total amount of groundwater withdrawal in accordance with groundwater replenishment conditions and strictly enforce such defined amount. The World Bank would make use of experience and expertise in groundwater management in Africa and other countries to support the Chinese Government to gradually establish a groundwater control and management system.

Drinking Water Safety

175. Ensuring drinking water safety is an important task of the Chinese Government to improve people's livelihoods, which has been advanced in recent years. By 2010, the Chinese Government had provided safe drinking water to 215 million rural people. It is proposed in the 12th Five-year Plan prepared by MWR that rural drinking water safety would be ensured in the next five years and proportion of rural beneficiaries of centralized water supply would increase to 80%.

176. Based on the already defined targets, the Chinese Government would continue to increase investments in ensuring drinking water safety and improve drinking water conditions of residents, including farmers, workers of farms and tree farms as well as school teachers and students, through implementing a number of large, medium and small water source projects. In combination with the rural-urban integration process, the Chinese Government is actively promoting implementation of centralized water supply projects in rural areas and developing integrated rural-urban water supply networks in areas with appropriate conditions to increase tap water coverage in rural areas. This would benefit hundreds of millions of Chinese farmers.

177. Apart from strengthening implementation drinking water supply projects, main management tasks include establishing water user cooperative organizations following the principles of "guidance by the government, voluntary participation by farmers, registration according to law and standardized operation" to improve the management model combining specialized service delivery and independent management by water users; advancing property rights system reform for small water projects including drinking water projects to clearly define project management entities. For "public good" water projects, corresponding policies shall formulated so that project management and maintenance expenses can be borne by the government; for small profit-oriented projects, it is necessary to achieve diversified operations of such projects through contracting, leasing, auctioning, shareholding and other approaches that are appropriate to local realities.

Information Technology Development

178. The 2011 No. 1 Document of the Chinese Government proposed a pathway of Chinese characteristics for modernization of China's water sector and strengthening information technology development in this sector is an important approach to achieving water conservancy modernization. One of the priorities for information technology development is to strengthen development of basic monitoring systems, including development of flood and drought control information monitoring stations, points and facilities for rain, water and drought conditions, typhoons and storm tides, monitoring systems for hydrological conditions, water resources and groundwater, monitoring facilities for water and soil conservation, and monitoring systems for water management and policy implementation.

179. Another priority for information technology development is development of regulation and management systems for major water structures, including water regulation system for the Yellow River, Tarim River and Hei River and regulation systems for key water structures of other river and lake basins such as the Tai Lake, Yellow River, Pearl River and Huai River. Information technology based regulation can enhance real-time regulation and fully achieve the comprehensive benefits of major water structures including flood control, water supply, irrigation and ecological protection.

180. It is necessary to achieve office automation, especially for grassroots water units, which includes a complete set of hardware equipment and corresponding software

systems as well as skilled technical staff. Office automation and e-governance will improve work efficiency, enhance transparency in all segments of management and increase standardization of water sector management.

Water Pricing Reform

181. Following the requirements for deepening resource product pricing reform and factor market reform, water pricing reform will be advanced in a step-by-step manner to establish a pricing mechanism which encourages productive water use, and also achieves social affordability and equity and contributes to saving water and optimizing water resource allocation. Establishment of such mechanism is an important next step for the Chinese Government to take in water pricing reform.

182. The National Development and Reform Commission (NDRC) and MWR are gradually implementing a two-part water price scheme combining base water price and measured water price. A number of cities are also exploring a management model linking water price and water consumption, through rising block tariffs, where charges will be collected at ascending prices for water consumed above the basic amount. This model is an effective tool to promote water saving through the economic lever. For the soon-to-be completed and operational middle route of the South-North Water Transfer Project, water price will be set using a different approach, which includes base water price and measured water price, i.e. provinces will pay base water charges in proportion to water allocated to them by the South-North Water Transfer Project and pay charges for additional water consumed based on the actual measured water.

183. An important task of water pricing reform is to advance comprehensive agricultural water pricing reform to establish in an explorative manner agricultural water reform model which suits the local economic development level and water resource conditions and promotes establishment of a mechanism under which agricultural water supply costs are shared by the government and farmers. This includes improvements in agricultural water measurement facilities, terminal water pricing system involving water price for state water supply projects and that for tertiary canal systems, system of financial subsidies to expenses on operation and management of agricultural irrigation and drainage schemes, and discounted water price for below-quota water use and ascending water price for extra-quota water use.

Integrated Small Watershed Management for Soil Erosion Control

184. In 2007, MWR implemented ecologically clean watershed management pilot projects for 81 watersheds in 30 provinces (autonomous regions and municipalities) across the country. The objective of the project are to carry out a series of activities including integrated watershed management, ecological restoration, water system rehabilitation and improvements in human habitat environment with rural "production development and building clean and tidy villages" as the entry points and integrated watershed management as the priority. As a result of the pilot project implementation, integrated watershed management has played an effective role in water and soil conservation, water preservation, purifying water and improving ecological environment, among others. This practice and exploration can prevent activities harming water ecology environment from the source, combine water preservation with water quality protection, avoid fragmented sectoral management and more effectively protect and improve ecological environment.

185. Integrated watershed management requires a combination of artificial restoration and natural restoration as well as water and soil conservation measures and other measures to

achieve good ecological environment, beautiful landscape and comfortable living environment, which are consistent with the World Bank's concept on ecological protection. The World Bank has accumulated valuable experience and achieved great success in Loess Plateau Watershed Rehabilitation projects, which have laid a solid foundation for further cooperation with the Chinese Government in integrated watershed management. China has a large amount and area of waterborne soil erosion with different soil erosion externalities and types of waterborne soil erosion in different regions. Based on the master plan for waterborne soil erosion management in MWR's 12th Five-year Plan, the World Bank can select typical watersheds from the Loess Plateau region, the Karst region in southwestern China, inland river regions in northwestern China and black soil regions in northeastern China for testing and piloting integrated management and to accumulate more experience to promote waterborne soil erosion management in China and provide support for the World Bank to improve knowledge, experience and techniques in this area.

Annex 1 - Decision on Accelerating Water Sector Reform and Development By the CPC Central Committee and the State Council

(December 31, 2010)

1. Water is the source of life, the essential for production and the basis for ecology. It concerns human survival, economic development and social progress and has always been an important issue in managing state affairs and ensuring peace and security throughout the history to beneficially use water and eliminate water hazards. To promote long-term, steady and rapid economic development, to maintain social harmony and stability, and to successfully build a moderately prosperous society in all aspects, we are determined to accelerate water development, effectively increase our capacity to support it and guarantee to achieve sustainable water resources utilization. Serious flood and drought calamities taking place in China in recent years have caused major losses of life and properties and revealed fundamental weaknesses in inadequate irrigation systems/ works and other water infrastructures. We must step up our efforts to strengthen water sector development. Hence, the following decisions are made on accelerating water sector reform and development.

I. Strategic Importance of Water Sector Development in the New Situation

2. The new situation facing water sector development. Since the foundation of new China, especially since the inception of reform and opening-up to the outside world, the Party and the Government have always attached great importance to water sector development. Under their leadership the Chinese people have carried out magnificent water infrastructure construction, gaining tremendous achievements which have drawn worldwide attention, making outstanding contribution to the economic and social development, and ensuring that the people can live and work in peace and contentment. However, it must be noted that limited amount of water resources

for a large population and their uneven temporal and spatial distribution are the basic national and water conditions of the country. Frequent flood and drought disasters are still a thorn in the hearts of the Chinese people; the sharp conflict between supply and demand of water resources is still the main bottleneck in attaining sustainable development; lagged-behind construction of irrigation systems/works is still the biggest problem that affects stable agricultural development and national food security; and poor water facilities are still an obvious shortcoming of the nation's infrastructure. With deeper industrialization and urbanization and bigger impact of global climate change, the water sector in China is facing a more severe situation. The requirement for greater capacity for calamity prevention and mitigation is increasingly urgent. The work of intensifying water saving and conservation is becoming more and more strenuous. The task of improving speedily the situation of "living at the mercy of the weather" in agriculture is getting increasingly onerous. In 2010, a catastrophic drought occurred in the southwestern region, serious flood disasters struck most of the country's provinces, autonomous regions and municipalities, and flash floods and debris flows took place in a number of areas. All of these sound a warning to us again that speeding up construction of irrigation systems/works brooks no delay.

3. Importance and impacts of water development in the new situation. Beneficial use of water is the first vital prerequisite for modern agricultural development, the irreplaceable fundamental support for economic and social development and the indispensable supporting system for ensuring eco-environmental improvement, being of major importance in terms of public benefit, essential need and strategy. To accelerate water sector reform and development concerns not only agricultural and rural development but also the overall economic and social development; not only the security of flood control and the water and food supply but also the economic, ecological and national security. We must give great prominence to water sector development in the undertakings of the Party and the nation, with special effort put into stepping up construction of irrigation systems/works and propelling the leapfrog development of the water sector.

II. Guiding Theory, Objectives and Basic Principles of Water Sector Reform and Development

4. Guiding Theory. We will implement the main spirits of the Seventeenth National Party Congress and the third, fourth and fifth plenary sessions of the Seventeenth CPC Central Committee in an all-round way, take Deng Xiaoping Theory and the Important Theory of "Three Represents" as our guide and thoroughly implement the Scientific Outlook on Development. Priority will be given to water sector development in the construction of national infrastructure, with improvements of irrigation works regarded as a key task in the construction of rural infrastructure. We will take strict water resources management as a strategic measure for accelerating transformation of economic development pattern, with emphasis laid on scientific water management in accordance with the law and with the focus on strengthening weak links, and develop beneficial use of water vigorously for the purpose of the people's wellbeing, keep deepening water sector reform, accelerate the establishment of a "water saving society", promote sustainable water sector development and endeavor to pave a road of water sector modernization with Chinese characteristics.

5. Objectives and tasks. In the next five to ten years, we will strive to reverse fundamentally the obvious backwardness of water works construction. A system of flood control, drought resistance and calamity mitigation will be basically established to substantially enhance

flood control capacity and drought resistance capabilities in key cities and protected areas of flood control by 2020, basically fulfill the training of important reaches of key small and medium rivers (including tributaries of major rivers, independent sea-entering rivers and inland rivers), comprehensively accomplish hazard elimination and dam reinforcement for small reservoirs and set up an early warning and forecast system in areas prone to flash floods during the "12th Five Year Plan" period. A system of reasonable water allocation and efficient water utilization will be basically set up to try to keep total water use of the country below 670 billion m3/year and to guarantee water supply to a greater degree in urban and rural areas and ensure drinking water safety in an all-round way for urban and rural residents. We will considerably cut down water use per ten thousand Yuan GDP and that per ten thousand Yuan industrial value increase and boost irrigation water use efficiency coefficient to more than 0.55, with effective irrigation area expanded by 40 million mu during the "12th Five Year Plan" period. A system of conserving water resources and guaranteeing river and lake health will be basically established; water quality in the function zones of main rivers and lakes will be distinctly improved; water quality standards will all be met in the source zones of urban water supply; soil and water erosion will be effectively controlled in key regions; and groundwater overexploitation will be essentially curbed. An institutional system favorable for water science development and a system of the strictest water resources management will be basically set up. A mechanism for steadily incremental investment in water development will be further enhanced; a water pricing mechanism instrumental in water saving and reasonable water allocation will be primarily established; and a mechanism for virtuous-circle operation of water works will be basically brought into being.

6. Basic principles. First, priority given to the people's wellbeing must be stuck to. We will strive to solve the most immediate and most practical water-related problems that concern the people most to push for new development of wellbeing-oriented water utilization. Second, unified planning with due consideration for all aspects concerned must be adhered to. We will give equal attention to both deriving benefits and eliminating hazards, both preventing and mitigating calamities and both treating the symptoms and addressing the root causes and facilitate coordinated water sector development between basins and regions, between urban and rural areas and between eastern, central and western parts. Third, harmony between man and water must be kept to. We will accommodate to the law of nature and that of social development by rationally developing, optimally allocating, comprehensively saving and effectively conserving water resources. Four, government leadership must be stuck to. We will use public funds as a guarantee for water development and establish synergy between the government and the non-government sector in managing and tapping water resources. Five, reform and innovation must be adhered to. We will accelerate reform by tackling major problems in key areas and key links of water sector and overcoming system or mechanism related obstacles to water development.

III. Prominence will be given to Strengthening Construction of Irrigation Systems/Works and Other Weak Links

7. Construct irrigation systems/works on a large scale. By 2020, we will basically accomplish the tasks of extension, supplementation and water-saving technical transformation of large-size irrigation districts and key medium-size irrigation districts. A number of new irrigation districts will be constructed in areas where soil and water conditions are appropriate to increase effective irrigation areas in line with implementation of the national plan for an additional grains production capacity of 100 billion jin (50 billion kilograms – translator). Large and medium-size irrigation

and drainage pump stations will be replaced and transformed and improvement of key water-logging-prone areas will be stepped up to enhance the irrigation and drainage system. A sound and complete mechanism for construction of irrigation systems/works will be newly established; the central and provincial finance departments will provide a lot more earmarked subsidies for their construction, and governments at municipal and county levels will also tangibly increase their investment in the on-farm water infrastructure, with farmers guided to contribute labor on a voluntary basis. The program of key counties' small on-farm water works construction will be implemented more rapidly, in which priority will be given to major grain-producing counties, and construction of terminal canal systems and supplementation to on-farm water works in irrigation districts will be intensified to promote construction of high-standard farmland which ensures stable yields despite drought or excessive rain. Small and medium-sized water works will be built in the light of local conditions, and support will be given for construction of the "five small on-farm water works" of small cisterns, small ponds, small dams, small pump stations and small canals in hilly areas, with priority given to old revolutionary base areas, ethnic minority areas, frontier areas and poverty-stricken areas. Water saving irrigation will be vigorously promoted by extending such techniques as canal lining, pipe conveyance, sprinkler irrigation, drip irrigation and so on and subsidies for installation of water saving and drought resistance equipment will be more extensively granted. Rain-fed crop farming will be actively encouraged and techniques of mulching, deep plough and scarification, conservation tillage and so on will be adopted. Water-saving, efficiently irrigated forage growing areas will be constructed to facilitate steady water development in pasture regions.

8. Accelerate improvement of small and medium rivers and hazard elimination and dam reinforcement for small-size ailing reservoirs. With regard to small and medium river improvement, priority will be given to rivers and reaches on which there are frequent floods and water-logging events, densely populated protection areas and protected important objects. Dike strengthening and river dredging will be carried out so that the improved reaches will basically meet national flood control standards. Achievements made in hazard elimination and dam reinforcement for large and medium-size ailing reservoirs will be consolidated, and for small-size ailing reservoirs, hazard elimination and dam reinforcement will be stepped up to remove hidden dangers, restore the storage capacity for flood control and increase the capacity for water resources regulation as soon as possible. Reinforcement of large and medium-size ailing gates will be urged. Structural measures will be adopted in combination with nonstructural measures in preventing and mitigating flash floods induced geologic calamities. The monitoring and early warning system operated jointly by specialized organizations and the people will be improved as soon as possible, and the program of disaster prevention and avoidance and key areas improvement will be implemented more quickly.

9. Press for solutions to water shortage due to lack of infrastructure. We will speed up construction of key water supply systems in the southwestern region and other areas of water scarcity due to lack of infrastructure. The principle of storage, diversion and pumping in combination with rational groundwater exploitation will be stuck to, and a large number of small and medium-size county-based reservoirs, water diversion and pumping works, and water transfer projects will be constructed as soon as possible. We will support farmers in building small and micro water works to substantially increase their capacity for rain and flood resources utilization and for ensuring water supply so as to essentially solve the water supply problems in water scarce cities and towns and populous villages.

10. Increase capacity for flood and drought emergency response. We will establish as soon as possible a sound emergency management mechanism of quick response and concerted, orderly and efficient operation for unified commanding in flood control and drought resistance with responsibilities assigned at different levels. Greater capacity for monitoring and early warning will be developed through further investment and integration of resources to increase the capabilities for rain, flood and drought forecasts. Non-governmental as well as specialized emergency response and rescue teams will be set up, with the focus on the establishment of flood and drought emergency response service organizations at the county and township levels. A system of emergency rescue materials reserves will be established and contingency plans will be improved. A large number of drought emergency water supply works of reasonable scale and proper standard will be constructed and a water reserves system for response to catastrophic drought and water safety emergencies will be set up. We will intensify the development of cloud seeding demonstration zones to tap cloud and water resources in the atmosphere in a scientific manner.

11. Continue to promote the drinking water safety program in rural areas. By 2013, we will solve the problem of drinking water safety in rural areas as laid down in the plan and, during the "12th Five Year Plan" period, basically solve the drinking water problem for new rural populations who drink unsafe water. Construction of concentrated water supply works will be actively facilitated in an effort to boost coverage of tap water supply in rural areas. Concentrated water supply pipeline networks will be extended to wherever it is possible to achieve urban and rural water supply integration. Operation and management of rural safe drinking water works will be strengthened, with responsible people or organizations specified. Water source protection and water quality monitoring will be intensified and the long-term benefits derived from the infrastructure will be guaranteed. We will adopt a land use policy on supporting construction of rural safe drinking water works to ensure their land supply, with preferential tax on their construction and operation. Electricity used for water supply will be charged at the same price as that for residential purpose or agricultural irrigation and drainage.

IV. Accelerate Water Infrastructure Construction in an All-round Way

12. Continue to improve the major rivers. We will further harness Huai River, improve the lower reaches of Yellow River and better control the middle and lower reaches of Yangtze River, with constant efforts to train the main rivers and build dikes on them, intensify comprehensive improvement of Tai Lake, Dongting Lake and Poyang Lake, step up construction of flood storage and retention zones comprehensively and properly arrange for resettlement of the local residents. Safety on the beach land of the downstream areas of Yellow River will be enhanced. We will press for construction of a number of key flood-control works for the basins during the "12th Five Year Plan" period to keep increasing the capacity for flood regulation and storage. We will intensify construction of flood prevention and drainage works in urban areas to improve their drainage standards. At the same time, construction of sea walls and training of cross-boundary rivers will be boosted.

13. Strengthen infrastructure construction for better water resources allocation. We will improve and optimize the strategic water resources allocation pattern. On condition that the ecology is conserved, an array of key water supply works and the connection works of river and lake systems will be constructed as soon as possible to enhance the capacity for water resources regulation and control and ensure water supply. Construction of Phase I schemes of the South-North Water Transfer

Project East and Middle Routes and that of the supplementary works will be sped up with guaranteed construction quality, and preliminary studies on the project's West Route will be conducted in due time. We will actively promote the construction of a number of inter-basin and inter-region water transfer projects with emphasis placed on solutions to the problem of physical water scarcity in the northwest part and other areas. Reuse of treated wastewater will be vigorously promoted; desalination and comprehensive use of sea water will be energetically encouraged; and great attention will be paid to utilization of rain water and brackish water.

14. Improve soil and water conservation and aquatic ecological conservation. We will implement key national projects of soil and water conservation to effectively prevent and control soil and water losses by taking such measures as comprehensive improvement of watersheds, warping dam construction, slope land remediation, afforestation, ecological rehabilitation and so on. We will further strengthen prevention and control of soil and water erosion on the upper and middle reaches of Yangtze River and Yellow River, in stony desertification areas in the southwest region, black soil region in Northeastern China and other key areas and places prone to flash floods induced geologic calamities. Ecological rehabilitation in fragile rivers and areas will be pushed ahead with and aquatic and ecological remediation in heavily polluted rivers and lakes will be accelerated. Important ecological conservation zones, water source conservation zones, headstreams and wetlands will be better protected. Rural rivers will be comprehensively improved and ecologically clean watersheds will be vigorously developed. We will put great effort into supervision and management of the soil and water conservation implemented by production and construction projects. A sound and complete institutional system of compensation for water facilities, water areas and so on occupied by soil and water conservation and construction projects.

