Experience with Dams in Water And Energy Resource Development In The People’s Republic Of China

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The WCD Knowledge Base

This report is one component of the World Commission on Dams knowledge base from which the WCD drew to finalize its report “Dams and Development - A New Framework for Decision Making”. The knowledge base consists of seven case studies, two country studies, one briefing paper, seventeen thematic reviews of five sectors, a cross check survey of 125 dams, four regional consultations and nearly 1000 topic-related submissions. All the reports listed below, are available on CD-ROM or can be downloaded from www.dams.org

Case Studies (Focal Dams)
- Grand Coulee Dam, Columbia River Basin, USA
- Tarbela Dam, Indus River Basin, Pakistan
- Aslantas Dam, Ceyhan River Basin, Turkey
- Kariba Dam, Zambezi River, Zambia/Zimbabwe
- Tucurui Dam, Tocantins River, Brazil
- Pak Mun Dam, Mun-Mekong River Basin, Thailand
- Glomma and Laagen Basin, Norway
- Pilot Study of the Gariep and Van der Kloof dams - Orange River South Africa

Country Studies
- India
- China

Briefing Paper
- Russia and NIS countries

Thematic Reviews
- TR I.1: Social Impact of Large Dams: Equity and Distributional Issues
- TR I.2: Dams, Indigenous People and Vulnerable Ethnic Minorities
- TR I.3: Displacement, Resettlement, Rehabilitation, Reparation and Development
- TR I.4: Ecosystem Functions and Environmental Restoration
- TR II.1: Dams and Global Change
- TR III.1: Economic, Financial and Distributional Analysis
- TR III.2: International Trends in Project Financing
- TR IV.1: Electricity Supply and Demand Management Options
- TR IV.2: Irrigation Options
- TR IV.3: Water Supply Options
- TR IV.4: Flood Control and Management Options
- TR IV.5: Operation, Monitoring and Decommissioning of Dams
- TR V.1: Planning Approaches
- TR V.2: Environmental and Social Assessment for Large Dams
- TR V.3: River Basins – Institutional Frameworks and Management Options
- TR V.4: Regulation, Compliance and Implementation
- TR V.5: Participation, Negotiation and Conflict Management: Large Dam Projects

Regional Consultations – Hanoi, Colombo, Sao Paulo and Cairo

Cross-check Survey of 125 dams
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- ABB
- ADB - Asian Development Bank
- AID - Assistance for India's Development
- Atlas Copco
- Australia - AusAID
- Berne Declaration
- British Dam Society
- Canada - CIDA
- Carnegie Foundation
- Coyne et Bellier
- C.S. Mott Foundation
- Denmark - Ministry of Foreign Affairs
- EDF - Electricité de France
- Engevix
- ENRON International
- Finland - Ministry of Foreign Affairs
- Germany - BMZ: Federal Ministry for Economic Co-operation
- Goldman Environmental Foundation
- GTZ - Deutsche Gesellschaft für Technische Zusammenarbeit
- Halcrow Water
- Harza Engineering
- Hydro Quebec
- Novib
- David and Lucille Packard Foundation
- Paul Rizzo and Associates
- People's Republic of China
- Rockefeller Brothers Foundation
- Skanska
- SNC Lavalin
- South Africa - Ministry of Water Affairs and Forestry
- Statkraft
- Sweden - Sida
- IADB - Inter-American Development Bank
- Ireland - Ministry of Foreign Affairs
- IUCN - The World Conservation Union
- Japan - Ministry of Foreign Affairs
- KfW - Kreditanstalt für Wiederaufbau
- Lahnemeyer International
- Lotek Engineering
- Manitoba Hydro
- National Wildlife Federation, USA
- Norplan
- Norway - Ministry of Foreign Affairs
- Switzerland - SDC
- The Netherlands - Ministry of Foreign Affairs
- The World Bank
- Tractebel Engineering
- United Kingdom - DFID
- UNEP - United Nations Environment Programme
- United Nations Foundation
- USA Bureau of Reclamation
- Voith Siemens
- Worley International
- WWF International
Executive Summary

China, the world's most populous country, has one of the longest traditions of water resources development and river management in the world. The civilisation has sought to address the effects of floods and drought in some of the world’s largest river basins for many thousands of years, and to utilise the water flows for irrigation and navigation. In the last century hydropower generation and municipal and industrial water supply have also become reasons for the regulation and abstraction of fresh water flow in rivers.

Today China is at a crossroads in water and energy development. This is in respect to selecting the way forward to achieve sustainable development and in making strategic choices among the different visions of regional development. Among the factors that have enter the discussion within China’s of it strategic options for future water resource development and management include: the increasing severity of the effects of flooding and drought and implications for the wider economy, and threat to lives and livelihood; the growing scarcity of surface and ground water resources in many regions, and growing competition for fresh water; the net losses of agriculture lands with encroachment by urbanisation and soil erosion; and, changing social development priorities centering on concerns over the displacement impacts of large infrastructure projects as well as urban-rural income disparity and poverty alleviation. Finally there is growing understanding of and concern over the progressively deteriorating state of the natural environment including land, water and air quality and the ecosystem effects as well as the longer term viability of water resource projects.

Recently China has been undergoing two major, interrelated transformations that have a profound influence on all aspects of life in the PRC. These transformations also underlay changes in patterns of demand for water and energy services. The influence decision-making on water and energy sector and broader development programmes. They also shape views of what sustainable development actually means, and the priorities for management of existing infrastructure and the evolving legal and institutional arrangements. The first is the accelerated pace of transformation from a rural agrarian society to a more urbanised industrial society. At present China is just over 30% urban. With current trends China is projected to be up to 60% urban by 2050. Increasingly the demand for water and energy services will be concentrated in larger urban centers. One indication of this trend is that agriculture GDP fell to less than 20% of overall GDP in the mid 1990’s. The second major transformation is the shift from a centrally planned to a socialist market economy. These transitions broadly have led to, or promise to lead to, greater openness and a devolution of centralised control with the adoption of more localised decision-making and reliance on market forces, in a socialist political context.

There is evidence of a more open debate in the People’s Republic of China which is similar to the debate occurring world-wide on the future direction of water and energy resource development and the rate of progress in addressing problems that remain from the past. It is more specifically focused on the role that dams and non-dam alternatives may play, and the choices that are made among them either as complementary or mutually exclusive means of achieving sought after sustainable development outcomes, recognising the unique circumstances in China and special challenges that it faces.

China’s physical situation as regard to water and energy resource development is somewhat unique in world terms, for many reasons discussed in this paper. They include the sheer scale and magnitude of the challenges it faces in providing water and energy services for over 1.2 billion citizens and the extent to which it is constrained or locked in by past development choices. To date, China has built almost half of the world’s estimated 45,000 large dams. And China remains one of the most active dams building countries today. Dams have and continue to enjoy considerable political and institutional support. China has also been involved in the displacement of more people and the alterations of more rivers than any other society.
Over 22,000 of the estimate 85,000 significant reservoirs and dams in China are considered as large dams, though there are perhaps a few million small-scale and localised water diversions, check dams and weirs built by local collectives or individual farmers that are unrecorded. China has thus built more the three times the number of large dams than the USA and over five times the number in India. Virtually all these dams were built since the founding of the People's Republic of China in 1949, as only 22 large dams existed before that time. What is remarkable is that this massive dam building programme was undertaken in parallel with the construction of many thousands of km of dykes, levees, retention basins, pumping schemes and other projects such as navigation locks on its river systems.

A considerable portion of China's inventory of large dams were actually built in the 1950's and 1960's. Thus while China is adding to this inventory, much of the existing infrastructure is ageing. The management of existing dams is thus seen to be increasingly important, not only because of the numbers, but for reasons of safety, restoration, modernisation and adapting operating practices to the circumstances of today. The optimisation of existing dams and reservoirs in the context of an integrated basin development plan is also seen to be an essential way forward to address cumulative impacts and reconcile competing demands for water between nature and human activities. The concerns are increasing and have in some basins such as the Yellow River reached critical thresholds. Adding to this there is also growing concern about the potential risk and uncertainty of climate change, where river basin management practices and development planning will have to take into account likely changes in the flow regimes of China’s rivers.

The Chinese circumstances and debate links to international concern for water and land use and sustainable development more generally. The limited availability of water and of land suitable for agriculture is recognised as being one of the greatest challenges facing humankind in the 21st century. In China as in other parts of the world opportunities for tapping unused water resources or finding unused land suitable for agriculture are increasingly limited. The option of damming more rivers for water and ploughing grasslands or cutting forests to provide land for agriculture has also come under increased scrutiny for many interrelated environment and social concerns and sustainability.

The issues are particularly acute in China because of the rising standard of living of many of its 1.2 billion people. China after the devastating experience of the Cultural Revolution is particularly aware of the need to ensure adequate food supplies for its population and food security remains a national priority. Nonetheless, with past approaches in water resources development and current management practices major river systems are drying up, groundwater aquifers are increasingly over exploited, and competition for water between communities, sectors of the economy and between provinces is growing. The situation is not uniform throughout the country. Some regions are water stressed while other suffer from excess water in the form of flood and waterlogged soils. New strategies for meeting the human need for water supply and food production thus have to be found in China, perhaps more than in many other part of the world. Financial resources and its highly educated and capable human resources redirected to achieve this.

The purpose of this paper is to provide an overview of water resources development in the People’s Republic of China (PRC), and background information on the benefits and concerns of large dams. This is to provide an input to the WCD process on the issues around the development effectiveness of dams worldwide. This paper identifies and examines some of the strategic challenges China faces in its water and energy resource development plans and programmes; as well as the policy, legal, institutional framework that is evolving for decision-making. The paper also looks at the environmental and social issues and the scope and challenges for integrated river basin planning and management that are increasingly highlighted in policy statements, but otherwise appear to be a very promising direction, but slowly emerging.

Section 1 looks at the context of the dam debate in China and provides a profile of its dam building programme and financing. Section 2 of the paper then looks more closely at the land, water and energy resource situation and challenges China faces in developing these resources. Section 3 looks at
the evolving development policy environment and the legal, regulatory and institutional framework for water resources planning and management. Section 4 considers the scope and potential for some of the non-dam alternatives. It also provides a more in-depth illustration of two specific strategic challenges that China faces by way of describing how it is approaching flood management on the Yangtze river, and the water scarcity problem in the North China plain where transbasin diversions are now being considered. Section 5, looks at some of the issues and the evolving practices in social and environmental management related to resettlement and large dams.

The Annexes to the paper provide general descriptions of three large dams, and examines some of the controversies and the manner in which the government is approaching the local and regional development issues, as well as social and environmental challenges. These projects include the Three Gorges project, the largest water and energy resource project in the world (intended primarily for flood defence in the middle and lower reaches of the Yangtze) and power generation, the Xiaolangdi project and the Shuikou project. The Shuikou write-up focuses mainly on the resettlement component of the project and suggests what is considered to be emerging good practice in the implementation of China's resettlement policies, and provides a set of lessons learned.