15. Develop water energy resources in a rational way. Development and utilization of hydropower resources will be accelerated under the condition that the ecology is conserved and farmers' interest is protected. Flood control, irrigation, water supply, power generation, navigation and so on will be planned in a unified scientific manner with all aspects taken into consideration in active hydropower development, with strengthened hydropower resources management, standardized permission system of resources development and intensified regulation of hydropower safety. We will energetically tap hydropower in rural areas, vigorously develop new-countryside-type counties equipped with hydropower and carry out the ecological conservation program for fuel replacement with mini-hydro power, and do a good job of electrical equipment transformation to hydropower grid in rural areas.

16. Bolster hydrometeorologic and water-technology support services intensively. We will strengthen construction of hydrometeorology infrastructure to expand its coverage, optimize the network configuration of hydrological stations, enhance greatly the capacity for hydrologic monitoring and reporting in key regions, important cities and groundwater overexploited areas, increase quickly the capacity for maneuverable emergency response monitoring, achieve data and information sharing, and improve the overall service standards. A sound system of water scientific innovation will be set up, a platform of basic facilities will be intensified, essential researches and technical development will be strengthened, in an endeavor to achieve new breakthroughs in key water resources areas, key links and core technologies and to make a lot of major achievements of practical value in scientific research, and technical import, extension and application will be intensively carried out. The

standards of water technical equipment will be raised. For water information technology enhancement, we will implement the "Golden Water Project" in an all-round way. We will accelerate the development of the national flood control and drought resistance commanding system and water resources management information system so as to increase the capacity for IT-based water regulation, control and management and water works operation and to attain water sector modernization propelled by water information technology development. International exchange and cooperation in water sector will be strengthened.

V. Establish a Mechanism for Steadily Incremental Investment in Water Development

17. Increase fiscal investment in water development. We will raise funds through multiple channels and strive to make the annual average investment in the coming ten years in water development from the whole society twice as much as that in 2010. The government will provide leadership in water infrastructure construction and take water-related works as a key area of public fiscal investment. Finance departments at all levels will significantly and substantially increase the total investment in water works and further raise the proportion of water construction funds to the national fixed assets investment. The funds earmarked for water development by the central and local finance departments will be greatly increased. 10% of the proceeds from the transfer of land-use rights will be used for agricultural water infrastructure construction so that full use for comprehensive benefits will be made of the revenues from paid land use for new construction sites and from other land consolidation and improvement activities. The policy for water infrastructure construction funds will be further improved and its collection period will be extended, with broadened channels and enlarged scale. The system of paid use of water resources will be enhanced; the rate of the water resources fee will be reasonably adjusted; and the fee will be levied more extensively and collected, used and managed stringently. In cities which have major flood prevention tasks and where water is particularly scarce, a certain percentage of their urban maintenance and construction tax will be allocated for construction of urban flood control, water supply and drainage works. Supervision and management of water investment projects and their funds will be effectively strengthened.

18. Provide stronger financial support for water works construction. We will operate fiscal and monetary policies in a comprehensive way to guide financial institutions towards increasing credit funds for water development. The scale, duration and rate of fiscally subsidized interest will be set according to the features and nature of different water works, where it is possible. Under the condition that risks are controllable, the agricultural development bank will be supported in actively providing mid and long-term policy loans for water works construction. China Development Bank, Agricultural Bank of China, the Rural Credit Cooperatives, Postal Savings Bank of China and other banking financial institutions will be encouraged to further increase their credit funds for irrigation systems/works construction. Qualified water enterprises will be supported in being listed on the stock market and issuing bonds; financing and leasing operations for large-size water equipment and facilities will be explored and developed; water project usufruct mortgage loan and other multiple forms of financing will be strongly promoted. Flood insurance will be encouraged and supported. More foreign capital will be used for water development with better quality.

19. Attract nongovernmental investment in water development extensively. We will encourage qualified financing platform companies established by local governments to expand channels of direct or indirect investment

and financing for water development so as to attract nongovernmental funding for water infrastructure construction. Farmers will be encouraged to keep up the spirit of self reliance and arduous efforts and fiscal awards and subsidies for activities through case-by-case meetings will be intensified, based on unified planning, in accordance with the principle of "more subsidies for more raised funds and more work" so as to fully summon up the farmers' enthusiasm for irrigation systems/works construction. The policy on water and electricity value-added tax in rural areas will be enhanced in line with the value-added tax reform and legislation process. The tax policy on farmland occupation by water works will be improved. Market financing of business-oriented water projects will be facilitated in a vigorous and reliable manner.

VI. Implement the Strictest Water Resources Management System

20. Establish a system of total amount control of water use. We will adopt a red line of water resources development and utilization control and press ahead with formulation of the master plan for water allocation on major rivers and set up a system of total water withdrawal and use control indicators. Justification will be strengthened for water needs in the relevant plans and location of the water projects to be constructed; the national economic and social development plan, general plans for city development and configuration of major construction projects will be adapted to local water resource conditions and conform to the local flood control requirements. The system of water resources justification for construction projects will be strictly implemented; anyone who starts construction of or puts into operation such a project without authorization must be ordered to stop. Review and approval of water withdrawal permits will be strictly administered; for any place whose total water withdrawal and use has reached or exceeded the control indicator, review and approval of construction projects for additional water withdrawal will be suspended; for any place whose total water withdrawal and use is close to the control indicator, review and approval of construction projects for additional water withdrawal will be restricted. Groundwater abstraction prohibition areas and restriction areas will be checked and ratified and be proclaimed as soon as possible and groundwater overexploitation will be gradually reduced through strict management and protection to achieve water balance between recharge and abstraction. Unified allocation of water resources will be strengthened to keep good balance between domestic, productive and eco-environmental uses, with improved water resources allocation plans, contingency plans for water allocation and water allotment plans. The national water right system will be established and improved and market mechanism will be fully utilized for optimization of water resources allocation.

21. Establish a system of water use efficiency control. We will adopt a red line of water use efficiency control and resolutely prevent water wasting and put water saving work into the entire process of economic and social development, production and the people's daily life. A system of water use efficiency indicators for regions, sectors and water use products will be quickly set up and quota management of water use in a planned manner will be strengthened. Focused monitoring and control will be conducted of water users whose water withdrawal and use have reached certain amounts. In water scarce areas, industrial projects that consume a lot of water will be strictly restricted. The system of designing, constructing and operating water saving works at the same time as the construction of main works will be implemented. Technical transformation for water saving will be accelerated; water saving management of enterprises will be intensified in an all-round way; water saving demonstration projects will be constructed;

and high efficient water saving technology in agriculture will be popularized. We will push forward with formulation of compulsory water saving standards and weed out the technologies, equipment, and products that do not meet water saving standards as soon as possible.

22. Establish a system of restriction on per pollutant assimilation of water function zones. We will adopt a red line of restriction on per pollutant assimilation of water function zones and strictly check and ratify pollutant assimilative capacity of water bodies and strictly control the total amount of pollutant discharge into rivers and lakes. Governments at all levels will take total amount pollutant discharge restriction as an important basis for water pollution prevention and control and the reduction of pollutant discharge, with responsibilities clearly specified and measures put in place. For areas where pollutant discharge has exceeded the restriction on the total amount of pollutant discharge in water function zones, new applications for water withdrawal and outlets of pollutant discharge into rivers will be restricted. A system of function zone water quality standards compliance evaluation will be established and a system of monitoring, early warning, supervision and management will be improved. We will intensify conservation of water source zones, specify conservation zones of drinking water sources in accordance with the law and strengthen emergency management of drinking water sources. A water ecological compensation mechanism will be set up.

23. Establish a water resources managerial responsibility and appraisal system. Main leaders of local governments at or above the county level will take overall responsibility for water resources management and conservation in their respective administrative regions. To strictly implement the water resources management appraisal system, the water administration department will, jointly with other relevant departments, appraise the fulfillment of the main performance indicators of water resources development, utilization and conservation in all the regions and submit the appraisal results to the department in charge of leaders as an important basis for the comprehensive appraisal and evaluation of the relevant leaders of local governments. Capacity building for water quantity and quality monitoring will be strengthened to provide technical support for supervision and appraisal enhancement.

VII. Keep Promoting Innovations in Systems and Mechanisms for Water Development

24. Improve the water resources management system. We will intensify unified management of urban and rural water resources and implement in a coordinated manner urban and rural water supply, comprehensive water resources utilization, water environment improvement, flood control and drainage, and so on through unified planning to facilitate optimized water resources allocation. The system of basin management in combination with administrative region management of water resources will be improved and a mechanism of water resources administration with clearly specified powers and authority, explicitly assigned division of work, standardized behavior and coordinated operation will be set up. The mechanism for coordination of water resources conservation and water pollution prevention and control will be further enhanced.

25. Accelerate water infrastructure construction and water management system reform. We will push for the reform in a classified manner by differentiating the nature of water works and establish a sound mechanism of virtuous-circle operation. Reform of state-owned water works management system will be deepened, with ensured availability of funds for basic expenditure of public service and quasi-public service water management organizations and for system repair and maintenance. The

central finance department will provide subsidies on repair and maintenance of public benefit structures in the mid-western region and poverty-stricken areas. The problem of social security for redirected staff from water management organizations will be properly solved. Reform of small water works property right system will be deepened, with ownership and usufruct clearly stated, and management and maintenance entities being in place and their responsibilities clearly specified. Subsidies will be provided for management and maintenance of public beneficial small water works and multiple patterns of non-governmental and specialized water system management will be explored. For non-profit projects financed by the government, the agent system for their construction will be implemented more quickly. Full play will be given to market mechanism in water infrastructure construction and operation and profit-making water works will be guided towards the market so that the legal person management structure will be enhanced and the system of independent operation and operators' sole responsibility for profits and losses will be set up.

26. Establish a sound system of grass-root level water services. We will establish a sound grass-root level water service system with clearly specified functions, reasonable structure and competent staff to provide good services and the capacity for grass-root level water services will be increased in an all-round way. Grass-root level water service organizations based on townships and watersheds will be fully set up, the staffing quota of which will be checked and ratified in accordance with the relevant provisions and costs of which be included in county level government budget, to better perform public benefit functions of water resources management improvement, flood control and drought resistance, irrigation systems/works construction, water technology extension and so on. Farmer water use cooperation organizations will be energetically developed.

27. Actively press ahead with water price reform. We will make full use of water price as a regulation instrument, with equal attention given to efficiency and fairness, and vigorously promote water saving and industrial restructuring. The system of progressive block tariff for above-quota water use for industry and service sectors will be gradually introduced to make the difference in water price bigger between high water consuming sectors and other sectors. Reasonable adjustment will be made of the price for domestic water use in urban areas so that the block tariff system will be implemented steadily. In accordance with the principles of promoting water saving, reducing farmers' water use costs and ensuring virtuous-circle operation of irrigation and drainage systems, we will push forward with the comprehensive reform of agricultural water price, with proper fiscal subsidies provided for operation and management of irrigation and drainage works in agriculture, and explore ways for farmers to enjoy preferential price for below-quota water use and pay progressive block tariff for above-quota water use.

VIII. Effectively Strengthen Leadership in Water Development

28. Clearly specify responsibilities of the Party committees and governments at all levels. The Party committees and governments at all levels will effectively strengthen the work of water development, by adopting a panoramic and strategic perspective, and carry out studies and solve the serious problems existing in water sector reform and development in good time. The system of administrative chief executive responsibility will be implemented in flood prevention and drought resistance, drinking water safety guarantee, water resources management and reservoir safety management. All the measures and actions for water sector reform and development will be carried out earnestly everywhere in the light of the local actual conditions to ensure achievement

of tangible results. Water administration departments at all levels will effectively heighten the sense of responsibility with their duties fulfilled conscientiously and do a good job in accomplishing the various tasks of water sector reform and development. Relevant departments and organizations will formulate and improve as soon as possible various supporting measures and actions in accordance with the division of their functions to develop synergy for driving water sector reform and development. Intensification of irrigation/works construction will be regarded as an important part of the "Pursuance of Excellence in Performances" campaign conducted in the rural grass-root areas and rural Party organizations at the grass-root level will fully perform their role as the "fortress" with all their members playing a vanguard and exemplary role, to lead the farmers at large in accelerating improvement of the production and living conditions in the rural areas.

29. Press ahead with water management in accordance with the law. We will establish a sound system of water-related laws and regulations and speed up refinement of laws and regulations concerning water resources allocation, water saving and protection, flood control and drought resistance, rural water works construction, soil and water conservation, basin management, and so on. Integrated water law enforcement will be pushed for in an all-round way and the systems of water resources justification, water withdrawal permission, letter of consent to water works construction plans, flood impact assessment, soil and water conservation planning, and so on will be strictly implemented. Management of rivers and lakes will be strengthened and construction projects' illegal occupation of river and lake areas will be strictly prohibited. The national flood prevention and drought resistance supervision will be intensively institutionalized. A sound water dispute mediation and resolution mechanism with the focus on prevention in combination with mediation and resolution will be established and the contingency planning system will be enhanced. The reform of water administrative license review and approval system will be deepened. Water resources development master plans will be prepared in a scientific way to improve the system of national, basin and regional water use planning. Preparatory work for key construction projects will be accelerated. The functions of management and constraint on water related activities performed by water resources development master plans will be intensified. Achievements in resettlement will be ensured for reservoir construction with policies for post-construction support effectively carried out.

30. Enhance water sector staff capacity building. We will adapt to the new requirements of water sector reform and development, improve comprehensively the capacity of the water sector officials and staff and increase effectively the capabilities for water resources survey and water works design, construction and management and for administration in accordance with the law. Establishment and development of water-related subjects and disciplines in universities, colleges and secondary vocational schools will be supported. Various managerial specialists, technical professionals and high-tech experts will be intensively introduced, trained and selected and an incentive mechanism for personnel appraisal and exchange will be enhanced. A vast number of scientists and engineers will be encouraged to serve on the front line of water sector reform and development, in-service education and post-school training provided to water staff at the grass-root level will be intensified, and actual problems and difficulties existing in their production and life will be solved. The spirit of "dedication, responsibility and pragmaticness" of the water sector will be promoted among the officials and staff at large to pay closer attention to the people's wellbeing, offer more services at the grass-root level and render greater assistance to the overall economic and social development.

31. Mobilize the forces of all walks of life to care about and support water development. We will intensify publicity about the conditions of the country and of water development, raise the awareness of all the people of water calamities, water saving and water resources conservation and call up all the forces throughout the society to participate in water development. Education about the water resources conditions will be included in the national quality education system, in school courses of primary and middle schools and, as an important part, in the education and training courses for leaders at all levels and civil servants. To create a good atmosphere of public opinion for better and faster water sector development, it will be taken as one of the non-profit publicity subjects. Governments at all levels will give commendations and awards in accordance with the relevant provisions to those who have made outstanding achievements in stepping up water sector reform and development.

32. Accelerating water sector reform and development is an arduous task and a major responsibility as well as a glorious mission. We will unite closely around the CPC Central Committee with Comrade Hu Jintao as General Secretary, keep up with the times, forge ahead in a pioneering spirit, work conscientiously and strive to open up new prospects for water development.

Annex 2 - Summary of the 12th Five-Year Program (2011-2015) on Water Sector Development

Strategic Importance of Water Sector Development

1. The Government of China pays great attention to water resources development. The CPC Central Committee No. 1 Document in 2011 clearly articulates the strategic importance of water resources development in the new situation: water resources are the first vital prerequisite for modern agricultural development, the irreplaceable fundamental support for economic and social development and the indispensable supporting system for ensuring eco-environmental improvement, being of major importance in terms of public benefit, essential need and strategy.

2. To accelerate water sector reform and development concerns not only agricultural and rural development but also the overall economic and social development and not only the security of flood control and water and food supply but also the economic, ecological and national security. This represents a major leap forward that the Chinese Government has made in understanding water resources development and serves as important guiding principles of the "12th Five Year" master plan for water resources development and also the fundamental basis for planning water resources development, deepening water sector reform and formulating water policies in the future in various regions and by various departments.

General Requirements during the "12th Five Year" Period

3. Basic ideas. Priority will be given to water resources development in the construction of national infrastructure, with on-farm water works improvement regarded as a key task in the construction of rural infrastructure. Strict water resources management will be taken as a

strategic measure for accelerating transformation of economic development pattern.

4. Focal areas. Emphasis will be laid on scientific water management and water management in accordance with the law, with the focus on strengthening weak links, and water resources will be developed vigorously for the purpose of the people's wellbeing, water sector reform will be continuously deepened and the establishment of "water saving society" will be accelerated.

5. Strategic direction. Strive to blaze a path of water sector modernization with Chinese characteristics.

6. Basic principles. Priority given to the people's wellbeing must be stuck to; unified planning with due consideration for all aspects concerned must be adhered to; harmony between man and water must be kept to; government leadership must be stuck to; and reform and innovation must be adhered to.

Main Objectives

7. Flood control and calamity mitigation. A system of comprehensive flood control and calamity mitigation on major rivers through structural measures in combination with non-structural measures will be basically established. Dikes on key reaches of major river mainstreams, important tributaries, independent sea-entering rivers and inland rivers and important sea walls will meet the planned standards; important flood protection cities will meet the flood control standards specified by the nation; the flood control capacity of important reaches of key medium and small rivers which have flood control tasks will be significantly improved; monitoring and early warning systems and the people's monitoring and prevention systems in flash floods and geologic disaster prevention and control areas will be basically established; and drainage standards in key low-lying regions will reach more than one in five year frequency.

8. Water resources guarantee. The problem of rural drinking water safety will be solved quickly; the proportion of concentrated water supply beneficiary population in rural areas will be raised to 75%; there will be an additional water supply capacity of 40 billion m^3 nationwide, including about 26 billion m^3 for urban areas; the probability of urban water supply will be no less than 95%; and effective irrigation area will be increased by 50 million mu.

9. Water saving and conservation. Water use per 10 thousand Yuan industrial value increase will be reduced to less than 80 m3; high efficient water saving irrigation area will be increased by 50 million mu; and agricultural irrigation water use coefficient will be increased to 0.53. Compliance with the main water quality standards in the water function zones of important rivers, lakes and reservoirs nationwide will be boosted to 60%; the main water quality indicators of national important drinking water source zones will meet the standards specified by the nation; 80% of municipal wastewater will be treated and 10% of the treated wastewater will be reused.

10. Soil and water conservation and ecological rehabilitation in rivers and lakes. An additional area of 250 thousand km2 of soil and water losses will be improved in a comprehensive manner. Eco-environmental water use in ecologically fragile areas and key rivers and lakes will be enhanced; eco-environment will be rehabilitated to a certain degree; the groundwater situation in serious overdraft areas will preliminarily become better.

11. Water sector reform and water resources management. The reform will serve as a powerful push for water resources development and efforts will be stepped up to tackle major problems in key areas and key links in the reform. A national water right system will be

basically established, water allocation plans for main rivers will be accomplished, and significant progress will be made in the reform of integrated basin management system. Major breakthroughs will be achieved in the reform of investment in and financing water resources development. Water works construction will be open in an all-round way, the project legal person bidding system, agent system and so on will be extensively applied and a sound mechanism for virtuous-circle operation and management of water works will be essentially set up. A rather complete system of water-related laws and regulations will come into existence so that the capacity for management of rivers and lakes will be substantially enhanced. The capability for water scientific innovation will be greatly increased and information technology will be further advanced.

Main Tasks of Water Infrastructure Construction

Flood control and calamity mitigation

12. Improvement of major rivers and lakes. Huai River will be further improved, improvement of Yangtze River, Yellow River, Pearl River and other major rivers will be continued and training of important estuaries will be actively promoted. Improvement of waterlogging-prone regions in key plains will be accelerated and construction and reconstruction of drainage works in urban areas will be strengthened. Key control structures on Tingzikou in Sichuan Province, Xiajiang in Jiangxi Province, Jinling in Liaoning Province and so on will be completed and construction of a number of key flood control projects will be started in due time. Sea wall construction and trans-boundary river training will be strengthened.

13. Improvement of medium and small rivers and hazard elimination and dam reinforcement for medium and small reservoirs. The law of nature will be respected, relationships between upper and lower reaches, between tributaries and mainstreams and between regions and basins will be smoothed out through unified and coordinated planning, the areas and measures of improvement and the scopes and standards of construction will be reasonably specified, and the improvement of key medium and small river basins of more than 200 km^2 that have flood control tasks will be basically fulfilled. The achievements made in hazard elimination and dam reinforcement will be consolidated, hazard elimination and dam reinforcement for large and medium ailing reservoirs will be sped up, the tasks of hazard elimination and dam reinforcement for small ailing reservoirs will be basically accomplished and hazard elimination and reinforcement of large and medium ailing gates will be planned and arranged for in a unified manner.

14. Construction of key flood storage and retention zones. Construction of flood storage and retention zones that will be used frequently and be particularly effective at flood control will be accelerated. The residents will be guided and encouraged to resettle so that those in high risk areas will be properly resettled, with a rather complete management system and operation mechanism preliminarily set up. The key polder dikes on Dongting Lake and Poyang Lake will be strengthened and the tasks of dike reinforcement for key flood storage and retention zones and their safety improvements will be basically accomplished.

15. Prevention and control of geological calamities from flash floods. The policy of prevention in combination with control with the focus on prevention will be followed to carry out in-depth surveys and assessment of geological calamities from flash floods, find out the basic conditions of hidden perils in an all-round way, press ahead with improvement of monitoring and early warning systems and the people's monitoring and prevention systems and

accelerate implementation of resettlement for disaster avoidance and key areas improvement.

16. Non-structural measures for flood control. Infrastructure construction of hydrological monitoring stations will be strengthened, flood prevention and warning telecommunications systems for medium and small reservoirs will be enhanced, flood control contingency plans for medium and small rivers and reservoirs will be formulated and improved, a flood risk management system will be established and flood water will be made better use of as resources.

Water resources assurance

17. Construction of water resources allocation works in key areas. Construction of Phase I schemes of Middle and East Routes of South-North Water Transfer Project and their supplementary works will be accelerated, with good quality ensured and service provided in good time. Construction of Tao River Water Diversion Project in Gansu Province, Dahuofang Reservoir Water Transfer Project in Liaoning Province, Nenjing River to Baicheng City Water Diversion Project in Jilin Province, Continent to Zhoushan Water Diversion Project in Zhejiang Province and so on will be completed. Construction of Central Guizhou Water Diversion Project, Lijiang River Water Supplementation Project in Guilin City, Water Supply Project in Central Jilin Province, and other inter-basin and interregional water diversion or transfer projects will be stepped up. Preparation for Hanjiang River to Weihe River Water Diversion Project, Yangtze River to Huai River Water Diversion Project, Central Yunnan Water Transfer Project and so on will be continued and their construction will be started in due time.

18. Construction of water source projects. Construction of Pangduo Reservoir, Hadashan Reservoir and so on will be quickened and construction of a number of other important water source projects, if they are ready, will be started in due time. Construction of medium-size reservoirs in the southwestern region will be strengthened to increase the capacity for water supply assurance in key arid counties. Urban and rural water source works construction in former revolutionary base areas, minority-inhabited areas, remote and border areas and poverty-stricken areas will be strengthened to improve their drinking water safety, develop and improve irrigation areas and better guarantee urban, rural, industrial and agricultural water supply. Construction of water source projects and their supplementary works in drought-prone areas, main grains production areas and city and town concentrated areas will be accelerated to enhance the capacity for response to catastrophic droughts, continuous droughts and water supply security emergencies.

19. Utilization of non-conventional water sources. Recycle of treated wastewater will be increased, rain and flood water and brackish water will be utilized in a scientific and reasonable way, direct use and desalination of sea water will be boosted, and freshwater exploitation will be reduced. Studies and utilization of "virtual water" will be strengthened.

Water works construction in rural areas

20. Drinking water safety in rural areas. Water works construction in rural areas will be further accelerated to ensure that the problem of drinking water safety for rural population will be solved as planned before the end of 2013. Based on scientific planning and justification, the drinking water problem for new rural populations who drink unsafe water will be solved through unified planning. Different methods of water supply will be adopted in the light of the local conditions and concentrated water supply projects of proper scales will be encouraged. Operation and management of water works will be strengthened and water

sources will be strictly conserved with water quality monitored so as to ensure that farmers drink clean and safe water.

21. Construction of on-farm water works. Extension, supplementation and water-saving technical transformation of large and medium irrigation districts will be sped up and the tasks of large-size irrigation and drainage pump station replacement and reconstruction will be fulfilled. A number of new irrigation districts will be constructed in areas where soil and water conditions are appropriate. Construction of small on-farm water works will be intensified, main and supplementary on-farm works will be very well built, construction of the "five small water works" of small ponds, small cisterns (water tanks or cases), small weirs and gates, small pump stations and small canals will be constructed in the light of the local conditions to improve agricultural production conditions. Steady water resources development in pasture regions will be facilitated.

22. Construction of mini-hydro works. 300 new-countryside-type counties equipped with hydropower will be established.

23. Schistosomiasis prevention and control through water works. Construction of schistosomiasis prevention water works will be accelerated on middle and lower reaches of Yangtze River and other regions. By the end of 2015, transmission control standards will be met in all the counties (cities and districts) where schistosomiasis is prevalent; and transmission blocking standards will be met through efforts in the counties (cities and districts) where transmission control standards have already been met.

Water resources saving and conservation

24. Water saving in agriculture. High efficient water saving equipment and technology of pipe water conveyance, sprinkler irrigation, drip irrigation, micro irrigation and so on will be vigorously developed in the light of the local conditions. In this endeavor technological integration and large-scale development will be pushed for, with priority given to construction of high efficient water saving works in water scarce areas, ecologically fragile areas and main grains production areas in their agricultural development. Rain water harvest for efficient irrigation will be intensified in rain-fed regions.

25. Water saving in cities, towns and industrial sector. Water saving technical transformation through water supply pipe networks construction will be accelerated in cities and towns, installation of supplementary water saving equipment will be promoted in public buildings and residential quarters, domestic water saving devices will be extensively popularized in urban areas, water use equipment and products which do not comply with water saving standards will be weeded out gradually and reuse of treated wastewater in urban areas will be pressed ahead with; water saving in industrial sector will be intensified, advanced water saving techniques and technology will be popularized, water use per unit product in industries and enterprises will be cut down, and water recycle in industries will be encouraged. A large number of advanced representative demonstration areas for water saving society development will be established.

26. Conservation of drinking water source zones. Drinking water source zones in urban and rural areas will be distributed reasonably, conservation, protection and comprehensive improvement of water source zones will be strengthened, and pollutant discharge outlets along rivers within protected drinking water source zones will be prohibited in accordance with the law. Conservation of important drinking water source zones will be intensified, with emphasis placed on protection and conservation of water source zones for South-North Water Transfer Project and those along its

routes and in the Three Gorges Reservoir area and other large and medium reservoir areas.

27. Groundwater conservation and restoration. Groundwater exploitation will be strictly controlled and management in groundwater overdraft areas will be intensified. Plans for groundwater extraction reduction will be launched in the water receiving areas of the Middle and East Routes of South-North Water Transfer Project, ground subsidence areas, seawater intrusion areas, Shiyang River Basin and other key regions. Alternative water source works will be constructed in groundwater extraction reduction areas to cut down its withdrawal and strategic groundwater reserves and groundwater emergency response reserves will be gradually built up to increase the groundwater capacity for drought emergency response. In areas where it is possible, measures of groundwater reservoir construction, rain and flood water utilization, reuse of treated water for groundwater injection and so on will be adopted to replenish and conserve groundwater sources. Implementation of pilot projects for groundwater conservation actions nationwide will be continued.

28. Hydrological and water resources monitoring. The distribution and structure of hydrological station networks will be optimized and various hydrological monitoring station networks will be improved. A national groundwater monitoring system will be established. Equipment of water quantity and quality monitoring systems on inter-provincial cross-sections, important control cross-sections, important water function zones and important pollutant discharge outlets will be strengthened. Installation of online monitoring of important drinking water source zones and bulk water withdrawers will be actively facilitated.

Soil and water conservation and ecological rehabilitation in rivers and lakes

29. Soil and water loss control in key areas. Soil and water conservation and ecological rehabilitation and improvement on upper and middle reaches of Yangtze River, middle and upper reaches of Yellow River and upper reaches of Pearl River and in the black soil region in northeastern China, dust storm source areas for Beijing and Tianjin, upstream water source conservation areas and downstream dust storm source areas in the basins of inland rivers in northwestern China, Three Gorges Reservoir area, Danjiangkou Reservoir area and other key regions will be continuously intensified. Comprehensive rectification of soil and water losses on slope farmland will be accelerated to protect arable land and eco-environment. Slope collapse in southern China will be controlled in a comprehensive way. Soil and water conservation monitoring systems will be rapidly established.

30. Ecological rehabilitation in rivers and lakes. Ecological rehabilitation and comprehensive improvement will be fulfilled in ecologically fragile and heavily polluted rivers and lakes by rationally determining the scales of soil and water resources development and optimally adjusting industrial structure in the light of the water resources conditions of the basins and the regions and by comprehensively intensifying efficient water use and pollution control and properly transferring water and so on. Rectification and standardized management of pollutant discharge outlets into rivers and lakes will be strengthened. Measures for pollutant detention and flow redirection, river training and dredging, ecological rehabilitation and so on will be taken to reduce pollutant discharge into water bodies; in regions where it is possible water can be allotted or diverted from other basins to increase ecological water in lakes and facilitate regional water environment improvement. Rural rivers will be trained in an all-round way so as to improve water ecological environment in rural areas.

Main Tasks of Water Sector Reform and Water Resources Management

Deepen institutional reform

31. Water resources management system reform. The national water right system will be basically established, formulation of water allocation plans for main rivers will be completed. With initial water right clearly defined, the control indicators for total amount water use for various administrative regions will be determined; water use quota for various sectors and products will be allocated. Recommendations for water right system implementation will be produced, water right transfer market will be fostered, and water right transfer activities will be standardized. A complete and sound water resources development right permission system will be established to guide market participants to acquire water resources development right through open and fair competition in a standardized manner.

32. Comprehensive basin management system reform. The system of basin management in combination of administrative region management of water resources will be enhanced. A basin level deliberation and decision-making mechanism of high efficient execution for all parties' participation, democratic consultation and joint decision-making with divided responsibilities will be established to implement comprehensive basin management.

33. Reform of water resources investment and financing system and that of water works construction management system. At the same time as the establishment of the mechanism for steady incremental government investment in water resources development and governments acting as the main investors, the areas of water works investment and financing and their construction management will be open to the society.

34. Water works management system reform. Ownership of water works will be clearly defined, their managers will be specified, the mechanism for maintenance and management of public benefit water works will be enhanced, the system of specialized services in combination with independent water users' management will be gradually improved and a sound maintenance and management mechanism will be established.

35. Water pricing reform. The system of paid use of water resources will be enhanced. Standards of water resources fee collection will be set in a scientific manner in the light of the local water resources conditions and water resources fee collection and use management will be strengthened. A mechanism for government and farmers joint sharing agricultural water supply cost will be gradually set up. Water demand will be based on its supply, irrigation will be managed by quota, water will be saved and transferred, and an incentive and restriction mechanism for extra charges for above-quota water use will be put in operation. The system of block tariff will be steadily implemented, high price will be charged for special sectors of high water consumption, and reuse of treated wastewater will be encouraged.

36. Improvement of ecological compensation mechanism. Fiscal transfer payment will be intensified to important water source conservation areas in the western region, headstream areas of major rivers, source zones of concentrated drinking water supply, soil and water loss prevention and protection areas, flood water retention and storage areas, and other water development prohibition and restriction areas. Exploration will be made of establishment of mechanisms for water eco-environment protection and collaboration in different regions.

Intensify social management

37. The system of the strictest water resources management will be implemented, the objectives of total amount water use control, water use quota control and control of total pollutant discharge into rivers will be formulated and improved, the water resources management responsibility system and its appraisal system will be established and the system of accountability will be strictly implemented.

38. Management of rivers and lakes will be strengthened, prevention, supervision and management of soil and water conservation will be stepped up, water calamity prevention and mitigation will be intensified, a mechanism for catastrophic flood and drought emergency response will be set up, a monitoring, forecast and early warning system for flood control and drought resistance will be improved, and a sound emergency management mechanism for calamity warning, response and evacuation and rehousing will be established.

Promote scientific innovation

39. A complete and sound system of water scientific innovation will be set up, in-depth scientific researches on major water problems will be conducted, extension and popularization of water scientific and technological achievements will be intensified, water information technology development will be promoted, water staff capacity building will be accelerated and international scientific cooperation and exchange will be strengthened.

Annex 3 - Policy Note on Integrated Flood Risk Management Key Lesson learned and Recommendations for China

Policy Note
August 28, 2010

Executive Summary

Over the last decade, China has successfully invested in flood control measures along its rivers. Flood disasters are increasingly happening along small and medium-sized rivers due to rapidly changing human activity and higher intensity and frequency of rains. Recognizing the problem, the Government of China has vowed to prioritize policies and investment to reduce flood disasters in small and medium-sized rivers. This Policy Notes provides a summary of key experience and lessons learned from the Bank operations in China and around the world and recommendation for integrated flood risk management in China.

Much of current urban expansion and infrastructure investments along small and medium-sized rivers in China are vulnerable to flood related disasters. Therefore, China should continue to strengthen the integration of risk management in urban planning and investment planning, especially in key infrastructure: transport, sanitation, hospitals and schools. The benefits of investments in risk management largely outweigh the costs, especially when done in the early stages of the project cycle.

China should further build on integrated flood risk management strategies at the river basin levels, taking into account the risk and vulnerabilities of the entire systems and designing most cost effective measures to protect or response to flood disasters and incorporate locally acceptable and adequate techniques and approaches. Risk management should be informed by systematic hazard and risk exposure and vulnerability mapping, to develop possible economic loss scenarios. The systems approach allows the definition of resilience and resistance strategies for flood risk.

Flood risk management, especially in secondary river basins, should balance between structural and non-structural measures that reduce risks and vulnerabilities, and improve response to potential disasters. China's achievements in this balanced approach are considerable and should be further strengthened. Engineering measures can play very important role for flood prevention but are often very costly and difficult to maintain, they can also create a false sense of security among the people. Special attention should be given to the safety of small dams in rural areas, which pose great risk for surrounding population, economy and environment. Therefore, Government should accelerate necessary improvements of structural measures and balance them with critical investments in non-structural measures such as flood plain management; integration of flood risk into urban planning, economic incentives, risk sharing, awareness raising and disaster preparedness and response.

A first key step in flood risk management process is developing a comprehensive understanding, analysis and assessment of flood risks and vulnerabilities that will guide river basin flood disaster risk management strategies, urban development and land use plans. China's has completed the first phase of flood risk mapping and should continue to invest as this has proven to be a powerful tool to illustrate local risks and vulnerabilities, and assist in decision making and raise public awareness. It is important the climate change impacts and future land use changes are taken into account.

The institutional coordination mechanisms for flood disaster preparedness and response are in generally very sound. The Government should focus especially on strengthening the coordination and response capacity of local authorities, communities and other locally relevant stakeholders. The participation and involvement of the local communities are essential since they are most affected and the first to respond to a disaster. Local communities can also assist government in protecting risk areas and enforcing land use plans and ensure emergency plans meet local needs and circumstances.

The government should design mechanisms to finance relief and recovery investments. Risk transfer mechanisms, such as insurance for example, should be designed in a way that they encourage beneficiaries to avoid occupation of high-risk areas, comply with building standards and further implement flood-proofing and other mitigation measures. Different options for catastrophic hazard insurance need to be explored. Many innovative mechanisms are used around the world and could be adapted for China.

Based on the analysis and key recommendations, a possible implementation plan includes the short to long-term actions has been proposed to strengthen the future cooperation in integrated flood risk management in China between the Bank and Chinese Government.

I. Background

1. Since the historic 1998 floods of the Yangtze River that claimed the lives of over 2,300 people, China's flood disaster prevention capacity and infrastructure has been improved and strengthened markedly over the past decade. Many reservoirs and dikes along the main rivers have been improved and reinforced, no serious incidents happened along the main rivers and none of the recently constructed main dikes were breached.

2. With the improvement of flood control systems, especially along the main rivers, problems with flood disasters are increasingly happening along small and medium-sized rivers. During the past 10 years over 90% of the flood-related disasters occurred in small towns, cities and rural areas, mostly caused by landslides

and flashfloods due to excessive rainfall. This year to date, floods in China have left over 2,690 people dead and 1,170 missing, including the devastating landslide in Zhouqu, Gansu Province, which killed 1,239 people and left 505 missing. The floods have already affected 140 million people and 7 million hectares of agricultural areas across 28 provinces and regions. The direct economic losses are estimated to be around US$ 40 billion, mostly as a result of landslides and flashfloods in small and medium-sized river basins.

3. While considerable investments were made by the Government, many flood control infrastructure along small and medium rivers is old, poorly maintained and engineering standards are often inadequate to withstand the current frequency and intensity of floods. Besides, the vulnerability and losses as result of floods and mudslides are exacerbated by poor land use planning and lack of awareness by the people regarding the risks and effective response to disasters. A key challenge in China is addressing issues of flashfloods, landslides and floods due to excessive rainfall along tributaries and secondary rivers affecting mostly smaller cities and rural areas. Further, extreme events are likely to become intensified and more frequent as a consequence of climate change and increase vulnerabilities. It is extremely important to start integrating flood (and other disaster) risk management into regional and urban development and land use plans and infrastructure investments to reduce future impacts and costs of disasters.

4. At the meeting of the State Council on July 21, the Chinese Premier Wen Jiabao recognized the tangible progress in flood control along China's big rivers, but expressed concern with current floods. He requested that the highest priority should be given to flood management along small and medium-sized rivers, where flood control infrastructure is often weak, many small reservoirs are at risks, and landslides and flashfloods impose particular challenges. At the meeting it was agreed to prioritize and increase investments to improve planning, prevention, mitigation and response to floods in small and medium-sized rivers. On July 26, 2010, the World Bank President Robert B. Zoellick sent a letter to Premier Wen Jiabao extending his deep sympathy on the loss of life and property as a result of current floods in China, and expressing the World Bank's readiness to support the Government in recovery and reconstruction efforts, as well as assisting the Government in developing integrated river basin flood management systems.

5. As a first step of the Bank assistance, this note summarizes experiences and lessons learned in China and worldwide with flood management, focusing on flooding along small and medium-sized rivers.