The Appendix provides comments that were received from the different constituencies in the dams debate on the draft version of the paper circulated in March 2000. The perspectives expressed range from highly critical views of China's water and energy management policies and practices, particularly those on resettlement and environmental management, to those supportive of the direction of China's evolving policies, programmes and practices.
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<th>Definition</th>
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<tr>
<td>3-H Plain</td>
<td>Hai-Huang-Huai</td>
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<tr>
<td>ADAS</td>
<td>Automatic Data Acquisition System</td>
</tr>
<tr>
<td>bcm</td>
<td>Billion cubic meters</td>
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<tr>
<td>BOO</td>
<td>Build-Own-Operate</td>
</tr>
<tr>
<td>BOOT</td>
<td>Build-Own-Operate-Transfer</td>
</tr>
<tr>
<td>BOT</td>
<td>Build-Operate-Transfer</td>
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<tr>
<td>CRFD</td>
<td>Concrete rock fill dams</td>
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<tr>
<td>DH</td>
<td>Department of Hydrology</td>
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<tr>
<td>DOE</td>
<td>Department of Environment</td>
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<tr>
<td>DSM</td>
<td>Demand Side Management</td>
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<tr>
<td>EIA</td>
<td>Environmental Impact Assessment</td>
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<tr>
<td>EPB</td>
<td>Environmental Protection Bureau</td>
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<td>EPL</td>
<td>Environmental Protection Law</td>
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<td>GDP</td>
<td>Gross domestic product</td>
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<td>GHG</td>
<td>Greenhouse gas</td>
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<td>GWh</td>
<td>GigaWatt hours</td>
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<td>HV</td>
<td>High voltage</td>
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<tr>
<td>ICB</td>
<td>International competitive bidding</td>
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<tr>
<td>ICOLD</td>
<td>International Committee on Large Dams</td>
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<td>LRMC</td>
<td>Long-run marginal cost</td>
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<td>MRC</td>
<td>Mekong River Commission</td>
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<td>MW</td>
<td>megaWatts</td>
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<td>MWR</td>
<td>Ministry of Water Resources</td>
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<td>NGO</td>
<td>Non-governmental Organisation</td>
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<td>NPC</td>
<td>National People’s Congress</td>
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<tr>
<td>O&amp;M</td>
<td>Operations and maintenance</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<td>OECF</td>
<td>Overseas Economic Cooperation Fund</td>
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<tr>
<td>PAA</td>
<td>Power Purchasing Agreement</td>
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<tr>
<td>PRC</td>
<td>People’s Republic of China</td>
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<td>RBC</td>
<td>River Basin Commission</td>
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<tr>
<td>RCC</td>
<td>Roller-compacted concrete dams</td>
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<td>SDPC</td>
<td>State Development and Planning Commission</td>
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<tr>
<td>SEPA</td>
<td>State Environmental Protection Administration</td>
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<tr>
<td>SHP</td>
<td>Small hydropower</td>
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<td>SIA</td>
<td>Social Impact Assessment</td>
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<td>SRRO</td>
<td>single purpose provincial resettlement office</td>
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<tr>
<td>TWh</td>
<td>TeraWatt hours</td>
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<td>WWF</td>
<td>World Wildlife Fund</td>
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1. Profile of China’s Large Dam Building Programme and Emerging Issues

1.1 Purpose of the Paper

The purpose of this paper is to provide an overview of water resources development in the People’s Republic of China (PRC), and background information on the benefits and concerns of large dams. The review is part of a series of country reviews and case studies that have been undertaken by study groups engaged by the World Commission on Dams (WCD) to provide information on the experience, role and development effectiveness of large dams in different regions of the world, and different perspectives of on these issues. This paper identifies and examines some of the strategic challenges China faces in its water and energy resource development plans and programmes; as well as the policy, legal, institutional framework that is evolving for decision-making. The paper also looks at the environmental and social issues and the scope and challenges for integrated river basin planning and management that are increasingly highlighted in policy statements, but otherwise appear to be very slowly emerging.

The purpose of this, the first section of the paper, is to sketch out the circumstances and background for the dams debate in the Chinese context, and describe the main stages in China’s dam building programme in the current era, including the financing aspects.

1.2 Context of the Dams Debate in the PRC

China has built almost half of the world’s estimated 45,000 large dams and remains one of the most active dams building countries today. The PRC has over 85,000 significant dams and reservoirs, though the actual numbers of all types and scales of dams, weirs and water course diversions is considerably higher if all the unregistered small dams built and operated locally by collectives and individual farmers were counted. Over 22-24,000 dams in China are considered large dams by the definition of the International Committee on Large Dams (ICOLD), that is dams over 15 meters in height from base of the foundation in the river.

China therefore has built more than three times the number of dams in the USA and over five times the number in India. Virtually all these dams were built since the founding of the People's Republic of China in 1949, as only 22 large dams apparently existed before that time. What is perhaps most remarkable is that this massive programme was undertaken in parallel with the construction of many thousands of kilometers of dikes, levees, retention basins, pumping stations and other schemes on China's river systems. Many of these structures, including a considerable portion of China's current inventory of large dams, were actually built in the 1950's and 60's to the technical standards of the day. Environmental and social standards were largely absent at that time. This large build-up also spanned the period of the Cultural Revolution when major social transformations and dislocations where underway. Thus while China is adding to its inventory of dams, much of China's existing infrastructure for large-scale water and energy resource projects is ageing. The restoration of dams and dam safety programmes are of an increasing concern to the PRC. In recognition of this China is now investing some $US 30 billion in its dam refurbishment and safety programmes, has passed laws and regulations, and has set up new regulations and institutions for dam safety programs, and

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1 USCOLD indicates there may be as many as 2 million dams, weirs, diversions in streams and water courses all over the United States. China would undoubtedly have at least a similar or greater number.

2 Various sources including the World Register of Large Dams (1998), ICOLD

3 Other countries among the top five dam building nations include the United States with over 6 390 large dams; India with over 4 000; and Spain and Japan with between 1 000 and 1 200 large dams each.
monitoring and enforcement. Repair and replacement of such vast infrastructure is nevertheless very expensive.

The management of existing dams is important, not only because of the sheer numbers of dams that exist, or for the reasons noted above, but also because of the opportunities available to modernise the equipment and practices, optimise operations, improve or expand existing facilities, and to meet the new regulations (including environmental and social regulations), and the changing needs and circumstances for water and energy management. Among these factors are the risk and uncertainty of climate change where responsible river basin management will have to take into account likely changes in the flow regimes of China’s rivers due to global climate change.4

As section 2 describes in more detail, many of China’s 1.2 billion citizens face the direct and indirect effects of the regular cycles of drought and flood. And there is an uneven distribution of water between regions in the country considering ground and surface water resources. Thus the main driving influences behind the government’s programmes for building large dams has been the regulation of rivers for flood control, for local and national food security, and to supply water and power to meet increasing urbanisation and industrial needs. Additional aims have been to improve river navigation (when ship locks are incorporated in dams) and to prevent soil erosion.

There is also no doubt that the central planning system, which by nature was oriented to large projects, and that China’s considerable institutional capacity at all levels of government with almost and exclusive mandate to build large dams, were contributing factors that permitted the massive scale and pace of dam construction throughout the country. These organisations had ready access to government loans, taxes and other financing, while dams enjoyed considerable political support. Indeed, dams have been seen by many segments of Chinese government, scientific and professional society as synonymous with development and modernisation. The example of western countries undertaking similar dam construction programmes during China’s most active dam building phases has also served to reinforce this view in China as in most countries.

However, China did not just pursue large-scale options in its water and energy resource management programmes. At the same time as it mounted the world’s largest dam building programme, the PRC also put in place of the world's largest small-scale, water and energy programmes. It has extensive experience in small-scale renewable energy options for rural needs, and is a world leader in many aspects of appropriate technology from design and manufacture to entrepreneurial methods of disseminating technology in rural areas and local training.

More recently, China has been undergoing two major and interrelated transformations that have profoundly influenced all aspects of urban and rural life in the PRC, as well as its water and energy development programmes. The first is the accelerated transformation from a rural agrarian society to a more urbanised industrial society. The second is the transformation from a centrally planned to socialist market economy. At present China is still only 30% rural. Projections are that by 2050 China will be 60% urban. Agriculture GDP has now dropped to less the 20% of total GDP. These overall

4 Global climate models exhibit an exceptionally high degree of consensus with respect to both precipitation and temperature trends over Central and Eastern Asia. Most of China can expect much greater than average increases in annual warming and large increases in mean annual precipitation over the next 50 years. In common with other continental interiors, central China – the source of its major rivers - can also expect greater climatic variability with greater extremes of both floods and droughts of extreme high and low temperatures. The effects that overall greater precipitation and extremely high rainfall will have on China’s flood regime are self-evident. The likely effect of an increase in mean annual temperature is more difficult to determine. Although higher temperatures will give rise to increased evaporation the dominant effect is more likely to be an increase in the amount of precipitation falling as rain – with a consequent reduction in snow fall. Autumn and winter river flows can therefore be expected to increase while spring run-off from snow-melt will be somewhat lower than currently experienced. (Source IPCC)
demographic trends are clearly reflected in China's long-term strategic planning and infrastructure priorities, discussed in section 3 of this paper.

The transition from a centrally planned to a market economy has led to a more open discussion on the role of dams and the policy reforms needed to improve performance in the water sector. Sustainable development is increasingly seen as a necessary development goal, so that water and energy will not become impediments to growth and development in sectors and regions that depend on water and energy services, and the state of the environment. There are nonetheless divergent views within China, and externally on what may constitute sustainable development in China's situation and how it is to be achieved.

Opponents to large dams in China and abroad argue that over reliance on structural responses to China's water and energy problems have led to unsustainable practices in the long term and largely ignore the delicate balance of nature. They suggest the physical manifestations and direct effects of practices that degrade ecosystems and habitats are very clear. These effects include an increase in the drying up of, and pollution of major river systems such as the Yellow river (which no longer reaches the ocean for much of the year, and is dry in the lower reaches much of the year, as well as the economic implications of unsustainable practices of raising levees every year to the point that they become unstable and pose a threat to human settlements.

Opponents argue that the direct and indirect social impacts of dams on rural populations and their environmental impacts outweigh the benefits of large dams; that the implementation of the announced set of reforms is weak and there is limited compliance capacity; and that small scale projects and other alternatives to large dams offer greater promise for long-term sustainability but are overlooked by planners and developers and are consequently under funded. Many of the non-government organisations suggest that the uniquely large numbers of people resettled for dam construction and reservoir inundation present challenges that simply overwhelm the capacity of the system to handle; such programmes fail to meet all the objectives for protection, compensation and revival of livelihoods specified in government policies. For the large riverine communities affected by dams, the loss of livelihoods, cultural property, loss of social cohesion, disruption of social networks, increasing marginalisation of minorities, and so forth are all concerns. Other views focus on the problems of equity, the “haves” get richer and the poor get poorer because they do not have the resources to capitalise on the opportunities that new initiatives bring.