II. Characteristics of Flood Disasters in China

6. Most of China's rivers are small and medium-sized rivers with a basin area less than 2,000 km^2. Over the years, the proportion of damages and losses from floods in these river basins have grown gradually compared to the overall flood related damages and losses. This is due to rapid urbanization in rural areas and aging flood control infrastructure along these rivers and reservoirs. Statistics indicate that during the past 10 years more than two thirds of flood related deaths were the result of disasters along small and medium rivers, including floods, landslides, mud-rock flows, and local flash floods. The particularities and characteristics of flood disaster in small and medium river basins in China are described in the following paragraphs.

7. ***Flood disasters can hit anywhere within the vast territory and great number of small and medium rivers.*** Small cities are rapidly growing and more human activities are taking

place in floodplains in rural areas, resulting in a significantly increase in the number and spread of flood related disasters, further exacerbated by more frequent and intensified rainfall due to climate change, especially in recent years. These rainstorms have often occurred in very localized areas with great intensity, resulting in flash flood and very localized emergencies and disasters.

8. ***Flash floods occur suddenly for brief duration, which makes issuing forecasts and warnings difficult.*** Flash floods last for a relatively short time, from a few hours to dozen of hours, especially in small rivers, ravines and small streams. Reliable forecasts and warnings for these floods are difficult, making effective emergency responses challenging, resulting in more casualties and property losses.

9. ***Disasters are often catastrophic and have lasting local impact.*** Floods along medium and small rivers are often destructive and tend to have great impact on local economies and almost completely destroy local infrastructure, properties and people's livelihoods. With exception to wealthier and more developed regions, it is very difficult for smaller cities to carry out basic relief efforts and recover from disaster without considerable support from the national government.

10. ***Floods in traditionally safe areas.*** Floods are and will increasingly occur in places outside the historical floodplains as a result of increased vulnerability induced by climate and human induced land use changes. Overall rainfall patterns are expected to intensify in response to a warmer atmosphere. This may result in expansion of traditional floodplains. Also, runoffs may be intensified in built up areas and the upper watersheds in the western mountainous part of the country as glaciers retreat.

11. ***Local and aggregate economic losses are very large.*** With accelerated urbanization and rapid economic development, population and assets have been growing fast in high risk areas along medium and small rivers. While each event is unlikely to have a large effect on national economy, the effects to the people and local economy can be devastating. Besides, the aggregated effect of damages and losses due to each flood is considerable in China. Current estimates are that the aggregate losses of lives and properties to date in 2010 due to the floods in small and medium river basins are comparable to the catastrophic impacts of the infamous flood of 1998.

III. Key Challenges For Flood Management Systems in China

12. Since the foundation of the People's Republic of China more than 60 years ago, a framework for flood protection has been established comprising of important flood control structures and dikes along big rivers and main tributaries. However, comprehensive flood control management along small and medium sized rivers is very complex due to the extent of China's territory and wide variety of issues and local conditions. Many flood control structures along small and medium sized rivers are poorly maintained, and measures to effectively respond to regular flooding are absent. The current issues and challenges are very complex and briefly summarized below.

13. ***Investment issues.*** An important issue is insufficient investment in necessary structural and non-structural measures for flood disaster prevention and mitigation in small cities, towns and villages in rural areas, particularly in the mountainous areas of the western provinces. There is a policy gap to ensure availability of investment in non-structural measures. There is also a gap between actual investments and the actual needs to improve flood management along medium and small rivers in vast rural areas. Most regions do not have the means to invest in the required infrastructure and capacity for

developing and implementing strategies on flood risk management. Insufficient investments over a long period of time and lack of a comprehensive plan has left a vast majority of people and properties along small and medium rivers poorly protected from floods and ill-equipped to effectively respond to disasters. Given the above, flood control for the medium and small rivers is faced with increasingly acute problems. Lower cost and long term non-structural measures deserve higher priority to reduce flood risks and local vulnerabilities.

14. ***Inadequate land use planning and enforcement.*** Urbanization with competing interests for land is going on in China at an unprecedented speed and at the expense of floodways, which are increasingly being used for settlements, agriculture and other human activities. Urbanization and population growth has led to increased vulnerability to disasters related to storms and floods since more people and activities are taking place in vulnerable areas. The construction of settlements and structures without adequate technical review have hampered the natural flow of water and contaminated the water, increasing the intensity and impacts of each event. Unfortunately, enforcement, especially in small towns and rural areas is weak. The challenge currently confronted is how to closely link flood control and disaster mitigation with economic development in the urbanization process, which requires full consistency of urban and rural economic development plans with flood control, disaster mitigation and land use plan. Planning needs also to include the climate change variable, especially as long-term perspectives are incorporated in the decision process for land use and for preventive infrastructure.

15. ***Flood control infrastructure issues.*** Despite huge investments by the Government in recent years, flood control infrastructure along small and medium sized rivers is deficient due to old design standards, aging infrastructure and lack of proper maintenance. This has increased the risk of the population, especially along small and medium-sized rivers in China. One of the key challenges is establishing cost effective standards for flood control design based on systematic risk assessment. China needs to continue investing in comprehensive flood control along most medium and small rivers. Many dikes and flood control structures along small and medium rivers were constructed through labor programs between 1950s and 80s, targeting poor farmers. These structures mostly do not comply with current flood control standards and are poorly maintained and operated, thereby amplifying flood disasters risks. About two thirds of the rivers in the country do not meet the flood risk standards set by the Government.

16. ***Small dams.*** Probably the major hazard in China is poorly maintained dams, which also constitute a problem for implementing flood control measures. Altogether, there are more than 87,400 dams in China, of which 90% are small with storage capacity of less than 10 million m3. In the case of the Wenchuan Earthquake, more than 2,300 dams were affected, of these only 30 dams are large or medium size dams. These small dams are often poorly designed and not well maintained, posing a risk for the people and downstream settlements. A detailed assessment of the risk posed by these dams is needed to develop appropriate strategies to mitigate risks.

17. ***Poor management of rivers.*** The management of small and medium rivers is very weak. In many watersheds, there is serious water and soil erosion, irrational earth extraction, human barriers and obstructions of the water flow, garbage dumping contaminating and clogging the drainage system and rivers, and land reclamation for farm and town development in floodplains and stream, directly violating the river management regulations. In addition, in many rivers the water quality is deteriorating, river ecosystems worsening, and water resources overexploited and hydropower and other waste

related activities are left largely unregulated, which have resulted in continuous degradation of the rivers. Besides, many secondary rivers were not dredged for many years, reducing water flow and increasing flood risk. Most medium and small rivers are lacking management frameworks, including basic assessment and monitoring data, strategies that integrate different sectors and consider competing demands, comprehensive river improvement programs and clear division of responsibilities for implementation.

18. ***Vulnerable cities.*** There are 639 cities in China which are required to prepare flood control strategies. Out of these, 567 are small and medium cities located along tributaries of major rivers or medium and small rivers. Many cities or small towns are vulnerable to flood risk and priority should be given to preparing and implementing flood control strategies, following a comprehensive river basin approach.

19. ***Poor flood risk awareness.*** A major problem faced in the current flood control and disaster mitigation endeavors is the poor flood risk awareness of most of people. Flood risk awareness at all levels of governments, of stakeholders and of the general public is generally not strong, reflected by lack of understanding of flood risk and vulnerabilities and wrong assumptions about effectiveness of flood control works, which has resulted in inadequate flood disaster preparedness and response, delaying and hampering full economic recovery.

20. ***Slow disaster response and recovery.*** In many small town and rural areas, real-time flood warning systems are inadequate, further exacerbating the impact of floods on vulnerable people and increased the costs of each event. Besides, the recovery of vulnerable people from flood disasters is often very slow, particularly of smaller events in remote areas, increasing the burden to affected people.

21. ***Lack of integrated approach.*** Integrated flood management systems most of small and medium and small rivers have not been established or are lagging behind. Both structural and non-structural measures for flood management have been implemented, including engineering measures, land use planning, small watershed management, flash flood management and urban flood management, but a unified strategy that assesses and balances between different measures is lacking in smaller and medium-sized rivers.

22. ***Climate change and land use.*** Limited consideration is given to future climate change and land use modification in flood risk management planning and practices. Flood management planning and practices have lacked in the past consideration of the climate change variable, even though substantial information is available on the type and pace of changes that may be expected and the consequence to intensified rainfall and flooding. Besides, land use changes and human activity can considerably change local weather and hydrological cycles and need to be taken into account. Failure to incorporate these variables, especially at a regional level, may result in an under estimation of current and future risks and vulnerabilities.

IV. Principles of Flood Management in Small And Medium Rivers

23. Integrated flood risk management aims at preventing human loss and minimizing economic damages, while making use of the natural resources in a sustainable way. It should be integrated into comprehensive watershed management plans taking account of the socio economic realities, water uses and vulnerabilities and risks at the watershed level. A set of key principles should be taken into account when designing integrated flood disaster risk management strategies at the watershed level.

24. ***People and communities first.*** Protecting people's safety and preventing and minimizing property damage should be the first priority of a flood disaster risk management strategy. People affected by disasters are not victims, but the first responders during emergency work and critical partners in reconstruction and building of resilience. Communities should be effectively involved by the government and be part of the decision making process during the assessment, preparedness, response, and recovery process. Long term and local financing mechanisms should ensure full recovery of the affected population.

25. ***Moving from flood control to flood risk management and planning.*** Management of small and medium river floods should be based on risk management, with emphasis laid on managing and reducing flood risks. Traditional flood control and management is often marked by a narrow view on floods, concentrating on hydraulic and engineering measures while overlooking planning, ecological, political and socio-economic aspects and risks. Controlling floods is often proved to be unrealistic and strategies should focus on flood risk management that aims at enabling communities to 'live with floods' instead of controlling them, minimizing risks, losses and improving preparedness and response to eventual flood disasters.

26. ***Integrated watershed management and planning.*** Flood hazards are not isolated phenomena. There are multiple causes and factors contributing to floods as well as multiple consequences. Up- and downstream aspects have to be integrated in local flood risk management because too extensive drainage, deforestation, erosion and other vulnerabilities upstream may constitute a severe flood hazard for downstream settlements. Reducing risk of storm and flood disasters is largely a matter of watershed management, which integrates engineering, planning and ecological measures to achieve multiple goals: flood mitigation, water supply, conservation of risk areas, establishment of parks and areas for recreational and leisure activities, groundwater recharge and better urban planning.

27. ***Structural and non-structural measures.*** Successful flood risk management should combine structural and non-structural measures, with particular emphasis on improved land use and urban planning and disaster response. Trade-offs in terms of costs and benefits between hydraulic and engineering measures, spatial, ecological and socio-economic aspects should be assessed before developing a comprehensive and cost-effective strategy flood disaster risk management plan.

28. ***Mainstreaming disaster risk management in investment projects.*** Evidence shows that investments in Disaster Risk Management (DRM) bring greater benefits than costs, and therefore should be an integral part of urban planning and fully integrated in sectoral investments, especially in key infrastructure: transport, sanitation, hospitals and schools. Further economic evaluation is needed to demonstrate that mainstreaming disaster risk management is financially and economically justified.

29. ***Institutional coordination and cooperative planning.*** Effective flood risk management measures and disaster preparedness strategies require planning across administrative and sectoral boundaries. Creation of coordination mechanisms and defining and institutionalizing roles and responsibilities between local, regional and national authorities facilitates flood mitigation and disaster risk preparedness and response. Stakeholders and local communities should be fully integrated in the framework.

30. ***Disaster preparedness and response*** is essential for a successful flood risk management strategy, since, despite all flood control measures, there always will be a 'residual' risk that a disaster might happen. Assessing risks and vulnerabilities, developing forecast systems and establishing effective early warning systems can greatly reduce property and personal

losses during flood events. Public awareness and emergency response plans should be well known within the community and roles and responsibilities clearly defined between agencies.

31. ***Climate change impacts and adaptation.*** Climate change is likely to increase flood magnitude and frequency, as well as intensify extreme weather events. Heavy thunderstorms and rains appear to have already increased in frequency. Flood risk management strategies are part of adaptation strategies to climate change and building local resilience to more extreme local weather conditions. This means not only understanding current vulnerabilities and risks based on existing data, but building more resilient communities based on scenarios of future risks based on more extreme weather conditions and increased vulnerabilities to climate change.

V. Main Conclusions And Recommendations

32. This review of World Bank experience around flood impact and prevention in China and other regions worldwide suggests that China has a real opportunity to strengthen its flood risk management and protect human lives as well as properties and infrastructure by adopting cost effective strategies that focus less on controlling floods and integrate the concept of living with floods, protecting key assets, and minimizing losses. Recommendations to further strengthen China's flood disaster management capacity are presented below.

Inclusion of flood risk management into national regulations, policies and investments for flood prevention

33. Mainstream flood risk management into national flood control regulatory, policy and investment framework for flood prevention. Integrate flood risk management, particularly the non-structural measures, into government financed investment programs, by adopting early risk identification (for instance by applying a quick and simple risk-screening tool) and following up throughout the design process if necessary. Independent review or incorporation of flood risk experts in investment programs has also proven to be very cost effective.

34. It is very important that sectoral investments, especially by the Government, integrate preventive risk reduction measures. A recent brief by the World Bank's Independent Evaluation Group has shown that disaster vulnerability warrants serious consideration on solely financial grounds, especially since 60 percent of the World Bank investments in infrastructure, rural development, and environment are at risk to flooding. The United States Federal Emergency Management Agency (FEMA) estimates that 1 dollar invested in mitigation measures generates an estimated US$ 4 on average in future benefits. An integrated water management and flood protection scheme in Indonesia has an estimated benefit to cost ratio of 2.5. After a devastating hurricane hit Granada in 2004, only two retrofitted schools were still standing and were used to accommodate displaced people.

35. FEMA has developed tools to structure and guide the cost–benefit analysis of disaster risk reduction measures, including those related to earthquakes, riverine and coastal floods, hurricanes and tornados. A related helpline has been established to provide technical support. The Regional Agency for Technical Assistance, "RUTA", was created to provide technical assistance in sustainable rural development to Central American ministries of agriculture. It has developed guidelines that identify entry points for disaster risk management at the project identification and formulation phases and guidance on actions to ensure the disaster risk management approach is adopted at other phases in the project cycle. This is presented in the form of issue/question frameworks, flow charts and decision-making trees.

Development of a risk-based national flood management strategy

36. Integrated flood risk management strategies should be implemented at the river basin levels taking into account the risk and vulnerabilities of the entire systems and designing most cost effective measures to protect or response to flood and other disasters and incorporate locally acceptable and adequate techniques and approaches. Risk management should be informed by systematic hazard and risk exposure and vulnerability mapping, to develop possible economic loss scenarios. The systems approach allows the definition of resilience and resistance strategies for flood risk management. Resistance strategies aim at flood prevention, while resilience strategies aim at minimizing flood impacts and enhancing the recovery from those impacts. In The Netherlands, the approach based on comparing cost of flood infrastructure investments, cost of non-structural measures and cost of socio-economic impacts of flood disasters, shows that flood risk management investments can be considerably reduced. It is often referred to as learning to "live with floods" instead of "fighting floods". Climate change impacts need to be considered in the definition of land use plans and actualization of floodplains. Climate considerations however need to be meaningful at regional and local levels, which mean a hierarchy of areas that are most vulnerable to these impacts needs to be developed.

37. The building codes could also follow risk based assessment and be based on "performance-based design" which determines acceptable risk levels for different types of structures, on the basis of their desired performance during and after natural hazards. Risk posed by the failure of non-structural components (e.g., the loss of a facility's serviceability due to damage to equipment) should also be considered when doing this. Performance based design would result in the prioritization and more stringent design of hospitals, schools and other critical infrastructure.

Prior assessment of flood risk and vulnerability

38. The first step in flood risk management process is developing a comprehensive understanding, analysis and assessment of flood risks and vulnerabilities that will guide river basin flood disaster risk management strategies, urban development and land use plans. Maps provide powerful tools to illustrate vulnerabilities and risks and assist in decision making. The assessment and maps should comprise of three key elements: (i) the hazard occurrence probability: the likelihood of experiencing any natural or technological hazard at a location or in a region; (ii) the elements at risk: identifying and making an inventory of people or buildings or other elements which would be affected by the hazard if it occurred, and where required estimating their economic value; and, (iii) the vulnerability of the elements at risk: how damaged the buildings or people or other elements would be if they experienced some level of hazard.

39. A very useful approach is to use satellite maps that provide vital information required by the decision makers at different phases in the flood disaster cycle i.e. pre flood (preparedness), during flood (relief and rescue operations) and post flood (mitigation measures). Disseminating disaster maps can help reduce risks and become a mechanism for local community participation in flood disaster management. The United States' HAZUS Flood Model is an example of a powerful tool in the hands of communities, allowing proactive analysis and mitigation at the national and local level. The HAZUS Flood Model is based on an integrated set of flood hazard analysis algorithms, using national elevation and other hydrologic and hydraulic datasets. The HAZUS Flood Model permits rapid analysis of a wide variety of data with various GIS formats to determine flood-frequencies over entire floodplains.

40. The China national flood management strategy for river basins in China proposes the development and implementation of different flood models as the basis for integrated flood risk management in small and medium rivers. The proposed flood models have to be accompanied by assessment of the context of the river basin, and the economic, political, socio-cultural and ecological environment of the flood prone area. Such an assessment should give information about the probability of a hazard's occurrence and the respective potential of economic and human losses.

Balance between structural and non-structural control measures

41. Since structural risk mitigation cannot alone suffice for effective flood risk management and is a costly option, an integrated flood risk management strategy should be able to balance between disaster risk reduction and preparedness measures, by defining minimum or optimal levels of acceptable risk. Strategies should apply a systems approach that balances structural and non-structural measures and the socio-economic context in which the flood risk management occurs. Structural measures are often costly and have the potential to provide short-term protection at the cost of long-term problems. In some cases, flood control systems have exacerbated rather than reduced the extent of flooding; sediment deposit in river channels has raised the height of river channels and strained dike systems. Now when floods occur, they tend to be of greater depth and more damaging than in the past. Furthermore, structural measures often provide people with a false sense of security and unawareness about the risk that remains and. The damages from the 1993 flooding of the Mississippi river in the United States were magnified because of misplaced confidence in structural mitigation measures that had encouraged development in high-risk areas.

42. Investing in non-structural measures are often less costly and provide many additional benefits. For example, the city of Curitiba, Brazil, instead of investing in massive infrastructure decided to implement floodplain regulations and tax incentives for protection of green space and restricted land occupation in flood prone areas of the city. It created retention ponds, parks and recreational areas along the main river that are widely used by the population. A similar approach was followed by the State of California when creating the Yolo bypass to protect the city of Sacramento. During inundation, the bypass provides habitat for birds and native fish and provides additional ecosystem services, such as open space for a rapidly growing region, recreation (including revenue-producing duck-hunting clubs), and groundwater recharge (of great value as a water bank during droughts).

Strengthening management of small/rural dams and Barrier Lake

43. Safety of small/rural dams is critical because of their vast number, lack of proper designs, poorly maintained, operated and monitored. Chinese government has made achievement to ensure safety of small dams with structural measures, but it needs to continue improving management of these dams. An important step towards improving dam safety is recommending that owners of these small dams work out an OMS manual for their dams to strengthen dam safety management. Several international guidelines exist on post-earthquake safety inspections of dams, but they are by necessity quite generalized because each dam owner needs to set up safety inspection procedures which are case-specific. These procedures should be specified in the standing operation procedures for each dam, and in particular in the "Emergency Preparedness Plans" (EPP). Most of the small dams in China have no EPPs at present. It is recommended that the Chinese Government issue guidelines on EPP for small dams with reference to international experiences.

44. Special concern is related to the safety of barrier lakes formed after disasters due to landslides, avalanches or other mechanisms. Many of these dams only last for days or weeks, depending on: water and sediment flow; size and shape of the barrier; materials forming the barrier; and rate of seepage through the barrier. After the occurrence of a barrier lake, the immediate priority is to facilitate river flow by removing, at least partly, the barrier. After successful implementation of emergency measures, the barrier lakes that are expected to last for some time require monitoring and, as appropriate, early warning systems. In some cases structural measures to reduce/ remove risk of failure are required; these may represent opportunities for delivering social services such as water supply, recreation, hydropower and irrigation. Long living barrier lakes should have in place emergency preparedness plans such as those used for man-made reservoirs.

45. The Bank has extensive experience with risk analysis to guide the design and operation of dams, as well as the monitoring system. A specific Bank Operational Policy ensures that Safety of Dams is properly integrated into Bank investment and can be shared with the Government.

Institutional emergency coordination at the local government and community level

46. Establish coordination principles for flood disaster response and recovery focused on the role of local authorities, communities and other locally relevant stakeholders. In the process, build the capacity of these stakeholders to build resilience and more effectively respond to future disasters. Reduce vulnerability to floods and disaster needs to be taken in all appropriate sectoral ministries, especially those involved infrastructure investments and planning. Local governments also will need to play an increasingly important role in the planning process.

47. Communities should be an integral part of any flood risk management program. One of the key lessons of the Bank's disaster-related projects is that successful projects strongly involve the affected communities. The participation and involvement of the community is essential since the effects of a disaster are first felt at the level of the community, and the community is the first to respond to a disaster. The greatest numbers of lives are saved during the first few hours after a disaster occurs, before outsiders arrive. Communities that are prepared are better able to provide an effective response and to reduce the impact of a disaster. Involvement of local people promotes self-reliance and ensures that emergency management plans meet local needs and circumstances.

48. In the Philippines, for example, Albay province is frequently hit by major disasters such as typhoons, floods, landslides and earthquakes. To more effectively respond to the disasters, the Province created the Albay Public Safety & Emergency Management Office (APSEMO) in 1995. APSEMO helped mainstream and institutionalize disaster risk reduction strategies into local government plans and programs. As a result, disaster prevention, preparedness and response are well coordinated, and casualties have been reduced considerably. The APSEMO has also helped establish a disaster operation center that involves a number of relevant line agencies involved in disaster risk management activities. APSEMO coordinates the preparation of action plans with government, private sector and local communities that have been more cost effective and improved preparedness and coordination.

49. A new way of delivering real landslide-risk reduction to vulnerable communities was piloted by MoSSaiC, a program aimed at improving the management of slopes in communities in the eastern Caribbean. MoSSaiC identifies and implements low-cost, community-based approaches to landslide-risk reduction, in which

community residents indicate areas of perceived drainage problems before assessing options for reducing land¬slide risk by managing surface water.

Emergency preparedness and response

50. Flood forecasts are just a small piece in the early warning chain. In case of flash floods such systems play a very crucial role in saving lives. A successful warning system depends not only on forecasts but has to connect many specialties and organizations, including engineering, social sciences, government, news media, and the public. The melding of scientific, managerial, technological, and social components is essential. Emergency response education toolkits can be developed that can be easily disseminated and implemented at school and community levels, encouraging planning, simulation drills and community participation in early warning, disaster response and recovery.

51. Jamaica, for example, has Red Cross community based disaster response teams, which warn residents by issuing warnings from street to street and by cell phone. They check that the shelters are ready and borrow vehicles to evacuate the disabled and blind. In São Paulo State, Brazil, a Civil Defense Preparedness Plan (CDPP) was developed to protect population living in a mountainous region undergoing rapid urbanization and vulnerable to flashflood and mudslide as a result of excessive rainfall. The CDPP uses meteorological and geological data as well as trained field observers to declare emergency situations and evacuate people at risk. It includes a significant public education component and has been highly successful in reducing numbers of deaths due to landslides.

Risk transfer and insurance mechanisms

52. Due to the increase in frequency and intensity of flood disasters that have occurred in China it is important to design mechanisms to finance relief and recovery investments. Opportunities can be explored for the gradual implementation of effective risk transfer mechanisms to reduce impacts of disasters and support individuals to expedite recovery from flood events. Insurance mechanisms should be designed in a way that they encourage beneficiaries to avoid occupation of high-risk areas, comply with building standards and further implement flood-proofing and other mitigation measures. Insurance and other kinds of disaster risk management can facilitate public-private partnerships for dealing with extreme weather related calamities and play a critical role in disaster recovery and reconstruction. Many innovative schemes utilize parametric, or index-based, approaches which are transparent and simple and do not require the assessment of damages in order to pay an insurance claim because the contract is defined against a weather proxy or index, such as rainfall, sunlight or temperature. If a chosen weather proxy exceeds a certain threshold, a payment is triggered.

53. Some developed countries have used crop index based insurance, such as the United States of America and Canada. An interesting pilot project by BASIX, a microfinance and livelihood institution in India, has expanded support from an initial number of 230 farmers in 2003 to more than 250,000 farmers today. A successful livestock index based insurance in Mongolia combines self-insurance, market-based insurance, and social insurance. Herders retain small losses that do not affect the viability of their business (self-insurance), while larger losses are transferred to the private insurance industry (market insurance through a base insurance product). This is not a purely commercial program, however, as the government bears the final layer of catastrophic losses (social insurance through a disaster-response product).

Action plan

54. Based on the above analysis and key recommendations, a possible implementation plan includes the following short to long-term actions:

Short-term actions (1 year)

- Carry out a critical review of national flood policies and laws
- Assess integration of disaster risk assessments into infrastructure investments
- Prepare community response, contingency, and evacuation toolkits
- Gradually implement river basin flood risk and vulnerability assessments
- Detailed assessment of existing flood control infrastructure in secondary rivers
- Review existing building codes
- Prepare and disseminate information on cost-effective flood proofing techniques

Medium-term (1 -2 years)

- Develop new risk-based building codes and strengthen training and enforcement
- Prepare floodplain land use guidelines and laws
- Raise awareness on flood risks and vulnerabilities
- Strengthen disaster monitoring and early warning systems
- Develop community based disaster preparedness and response plans
- Review opportunities for flood risk financing

Long term (2-5 years)

- Implement and enforce preventive land use plans
- Adopt revised flood management legal framework
- Implement risk financing mechanisms with incentives for compliance to flood control regulations and building codes

Annex 4 - Summary of Climate Change and Strategies in China's Major River Basins

Overview on China's Large River Basins and Climate Change

The effects of climate change are attracting wide global attention. In the 2009 Copenhagen Climate Change Conference, the issue became a political bargaining chip between different countries, making the problem more complex and sensitive. The Chinese government is keen to be recognised internationally as a responsible country, taking positive measures on carbon emission reduction and responding to climate change in multiple ways.

Domestically, the Government attaches particular importance to the impacts of climate change on water resources. China's "National Climate Change Program" sets out related policies and actions for adaptation and mitigation, including industrial water recycling; technologies to use seawater, wastewater, rainwater and cloud-seeding; development of hydropower is and upgraded monitoring system for typhoons and storms. The standards for the design of breakwaters have been improved, aquifers are being have been recharged to prevent land subsidence in coastal areas. The justification for these measures is clear from the following review of recent experience.

Regional water scarcity, droughts and floods are major features of China's monsoon-dominated water sector. Climate change, with its strong links to the hydrological cycle, is expected to have significant implications for China, and there is evidence that changes are already underway – mostly in the direction of increasing the challenges for the future.

Over the past century, the average temperature has increased by 0.5-0.8°C, slightly higher than the global average. In recent decades, warming has been particularly significant. Increased temperatures mean higher crop water demands to achieve the same level of production. Changes in annual

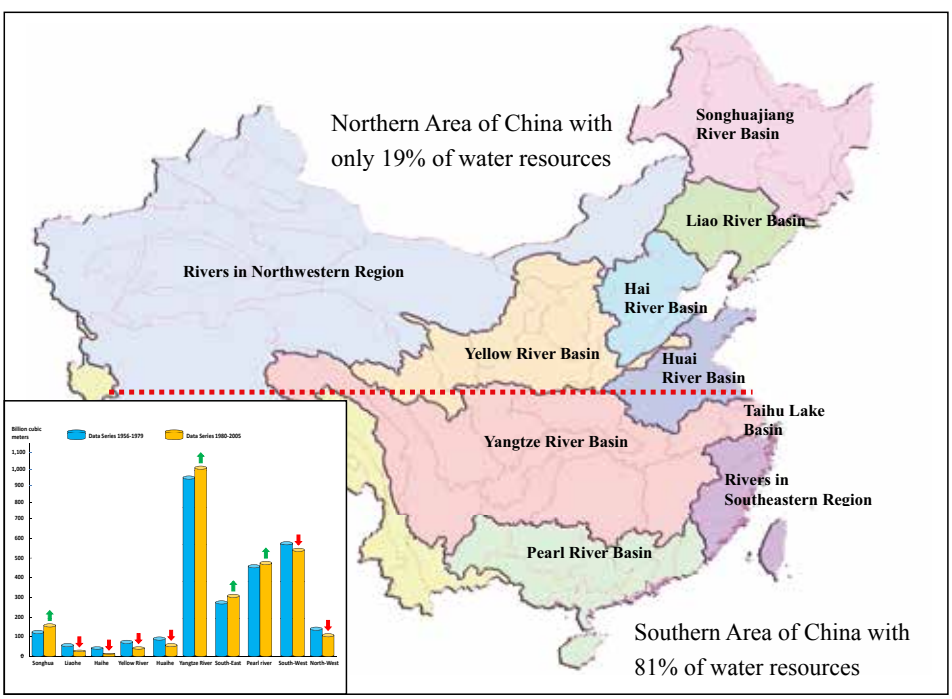
precipitation do not show a clear trend: average annual precipitation decreased after 1950 by almost 3mm per decade until 1990, when an upward trend began.

Over the same period, the frequency and intensity of extreme weather events has worsened. Droughts in northern and north-eastern China became more severe, and affected a wider area. The recent severe drought which occurred in the normally wet southwest regions lasted for more an unprecedented 200 days, while an increasing number of floods occurred in the middle and lower reaches of the Yangtze River and south-eastern China. For the future, Chinese scientists have predicted that:

- Compared with 2000, the annual average temperature will rise by 1.3-2.1°C in 2020 and 2.3-3.3°C in 2050. The magnitude of the national temperature rises will increase from south to north; the temperature will rise significantly in Northwestern China and Northeastern China.
- In the next 50 years, the annual average precipitation in China will display a rising trend; it is expected to increase by 2% to 3% by 2020 and by 5% to 7% by 2050. The southeast coast will see the greatest rise.
- In the next 100 years, the frequency of extreme weathers and climates might increase, which will impact economic and social development and people's life greatly.
- The range of arid areas will expand, and the possibility of desertification will increase.
- The sea levels in China's coastal regions will continue to rise.
- Glaciers in the Tibetan Plateau and the Tianshan Mountain will shrink at an increasing speed, with some small glaciers disappearing.

In the course of thousands of years of river basin development and water management, each basin has specific characteristics and issues that must be dealt with differently, depending on local conditions. China is also undergoing reform and innovation in river basin management. For

China's Southern and Northern Areas



the purpose of water resources assessment and management, the country is divided into 10 large river basins and regions as shown in the figure below.

Overall Strategy on Climate Change Adaptation in China

The World Bank and the Chinese government will cooperate to develop water resources management strategies that respond to climate change. Through technical assistance, knowledge sharing and exposure to international best practice, the long-term water sector strategy and policy framework for coping with climate change will be formulated.

Based on the concept of Integrated Water Resources Managment at river basin level, China will accelerate the shift from expansion of resource supply management to demand management, thus reducing the risks brought by climate change. This will require changes in water resources planning, water infrastructure construction, and water resources management. The core of water demand management is definition of sustainable water use rights, which will encourage improved water use efficiency and effectiveness. Promotion water saving and water resources protection and achieving the transformation of industrial structure follow from this.

To support these aims, China should incorporate climate change into the water resources planning system. The World Bank should help the Chinese government to develop water resources planning guidelines in response to climate change, and also to set up a system to assess the influence of climate change on water resources.

Inter-regional and inter-basin water resources allocation systems should also be established to improve capacity and regulating capabilities.

China shall improve its work on water resources protection and reduce the impact of water pollution on water supply. China shall promote the point source and non-point source pollution control and treatment, and reduce the water pollution caused by economic and social development and urbanization. The World Bank and the Chinese government should cooperate on non-point source pollution control technologies and policies.

China shall actively develop non-conventional water use. The reuse of rainwater and wastewater as resources and seawater desalination shall be strengthened. We should make good use of the funds by the World Bank to promote the construction of urban wastewater treatment and reuse projects.

Hydropower development and clean energy utilization, which can reduce emissions of carbon dioxide and other pollutants, are important measures to develop a low-carbon economy. The World Bank and the Chinese government shall continue to cooperate on investment in the development of small hydropower as green energy, to reduce carbon emissions in order to help people in poor areas raise their living standards and to improve the ecological system.

To further strengthen World Bank cooperation with China, a research program should be initiated to produce an assessment of the impact of global climate change on China's flood control and water security, and establish responding strategies, policies, etc.

Overall Action Plan for Climate Change Adaptation

The construction of embankments is necessary to recover lakes from agricultural lands, protect flood plains, and to dredge rivers and lakes. Positive measures shall be taken to restore and protect rivers with severe ecological deterioration.

Construction of the South-to-North Water Transfer Project will be accelerated, connected with the four major rivers—the Yangtze River, Yellow River, Huai River and Hai River—through the three water transferring routes, gradually forming the water resources distribution system of "Four Horizontal and Three Vertical, South-North Allocation and Mutual Aid between East and West". The construction of key water projects (reservoirs, etc.) and the (re)construction of irrigation districts shall be revamped. A number of regional water diversion and storage projects shall be continued.

The development and promotion of the technology of water resources allocation, integrated water saving and seawater utilization will continue, focussed on research and development on the relationships between atmospheric water, surface water, soil water and ground water and the technology of optimizing their allocation. Technology for utilising wastewater and storm water for cloud-seeding will also be stressed. The industrial water recycling technology, the integrated technology of irrigation water saving, rain-fed water saving and biological water saving will be developed. Major breakthroughs are expected in the development of precision irrigation technology, and the techniques and equipment of intelligent agricultural water utilization management. The development of domestic water saving technology and equipment will be strengthened. The research, development and promotion of seawater desalination technology will also be enhanced.

Hydropower will be developed as the basis for ecology conservation, which will help transform China's energy structure to one with clean and low carbon emission. Hydropower development will focus on Western China and the development of small hydropower resources, according to local conditions.

China will develop adaptive countermeasures against rising sea levels, including raising and strengthening seawalls; upgrading the standards for slope height design through the combination of slope protection, beach protection and the integration of engineering and biological measures. Groundwater over-exploitation and land subsidence in coastal regions will be controlled. In areas with groundwater funnels and land subsidence, artificial recharge will be conducted. To prevent the intrusion of seawater and salt tides at river mouths, measures like diverting water from inland rivers and reservoirs to drive back salt water shall be taken. The protection standard for coastal cities and major projects will be enhanced, as well as the standard height for port designing. The bottom height of water outlets will be adjusted.

Strategies and Actions for China's Major River Basins

Songhuajiang River Basin

Songhuajiang River Basin is rich in water resources, with a per capita water resources sharing of 1,795m^3 and a per mu farmland allocation of 461m^3, to go along with the fine soil resources and high forest coverage. Hence, Songnen Plains and Sanjiang Plains are commonly known as the "breadbasket" of China, being an important grains production zone. Zhalong, Xianghai, and other wetlands in the basin are included in the "List of Wetlands of International Importance" and are habitats for many rare migratory birds. The basin is also an important old industrial base. However, irrigation water in agriculture accounts for more than 70% of the total water use. There are a number of reclamation areas in the basin, which makes it possible for clustered farming in a vast area and enables easy extension of modern irrigation technology.

In spite of its relatively abundant water resources, there are severe problems of water environment and ecology as well as water resources shortage in some local areas of Songhuajiang River Basin. The pressure of the national plan for 50 billion kg additional grains production in future worsens the water problem. The area of natural wetlands in Songhuajiang River Basin has already decreased by three fourths over the past 50 years, particularly in Sanjiang Plains and Songnen Plains. The basin also faces with problems of soil (black soil) and water losses and worsened water pollution. In the past 50 years, the runoff of Nen River Basin generally increased. It is estimated that in the second half of 21st century, precipitation will significantly increase and the changes of runoff will be more sensitive.

The priority will be to protect the eco-environment, maintain river health, avoid flood and water-logging, address pollution risks, and efficiently use and scientifically allocate water resources to ensure water availability for the important grain production. It is advisable to extend the experience of ET management introduced by the World Bank and strengthen water saving and consumption management in agriculture, so as to protect water use for rivers, lakes and important wetlands and maintain good eco-environment. In recent years, major pollution emergencies have taken place occasionally in the basin, so it is also necessary to strengthen development of emergency response plans for water allotment and emergency response commanding systems.

In the river basin, the key tasks include water saving (especially to benefit Songnen and Sanjiang Plains), rational use of groundwater, reduction of the negative effects of human activities on wetland ecosystems, ensuring to meet the ecological water requirement of the rivers and to recharge water for major wetlands, and improved capacity to address the challenges of climate change.

Liaohe River Basin

Water resources are scarce in Liaohe River Basin, with per capita water resources availability of 656m^3 and per mu farmland allocation of 285m^3. Being China's traditional heavy industry base, the basin has a high requirement of water supply security.

In the upper reaches of Liaohe River, water resources are over-developed and utilized. More than 70% of the water resources in the whole basin have been developed and utilized, resulting in river drying, pasture degradation, land desertification, and other serious problems. Liaohe River Basin suffers from a large amount of wastewater discharge (increasing yearly) and severe water pollution.

Liaohe River Basin should re-allocate water resources and strengthening water saving, while restricting development of high water-consuming and high polluting industries so as to raise the productivity of water resources utilization. Currently the basin is improving its water resources and environment carrying capacity by transferring water from the neighboring river and by intensifying pollution control.

On the one hand, water availability can be improved by rational allocation of water resources and promoting water saving in the Liao River Basin; and on the other hand, industries with high water consumption and severe pollution should be restricted. The carrying capacity of the basin's water resources and water environment will be enhanced with measures like diverting water from rivers nearby and improving sewage treatment.

Hai River Basin

Hai River Basin is the most water-short in China, with a per capita water resources availability of only 270m^3, equal to about 13% of the average of

the country and 4% of the average of the world. Densely populated, it is located in the city circle of Beijing Municipality, Tianjin Municipality and Hebei Province, the political and cultural center. Its per capita GDP is higher than the average of the country, leading to a higher requirement for water supply security, while also having more financial resources for water infrastructure construction.

The severe problem of Hai River Basin is that water consumption exceeds the renewable water resources. This has resulted in serious groundwater overexploitation and pollution, which has brought about eco-environment problems. Currently, the area of groundwater overdraft has reached more than 100 thousand km2. Some rivers have perennially dried and wetlands have shrunk.