Proponents and supporters of China’s ongoing dam building programme argue that given the historical patterns of human development in China's river basins and cycles of drought and flood, large dams are necessary to manage water resources in a sustainable manner, and to reduce the vulnerability and risk to lives, property and the economy. The various alternatives that are available to improve water and energy services can be developed at the same time as large dams, but the alternatives on their own could not deliver the services on the scale, and in the timely manner needed for growth, especially considering China's stage of economic development. They argue that the choice between large and small projects is not mutually exclusive and is largely determined by geography; and that there is a clear and continued need for large dams as a part of national and regional development strategy to support economic reforms and to meet the growing demands for irrigation, water supply, power, and flood control. Proponents point out that social and environmental practices are constantly being improved and that beneficiaries of projects are often small farmers and local collectives. They note that hydropower development which currently only meets 19% of electricity generation in China, is urgently needed to reduce the current overwhelming reliance on coal-fired power generation, and reduce air and water pollution with resultant health and ecological benefits to the nation. Hydroelectricity will also permit a reduction in China's greenhouse gas (GHG) emissions, which are now second only to the USA, and are considered by many scientists to be a contributing factor in global climate change which only exacerbates cycles of flood and drought.

The Fifth Plenary Session of the National People's Congress faced all these issues on 3 April 1992 when it considered the resolution to proceed with the Three Gorges Project on the Yangtze, the third
largest river in the world. For an undertaking of this magnitude, significance and controversy, the approval was by no means automatic in Chinese political terms. The vote was 1767 in favour, with 664 deputies abstaining and 177 voting against. The yes vote was thus just 12 clear of the minimum of 1755 or two-thirds of the electorate required to proceed with development of the scheme.

Over the past decade, the PRC government has taken significant steps to formulate and adopt policies to manage resource development with emphasis on environmental and social impacts of dams and other infrastructure. All proposed new dam projects are, in principle, now subjected to detailed environmental and social impact assessments and mitigation plans, although the institutional capacity to undertake the necessary studies is still being developed. Such assessments are now required as part of the project approval and justification studies, and not just as a post-project assessment; it is not clear how heavily the results are weighed relative to technical or economic considerations in the decision on whether the dams should be built at all. Perhaps equally significant, the stage has not yet been reached when strategic environmental and social assessments are being undertaken at the basin-level or sector-level where cumulative impacts and a broader comparison of alternatives may be more readily seen and debated by scientists, the concerned government departments at all levels and the public.

### 1.3 Overview of the Resource Situation and Management Approach

China extends over an area of 9,561,000 km² and has a population of about 1,240 million growing at a rate of 1.1%, down from 2-3% growth rates in the middle of the last century. China is predominantly an agriculture-based country though this is changing relatively rapidly. China's rural population accounted for less than 70% of the population in 1998 compared to 82% in 1970. Most significantly the agriculture gross domestic product (GDP) dropped to less the 20% of total GDP by 1995 and average incomes in the more prosperous eastern and coastal areas are two to three times higher than interior provinces. Urban incomes and facilities provided in the Chinese system in place of income are markedly higher than in the rural areas.

Fuelled by a high level of national savings, an educated and industrious workforce, and the economic reforms, per capita GDP officially doubled in the 10 years preceding 1987 and again doubled by 1997. China escaped most of the economic downturn in Asia’s economic crisis in the late 1990s, but due to its own internal industrial and economic restructuring, some segments of industry, especially heavy industry, have faced a downturn. This has led to a slower rate of growth in areas such as industrial power and water demand. Export oriented industries have been facing more sustained and rapid growth and in the past few years have returned to double digit growth rates. These economic transformations plus the rising standards of living in urban areas are promoting structural changes in the demand for water and energy services not only in urban and industrial areas.

Much of China has relatively rugged topography and of its total area, 69% consists of mountains, plateaus and hilly areas. The plains represent about 12% of China's land area, and river valleys and basins account for the remaining 19%. Close to a third of China is very dry and arid, mainly in the northern western and interior regions. Agriculture in the northwestern inland area is largely dependent on irrigation. Another third of China in the coastal and southeast, is humid and subject to frequent floods and water logging of soils.

The potentially arable land in the PRC is estimated at 139 million ha, which is only about 15% of the country’s area. The current cultivated land is estimated at 95.89 million ha (1998). The cultivated land per capita is between 0.077 and 0.11 ha, much less than the world average of 0.29 ha per capita. Large-scale urbanisation is leading to a decline in the amount of land in cultivation. The 1998 State of the Environment Report indicates that in 1998 the PRC experienced a net loss of some 261,000 ha of

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5 The State of the Environment Report for 1998 gives the figure as 0.11 ha per person.
China has more than 50 000 rivers with catchment areas over 100 km² and about 1 500 rivers with catchments over 1 000 km². Most rivers are in the east where monsoon climates produce abundant rainfall. Annual precipitation averages 640 millimetres, but is unevenly distributed both over regions and seasons. Annual rainfall declines from a maximum of 1 600 mm in the southeast-southeastern coastal region to less than 200 mm in the northwestern region. Approximately 45% of the PRC’s territory has less than 400 mm of annual rainfall, though year-to-year variations are significant. Most of the country has a monsoon-type climate with cold, dry winters and warm, humid summers, during which approximately 80% of the annual precipitation occurs. While floods are the most significant form of natural disaster experienced, in the eastern provinces droughts are of more significance in the west. In the northwestern provinces strong winds and dust storms are also a problem.

Average annual surface runoff is about 2 700 billion cubic meters (bcm), two-thirds of which is generated by flood runoff. The southern PRC contains over 81.5% of the country’s water resources, 53% of its population and 35% of the cultivated lands. Conversely, northern PRC contains only 13.8% of the country’s water resources but must support 45% of its population and approximately 60% of its cultivated land.

As noted China suffers from floods and droughts. Historical records show that the country experiences one serious flood every two years. On average, 7.9 million ha of farmland are affected by flood annually. In some years, farmland affected has been even larger: 24.6 million ha in 1991, 31 million in 1996 and 25 million in 1998. Economic losses resulting from flood damage to industrial and infrastructure developments are mounting. The PRC also appears to be experiencing a severe drought every two years. On average, drought affects 20.7 million ha yearly, of which 40% are seriously damaged. Drought-prone areas are mainly located in the northern PRC. However, unstable crop production in the humid southeast is often caused by drought, mainly during spring and autumn. Losses caused by drought underline the need for the development and implementation of comprehensive irrigation and drainage projects.

Industrial and socio-economic development, population growth and improvements in the standard of living are placing increasing pressure on the country’s limited surface and ground water resources. Signs of water shortage are appearing in various sectors and regions. Municipal water demand exceeds supply over 300 of China's 617 major cities. Ground water levels are declining at a rate of 1 to 2 meters as year in some areas. In 1995, reportedly 18% of the country’s irrigated area was subject to water shortage, resulting in low crop yield and a decline in irrigated area. Industrial and socio-economic developments in many areas of northern PRC are hindered by a lack of water. Additionally, competition among water users, water using sectors and provinces is growing. The increase in water pollution from industrial and municipal wastewater discharges has reduced the availability of fresh water. Approximately 60% of the cities subject to water shortage in the eastern coastal areas are also suffering from polluted water sources.

As noted, the government of the PCR has paid special attention to water resources development since it’s founding in 1949. Most of these works were carried out from 1949 to 1969, when the focus was more on construction than on management of water resources. Insufficient attention was paid to the financial structure and performance of the projects, and little allowance was made for operation and maintenance and rehabilitation.

The shift in emphasis from construction to broader water resources management began in the early 1980s. A water pollution-control law was adopted in 1984 and reviewed in 1996. This was followed in 1988 by the Water Law, covering water and soil-resources management, the Environmental Protection Law in 1989, the Law for Water and Soil Conservation in 1991, and the Law for Flood Control in 1997. In addition, seven basin commissions for administration of water-resources
development in inter-provincial river systems were established under the aegis of the ministry of water resources. The Energy Act (1995) and a series of comprehensive reforms in company laws have led to fundamental changes in the management and operation of the power sector, involving dams.

By the end of 1998, China had more than 100 million water storage and soil maintenance projects. Government sources indicate that every year, construction and maintenance increase water storage capacity by 25 billion m$^3$ and prevents 1.5 billion tonnes of silt entering river systems$^6$. In order to control soil erosion and what is considered to be a trend of ecological environment deterioration, a National Plan of Ecological Environment Construction, has been being initiated. According to this plan, PRC will invest about 370 billion-yuan (over US$ 45 Billion) into preliminary renovation of the loess plateau, which PRC recognises as “the most serious water and soil erosion area in the world” (SoE Report 1998). In 1998, the construction of water and soil conservation projects in the seven main basins extended over more than 20 000 small water basins in 800 counties of 26 provinces. Of these small basin projects, 5 000 had been completed. Many provinces, regions and large cities had carried out local key projects. Both central and local governments increased investment in water and soil conservation projects.

### 1.4 China's Large Dams Building Programme

There are considered to be three stages in dams development in China since the founding of the PRC in 1949 which correspond to levels of activity and the type, nature and circumstances under which dams have been built$^7$. The first period was from 1949 to the early 1960s, the second was from the mid-1960s to the late 1970s, and the third is what is considered to be the modern era from 1980 on. Prior to these periods all in the last century Chinese society has always been closely associated with river systems.

#### 1.4.1 Early Dams

There are records of dams in the PRC as far back as 600 BC. The Qebei Dam in Anhui, built in 598 BC, consisted of soil and turf levees of more than 100 km in length. In Hebei, 12 masonry dams were built on the Zhang He in 446 BC. The Dujiang Weir in Sichuan was built in 276 BC. A 470 m long masonry dam was built to form a canal in Guanxi in 219 BC, and in Henan, a 16 m high dam was built in 34 BC. Some of these ancient dams have been repaired and strengthened and still serve their purpose. Similarly, a number of masonry dams built between 1000 AD and 1700 AD are still in service.

Other water management infrastructure built in ancient China include the Grand Canal, the Jingjiang Levee on the Yangtze first built in 356 AD, the main levee of the Hongze Hu, and the sea walls of Zhejiang Province. Many of these were created by dynasties that flourished in the flood plains of China's great rivers, and where fertile soils were found along rivers that fluctuated between flood and drought.

No national policy for developing water resources existed in the PRC prior to 1949. There were no organized plans for dam construction, and only 22 large dams with a total storage capacity of 250,000 m$^3$. Installed hydropower was 163 MW in 1949, and only one dam exceeded 100 m in height. For the Communist Party and leadership in 1949, the development of the country’s water resources was a high priority.

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This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
1.4.2 Dam Building from 1949 to the late 1970's

In what is considered to be the first phase of large dams development lasting from 1949 to the early 1960's the experience and capacity was limited. Many small and medium dams were started, many of them single and multipurpose irrigation dams. The first large-scale hydropower dam was the Xin'anjiang a 102 m dam with an installed capacity of 662.5 megaWatts (MW). A series of large dams in cascade developments were then initiated during this period on several rivers such as the Lonxi, Mantoiao and Yili rivers. A few of the dams were over 100 m with storage in excess of one bcm. There were virtually no environmental regulations in this period and resettlement practice were not standardised or regulated, and were handled locally.