Hai River Basin, on the one hand, will receive increased water supply through the South-North Water Transfer Project. It will also benefit from strengthened water management, use of non-conventional water sources, and various methods of water saving. At the same time, it will intensify water resources protection and ecological rehabilitation in the important water source zones and water function zones. The World Bank has carried out a trial project on ET management in Hai River Basin, involving a new approach to water demand management. Additionally a groundwater overexploitation control plan for Haihe River Basin has been developed and will be implemented under the national polices including financial investment and water pricing and resources management by the local government.

The changes in land use in the Hai River Basin have led to changes in rainfall-runoff relation. In the past 20 years, precipitation reduced by 10%, surface water resources decreased by 41%, and the total amount of water resources reduced by 25%. Although according to analysis under the conditions of future climate change precipitation will increase, the conflicts between water supply and demand will still be very sharp.

Yellow River Basin

Yellow River is the second largest river in China, known as the "mother river" of the Chinese nation. In the basin, water resources are scarce, with a per capita water resources availability of 473m3 and per mu farmland allocation of 220 m3. With only 2% of the country's water resources, it supports 15% of the nation's population and ensures water security for 7% of the national economic output. With its complicated natural conditions and extraordinary river regime, the river is characterized by more by sand than by water, carrying the greatest quantities of silt in the world. Mostly located in the mid-west regions of China, Yellow River serves as an important water source in the northwest and North China regions. It is of tremendous importance strategically, being full of energy resources.

Being dry, windy and sandy with heavy soil and water losses in the upper reaches, being a "secondary perched river" formed by many years of siltation in the upper reaches, and having great threat of floods and river drying, are the main problems of Yellow River Basin, and these are responsible for poverty in the surrounding areas. In some parts of the upper reaches hydropower is highly developed.

The Yellow River Basin is facing the risk of runoff decrease caused by changes in rainfall-runoff relationship. From the 1970s to the beginning of this century, precipitation reduced in the basin, and the runoff from the upper and middle reaches also significantly decreased. Although it is estimated that future global warming will increase precipitation and that water resources are not sensitive to climate change, water resources problems in the middle reach of the basin will still be serious.

China will continue comprehensive management of soil and water conservation in the Yellow River Basin regarding each small watershed as a unit to reduce the sediment entering the main stream, and take full advantage of the joint water and sediment regulation of Xiaolangdi Reservoir and other reservoirs in the middle and lower reaches to alleviate river siltation. Additionally, water use efficiency will be increased, and integrated water regulation and risk management of water resources in the river basin will protect common interests. The World Bank has already implemented the Loess Plateau Watershed Rehabilitation Project which is aimed at poverty alleviation and eco-environment improvement, and it has already achieved great social and ecological benefits.

Huai River Basin

Huai River Basin is located in the transition belt between southern climate and northern climate. With great variation in precipitation within a year and between years, water resources availability fluctuates severely. The average population density in the basin is as high as the average of the country, with the per capita water resources sharing being equal to only one fourth of the national average. Owing to its low and flat area, water storage and discharge are not easy. Huai River Basin is an area of transportation hub as well as important bases for grains, cotton, oil and energy.

Because of the special characteristics of topography and rainfall, as well as its dense population living in relatively low regions, the basin suffers from serious floods and water-logging disasters. These two kinds of disasters usually occur at the same time, affecting a wide range of areas and causing great losses. Meanwhile, there is heavy water pollution, and the water quality in more than half of rivers does not meet the required standards of the function zones. Particularly, the pollution of the major tributaries on the north of the Huai River is extremely severe. The decline or even loss of some water functions due to water pollution has further intensified the conflicts of water resources shortage in the Huai River Basin. In the last 50 years, Anhui Province in the river basin showed insignificant increase in annual precipitation, but the numbers of rainstorm days increased significantly, and extreme precipitation events increased both in frequency and intensity.[1]

China proposes to strengthen the construction of flood prevention and water-logging control projects in this river basin, in order to effectively alleviate flood disasters. The construction of flood detention zones will be enhanced. The key to flood control in the basin is to properly handle the relationship between flood storage and discharge. The total quantity of pollutants discharged into rivers shall be controlled by ways of pollution source treatment and improving the ecological environment of rivers and lakes. The World Bank has already implemented the Huai River Key Plain and Low-lying Land Treatment Project, providing support for the alleviation of flood disasters.

Yangtze River Basin

Yangtze River is the largest river in China and the third largest in the world, known as one of the cradles of the Chinese nation. With a total area of 1.8 million km^2, accounting for around 19% of the country's territory, Yangtze River Basin has 35% (on a mean annual basis) of the total water resources in China, which ensures water security for 34% of the population, 33% of the GDP, and 26% of the China's farmland. The river runs through three regions: the west, the

[1] http://218.22.3.218/product/analysis/200902.htm

middle and the east. The River Delta is the most competitive, highly industrialized region, being the core area that drives the economic and social development of the nation. Since ancient times, it has been a political, economic and cultural area of national importance and plays an extremely important role in the country's economic and social development.

Flood control standards on the medium and small rivers in Yangtze River Basin are low and the areas are prone to flood and water-logging disasters. In the upper reaches, soil and water losses are serious, and hydropower is not well developed. On the main tributaries, hydropower is developed in an uncoordinated manner and there is huge pressure on eco-environmental protection and resettlement. In the middle and lower reach areas, water pollution is quite serious. Chaohu, Dianchi and some other important lakes suffer from eutrophication.

According to the data from 147 meteorological stations in the Yangtze River Basin, compared with the average temperature of the year 1961 to 1990, the annual average temperature of the whole river basin increased by 0.33°C in the 1990s, and the extent of temperature rise reached 0.71°C during 2001-2005. The characteristics of the monsoon climate of the Yangtze River Basin determine that the region is submitted to significant influence from extreme climate events. During the climate warming process in the past few decades, especially since the 1990s, the frequency of flood disasters in the Yangtze River Basin has risen.[1]

In the next 50 years, temperature in the basin is likely to rise, and the frequency of extreme climate events will show a further rise, which might affect the Three Gorges, the South-to-North Water Transfer Project and other water projects. At the same time, Shanghai, the city at the delta of the river, will become more vulnerable, and must consider the impact of climate change in its city planning, construction and management, strengthening the development of its emergency response system against extreme climate events.[2]

The influence of the Three Gorges Reservoir and the South-to-North Water Transfer Project and other major water projects on regional and the river basin's hydrology, water resources and ecological environment is the new challenge facing the water sector development in the basin. The flood control of the main streams of the Yangtze River will be based on the Three Gorges Reservoir and non-structural measures will also be strengthened. China must further reinforce the construction of flood control infrastructure, and develop and utilize water resources rationally in the basin, increase water supply capacity and further develop hydropower.

Taihu Lake Basin

Characterized by a semi-humid climate, Taihu Lake Basin has plentiful rainfall. It is located in the core of Yangtze River Delta economic development zone, with its population accounting for 3.5% of the total in China; per capita GDP approaching 6,000 US dollars, being 3.4 times as much as the national average; and urbanization exceeding 70%. Although it is one of the most socially and economically developed, most densely populated and most dynamic industrialized zones, Taihu Lake Basin suffers from various problems owing to its densely distributed river network and complicated water systems.

Water pollution is a prominent problem in the Tai Lake. The outbreak of blue algae in the Tai Lake in 2008 caused the breakdown of

[1] http://www.casted.org.cn/web/index.php?ChannelID=9&NewsID=3968
[2] http://www.21cbh.com/HTML/2009-11-11/153357.html

water supply for some residences. The local government has already carried out measures like sediment dredging and control over pollutant discharges into the river, but due to factors like urban expansion and population density, a lot of work still needs to be done.

We should emphasize the comprehensive management of the water environment in the basins of the Tai Lake; strengthen the development of water infrastructure; and construct a comprehensive system of water conservation – combining flood control and disaster resistance, water resources regulation and water environment management– to improve management and promote modernization.

Pearl River Basin

With a total of 472.2 billion m3 of water resources and 123.5 billion m3 of water resources available, Pearl River Basin is quite water-rich. The east part and lower reaches of the basin are economically well developed regions that have developed fastest in recent years. Pearl River Delta is one of the most developed areas in China. With a basin area that accounts for less than 5% of the Chinese territory, its GDP makes up approximately 13% of the country's.

Some cities in the Pearl River Basin have inadequate flood control and regulation ability, and serious storm surge disasters. In recent years, the problems of drought and water shortage due to lack of infrastructure in the upper and middle reaches of the Xinjiang River have become more and more significant. In the recent 100 years, the sea level of the South China Sea has been rising with an annual rate of 2.0 mm.[1]

China should strengthen the construction of storm resistance projects in the Pearl River Basin to deal with rising sea level, and to increase resilience to disasters. The security of water supply to economic zones like Hong Kong, Macao, the Pearl River Delta and regions around the Beibu Bay must be guaranteed. The water supply projects in Southwestern China should be enhanced. The studies on the water resources protection and the restoration of water ecology and water environment in major economic or ecological regions (e.g. the Pearl River Delta, lakes on the Yunnan-Guizhou Plateau, the Nanpan and Beipan River Basin of the upper reach of the Pearl River, etc.) and key cities will be promoted.

Rivers in Southeastern Region

Rivers in southeastern region are located in the southeast coastal zones, with quite a large basin area on Minjiang River and Qiantangjiang River, rich in water resources. Precipitation is affected by typhoons, mainly during the period between April and September. Rivers in this region are short and difficult to control. The region of the southeast rivers is a relatively economically developed area of China.

In Southeastern China, there are prominent problems in the storm resistance work of the coastal rivers and in the flood control work of small rivers. Some of the rivers are severely polluted. There are water shortage problems in some areas either due to pollution or lack of infrastructure. There is also a lack water supply security, with serious water shortage during dry years and dry seasons. In the past century the sea level has been rising with annual rate of 1.9 mm.[2]

China plans to push forward the improvement of medium and small rivers, increase the flood control standards, improve the facilities responding to storm surges and sea level rises,

[1] http://www.cjk3d.net/old/estuaries/haipingmian/yuce.html
[2] http://www.cjk3d.net/old/estuaries/haipingmian/yuce.html

and strengthen the system of early warning and forecast and the plan of disaster resistance to reduce losses caused by disasters in Southeastern China. In the areas with water shortage, water supply projects will be developed to guarantee water supply to important cities and industrial zones, and to solve the problem of seasonal water shortage.

Rivers in Southwestern Region

The southwestern region has many rivers, with a high total and per capita share of water resources. The area is characterized by complicated topography and geology, numerous high mountains and deep valleys and relatively poor economic development. The rivers of the region have abundant water energy, but due to extraordinarily uneven spatial and temporal distribution of water resources, very little water can be utilized.

The water infrastructure in this area is in a poor condition with a fragile ecological environment and a relatively low level of social and economic development. Moreover, there are a number of international rivers involved. Accordingly, the level of water resources development and utilization is still relatively low. The disasters of flash floods and mud-rock flows are quite serious in this area.

China plans to focus on water resources protection in this area, and give priority to the development of navigation and tourism. Poverty alleviation efforts with ethnic minorities, strengthening the development of small hydropower, and construction of an early warning and forecast system to prevent flash floods and mud-rock flows in this area wil also be pursued. For regions with water shortage due to lack of infrastructure, water sources development will be strengthened.

Rivers in Northwestern Region

Rivers in northwestern region are inland rivers, mainly distributed in Xinjiang, Gansu, Qinghai and some other provinces. With annual evaporation between 800 and 2,850 mm but precipitation between 50 and 600 mm in most areas, the climate is dry, precipitation rare and eco-environment fragile; so water resources are the key element for production. Owing to the economic underdevelopment in the region, there are 55 nationally designated poverty-stricken counties in Gansu and Qinghai provinces alone, where per capita incomes are far below the average of the nation.

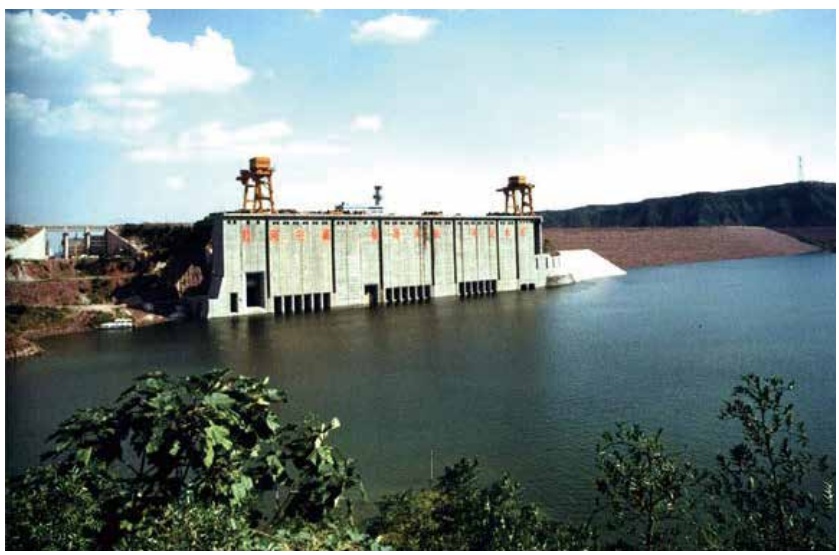
Overdeveloped in some rivers, the basin confronts a big problem of ecological degradation. Additionally, owing to management and infrastructure problems water use efficiency is low. Especially in areas of Shiyang River, Tarim River and other downstream places, the most serious problems are excessive demand for water resources and eco-environmental deterioration.

Water resources of river basins in the Northwestern regions are significantly impacted by climate change. In the past 50 years, in the Qilian Mountain areas and the basins of inland rivers in Xinjiang, the precipitation and runoff are significantly increasing. Meanwhile, the future will see an increasing trend of water availability. To some extent, this will ease the problem of water resources in the Northwestern regions.

China proposes to allocate water resources rationally, balancing the domestic, productive and ecological water use in the river basins of this region while reserving ecological water in the river and maintaining a stable groundwater level as the only measure to sustain the oasis landscape. It is also a key measure to avoid ecological disasters and tragedies similar to the disappearance of the ancient Loulan. To promote water saving and improve water use efficiency are important measures to improve the carrying capacity of the available water resources.

Annex 5 - Overview of the Irrigation and Water Resources Projects in China

1. Xiaolangdi Water Control Project



The Xiaolangdi Water Control Project, situated forty kilometers above Luoyang Municipality in Henan Province, is essential for the management of the Yellow River as it is the only control structure with a large storage capacity below the Sanmen Gorge on the river's mainstream. The project uses sophisticated technology and is regarded by international experts as one of the world's most challenging water engineering projects. The Xiaolangdi power plant has an installed capacity of 1,800 megawatts and the reservoir has a total storage capacity of 12.65 billion m^3, including a 7.55 billion m^3 storage capacity for silt. Construction started in September 1991 and the main structure was completed at the end of 2001. Intended primarily for flood control, ice prevention, and siltation reduction, the project also serves to supply water and provide irrigation and electricity generation.

2. Danjiangkou Water Control Project

Located on the mainstream of Hanjiang River in Junxian County in Hubei Province, the Danjiangkou Water Control Project is a key structure in the management and development of the Hanjiang River, as well as the water source for the middle route of the South-North Water Transfer Project. The project's reservoir has a storage capacity of 20.97 billion m^3 and its power plant has an installed capacity of 900 megawatts, to supply electric power to Hubei and Henan Province. Each year, 1.5 billion m^3 of water is diverted to irrigate 240 thousand hectares of farmland in the same provinces. Works to heighten the Danjiangkou dam have begun on September 26, 2005 and in 2014 the reservoir will be ready to supply water to the north as part of the transfer project. Danjiangkou project, among other functions, provides and supports flood control, electric power generation, irrigation, navigation, and aquaculture.

3. Miyun Reservoir

Miyun Reservoir is a large-scale water control structure on the Chaobai River. The project, which consists of a Chao River and a Bai River part, is located in Miyun County of Beijing Municipality. The reservoir has a total storage capacity of 4.375 billion m^3 and is important for the water supply to the capital city. The two power stations have a total installed capacity of 96.4 megawatts. Construction of the reservoir started in September 1958 and the structure was put into operation in September 1960. To ensure a stable water supply to the capital city, a diversion tunnel with a diameter of 3.5 meters and a designed daily diversion capacity of one million m^3 was constructed in 1995 to divert water to the Beijing No.9 Water Supply Plant on the left side of the auxiliary dam at Jiusong Mountain. Miyun Reservoir has various functions, including flood control, irrigation, water supply, electric power generation, aquaculture, and tourism.

4. Huai River Estuary Channel Project

The Huai River Estuary Channel Project is a strategic project to increase the flood discharge capacity of the Huai River, raise the flood control standard of Hongze Lake, and ensure flood protection for 20 million people and two million hectares of farmland. The channel, which is 163.5 km long, 750 meters wide, and approximately 4 meters deep, starts in the west at Erhe Gate on Hongze Lake and ends in the east at the Yellow Sea in Biandanxiang, Binhai County, within the municipalities of Huai'an and Yancheng in Jiangsu Province. Recent construction work,

initiated in October 1999, has added a direct estuary channel to the project.

5. Dongshen Water Supply Project

The Dongshen Water Supply Project is a large-scale inter-basin water transfer project to supply high quality fresh water to Hong Kong, Shenzhen and Dongguan. The project, of vital importance to Hong Kong and Guangdong Province, starts at the Taiyuan Pumping Station on Dongjiang River (Qiaotou Town, Dongguan Municipality) in the north, and ends at Shenzhen Reservoir in the south. The project is 69 kilometers long and has a designed flow of 100 m^3/s and an annual water supply of 2.423 billion m^3, including 1.1 billion m^3 to Hong Kong, 873 million m^3 to Shenzhen, and 400 million m^3 to Dongguan. Construction started in 1964 and the Project has later been expanded and reconstructed several times. The Dongshen Water Supply Project supports irrigation, drainage, power generation, and flood control.

6. Yangtze River Dike Reinforcement Project

The main dikes on the Yangtze River have been heightened and reinforced many times since the founding of the P.R. China in 1949. After the river flooded in 1998, a dike reinforcement program was carried out to heighten and enhance the dikes, treat foundations, and provide seepage control, slope protection, caving bank remediation, and cross-dike structure transformation. The reinforcement program was completed at the end of 2002 after heightening and reinforcing 3,576 kilometers of dikes, treating 1,931 kilometers of dike foundation, consolidating 2,519 kilometers of foundation through pond-filling, providing a remedy for 732 kilometers of caving banks, improving 2,037 cross-dike structures, building 2,142 kilometers of slope protection, and constructing 3,444 kilometers of road on top of the dike for traffic. As a result, the main dikes on the middle and lower reaches of the Yangtze River currently all meet the flood control standard established by the Master Plan for Comprehensive Utilization of Yangtze River Basin.

7. Gezhouba Water Control Project

The first large-scale water control structure ever constructed on the mainstream of Yangtze River, Gezhouba Water Control Project, located in Yichang Municipality, Hubei Province, serves as a navigation cascade and re-regulation reservoir of the Three Gorges Dam. The project has a total storage capacity of 1.655 billion m^3 and its power

plant an installed capacity of 2,715 megawatts. The reservoir has two navigation channels and three ship locks, allowing 10,000-ton fleets to pass through. Construction started in 1970 and was completed in 1988. The Gezhouba Water Control Project, among other functions, supports electric power generation, navigation, and tourism.

8. Zipingpu Water Control Project

Located 60 kilometers northwest of Chengdu Municipality on the upper reaches of Minjiang River, with its dam only 9 kilometers away from Dujiangyan City, Zipingpu Water Control Project is one of ten key projects in China's western development strategy. The reservoir has a total storage capacity of 1.112 billion m^3; the maximum height of the dam is 156 meters; and its power plant has an installed capacity of 760 megawatts. Project construction started in full in March 2001 and the project was completed and put into operation in May 2006. The project withstood the devastating 2008 Sichuan Wenchuan earthquake, its operation remaining safe and stable. Zipingpu Water Control Project is primarily built for irrigation and water supply but also contributes to electricity generation, flood control, environmental protection and tourism.

9. Jiangya Water Control Project

Jiangya Water Control Project is the first key flood control structure in Lishui River Basin, Hunan Province, and with its 131 meter high dam also one of the highest full-profile RCC gravity dams in the world. Located in Jiangya Town in Cili County, the project covers a catchment area of 3,711 km2. The reservoir has a total storage capacity of 1.74 billion m^3, including 740 million m^3 of flood control storage, and irrigates 5,800 hectares of farmland. With an installed capacity of 300 megawatts, its power plant generates 756 million kWh electricity on a mean annual basis. Construction of the dam started in May 1995 and was completed in January 2003. The project is intended primarily for flood control but also supports power generation, irrigation, navigation, water supply, and tourism.

10. Xin'anjiang Reservoir

Located on mainstream Xin'an River on the upper reaches of the Qiantang River, Xin'anjiang Reservoir is the largest reservoir in Zhejiang Province. It has a total storage capacity of 21.626 billion m^3 and provides multi-year storage. Xin'anjiang Power Station is the first large-sized hydropower plant independently designed and constructed by China with all equipment made in the country. The power station also has the largest regulating capacity in the East China power grid. Construction started in April 1957 and the station was put in full operation in 1978. The initial installed capacity of 662.5 megawatts has since been increased to 810 megawatts. The reservoir is primarily used for peak-load and frequency regulation and emergency use in the East China power grid, but also is used for irrigation.

11. Qiantang River Sea Wall

The Qiangtang River Sea Wall, situated on the banks of the Qiantang River estuary, is the main barrier against floods and tides to protect Hangjiahu Plain and Xiaoshao Plain in Zhejiang Province. Since the foundation of the P.R. China, the sea wall has undergone two main construction periods. The first period, between 1950 and 1957, involved emergency reinforcement and heightening of the main wall to increase the flood prevention standard from less than one in ten year frequency to one in twenty to fifty year frequency. During the second construction period, between 1997 and 2003, a standard wall was built to further raise the prevention standard to one in a hundred year frequency. By July 2008, 210 kilometers of sea wall, out of a total of 467 kilometers, had reached this higher standard.

12. Integrated Management of Tarim River

The integrated Tarim River Management Project in Xinjiang is a large-scale control project to resolve water resource shortages and promote economic and social development and eco-environmental protection in the Tarim River basin. The 1,321 kilometer long Tarim River is the longest continental river in China, covering a total basin area of 1.02 million km^2. Implementation of the integrated management project started in 2001 for a total investment of RMB 10.739 billion. Recent improvements to the project have brought ecological, economic, and social benefits to the area.

13. Wuluwati Water Control Project

The Wuluwati Water Control Project is a key water control project for Kalakashi River basin, the west tributary of Hetian River, and one of the

national key construction projects under the 9th Five-Year Plan. Located in Hetian County in the southern part of Xinjiang Uygur Autonomous Region, the reservoir has a total storage capacity of 333.6 million m^3, with a regulating storage capacity of 225 million m^3. The reservoir supplies 1.057 billion m3 of water to the Tarim River every year. The power station has an installed capacity of 60 megawatts and generates 197 million kWh electricity on a mean annual basis. The project was completed in September 2009 and its functions include irrigation, flood control, power generation, and ecological protection.

14. Liujiaxia Water Control Project

Located on the mainstream Yellow River in Yongjing County, Gansu Province, the Liujiaxia Water Control Project is the first large-scale, million kilowatt-level water control structure in Asia that has been independently surveyed, designed and constructed by China. With a maximum dam height of 147 meters, the power station has a total installed capacity of 1,225 megawatts and a maximum unit capacity of 300 megawatts. Construction started in 1958 and in 1974 the project was completed and put into operation to generate electricity. Between 1986 and 2001, station capacity was increased to 1,350 megawatts. Used primarily for electric power generation, the project is also important for irrigation, flood control, water supply, aquaculture, navigation, and tourism.

15. Wanjiazhai Water Control Project

Wanjiazhai Water Control Project is the first of eight cascade projects planned for the development of the middle reaches of the Yellow River. The project is also the starting point of the Water Diversion Project from the Yellow River to Shanxi Province. Located on a river reach in the valley from Tuoketuo to Longkou of the north mainstream of the Yellow River, the reservoir has a total storage capacity of 896 million m^3 and a power station with an installed capacity of 1,080 megawatts. The project, designed to store clean water and discharge turbid water, supplies 1.4 billion m^3 of water to the Inner-Mongolia Autonomous Region and Shanxi Province. Construction of the project started in November 1994 and was completed in 2002. The Wanjiazhai Water Control Project is used primarily for water supply and power generation but also provides flood control and ice prevention.

16. Sanmen Gorge Water Control Project

Located in the lower part of the middle reaches of the Yellow River, Sanmen Gorge Water Control Project is an important large-scale mainstream control structure of the flood prevention system on the lower-middle reach of the river, which connects the two provinces of Henan and Shanxi. The reservoir has a total storage capacity of 16.2 billion m^3 and its power station an installed capacity of 400 megawatts. Construction started in April 1957 and impoundment started in September 1960. As a result of siltation in the reservoir area, the structure has undergone new construction twice after it was put in operation, using three stages of "water storage and silt discharge," "flood detention and silt discharge," and "clean water storage and turbid water discharge," to explore how best to remove the siltation. The project provides flood control, ice prevention, irrigation, water supply, and power generation.

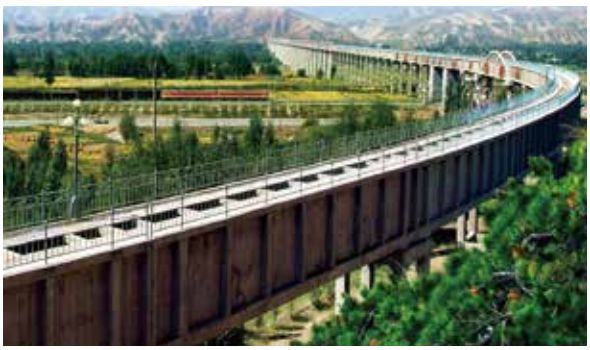
17. Standardized Yellow River Dike Project

The Standardized Yellow River Dike Project is a project to upgrade existing dikes to establish an overall "standardized dike system." The project integrates flood control with ecological needs and traffic access, and activities include widening the dikes, discharging silt and strengthening the dike, reconstructing and heightening weak waterworks, constructing roads on top of the dike, and establishing tide protection woodlands and ecological shelter belts. Construction of the first phase started in 2002 and was completed in 2005, with standardized dikes going all the way through the municipalities of Zhengzhou, Kaifeng, and Jinan, and along the Dongming reach of Heze. Construction for the second and final phase is underway. At the end of Phase II, the dike will have a total length of 1,147.27 kilometers.

18. Water Diversion Project from Yellow River to Qingdao City

As one of the key national projects under the 7th Five-Year Plan, this water diversion project diverts Yellow River water from Dayuzhang Gate in Binzhou Municipality to Qingdao Municipality in Shandong Province. The project runs through four municipalities and prefectures, as well as through ten counties, cities, and districts, covering a total length of 290 kilometers. Construction for the project officially started on April 15, 1986 and the project was completed and opened for water diversion on November 25, 1989. The project provides water diversion, desilting, water transfer, water storage, water purification, and water distribution. Over the past 20 years, the project has diverted 2.78 billion m^3 of water from the Yellow River and supplied 1.35 billion m^3 to Qingdao Municipality, bringing enormous social, economic and eco-environmental benefits to Qingdao and other places in the project area.

19. Water Diversion Project from Datong River to Qinwangchuan District



As a large-scale key water project and also the largest water project invested in and operated by Gansu Province since the foundation of the P.R. China, the system serves the inter-basin water diversion and transfer from Datong River, which rises in Muli Mountain in Qinghai Province, to the Qinwangchuan District of Lanzhou Municipality in Gansu Province. The project runs through four municipalities and six counties and districts in the two provinces. The main and branch canals are more than 1,000 kilometers in length, with a designed diversion capacity of 443 million m^3 to irrigate an area of 860 thousand mu (57.3 thousand hectares) farmland. Construction started in 1976, and since its operation in June 1994, basic conditions for agricultural production have been fundamentally improved in the irrigation areas, laying a solid foundation for the overall economic and social development in the municipalities of Lanzhou and Baiyin.

20. Manla Water Control Project

The Manla Water Control Project is the first large-sized, modern water control project in Tibet. Construction officially started in August 1995 and the structure was completed in August 2001. The project is located on the Nianchu River in Jiangzi County, Tibet. With a total investment of RMB 1.447 billion, its power station has an installed capacity of 20 megawatts and its reservoir a designed storage capacity of 155 million m^3 to irrigate 26.7 thousand hectares of farmland. The Manla Water Control Project is intended primarily for irrigation and power generation but also supports flood control, tourism, and environmental protection.

21. Linhuaigang Flood Control Project

As one of 19 Huai River improvement projects selected by the State Council in 1991, the Linhuaigang Flood Control Project serves as the key project to raise the flood control standard of mainstream Huai River to one in a hundred year frequency. Its construction ends the lack of flood control works on the middle reaches of Huai River. The project covers parts of the provinces of Henan and Anhui and the main works run through the three counties of Huoqiu, Yingshang, and Funan, together controlling an area of 42.2 thousand km^2. Construction started in December 2001 and was completed in November 2006.

22. Wangjiaba Gate

Wangjiaba Gate is the flood inlet control in the Mengwa flood storage area on mainstream Huai River. Commanded by the National Flood Control and Drought Relief Headquarters, the gate is known as the "No.1 Gate on the thousand kilometer Huai River." The structure is located between the middle and upper reaches of Huai River and at the confluence of three rivers, and also is situated in three counties of Henan and Anhui Provinces. First built in 1953, the Gate has been used fourteen times in eleven flood years, including in 1954, 1991, and 2003, and has played a major role in the prevention and control of floods in the Huai River basin. Upgrades in 2004 have enabled automatic and safe operation of the gate.

23. Foziling Reservoir

As a large-sized reservoir on the upper reaches of East Pihe River, a tributary of Huai River, in Huoshan County, Anhui Province, Foziling Reservoir is a multiple-arch dam independently designed in the early years after the foundation of the P.R. China in 1949. The reservoir was constructed in 1952, using the then most advanced technologies, to meet a flood control standard of one in a thousand year frequency. The reservoir has a total storage capacity of 496 million m^3 and its power station an installed capacity of 31 megawatts. The reservoir is intended primarily for flood control and also supports irrigation, power generation, and navigation.

24. Guanting Reservoir

Guanting Reservoir is the first large-sized reservoir constructed after 1949. The Reservoir meets the flood control standard of one in a thousand year frequency. Since its construction, the structure has controlled all floods upstream of Guanting, protected lives and economic activities in the downstream areas, and greatly reduced the threat of flood to those areas. Construction of the reservoir started in October 1951 and the project was completed in May 1954. With a total storage capacity of 4.16 billion m^3, Guanting Reservoir is designed primarily for flood control and water supply but is also used for power generation and irrigation.

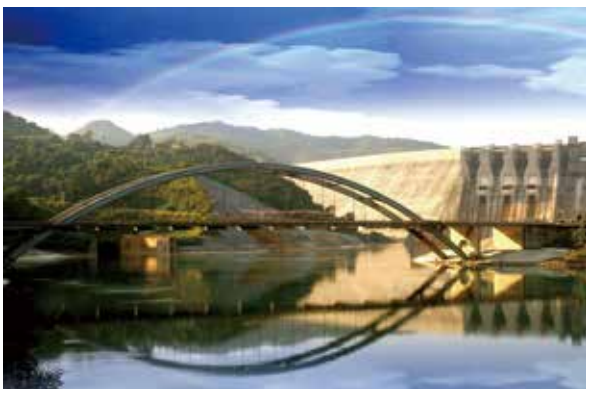
25. Panjiakou Water Control Project

As the general water source of the Water Diversion Project from Luanhe River to Tianjin City, Panjiakou Project is an important control structure for water resources development in Luanhe River, runoff regulation, and hazard elimination. Located on mainstream Luanhe River in Qianxi County, Hebei Province, the reservoir has a total storage capacity of 2.93 billion m^3, with an annual average regulating storage of 1.95 billion m^3.The project covers a basin area of 33.7 thousand km^2 and supplies water to Tianjin and Tangshan municipalities for industrial, agricultural, and domestic uses. As the largest mixed pumped-storage plant in northern China at present, Panjiakou Water Control Project has a total installed capacity of 420 megawatts. Its construction started in October 1975 and the project was fully completed at the end of 1993. While primarily intended for water supply and power generation, the project is also used for flood control.

26. Huangbizhuang Reservoir

Located on mainstream Hutuo River, one of the two main tributaries of the Ziya River System in Hai River Basin, Huangbizhuang Reservoir has a total storage capacity of 1.21 billion m3 and controls a total basin area of 23.4 km^2. The Reservoir is used together with the Gangnan Reservoir upstream. Built in 1958, the project was listed in the early 1980s as one of the first 43 reservoirs that were in need of an upgrade and repairs. Reinforcement construction work started in March 1999 and was completed in December 2005, with the project now meeting the flood control standard of one in ten thousand year frequency. Huangbizhuang Reservoir is used primarily for flood control but also provides irrigation, power generation, and water supply services.

27. Baise Water Control Project



The Baise Water Control Project, located in the middle part of Youjiang River on the upper reaches of Yujiang River, 22 kilometers upstream from Baise Municipality, is the key structure for the management and development of the Yujiang River in the Pearl River Basin. It is also another one of the ten key proje cts of the nation's western development. The project has a total storage capacity of 5.66 billion m^3 and the power station an installed capacity of 540 megawatts. Construction of the main works started in October 2001 and was completed in December 2006. The Baise Water Control Project is important for raising the flood control standard of Nanning Municipality, bringing about poverty alleviation and prosperity and promoting sustainable economic and social development

in the provinces of Guangxi and Yunnan. While intended primarily for flood control, the project also provides power generation, irrigation, navigation, and water supply.

28. Feilai Gorge Water Control Project

Feilai Gorge Water Control Project is the largest comprehensive water control works ever constructed in Guangdong Province since the 1949. The project is also the key structure for the integrated management of the Beijiang River basin. Located on the middle reaches of mainstream Beijiang River in Qingyuan City, Guangdong Province, the reservoir has a total storage capacity of 1.904 billion m^3 and an installed power generation capacity of 140 megawatts. The project, which controls a basin area of 34,097 km^2, was fully completed and put into operation in October 1999. The structure is used primarily for flood control but also functions to support navigation, power generation, water supply, and eco-environmental improvements.

29. Dahuofang Reservoir

Located on the middle reaches of the Hunhe River in the east suburb of Fushun Municipality, Dahuofang Reservoir has a total storage capacity of 2.268 billion m3 and a maximum flood discharging capacity of 5,480 m^3 / s. The reservoir, the largest in Liaoning Province, controls a basin area of 5,437 km^2, covers an irrigation area of 100 thousand hectares, and—with an installed capacity of 40 megawatts—serves to generate 40.57 million kWh electricity on average each year. Construction started in full on April 11, 1954 and was completed on September 5, 1958. As an important source of drinking water for residents in the large cities of Shenyang and Fushun, the project is primarily meant for flood control, water supply, and irrigation, but also is used for power generation and aquaculture.

30. Ni'erji Water Control Project

Located on the upper reaches of mainstream Nenjiang River at the border between Heilongjiang Province and the Inner-Mongolia Autonomous Region, the Ni'erji Water Control Project is also a key project of China's national western development strategy. The structure has a total storage capacity of 8.611 billion m^3, controls a basin area of 66.4 thousand km^2, and generates 638.7 million kWh electricity on a mean annual basis with a total installed capacity of 250 megawatts. Construction started in 2001 and the main works were completed in 2006. The water control project is primarily used for flood control and municipal, industrial, and agricultural water

supply, but also is used for power generation and improving the conditions for downstream navigation, while optimizing water resources allocation in Songliao Basin.

31. Songhua River Mainstream Dike Project

Songhua River is 3,267 kilometers long and covers a basin area of 556.8 thousand km^2 in the northern part of Northeastern China. Since the early 1950s, the dikes on the mainstream Songhua River and its main tributaries have been reinforced and strengthened several times. After the catastrophic flood in 1998, large-scale flood control works have been carried out and the overall flood control capacity in the basin has been significantly improved. Currently, the total length of dikes in the Songhua River basin is approximately 14,000 kilometers; the length of dikes on the mainstream is 2,901 kilometers, and that of dikes in major cities 661 kilometers. The current flood control standards of mainstream dikes range from one in twenty year frequency to one in fifty year frequency.

32. Cha'ersen Reservoir

Cha'ersen Reservoir is the only water control structure on the mainstream Tao'er River, a primary tributary of Nenjiang River. The reservoir is a large-sized "Class One" water project according to the national standard, and is used primarily for flood control and irrigation, but also to provide and support power generation and aquaculture. With a total storage capacity of 1.35 billion m^3, the project covers a basin area of 7,780 km2 upstream from the dam. The project serves to protect 142 thousand hectares (2.13 million mu) of farmland and 324.7 thousand hectares (4.87 million mu) of grassland downstream. The protected area also includes counties and cities in two provinces/autonomous regions and the project protects people in four towns and 929 natural villages, as well as three railways and three highways. The reservoir was constructed between 1973 and 1980 and its main works were completed and put into operation in 1990.

33. Tai Lake Shoreline Dike

The Tai Lake Shoreline Dike project is part of the comprehensive Tai Lake basin improvement effort initiated by the State Council in 1991. With a length of 393.8 kilometers, the dike along the shoreline consists of an "East Reach" and a "West Reach" part and runs from the north at Zhihu Harbor in Wuxi Municipality, Jiangsu Province, to the south at Changdou Harbor in Huzhou Municipality, Zhejiang Province. The project has improved flood regulation, increased storage capacity, and created conditions for water resources allocation in Tai Lake Basin.

34. Taipu River Project

Another key project part of the comprehensive Tai Lake Basin improvement effort, Taipu River Project is the main channel to connect Tai Lake with Huangpu River, a 57.6 kilometer long river in Jiangsu Province, Zhejiang Province, and Shanghai Municipality. Since construction started in 1991, the project has played a prominent role in flood control and calamity mitigation in the Tai Lake Basin and effectively reduced losses due to floods and water-logging. With water in the Tai Lake basin diverted from the river to the lake, the increased water supply through Taipu River to the well fields in the areas in Jiangsu, Zhejiang, Shanghai and downstream as well as along the Huangpu River in Shanghai has improved the environment in the water receiving areas, guaranteed the quality of water supplied from the well fields in Shanghai, and brought striking economic, social, and ecological benefits.