The second stage from the mid-1960s to the late 1970s was the period when the most of China’s dams were built. The size and complexity of the dams increased and China had technology transfer programmes with other countries such as Russia to help build capacity. Russia for example, assisted in the design of the strategically located Danjiankou project. The second era is considered to have culminated with the 2 715 Gezhouba multipurpose water control project (and 2,175 MW) on the main channel of the Yantze, just downstream of where Three Gorges is currently being built. In the second era there was still little attention paid to environmental issues, as was the case in many countries globally. This was also the period of the Cultural Revolution in China where conditions were confused and standards for resettlement were still not considered to be a priority. More attention began to be paid to resettlement with the initiation of the responsibility system in 1978, though the practices were far from the policy standards China has today. A notable feature is that China began to recognise problems with resettlement in the past and established what were called remaining problems funds and initiatives. For example, resettlement of 383 000 people began for the Danjiankou project in the mid-1960s and lasted until the mid-1970s, coinciding with the period of the Cultural Revolution. Initially the displaced people were worse off than before being resettled.8 Subsequently, government loans and other finances were made available for agriculture diversification and enterprise development and eventually a development fund was established, which was a share in the revenue generated by electricity sales from the project. Significant increases in productivity and living standards occurred thereafter for the second generation of the resettled population.

The third phase of China's dam building programme - also called the modern era - and which continues today, is considered to have started in the 1980s. This also coincided with the start of wider reforms in the economy. There have been more large dams built in this period than the earlier period, but fewer dams in total. Major advances in design and construction techniques were developed. Mechanised construction was adopted for earth and rock excavation and construction management practices were greatly enhanced. Technologies for roller-compacted concrete dams (RCC) dams (which can be cheaper and faster to build), and concrete rock fill dams (which offer advantages of lower cost, shorter construction periods and greater inherent safety and reliability) were introduced from other countries in the early 1980s. China has made considerable advances on its own in these RCC and CRFD technologies. China developed its experience in high arch dams and rock fill dams, and became probably the most experience in pumped storage plants of any country in the world. At the same time China's manufacturing and heavy industry - geared to supply electrical and mechanical equipment - came up to world standard and license agreements for production of advanced technology have been signed.

Among the major dams in this period is the Three Gorges on the Yangtze, now under construction. Another dam with flood control as its major purpose is Xiaolangdi on the Yellow River, partly financed by the World Bank. This is an earth and rock fill dam, 154 m high with a capacity of 1 800MW. Other large dams partly financed by the Multilateral agencies such as the World Bank are:

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8 Report of a field visit to Dainjiangko in 1987, CYJV meeting with officials of the Danjianhkou Management Bureau, (Martin Ter Woort), CIPM Yangtze Joint Venture Report, 1988

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- Ertan, a 240 m high arch dam and a 3,300 MW powerhouse, on a tributary of the Yangtze, the largest hydroelectric plant to date in the PRC;
- Shuiko, a 100 m high gravity dam and 1 400 MW powerhouse on the Minjiang River in Fujian;
- Lubuge, a 104 m high earthfill dam and 600 MW powerhouse on the Huangli He in Yunnan;
- Yantan, a 110 m high gravity dam and 1 200 MW powerhouse on the Hongshui He in Guangxi; and
- Jiangya, a 128 m high roller compacted concrete dam for flood control and irrigation in Hunan;
- Tinghuangping, a 1 800 MW pumped storage project on the Daxi in Zhejiang;

Annex A provides a longer list of dams that have been constructed in different size ranges.

**General Statistics**

More than 84,900 reservoirs were built from 1949-1999 for a total capacity of over 470 billion m$^3$, including 397 large reservoirs with a total capacity of 326.7 billion m$^3$. Additionally, 250,800 km of dikes and 31,700 km of sluices, as well as approximately 503,000 stationary pumping stations have been established. At the other end of the scale, in terms of height, are the thousands of sediment control dams built in the gullies of the Loess Plateau of the Yellow River Basin since the 1970s.

There are various sources of statistical information on large dams in China. A main source is ICOLD China, which provides information to the International Committee on large dams. Information on the 1,895 larger dams from the ICOLD (1998) is presented below in the following series of graphs. It shows some general statistics on dams built in the 3 periods. They illustrate the historical pattern of development of dams in the PRC (ICOLD, 1998) and the purposes and major attributes of these dams. The ICOLD 2000 data set of 4000 dams indicates that half the dams have irrigation as a primary or secondary purpose.
This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
One in 10 dams in the PRC was built with electricity generation as the primary purpose. Dams provide irrigation for about 40% of the PRC’s farms, especially those in the arid and semi-arid zones. Reservoirs hold and store water, helping to control flooding and drought.

1.4.3 Current Direction in Dam Building in China

The main policies for water and energy development that China has announced are discussed in section 3 of the paper and the environmental and social trends are discussed in section 5. The general view expressed by the government on the construction of dams in future is that flood management and hydropower will continue to be the priorities (multipurpose roles in the same dam), in addition to water storage for irrigation and water supply. In hydropower alone 149 large dams of more than 1000 MW have been identified which could provide 224 550 MW, and 1 700 medium sized projects averaging 26 MW and providing 45 000 MW have been identified as economically feasible.⁹ These

⁹ Lu Youmein, Op Cit.
are mainly in the central and western part of China. They include further cascade developments on the Yangtze River and its tributaries, the middle reaches of the Yellow, the middle and upper reaches of the Chaigjiang, and the middle and lower reaches of the Hongshui and Lincangjiang, and the Wujiang River. Part of the longer term strategy is to move power from the west to the east of the country based on interconnection of the various regional grid networks, with Three Gorges a centrepiece of the central grid. Moreover, government has announced a target to move from 19% to 40% of electricity generation from hydropower. Table 1.1 below illustrates some of the major dams that are in the pipeline.

Table 1.1: Major hydro and pumped-storage projects planned to go ahead soon in China

<table>
<thead>
<tr>
<th>Project</th>
<th>Province</th>
<th>River Basin</th>
<th>Dam type</th>
<th>Height (m)</th>
<th>Res. Vol. ((10^9 \text{m}^3))</th>
<th>Capacity (MW)</th>
<th>Gener’n (GWh/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hydro schemes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laxiwa</td>
<td>Qinghai</td>
<td>Yellow</td>
<td>Arch</td>
<td>250</td>
<td>1</td>
<td>3720</td>
<td>9700</td>
</tr>
<tr>
<td>Gongboxia</td>
<td>Yellow</td>
<td>Rockfill</td>
<td>133</td>
<td>0.55</td>
<td>1500</td>
<td>4960</td>
<td></td>
</tr>
<tr>
<td>Xiaoguanyin</td>
<td>Gansu</td>
<td>Yellow</td>
<td>Arch-gravity</td>
<td>143</td>
<td>7.02</td>
<td>1400</td>
<td>5340</td>
</tr>
<tr>
<td>Xiangjiaba</td>
<td>Sichuan</td>
<td>Yangtze</td>
<td>Gravity</td>
<td>150</td>
<td>5.46</td>
<td>6000</td>
<td>26100</td>
</tr>
<tr>
<td>Xiludou</td>
<td>Sichuan</td>
<td>Yangtze</td>
<td>Arch-gravity</td>
<td>295</td>
<td>14</td>
<td>14400</td>
<td>6100</td>
</tr>
<tr>
<td>Shuibuya</td>
<td>Qing</td>
<td>CFRD</td>
<td>232</td>
<td>4.7</td>
<td>1200</td>
<td>4000</td>
<td></td>
</tr>
<tr>
<td>Goupitan</td>
<td>Guizhou</td>
<td>Yellow</td>
<td>Arch</td>
<td>225</td>
<td>5.69</td>
<td>2000</td>
<td>8890</td>
</tr>
<tr>
<td>Pengshui</td>
<td>Sichuan</td>
<td>Yangtze</td>
<td>Gravity</td>
<td>115</td>
<td>1.16</td>
<td>1200</td>
<td>5770</td>
</tr>
<tr>
<td>Jinping</td>
<td>Sichuan</td>
<td>Yalong</td>
<td>Gravity</td>
<td>49</td>
<td>20.9</td>
<td>3000</td>
<td>20900</td>
</tr>
<tr>
<td>Pubugou</td>
<td>Sichuan</td>
<td>Dadu</td>
<td>Rockfill</td>
<td>188</td>
<td>5.55</td>
<td>3300</td>
<td>14300</td>
</tr>
<tr>
<td>Xiaowan</td>
<td>Yunnan</td>
<td>Lancang</td>
<td>Arch</td>
<td>290</td>
<td>15.2</td>
<td>4200</td>
<td>17400</td>
</tr>
<tr>
<td>Nuozadu</td>
<td>Yunnan</td>
<td>Lancang</td>
<td>Rockfill</td>
<td>254</td>
<td>22.7</td>
<td>5000</td>
<td>23100</td>
</tr>
<tr>
<td>Longtan</td>
<td>Guangxi</td>
<td>Hongshui</td>
<td>RCC</td>
<td>192</td>
<td>16.21</td>
<td>4200</td>
<td>15570</td>
</tr>
</tbody>
</table>

| **Pumped storage schemes** | | | | | | | |
| Tongbai   | Zhejiang |             | 0.1      | 1200        | 2010                         |             |                 |
| Xiangshuijian | Anhui |             | 0.19     | 1000        | 1670                         |             |                 |
| Taian     | Shandong |             | 0.1      | 1000        | 1470                         |             |                 |
| Baouquan  | Hebei    |             | 0.087    | 1200        | 1750                         |             |                 |
| Zhanghewan | Hebei   |             | 0.08     | 1000        | 1670                         |             |                 |
| Xilongchi | Shanxi   |             | 0.038    | 1000        | 1670                         |             |                 |
| Huhehaote | Hebei    |             |          | 1200        | 2000                         |             |                 |
| Yaoqiaoyu | Hebei    |             | 0.039    | 1000        | 1460                         |             |                 |
| Banqiaoyu | Hebei    |             | 0.062    | 1000        | 1460                         |             |                 |
| Pushihe   | Hebei    |             | 0.12     | 1200        | 1430                         |             |                 |
| Huanggou  | Hebei    |             | 1200     | 1800        |                              |             |                 |
| Tongguanshan | Hebei |             | 0.53     | 1000        | 1340                         |             |                 |


In addition to development in the regions and rivers noted above, one of the most active areas of dam building is in the Loess Plateau of the Yellow River Basin, where thousands of sediment control dams have been built and many more are planned. These earthfill dams can be as high as 30 m and are generally built without spillways; the reservoir capacity is sized to absorb a 100-year flood. Design standards have been improved in recent years. Some dams built in the 1970 did not have sufficient flood storage capacity and failures occurred after extreme storms. Fortunately the dam break floods were of short duration and confined to the uninhabited gullies.

Another aspect is that many of the major dams in the PRC will be multipurpose, but wide differences between dams in the relative importance of purposes such as irrigation, power and flood control will
remain. Flood control will nevertheless remain one of the most important functions for large dams. But the extremely high levels of erosion in catchments, particularly those of the loess plateau, reduce the effectiveness of flood control structures by reducing their water storage capacity through siltation. This also effectively reduces the capacity of dams to supply irrigation water. Some experts are of the opinion that the full long-term potential of dams in the PRC is not being realised because investment has traditionally focused on structural engineering solutions to water related problems rather than combining such approaches with non-structural measures identified in integrated basin planning and management. Though there is evidence to suggest that this balance is changing, and that increasingly, the benefits of integrated basin planning are being recognised.

In addition, more attention is being paid to existing dams under the initial $US 30 billion programme for rehabilitation and dams safety. Among the considerations include increasing spillway capacities to cope with larger floods and raising dams heights to increase storage capacity. In North America and Europe where the pace of new dam construction has slowed if not stopped, existing dams are undergoing similar transformations.\(^{10}\)

### 1.5 Sources of Finance for Large Dams and Water Resources Projects

While there are no detailed statistics available the investment that China has made in large dams is considerable, given that China has half the world's population of dams. The total investment in large dams worldwide has been very roughly estimated to be in the region of 2-3 trillion USD.\(^{11}\) In the west, much of the financing for dams came from government budgets and the issue of bonds. Capital investment for dams as well as other water and energy infrastructure and programmes in China generally came from the following sources:

- direct central government investment in the form of loans and capital grants;
- provincial loans and disbursements;
- other funds allocated by central or provincial government for special economic or poverty programmes;

and in the last few decades and more recently:

- the issue of bonds by revenue earning projects (enterprise bonds and electric power bonds);
- external funds from International Development Agencies;
- supplier credits backed by export guarantees in the suppliers’ countries;
- direct foreign equity investment and external commercial loans.

For smaller projects, not necessarily dam projects and their irrigation facilities, cost sharing with labour contributions from local beneficiaries is used. In addition to the capital from government, there are various central and local government appropriations for operating expenses that are subsidies for irrigation and drainage, flood control, water logging drainage, soil conservation and water supply. Repayment of loans in the case of power and water services comes from tariffs, which includes special taxes and other fees levied on the purchasers of the services.

In 1997, the total government investment in water resources projects was 31.5 billion yuan, of which about 42% came from the federal government, and 58% from provincial and local governments. However this does not include all sources. Of this 31.5 billion yuan, 10.1 billion or about one-third

\(^{10}\) WCD Thematic on Regulation and Operations of Dams  
\(^{11}\) WCD Thematic International Trends in project Finance
was reportedly invested in reservoir projects, 3 billion in irrigation projects, 6.5 billion in water logging alleviation, 5.1 billion in flood control, 2.8 in water supply and 7.9 in hydropower projects.\footnote{ADB Strategic options for the Water Sector, 1999, (Derived from the Water Resource Yearbook of the PRC, 1998 and Bulletin of Social and Economic Development, State Statistics Bureau, 1998 )}

The new funding policies for water resources stipulated in the Industrial Water Policies (1997) indicates two classes of projects:

- **Class A Projects**: those that are mainly for social benefits are to be subsidised and managed by government, though this does not preclude charging for at least some of the costs of services. There are national, provincial and local level projects and these projects include flood and water logging control projects, primary facilities for irrigation and drainage, soils and water conservation, and other water resource protection programmes.

- **Class B projects**: are primarily for economic benefits and have the potential to earn revenues. They including urban and rural water supply, secondary and tertiary irrigation, hydropower, fisheries and recreation projects. These projects are to be financed mainly through non-government channels in future so that operating incomes and financially viable projects will develop into autonomous enterprises operating in the new market system.

Policies call for full cost recovery on cost related to administration, operations and maintenance (O&M), rehabilitation and construction works. The current charges must be increased in stages over 2-3 years to achieve this depending on the type of project.

Large dams have a high initial capital cost, and locating sources of financing is expected to be challenging. The finance sources for the Three Gorges Project are noted below.

**Box 1.1: Financing of the Three Gorges Project**

The financing is from several channels. 50% of the capital is from the State. Domestic loans are from the State Development Bank and the issue of domestic bonds. Other funds and revenue sources during construction include: a tax of 0.3-0.7 cents/kWh on National power sales; a portion of the revenue from the downstream Gezhouba dam and power station; and power revenues from the first units to come on line while other units are being developed (2003 to 2009) in the third stage. Export credits are use for electrical and mechanical equipment. Resettlement is estimated to be 45% of the total project cost.


**Local Financing**

There are a number of issues in China related to the local financing of Class B water resources and hydropower projects. Increasingly the tendency is to issue bonds and secure loans from the banks in China. Government nevertheless still sets lending policies at the Banks, and may be a major purchaser of bonds indirectly through its corporations. Other concerns are on tax and tariff policies that are not consistent or uniform between provinces and those related to local investment and the issues of bonds. There are also particular controversies over the relative tax level for different projects as the transformation in the methods of local finance continue.\footnote{High taxes levied on hydro development are considered to present an obstacle to attracting financing of dams, a legacy of the days when most power projects were built with money from the central government and no pay back was required. A tax was levied to offset the expenditure. The tax levied on hydro energy currently amounts to 25% of its gross income (Water Conservancy in China, 1999).}
**International Institution Loans, Commercial Loans, and Suppliers Credits**

External agencies of which China is a member such as the World Bank and Asian Development Bank as well as the UNDP; as well as numerous bilateral development assistance agencies and funds have been involved as partners with China in the water and power sectors. The focus of these programmes varies between physical infrastructure, resource management and environment and capacity building projects. Since 1984, The World Bank Group has provided the largest multi-lateral development assistance, including support for dams listed earlier. To date eight dams were assisted by the World Bank with US$ 3.3 billion total support. This is seen by Chinese professionals to have assisted in developing the capacity of international competitive bidding (ICB), technology transfer generally, and specifically helped to focus on environment and social aspects of planning, construction and operation.\(^\text{14}\) As noted in the comments in Appendix A, there is considerable criticism from the NGO community of the World Bank’s involvement in dams projects in China and the Bank’s own independent review panels have criticised how issues were handled on specific projects.

Japan, through its Overseas Economic Cooperation Fund (OECF) is the largest source of bilateral funding. Other countries providing bilateral funding in management and environmental aspects include Australia, Canada, France Germany, Italy and the UK.

**Independent Power Producers**

The recent trend globally and in China in hydro financing is to attract private funding by offering projects with BOT (Build-Operate-Transfer), BOO (Build-Own-Operate), and BOOT (Build-Own-Operate-Transfer) types of agreements. These methods of financing transfer the burden of study, design, financing, construction, operation, and maintenance to the investors. In certain cases, ownership of the facilities is transferred back to the government following a previously agreed-upon period. The government’s responsibility is to agree on an acceptable price for the energy, sign the PPA (Power Purchasing Agreement) with the investors, and collect the taxes.

The usual length of the agreement is between 15 to 20 years. During this period, the investors have to operate and maintain the facilities, recover the capital, and show a profit. Investors also have to absorb the effect of inflation, and, since the energy sale is in local currency, the fluctuation of currency exchange rates. All these tend to raise the price of energy higher than existing projects built with government financing. The project will proceed if, after taking into consideration these factors, the price of energy is lower or equal to the alternatives.

Most projects supported by independent power producers are thermal projects. Hydropower projects, due to the revenue streams, are more amenable for private sector financing than other dams. However to date, attempts by the Chinese government to attract this type of development have not been successful. This is attributed to the complexity of the Chinese rules and regulations, the lengthy approval process, uncertainty of contractual agreements, contract changes and, as mentioned above the taxation rate.

2. China’s Land, Water and Energy Resources

This section provides background information on China's land, water and energy resources. In doing so it describes some of the challenges the PRC is facing in managing these resources in an integrated and sustainable manner. The latter part of the section also looks briefly at the outlook for water supply and demand balance in different basins and notes the regional and international watersheds China shares with its neighbours.  

In terms of its water resources China faces cycles of flood and drought and regional variations in resource availability. There is increasing competition for available fresh water resources including both ground water and surface water sources among different sectors of the economy and between provinces, and pollution of available ground water and surface water sources, and growing environmental stress from over extraction and use of the resources. It is also experiencing urban encroachment of agricultural lands as massive soil erosion and loss in parts of the country occurs. Considering the pressing needs for improving and expanding the level and quality of water and energy services, the management of these resources will clearly continue to be a priority for China and central to it’s development programmes in the foreseeable future. Section 3 will look at some of the policy environment, legal and institutional framework China is setting in place to address the challenges it faces.

2.1 Land Resources and Climate Zones

As noted in section 1, China extends over an area of 9,56,000 km². Over two-thirds of this land consists of mountains, plateaus and hilly areas. Plains and the valleys and basins account for the remaining land area in roughly equal proportion. Close to one-third of China is very dry and arid, mainly in the northern western and interior regions. Another third of China in the coastal and southeast, is humid and subject to frequent floods and water logging of soils. China has more than 50,000 rivers with catchment areas over 100 km² and about 1,500 rivers with catchments over 1000 km².

**Agro-Climatic Zones**

The PRC is divided into four main agro-climatic zones as shown in Figure 2.1 and Table 2.1. These describe the variability of conditions.

- **The arid, or full irrigation, zone** falls mainly in the internally drained basins. Cropping is generally dependent on the length of the frost-free period and on irrigation. Where temperature permits and water is available, the zone is suitable for irrigated cotton, grains, vegetables and fruits. Land is used predominantly for livestock and grasslands.

- **The semi-arid zone** is located largely in the upper and middle reaches of the Huang (Yellow River) basin. The main irrigated crops are wheat, corn and cotton. Rain-fed cropping is widespread but is generally low yielding given scant and uncertain rainfall.

- **The semi-humid zone** is subject to both floods and droughts. It has two sub-zones. The northeast sub-zone comprises the Songhua-Liao river basins. Though potentially fertile, it has a short growing season and suffers from extensive waterlogging and alkaline soils. Major crops include wheat, corn and soybean, with rice grown under irrigated conditions. The Hai-Huang-Huai (3-H...
Plain) sub-zone comprises the North China Plain within the Hai, Lower Yellow and Huai basins. A longer growing season than in the northeast allows some double cropping with irrigation. Wheat is the main crop, followed by corn, rice and other crops.

- The humid zone lies in the south and southwest. Rice is the predominant crop. The rains generally last from July to September, but early- or late-season droughts can limit crop yields. The zone has three sub-zones. The mid-lower Yangtze sub-zone has a subtropical climate, allowing double cropping. The Zhujiang/Mijiang sub-zone comprises the Zhu (Pearl) and southeast rivers. Its tropical monsoon climate makes year-round cropping possible. The mountainous southwest sub-zone has a mixed tropical/subtropical climate, with rice dominant in the lowlands, and wheat and other grains in the highlands.