35. Yunfeng Water Supply Plant

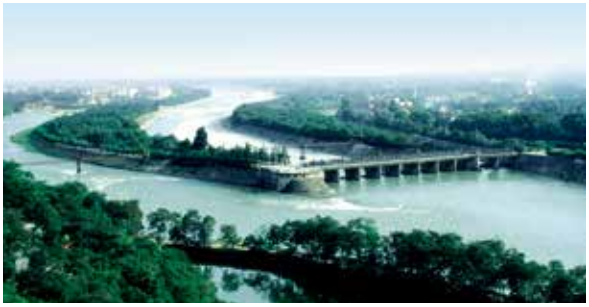
Yunfeng Water Supply Plant in Laizhou City, Shandong Province uses natural, unpolluted water from Lintuanhe Reservoir in Wenfeng Mountain to supply drinking water. Part of the national rural drinking water safety program, the plant has a designed water supply capacity of 75 thousand m^3 / day. With its automatic water purification equipment and advanced domestic water treatment technology, the water supplied by the plant meets drinking water standards. In Laizhou City, urban and rural water supply pipelines are integrated into one network that supplies drinking water for 260 thousand people in six towns and sub-districts, as well as for two industrial zones. The network also guarantees an emergency water supply for the urban area. Public water supply facilities are now available for 13 towns and sub-districts and 828 administrative villages on the outskirts of the city. The total water supply pipeline network covers an area of 1,100 km^2.

36. Shipaichangzheng Water Supply Plant

Shipaichangzheng Water Supply Plant is located in Shipai Town, Zhongxiang City, Hubei Province. The current plant is an upgrade from the earlier Shipaixiang Water Plant at the same location. The new plant has a daily water supply capacity of 20 thousand m^3 and serves an area within an18 kilometer radius. In 2008, the plant was included in the rural drinking water safety program and the extension of the pipeline network has solved the problem of drinking water safety for 31,580 people in 20 administrative villages of Shipai Town. The

network also has enhanced the quality of life for farmers and improved their health conditions.

37. Dujiang Weir Irrigation District



Dujiang Weir has a long history, with the first weir constructed over 2000 years ago in the late years of the Warring States Period. After 1949, the weir has been reconstructed and expanded several times to now cover the three basins of Minjiang, Tuojiang, and Fujiang Rivers. The district irrigates an area of 10.3 million mu (686.7 thousand hectares) and is considered an extra-large irrigation district. In 1986, a program was launched for irrigation district expansion and reconstruction. Dujiang Weir's water supply currently meets agricultural needs in the Chengdu Plain and the hilly central Sichuan area, but also supports livelihoods, industry, flood control, environmental protection, power generation, aquaculture, and tourism.

38. Pishihang Irrigation District

As one of the three extra-large irrigation districts established after 1949, Pishihang Irrigation District, the general term for three neighboring irrigation areas—Pihe River Irrigation District, Shihe River Irrigation District and Hangbu River Irrigation District—covers the Yangtze and Huai River Basins in the mid-western region of Anhui Province and the south-eastern region of Henan Province. The district's designed irrigation area totals 11.98 million mu (798.7 thousand hectares), including an effective irrigation area of more than 10 million mu (666.7 thousand hectares). Construction started in 1958 and in 1996 upgrades under the National Program on Rehabilitation of Large-Scale Irrigation Districts have begun. The irrigation district is intended primarily for flood control and irrigation but also contributes to hydropower generation, urban water supply, aquaculture, and tourism.

39. Hetao Irrigation District

As the largest gravity-flow irrigation district in China, Hetao Irrigation District consists of three irrigation areas: Bao'ertaolegai Irrigation District, Houtao Irrigation District, and Sanhu River Irrigation District, all three within Bayannol City in the western part of the Inner-Mongolia Autonomous Region. The command area is 17.43 million mu (1.162 million hectares) with irrigation water diverted from the Yellow River, which includes an effective irrigation area of 8.61 million mu (574 thousand hectares). Before 1961, only ten main canals in the region diverted water from the Yellow River, but in 1961, Sanshenggong Water Control Structure was constructed, which unified the irrigation district's water diversion system. More artery

drains, drainage pump stations, and canals have since been constructed, with major extension efforts underway since the 1990s.

40. Weishan Irrigation District

Weishan Irrigation District is the largest Yellow River water diversion irrigation district downstream of the river. The district is located in Liaocheng City, Shandong Province, and construction started in 1958. The designed irrigation area is 5.4 million mu (360 thousand hectares), with a designed diversion flow of 240 m^3/s, covering eight counties, cities, or districts. Over the years, the irrigation district has provided a reliable water supply for the economic and social development of Liaocheng City. Since 1981, it has also diverted water from the Yellow River to Tianjin, to Weishan Irrigation District and Hebei Province, and to Baiyangdian, which has effectively supported the economic development in Tianjin Municipality and Hebei Province. Upgrades under the National Program on Rehabilitation of Large-Scale Irrigation Districts began in 1998.

41. Qingtong Gorge Irrigation District

Qingtong Gorge Irrigation District is one of several ancient large irrigation districts in China. With the Yellow River in the middle, the district includes both Hedong and Hexi Irrigation Districts and is located in the mid-western region of Ningxia Hui Autonomous Region. The irrigation district has undergone several improvements throughout its 2,000-year history and is still in use. Since the foundation of the P.R. China, the ancient irrigation districts have been expanded and reconstructed to guarantee irrigation and drainage. Starting in 1998, the National Program on Rehabilitation of Large-Scale Irrigation Districts has also been implemented at the district. The district's current two general main canals and ten main canals have a total length of 1,085 kilometers and cover a total irrigation area of 4.75 million mu (316.7 thousand hectares).

42. Zhanghe River Irrigation District

One of the ten major irrigation districts in China, Zhanghe River Irrigation District is a large project of inter-basin water diversion and irrigation, located in a juncture of three cities—Jingmen, Yichang and Xiangfan—in Hubei Province. Its irrigation area is 2.605 million mu (173.7 thousand hectares) including an effective irrigation area of 2.33 million mu (155.3 thousand hectares). Construction started in 1958 and the district started operating in 1966. Construction has since continued and the district currently includes 16,061 structures, with a total canal length of nearly 7,200 kilometers. On June 16 1995, Zhanghe River Irrigation District also became the location of the first water user association

in China. Since then, 67 water user associations have been established across the country.

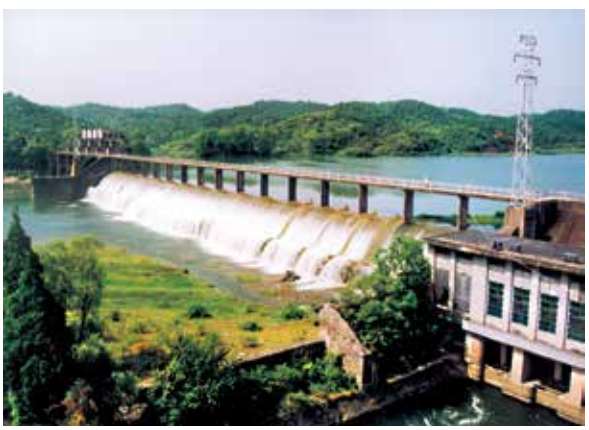
43. Yahekou Irrigation District

As another one of the ten major irrigation districts in China, Yahekou Irrigation District is the largest gravity-flow irrigation district with water supply from a reservoir in Henan Province and also a key area at the national level for investments in water saving transformation. Designated by the Ministry of Water Resources, the district is a pilot area for computerized information development, for the construction of terminal level canal systems, for the comprehensive reform of national-level large-sized irrigation districts, and for reform of national water works management systems. Located in the central part of Nanyang basin and on the Tangbai River, it has a designed irrigation area of 2.381 million mu (158.7 thousand hectares) including an effective irrigation area of 1.326 million mu (88.4 thousand hectares). Construction started in 1966 and implementation of the National Program on Rehabilitation of Large-Scale Irrigation Districts started in 1998.

44. Jinghui Canal Irrigation District

Located in the central part of Guanzhong Plain, Shaanxi Province, Jinghui Canal Irrigation District is a large gravity-flow irrigation district. With water diverted from Jinghe River, the district is responsible for irrigation of 1.45 million mu (96.7 thousand hectares) of farmland in six counties and districts. Construction of Jinghui Canal started in 1932. After the foundation of P.R. China, three large-scale expansion and reconstruction programs have been carried out in the district. These upgrades have continued in recent years.

45. Shaoshan Irrigation District



Located in the hilly area of the central part of the province, Shaoshan Irrigation District is the largest water diversion and irrigation project in Hunan Province. The project consists of three parts: Shuifumiao Reservoir, Yangtan

Water Diversion and Control Structure, and the irrigation district itself, which covers an effective irrigation area of one million mu (66.7 hectares). Construction of the district started in 1965 and the district was completed and put into operation in 1966. Shaoshan Irrigation District is used primarily for irrigation but is also used for flood control, drainage, power generation, navigation, aquaculture, and water supply.

46. Gaoyou Irrigation District

Located in Yangzhou Municipality in the central part of Jiangsu Province, Gaoyou Irrigation District is the source area for the water diversion of the east route scheme of the South-North Water Transfer Project. The district covers a total area of 649 km^2, including an irrigation area of 632.2 thousand mu (42.1 thousand hectares). Water is diverted from Jinghang Canal for gravity-flow irrigation and agricultural, industrial, municipal, and environmental purposes. When the water supply from the South-North Water Transfer Project is low, seven supplementary pump stations in the middle and lower parts of the irrigation district would pump water from Lixia River to supplement the water in the main canals. Construction of the irrigation district started in the 1950s and an extension and upgrade were started in 2000.

47. Dayuzhang Irrigation District

Dayuzhang Irrigation District is the largest Yellow River water diversion and irrigation district. It is also the first district to have been developed in Shandong Province and is at the same location as the main works of the water diversion project from the Yellow River to Qingdao City and the Jiaodong Region. The irrigation district is designed to cover an irrigation area of 660 thousand mu (44 thousand hectares), which accounts for 82% of the irrigation area of the county. Construction of Dayuzhang Irrigation District started in 1956. Since the completion in 1989 of the Water Diversion Project from Yellow River to Qingdao City, the Dayuzhang district's irrigation function has been extended to water supply for crude-oil production, municipal water supply, and other comprehensive services.

48. Qianguo Irrigation District

Located in Songyuan City in the northwestern part of Jilin Province, Qianguo Irrigation District is a pumping irrigation district with water pumped from the second Songhua River. Construction started in the 1940s and the district is one of several large-sized irrigation districts in the country. After more than sixty years of construction and development, the irrigation district has become an important base for producing commodity rice and growing green and organic rice in the province. With a designed irrigation area of 568 thousand mu (37.9 thousand hectares), the district currently irrigates an area of 450 thousand mu (30 thousand hectares), while 510 million m^3 of water is used each year for an annual production of 300 million kilograms of rice. In 1998, the irrigation district was listed for the National Program on Rehabilitation of Large-Scale Irrigation Districts.

49. Jiamakou Irrigation District

Located in Yuncheng City, Shanxi Province, the Jiamakou Yellow River water diversion and irrigation project is the first large electric pumping and irrigation project on the Yellow River, an integration of water supply, pumping, and canal irrigation. The water supply structure is designed with a pumping capacity of 51m^3/s and the two pumping stations, Jiamakou and Xiaofan, have a pumping capacity of 23.2m3/s and a lift of 70 meters, having 27 units installed. The district is designed to cover an irrigation area of 503 thousand mu (33.5 thousand hectares), including an effective irrigation area of 300 thousand mu (20 thousand hectares). Construction of the project started in 1958 and water pumping began in 1960. In April 2007, expansion started in the form of the Majiakou Project, which will increase the irrigation area by 333.6 thousand mu (22.24 thousand hectares).

50. Hongqi Canal Irrigation District

The Hongqi Canal Irrigation District in Linzhou City in the northwestern part of Henan Province is a large irrigation district integrating water diversion, storage, pumping, irrigation, drainage, and power generation. The district controls an area of 1,374 km^2, with a designed irrigation area of 540 thousand mu (36 thousand hectares). The canal mainly diverts water from Zhuozhang River, with an annual average flow of 258 million m^3. The district's headwork is located in Pingshun County, Shanxi Province, and the main, branch, and lateral canals are 1,500 kilometers long in total. Construction of the project started in 1960 and Hongqi Canal was officially opened for water diversion in 1965. Technical improvements since 1992 have increased the district's capacity for diversion, storage, and management.

51. Jingdian Pumping Irrigation Project

The Jingtaichuan Electric Pumping Irrigation Project, or "Jingdian Project," is an inter-basin, inter-province/region, large-scale Class II pumping irrigation project with a high water head, high energy consumption, multi-cascade and big flow discharge. The project is located in Jingtai County in the eastern part of the Hexi Corridor in Gansu Province. The irrigation district controls an irrigation area of one million mu (66.7 thousand hectares) and has 43 pumping stations with a total installed capacity of 259.7 megawatts. Construction of the project started in 1969 and the project has since been evaluated as "the best in China." Over the last forty years, project operation brought vast economic and social benefits.

52. Jiangdu Water Control Project

The Jiangdu Water Control Project is the first large electric pumping station independently designed, constructed, and managed by China. The project is a key structure in the Yangtze River Water North Transfer Project in Jiangsu Province and also the source of the East Route Scheme of the national South-North Water Transfer Project. The project is located on the lower reaches of the Yangtze and Huai Rivers, at the confluence of Jinghang Canal, Xintongyang Canal, and Mangdao River (the part of Huai River that runs into the Yangtze River). Construction started in 1961 and the project was completed in 1977. At the core of the project, there are four large electric pumping sub-stations with an installed capacity of 53 megawatts and a designed pumping capacity of 400m3/s, serving integrated functions of irrigation, drainage, flood discharge, navigation, power generation, and eco-environmental improvements.

53. Fankou Pumping Station

Located in Fankou Town, Ezhou City in Hubei Province, the Fankou Pumping Station is responsible for draining an area of 3,265 km^2 in the Liangzi Lake basin. Installed with 4×6,000 kW units, the main set comprises a Model 40CJ – 95 axial-flow pump and a Model TDL535/60 – 56 electric motor, which is the most powerful axial-flow pump set equipped for a single pump; the set has a designed pumping capacity of 214m^3/s. Construction of the station started in 1977 and the project was completed and put into operation in 1980. Up to today, more than 15 billion m^3 of water has been drained off.

54. Soil and Water Conservation Project in the Middle and Upper Reaches of the Yangtze River

In 1989, the government launched the Yangtze River Middle and Upper Reaches Key Area Soil and Water Conservation Project, which is also referred to as the Yangtze River Improvement Project. Over the last 20 years, the project has covered 195 counties in ten provinces; in total, nearly 95 thousand km2 of soil and water erosion areas have been improved and more than 5,000 watersheds have been treated. As a result, the size of the soil and water erosion areas in the Yangtze River basin has been reduced by 15% from 620 thousand km^2 in the mid-1980s to the current 530 thousand km^2. In addition, the area of soil and water erosion in the region of the Three Gorges Reservoir has decreased at a rate of 1% per year on average. Soil and water erosion have also been reduced in the Danjiangkou Reservoir area, the source for the Middle Route Scheme of the South-North Water Transfer.

55. Loess Plateau Warping Dams

Warping dams, small dams for silt retention, are an engineering measure for soil and water conservation unique to the loess plateau region. Warping dams serve several functions, including mud retention, water storage, soil conservation, and land warping. In 2003, the Ministry of Water Resources acknowledged the construction of warping dams as one of three key projects under its national water resources development program, and launched a pilot project of warping dam construction for soil and water conservation in the loess plateau region. By the end of 2008, a total of 91,176 warping dams had been constructed, including 5,503 key warping dams, 11,264 medium-sized warping dams, and 74,409 small-sized warping dams. The total storage capacity of these dams reaches up to 9.379 billion m^3, which is enough to retain about 12.661 billion tons of mud.

56. Comprehensive Control of Soil and Water Erosion in the Black Soil Region of Northeastern China

In 2003, the government launched a pilot project of comprehensive prevention and control of soil and water erosion in the black soil region of Northeastern China, covering 15 counties in the provinces of Heilongjiang, Jilin, and Liaoning and in the Inner-Mongolia region. The project involved 226 watersheds and a total area of 1,804 km^2. Following this pilot project, a second soil and water erosion control project for the black soil areas in Northeastern China was launched in 2008 under the State Office of Comprehensive Agricultural Development (SOCAD) and the

General Bureau of Heilongjiang Reclamation, this time covering 30 counties in Heilongjiang and Jilin Province. With a focus on controlling soil and water erosion on slope farmland, the project implemented comprehensive watershed improvement activities, preserved valuable black soil, and guaranteed national food safety.

57. Comprehensive Soil and Water Conservation in the Karst Region in Nanbeipan River Basin on Upstream Pearl River

The karst region in the Nanbeipan River Basin on the upper reaches of the Pearl River is a very poor and ecologically fragile area. The area has the most severe soil and water erosion in China. In 2003, the government launched a pilot project for comprehensive soil and water conservation in the area, covering 17 counties in the provinces of Yunnan, Guizhou, and Guangxi, as well as 136 watersheds. By focusing on remediating and improving slope farmland, the project constructed basic farmland and straightened out water systems on slopes, developed industries with local characteristics, and increased farmers' incomes.

58. Hankou Hydrological Station

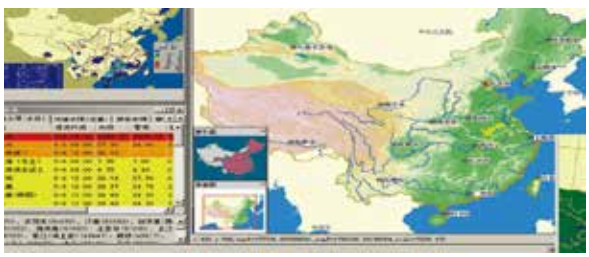
Established in 1865, Hankou Hydrological Station is an important hydrological control station on the mainstream of the Yangtze River. The station falls under the Hydrologic Bureau and the Middle Changjiang Hydrological and Water Resources Survey Bureau of Changjiang Water Resources Commission. The station is responsible for collecting basic hydrological data, providing services for industrial and agricultural production, and providing hydrological information for flood control and calamity mitigation. Station instruments have been constantly upgraded and are currently the most advanced hydrological gauging and reporting equipment used in the country. Observations of water levels and precipitation as well as flood forecasting are all automated. ADCP and GPS are used to measure flow.

59. Huayuankou Hydrological Station

Established in July 1938 and located in a northern suburb of Zhengzhou City in Henan Province, Huayuankou Hydrological Station is an important hydrological station at the national level. It also provides flood control for the downstream areas of the Yellow River. Since the foundation of the P.R. China, the station has managed ten floods with water flows of more than 10,000m^3/s, as well as the catastrophic and extraordinary floods of July 1958, August 1982, and August 1996. The hydrological station not only plays a crucial role in water regulation

for flood control, but also provides unified water resources management and river reach improvements, and has contributed to research on the Yellow River. On June 15, 2002, the first station using digital technology on the Yellow River was officially put to use for Huayuankou Hydrological Station.

60. National Flood Control and Drought Relief Commanding System



The National Flood Control and Drought Relief Commanding System provides timely and accurate flood control and drought relief information to the National Flood Control and Drought Relief Headquarters. From there, information is related to relevant government departments, including those for water resources, meteorology, and agriculture. Taking advantage of the latest technologies, the commanding system serves as an information collection system, communication system, computer network system, and decision-making support system. Phase I of the Commanding System, approved in June 2003 by the National Development and Reform Commission, has been basically completed and already has played a major role in flood control, drought relief, and calamity mitigation. The feasibility study for Phase II has been completed and implementation of Phase II is scheduled to begin soon.

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