Table 2.1: Main Features of the Agro-climatic Zones

<table>
<thead>
<tr>
<th>Agro-climatic Zones</th>
<th>Corresponding River Basins</th>
<th>Rainfall (mm)</th>
<th>Rainy Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Arid Zone</td>
<td>Inland Rivers</td>
<td>&lt; 200</td>
<td>Jun-Sep</td>
</tr>
<tr>
<td>2. Semi-Arid Zone</td>
<td>Upper Huang-he</td>
<td>200-400</td>
<td>Jun-Sep</td>
</tr>
<tr>
<td>3. Semi-Humid Zone</td>
<td>NE Sub-Zone</td>
<td>NE Rivers</td>
<td>400-1000</td>
</tr>
<tr>
<td></td>
<td>3-H Sub-Zone</td>
<td>Hai/Huang/Huai</td>
<td>400-900</td>
</tr>
<tr>
<td>4. Humid Zone</td>
<td>Lower Yangtze SZ</td>
<td>Mid &amp; Lower Yangtze</td>
<td>800-1900</td>
</tr>
<tr>
<td></td>
<td>Zhujiang/Minj. SZ</td>
<td>Zhujiang &amp; SE Rivers</td>
<td>1000-2000</td>
</tr>
<tr>
<td></td>
<td>SW Sub-Zone</td>
<td>Upper Yangtze &amp; SW</td>
<td>1000-1500</td>
</tr>
</tbody>
</table>

Source: Qian Zhengying, ed., Water Resources Development of China, 199

Figure 2.1: Agro-Climatic Zones of China

About 15% of China's land area is arable and while China is an agriculture country it is in transition to a more urban country. The focus here is on agriculture land as it is most relevant to water resources and large dams. Agriculture currently accounts for about 70% of the consumptive use of water in China.

This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
As one effect of its demographic and location trends, China’s land area under cultivation fell from 110 M ha in 1967 to 99 M ha in 1978, and to 95 M ha in 1997. This is equivalent to an annual reduction of about 0.5 M ha or 0.5%, due mainly to conversion of agricultural land to urban and other uses. The cultivated area in 1997 was about 10% of the land area; 25 M ha was laid out as paddy fields (26%) and the balance was classified as dry fields for other crops (74%). About a third of the land under non-paddy crops is irrigated. Arable land per person is low (less than 0.1 ha, corresponding to about 0.13 ha per rural household). Land pressure is the most striking characteristic of Chinese agriculture, and has implications for all aspects of rural and economic development.

In contrast to the decline in cultivated area, the sown area has remained fairly constant in recent decades and may even have increased. Cropping intensity increased from 151% in 1978 to 162% in 1997, and irrigation played a critical role in this increase. In 1957, the irrigated area was 27 M ha (25% of the cultivated area). By 1978, it had increased to 45 M ha (45% of the cultivated area) due in part to expansion of surface irrigation and the rapid spread of wells on the North China Plain. Expansion slowed during the 1980s but further growth has since occurred. In 1997 the irrigated area was just over 51 M ha (54% of the cultivated area).

The maximum irrigable area has been estimated at between 64 M ha and 67 M ha. An expansion in the irrigated area of 5.1 M ha between 1991-95 was offset by a loss of 3.3 M ha due to urbanisation and other factors, giving a net increase of about 1.7 M ha. At these rates, and depending on whether losses of irrigated land are adequately accounted for in the estimates of potential, the maximum irrigated losses could be reached within 20-30 years. Of particular note are losses due to urbanisation and transfers of water out of irrigation and into other sectors.

Regional Patterns of Agriculture Land Use

There are major regional differences in holding size and in the extent of irrigation. Farm holdings are largest in the northeast, reaching as high as 0.55 ha in Heilongjiang and 0.32 ha in Jilin. In contrast, they are less than 0.1 ha in the densely populated provinces of the Yangtze valley and along the southern coast, and are only marginally larger in the provinces of the 3-H Plain. They range between 0.15-0.45 ha in the provinces of the upper Yellow River basin and in inland basins.

In Heilongjiang, where holding size is greatest, the irrigated area accounts for only 18% of the cultivated area. In contrast, in the densely populated lower and mid-Yangtze valley and southern coast, its share reaches 80-90%, reflecting the predominance of paddy, which is almost invariably irrigated.

On the 3-H Plain, the share is typically 60-70% and in the semi-arid zone of the Upper Huang (Yellow) basin, about 30-50%. Thus, while lower rainfall in the north suggests a greater need for irrigation, the actual share is less due to water constraints and to a lower area under paddy. In the south, land is the main constraint and irrigated paddy rice is the predominant crop. In the north and west, water rather than land is the main constraint. Waterlogging and other factors may also limit cultivation, notably in the northeast. In the arid inland basins, cultivation is normally only possible with irrigation and the high salt content of many soils require extensive leaching and soil preparation before crops can be grown. The Chinese have developed considerable expertise in this regard.

2.2 Water Resources

Availability of Water Resources

The PRC’s water resources are unevenly distributed in space and time. Annual runoff is 2,710 billion m$^3$, which is equivalent to about 45% of precipitation. About 65% of the country's territory lies in catchments of rivers that flow to the sea, and 35% in inland, landlocked basins. About 27% of natural
runoff (732 billion m$^3$) flows into neighbouring countries, mainly in the southwest and the northeast. The Ertix River in the far northwest flows north to join the Ob River in Siberia. About 17 billion m$^3$, or less than 1% of the total runoff, flows into the PRC from other countries. Glaciers store about 5,100 billion m$^3$. Annual melt-water is about 56 billion m$^3$, accounting for some 20% of the combined discharge of inland rivers.

In the early 1950s, there were about 24,880 natural lakes of various dimensions, with a total area of 83,000 km$^2$. Of these, 2,848 lakes were larger than 1 km$^2$ and accounted for 97% of the total area. Over the past 30 years, the lake area has decreased by more than 12,000 km$^2$ due to siltation, encroachment by settlements, and other factors. By the beginning of the 1980s, the number of lakes larger than 1 km$^2$ had decreased to 2,305, the area to 70,988 km$^2$ and their combined storage to about 709 billion m$^3$. Freshwater lakes account for about 32% of all lakes. In addition to these natural lakes, there are some 85,000 reservoirs with a combined storage capacity of 460 billion m$^3$, some 17% of total annual runoff.

Surface water sources account for about 70% of the consumption of fresh water in China; the proportion between ground and surface water varies by region. Groundwater aquifers reportedly extend over 0.7 million km$^2$ and the total average annual groundwater recharge is estimated at over 800 bcm. The aquifers include sedimentary aquifers in the plains that may suffer from salinity and pollution and those in mountainous areas which tend to be of higher quality. Groundwater use in the Hai, Huai and Huang basins is equivalent to about 35% of river runoff; in the northeast about 17%; and in inland basins about 12%. Elsewhere, the contribution of groundwater to irrigation, municipal or industrial water supply is either very localised, or small to negligible.

**Spatial Distribution of Water**

Table 2.2 shows water availability for nine major river systems. Their location is shown in Figure 2.2.

**Table 2.2: Water Resource Indicators for Major River Basins**

<table>
<thead>
<tr>
<th></th>
<th>Population</th>
<th>Urban. Rate</th>
<th>GDP/ Head Index</th>
<th>Arable Land M ha</th>
<th>Net Water Resources BCM</th>
<th>Unit Water Availability</th>
<th>Population</th>
<th>Urban. Rate</th>
<th>GDP/ Head Index</th>
<th>Arable Land M ha</th>
<th>Net Water Resources BCM</th>
<th>Unit Water Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Songhua-Liao</td>
<td>113.2</td>
<td>41</td>
<td>107</td>
<td>19.5</td>
<td>193</td>
<td>1 705</td>
<td>113.2</td>
<td>41</td>
<td>107</td>
<td>19.5</td>
<td>193</td>
<td>1 705</td>
</tr>
<tr>
<td>Hai</td>
<td>117.6</td>
<td>24</td>
<td>113</td>
<td>10.8</td>
<td>42</td>
<td>3 355</td>
<td>117.6</td>
<td>24</td>
<td>113</td>
<td>10.8</td>
<td>42</td>
<td>3 355</td>
</tr>
<tr>
<td>Huang (Yellow)</td>
<td>99.2</td>
<td>22</td>
<td>84</td>
<td>12.4</td>
<td>74</td>
<td>746</td>
<td>99.2</td>
<td>22</td>
<td>84</td>
<td>12.4</td>
<td>74</td>
<td>746</td>
</tr>
<tr>
<td>Huai</td>
<td>190.5</td>
<td>17</td>
<td>85</td>
<td>14.7</td>
<td>96</td>
<td>504</td>
<td>190.5</td>
<td>17</td>
<td>85</td>
<td>14.7</td>
<td>96</td>
<td>504</td>
</tr>
<tr>
<td>Chang (Yangtze)</td>
<td>402.5</td>
<td>22</td>
<td>93</td>
<td>22.9</td>
<td>961</td>
<td>2 390</td>
<td>402.5</td>
<td>22</td>
<td>93</td>
<td>22.9</td>
<td>961</td>
<td>2 390</td>
</tr>
<tr>
<td>Zhu (Pearl)</td>
<td>141.5</td>
<td>28</td>
<td>130</td>
<td>6.5</td>
<td>471</td>
<td>3 330</td>
<td>141.5</td>
<td>28</td>
<td>130</td>
<td>6.5</td>
<td>471</td>
<td>3 330</td>
</tr>
<tr>
<td>SE Rivers</td>
<td>65.1</td>
<td>24</td>
<td>135</td>
<td>2.4</td>
<td>259</td>
<td>3 980</td>
<td>65.1</td>
<td>24</td>
<td>135</td>
<td>2.4</td>
<td>259</td>
<td>3 980</td>
</tr>
<tr>
<td>SW Rivers</td>
<td>18.3</td>
<td>11</td>
<td>32</td>
<td>1.7</td>
<td>585</td>
<td>31 970</td>
<td>18.3</td>
<td>11</td>
<td>32</td>
<td>1.7</td>
<td>585</td>
<td>31 970</td>
</tr>
<tr>
<td>Inland Rivers</td>
<td>24.7</td>
<td>37</td>
<td>91</td>
<td>5.4</td>
<td>130</td>
<td>5 265</td>
<td>24.7</td>
<td>37</td>
<td>91</td>
<td>5.4</td>
<td>130</td>
<td>5 265</td>
</tr>
<tr>
<td>Total China</td>
<td>1 172.6</td>
<td>24</td>
<td>100</td>
<td>96.4</td>
<td>2,812</td>
<td>2 400</td>
<td>1 172.6</td>
<td>24</td>
<td>100</td>
<td>96.4</td>
<td>2,812</td>
<td>2 400</td>
</tr>
</tbody>
</table>

Source: Primary Source is Institute of Water Resources and Hydropower Research, 1998

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Table 2.2 gives average water availability relative to population, urbanisation, income levels and arable area for 1993 (the most recent year for which detailed estimates are available). The area south of the Yangtze accounts for 81% of the water but for only 54% of the population and 35% of the arable land. Per capita water availability south from the Yangtze is thus almost four times that north of the Yangtze, and arable land is some eight times greater per ha. Runoff in the Hai basin is particularly low at 245 m$^3$/head. It is still only 355 m$^3$/head when one includes the net contribution of groundwater water. Availability in the Huai and Huang basins is higher, but is still below the internationally accepted definition of water scarcity (1 000 m$^3$/head). In contrast, areas to the south are reasonably well endowed by Asian standards, and in the southwest, water is abundant. Internally drained basins account for about 35% of the PRC’s land area and, although availability per head appears favourable, extreme shortages are faced locally in desert communities. Discharge is seasonal and lakes and wetlands are saline.

Urbanisation is high in the northeast (the traditional heartland of the PRC’s heavy industry); in the inland basins where rain-fed agriculture is constrained by low precipitation; and in the Zhujiang (Pearl) basin, which was the centre of the PRC’s early modernisation. Incomes are also high in southeast coastal areas. However, incomes are very low in the less developed southwest, where water is abundant. Average indicators of urbanisation and income for the Yangtze basin mask much higher levels in the lower reaches than in the interior. Similarly, the Beijing-Tianjin-Tanshan conurbation results in high levels of urbanisation and incomes in the Hai-Luan basin. In contrast, both the Huai and the Huang basins have urbanisation rates that are below the national average.

Table 2.2 shows the extent to which water is a limiting factor for irrigation in northern PRC but that land, not water, is the limiting constraint in Southern PRC. The situation in inland basins is mixed. The information suggests that there is still potential for irrigation expansion. However, conditions differ markedly from sub-basin to sub-basin and the true potential can only be established by detailed studies. The high altitude and saline soils are significant factors limiting agricultural potential in the western basins.
Variability of River Flows

Rainfall and river runoff in China is highly seasonal. South of the Yangtze, the runoff in the four months between April and July accounts for 60% of the annual runoff. North of the Yangtze the seasonality is even greater; the four months from June to September account for 80% of the runoff. There are also considerable year-to-year variations in river runoff. The ratio of maximum annual runoff to minimum annual runoff is around 5 for the southern rivers and above 10 for the northern rivers. About 70% of China’s arable land area is subject to floods. The eastern provinces can experience prolonged and intense rainfall on a scale that is seldom equalled in other parts of the world. Since 1949 there has been great progress in works to protect land and property from floods. Dams to store wet season flows for irrigation and water supply and to intercept floods have been an essential feature of China's economic development over the past 50 years. In the northwest droughts are a more significant hazard than floods.

2.3 Sedimentation and soil erosion

As sediment in many countries with sediment-laden rivers, impacts on storage reservoirs, retention basins and river bed levels where levees have been built to channelise rivers are major issues in China. These factors affect the performance and life span of the facilities. There are no overall statistics on reservoir sedimentation in China, though it has been a controversial issue in the dams debate, including projects such as Three Gorges. Many dams are designed with an expected limit on the live storage capacity that will eventually degrade over time.\(^\text{16}\) The Xiaolangdi project for example is expected to defer sedimentation build-up in the lower reaches of the Yellow river below the dam for 20 years.\(^\text{17}\) Consideration is also being given today to raising the height of some older dams to restore storage capacity lost to sediment.

Additionally, China faces extremes in natural erosion in many watersheds; such natural processes are made worse by land use changes and practices that contribute to erosion. The Huang (Yellow) River passes through the loess plateau of northern PRC. The soil of the loess plateau is easily eroded and over-exploitation of land and ground water resources has caused severe soil erosion and desertification. This causes a sediment content that is an order of magnitude greater than that for any other major world river. The average annual load is about 1.6 billion tonnes. In its lower reaches, deposition has raised the bed level well above the surrounding land, creating a suspended river for the last 200 km or so of its length. The Yongding tributary in the Hai basin has a comparable sediment content, as do some other rivers in the area. The annual load of the Yangtze at Yichang is 0.5 B tonnes (about 1/30 the flow of the Huang). This, plus the silt content of other rivers, has major implications for river management and for reservoir life, design and operations.

Soil erosion and deforestation in the catchments of China’s major rivers are key factors that have caused increased sediment loads. Although catchment management issues are receiving a great deal of attention in China they continue to represent a major challenge. According to the Trans-Century Green Project Report (NEPA, SPC & SETC, 1997), the area susceptible to soil erosion has expanded from 1.53 M km\(^2\) in the 1950s to 3.67 M km\(^2\) in 2000 (from 16% of the total land area to 38%). Annual soil erosion in the PRC is some five billion tonnes. Huge amounts of nutrients are washed away, and eventually pollute downstream lakes and rivers. Soil salinization and desertification are

\(^{16}\) Numerous sedimentation studies have been carried out suggesting the sediment performance of the Three Gorges Projects will be acceptable; other dissenting views have been published in China such as The Three Gorges Project Should Not Go Ahead in the Short Term, Consultation Group of the Chinese People's Political Consultation Committee, (Research on Regional Development Strategies) 9, 3 (1987), 89-92, translated by Nguan chun Liu; and Tian Fang, et. al, Assessing the Three Gorges Project from Three Macro Strategic Aspects, Qun yan 9 (1987): 23-31, translation by Alexandra Poon.

\(^{17}\) Cao Zengqui, Technical Challenges in the Xiaolangdi Project, Hydropower and Dams 2000.
also closely related problems. There are currently about 7 M ha of salinized farmland and 25 M ha of salinized barren land in the PRC; approximately one-third of the arable land area is affected by salinization though to varying degrees of severity. China has also reclaimed saline land.

Deforestation has contributed greatly to the reduced vegetative cover. For example, in the Yangtze Basin the forested area decreased from perhaps 30-40% in 1950 to about 10% of the basin in 1990. Although the relationship between deforestation and soil erosion has not always been clear, their combined impact on the Yangtze Basin has been significant.

2.4 Flooding and flood damage

More than 1 000 significant flood disasters, or one every two years, occurred between 206 BC and 1949 AD. Notable recent floods include: a) that of the Huai River in 1931, inundating 4.27 M ha and causing 75 000 deaths; b) one on the middle and lower reaches of the Chang (Yangtze) River in 1931, inundating more than 3.3 M ha of farmland, affecting 28.5 million people, and causing 145 000 deaths; and c) flooding of the Huang (Yellow) River in 1933, affecting more than 3.6 million people and causing 18 000 deaths. From 1949 to 1988, the area affected by floods averaged about 7.9 M ha per year. Although the number of deaths has declined, the cost of the damage has increased. Table 2.3 summarises the areas affected in these years.

<table>
<thead>
<tr>
<th>Year</th>
<th>Disaster Area (Mha)</th>
<th>Chief Disaster Region</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Affected Area</td>
<td>Seriously Affected Area</td>
</tr>
<tr>
<td>1954</td>
<td>16.1</td>
<td>11.3</td>
</tr>
<tr>
<td>1956</td>
<td>14.4</td>
<td>10.9</td>
</tr>
<tr>
<td>1963</td>
<td>14.1</td>
<td>10.5</td>
</tr>
<tr>
<td>1964</td>
<td>14.9</td>
<td>10.1</td>
</tr>
<tr>
<td>1985</td>
<td>14.2</td>
<td>8.9</td>
</tr>
<tr>
<td>1996</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>


The most recent flood events took place in 1996 and 1998. Preliminary figures suggest that the 1996 flood affected some 5.12 million houses, caused 4 400 deaths, impacted 31 M ha farmland, resulted in monetary losses of 220.8 billion yuan (US$27 billion at the current exchange rate), and reduced GDP by about 4%. Preliminary losses from the 1998 flood are 7.33 million houses, 3 656 deaths, 25 M ha, 248.4 billion yuan (US$30 billion), and 3-4 % of GDP. Although these are only estimates, it is clear that impacts have enormous implications for economic growth and human welfare.

The recurrence interval for both the 1996 and 1998 floods was in the order of 50 years for the middle Yangtze at Wuhan. Expressed differently, based on historical records the probability of such floods occurring in any year is approximately 2%. Clearly two extreme events have occurred within a few years. Whether such extreme events are the consequence of changes in weather and climate patterns or are largely a consequence of human activities in the river catchments is a matter of conjecture. A combination of these causative effects appears to be the most likely explanation.
2.5 Water quality and pollution

Table 2.4 summarises recent data on ambient water quality in the PRC’s major rivers. The poor quality of rivers in the northeast reflects the region’s high degree of urbanisation and industrialisation. For the Hai-Luan, Huang and Huai rivers, urbanisation impacts are aggravated by low river flows and limited natural dilution capacity. In contrast, large discharges and the resulting high dilution capacity support a significantly better average quality of rivers in the south. Despite limited improvements during the 1990s (e.g. in the quality of the Huai and Songhua rivers), water quality in northern rivers, eutrophication, pollution of major lakes, and deteriorating groundwater quality in urban areas remain major causes for concern.

### Table 2.4: Surface Water Quality Classification: 1996

<table>
<thead>
<tr>
<th></th>
<th>Mean Runoff (BCM)</th>
<th>Proportion of River length: %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Class I &amp; II</td>
</tr>
<tr>
<td>Songhua-Liao</td>
<td>165</td>
<td>2.9</td>
</tr>
<tr>
<td>Hai-Luan</td>
<td>29</td>
<td>17.6</td>
</tr>
<tr>
<td>Huang (Yellow)</td>
<td>7,466</td>
<td>8.2</td>
</tr>
<tr>
<td>Huai</td>
<td>74</td>
<td>17.6</td>
</tr>
<tr>
<td>Chang (Yangtze)</td>
<td>951</td>
<td>38.8</td>
</tr>
<tr>
<td>Zhu (Pearl)</td>
<td>468</td>
<td>49.5</td>
</tr>
<tr>
<td>SE Rivers</td>
<td>256</td>
<td>40.7</td>
</tr>
<tr>
<td>SW Rivers</td>
<td>585</td>
<td>N/A</td>
</tr>
<tr>
<td>Inland Rivers</td>
<td>116</td>
<td>63.5</td>
</tr>
<tr>
<td>Total China</td>
<td>2,711</td>
<td>32.2</td>
</tr>
</tbody>
</table>

Class I, II and III: Direct human contact and use as raw water for potable supply
Class IV: Restricted to industrial use and recreational uses other than swimming
Class V: Restricted to irrigation

**Source:** 1997 Environmental Yearbook, China

Water pollution in the PRC is caused by industrial and municipal wastewater discharges; agricultural runoffs of chemical fertilisers, pesticides and animal manure; and leaching of solid wastes. It is estimated that 80% of domestic wastewater is discharged without adequate treatment. In 1997, wastewater discharge was 41.6 B tonnes, of which 22.7 B tonnes was industrial wastewater and 18.9 B tonnes came from municipal sources. In the case of industrial wastewater, industries at the county level and above discharged 18.8 B tonnes, while TVEs discharged 3.9 B tonnes. Total industrial wastewater discharge has not increased over the past decade, even with the acceleration in industrial growth. However, the proportion of the discharge not meeting discharge standards has risen significantly, largely due to the increase in the number of TVEs. Occasionally, as in 1996 in the Huai basin, pollution levels reach unacceptable levels and emergency measures must be taken to address the threat to human health. In the Huai case, this included closing down industrial polluters, resulting in loss of employment and income.

The major point-source contaminants in the PRC’s rivers and other water bodies are organic pollutants from chemical, petrochemical, papermaking, food, tanning, and textile industries, and untreated domestic wastewater. Total urban wastewater and COD concentration have increased steadily. Increased pollution in water bodies in the vicinity of cities is generally due to the low level of treatment of urban releases, and the discharge of untreated wastewater. Non-point sources of pollution are widespread, and are estimated to contribute approximately 70% of the total pollution load to PRC's watercourses.
Polluted groundwater also poses severe problems. A groundwater assessment for 69 cities in five northern provinces and autonomous regions (Xinjiang, Gansu, Qinghai, Ningxia and Inner Mongolia) indicated that not one of these cities had Class 1 groundwater, 10 had Class 2, 22 had Class 3, and 37 had Class 4 and 5. A water quality assessment of 2,015 wells in the Hai Basin showed that two-thirds of the investigated wells did not meet quality standards for drinking. A distinct water quality problem reflected in these results is the widespread natural occurrence of fluoride in groundwater. The health of many millions living in northern PRC has been adversely affected by fluorosis both in cities such as Tianjin and in the mid-Yellow river basin.

According to statistics from 29 provinces, autonomous regions and large municipalities, there were 65 environmental pollution accidents in 1996, of which 29 were caused by chemical pollutants and 26 by biological pollutants. About half a million people were affected by these accidents, with 4,300 reports of illness. In 1993, wastewater irrigation polluted 3.3 million ha of farmland, affecting a population of 40 million. The incidence of cancer in regions that irrigate with wastewater can be twice that of regions that rely on freshwater. In 1993, about 8% of the PRC’s irrigated areas received water below Grade 5 standards, leading to lost grain output estimated at one million tonnes.

### 2.6 Energy Resources and Hydropower Potential

The PRC has an abundance of energy resources. It has the world’s largest coal reserves, 860 billion tonnes (unfortunately much of it with high ash and sulphur content), and in hydropower potential estimated at 378,000 MW (which is also the largest potential of any country), of which 44,600 MW has been developed. Reserves of natural gas of over 600 bcm have been identified so far with many structures still to be explored. Annual production of natural gas of about 20 bcm is growing rapidly as more urban centres and industry switch from coal.

The PRC’s total installed electricity generating capacity was 270,000 MW in 1998. Thermal plants, mostly coal-fired, account for 80% of the installed capacity, hydro 19% and nuclear 1%. Coal-fired thermal plants are well suited for base load but highly inefficient for peaking. Over half the thermal units in the PRC are small units (less than 200 MW) using very old technology. They operate with low fuel efficiency and are highly polluting. Section 4 of the paper provides additional information on the energy resource and conversion technology options.

The composition of power sources (conventional or renewable, centralised or decentralised) in rural areas depends on the locality. In China, of the 378 TWh supplied in the rural areas in 1995, 83.5% came from the national grid (100kV) and small thermal power plants, while 16.5% was contributed by small hydropower and other decentralised options in the country.

China has a significant small-scale, decentralised energy programme. By the end of 1999, China had more than 45,000 small hydropower (SHP) stations with total installed capacity of 24,000 MW and annual generating capacity of 830 GWh. Since 1990s, the annual installed capacity of SHP has increased over 1,500 MW. It has gained rich experience in SHP development, including planning, design, construction, operation, maintenance, equipment manufacturing and SHP grids management, etc. Since China is moving toward the market economy system, SHP is no longer the property of government. The diversity in fund raising, ownership, operation and management system had changed the shape of SHP ownership.  

Overall it is estimated that the PRC has an exploitable power potential of 378.5 GW, of which 60.0 GW (15%) had been developed by 1997. The major exploitable potential is in the Yangtze basin (197 GW or 52% of the total) and in the southwest river basins (23%). Other rivers include the Huang

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18 Hangzhou International Center on Small Hydro Power, [http://www.digiserve.com/inshp](http://www.digiserve.com/inshp), WANG Yansong
(7.4%), Zhujiang (6.6%), southeast rivers (3.7%), northeast rivers (3.6%), and inland rivers (2.6%). Potential in the Huai and Hai basins is small, amounting to no more than 0.5% and 0.1% of the respective total. Most large hydro stations are located in remote mountainous regions in the upper reaches of the Huang (Yellow) River, the Chang (Yangtze) River, and the rivers of the southwest. For the PRC to benefit fully from its hydro potential the development of an extensive power grid is an important consideration and optimisation of existing generation assets can serve to defer or delay the need for new generation.

Section 1 provided a list of the hydropower dams that were under consideration for near-term development. Section 4 of the paper discusses demand management, and renewable and conventional alternatives for power supply in more detail.

2.7 Factors Affecting the Demand and Use of Water and Energy Resources

A number of factors external to the water and energy resource sector influence the demand for services and the policies and development priorities in the water sector. The following provides an indication of the types of challenges that are faced in establishing the policy environment discussed in Section 3.

Population Growth and Demographic Change
After increasing by more than 2%/year during the 1950s and 1960s, the population growth rate has slowed as a result of an aggressive population control policy. The current rate is approximately 1.1%/year. The population is expected to peak at about 1,551-1,60 billion by the middle of the next century, by which time it will have aged radically. The ratio of people of working age (15-64) to pensioners (65+) is indeed expected to decline from approximately 10:1 in 1997 to a possible 3:1 by 2050.

Urbanisation
The PRC’s rate of urbanisation (30% in 1997, according to the official definition) appears low for a country at its level of income per capita. Moreover, urban areas are defined to include extensive agricultural areas, suggesting that the true rate may actually be even lower (of a total urban population of 370 million in 1997, at least 45% were classified as agricultural, according to some estimates). Offsetting this, however, are extensive areas defined in the official statistics as rural (e.g. in the Pearl River basin, lower Yangtze and Beijing-Tianjin-Tangshan regions), but that are in fact developing a dispersed pattern of industrial activity and intensive settlement more characteristic of urban than rural areas. Up to 30% of the population of China’s major cities may also go unrecorded as they lack the required residency permit and are thus deemed to be illegal migrants. Whatever may be the true position, the population is becoming increasingly urban. Based on official definitions, the urban population is increasing by about 10 million/year and the rate of urbanisation is expected to reach 60% by the middle of the next century. The government has also announced that under the new five-year plan, due to start in 2002, some 300 million rural people would be resettled in 10 000 new towns. This urban expansion will place great demands on already stressed land and water resources.

Income Distribution
Income distribution remains more equitable in the PRC than in many other developing countries, and the differential between the coastal and interior provinces is less marked than is sometimes claimed (World Bank, 1997). Nevertheless, according to official estimates, average incomes in prosperous coastal provinces such as Jiangsu, Zhejiang and Guangdong are still two to three times greater than those in interior provinces such as Sichuan, Guanxi, Gansu and Yunnan, and urban areas as a whole have markedly higher average incomes than rural areas. In the western provinces there are still many millions of people earning less than 300 yuan per annum. Given the pattern of economic growth, income inequalities both between provinces and between town and country can be expected to increase in coming years, creating a potential for social stress.
Food self-sufficiency
The PRC’s arable land is limited relative to its farming population (some 0.15 ha per head of rural population), and crop yields are already fairly high. This has led some observers to forecast that the PRC’s future food requirements could destabilise world grain markets (Brown, 1998), but this argument can be considered overstated. Government policy aims on average for at least 95% food self-sufficiency in order to sustain farming incentives and incomes, as well as to ensure basic food and national security. World Bank projections suggest that there would be little cause for concern on world markets even if the proportion of food produced relative to need were to fall to 90%. Both government and World Bank projections suggest some potential for continued agricultural growth, particularly under irrigation, at a rate sufficient to support continued growth in calorie consumption. Setbacks will undoubtedly be encountered due to weather and other events, but in such circumstances, increased Chinese demand will trigger price increases on world markets and this will generate a production response. In addition, technological progress will increase production potential.

Economic Growth
Fuelled by an educated and industrious work force, a high savings rate, and pragmatic market reforms, the Chinese economy has grown at a remarkable rate. Official estimates suggest an average GDP growth of 9.4%/year between 1978 and 1995 – up from about 6.5%/year in the 1960s and 2970s – as market reforms began to take effect. The rate of growth slowed to 8%/year in 1996 and 1997, and was expected to decelerate further. Although some unofficial estimates suggest that these rates may be considerably overstated, the PRC has to date avoided the worst effects of the Asian economic crisis. Official long-term perspectives still call for yearly growth of 6-7%. The GDP per capita officially doubled in the 10 years preceding 1987, and doubled again in the ten years to 1997. In 1997, it was an estimated 6 000 yuan at the official exchange rate, and substantially higher based on purchasing parity equivalence. There is nevertheless considerable regional disparity and according to the State Council some 80 million people still live in absolute poverty (meaning that they lack the basic means for subsistence, being unable to grow or purchase sufficient food for their immediate requirements). The National poverty reduction plan aimed to reduce poverty amongst 80 million people in the seven-year period from 1994 to 2000.

Structural Change
Increased productivity and rapid structural change contributed substantially to the PRC’s growth from an early stage, in contrast to many countries that initially relied predominantly on capital accumulation for expansion. For instance, agriculture’s share of the GDP declined from about 45% in the mid-1950s to 30-35% in the mid-1970s, to less than 20% in the mid-1990s. Meanwhile, industry’s share of GDP over the same period increased from less than 25% to 40-45%, then to almost 50%. The share of services declined between the mid-1950s and mid-1970s, but has risen from less than 25% to more than 30% since then. If rapid growth is sustained, services can be expected to account for an increasing share of the total.

Public/Private Balance
The first wave of industrialisation was fuelled by government investment in heavy industry during the early decades of the new PRC. The second wave, after 1978, took place in collectively owned and township/village enterprises, reflecting the phasing in of the reform programme which initially focused on the quasi-privatisation of government assets. A third wave is building, mostly in privately and individually owned enterprises supplemented by joint and foreign-funded ventures. This massive shift, first to the quasi-private and then to the private sectors, was complemented by an explosion in household savings. These were unimportant prior to the reform programme, but now account for more than 50% of the country’s total savings. The overall savings rate since 1978 has remained equivalent to over 35% of the GDP, and, in 1995, was a remarkable 40%. This markedly differs from the collapse of savings in the former Soviet Union, and indeed from the level of savings in most Western countries.
Delegation and Decentralisation
Transitions under way have been accompanied by delegation, decentralisation of decision-making, encouragement of private initiatives, and increased reliance on incentives rather than on central directives. Not only has management of economic assets been widely distributed, but every level of local government has also shown increasing independence. These trends can be expected to continue as the reforms are consolidated, alternative sources of financing are utilised, stakeholders are increasingly incorporated into decision-making processes, and provincial and local governments gain in confidence and capabilities.

Environmental Pressures
In common with most developing countries the nature of environmental pressures in China differ markedly between urban and rural areas. Urban areas suffering from problems of pollution and inadequate infrastructure while rural areas suffer from problems of natural resource depletion. Chinese cities suffer from a considerable degree of air and water pollution. Until 1980 the government had very little regard for managing air and water pollution. Since then the government has taken steps to control pollutants; however, much remains to be done. Environmental degradation will continue to increase exponentially in the absence of stringent pollution control accompanied by a shift to pollution mitigation, avoidance and prevention. This threatens health, reduces productivity, and disrupts ecosystem functioning. Controlling air and water pollution is costly, and World Bank scenarios suggest that possibly 1-2% of the GDP will be required to address these problems. However, this figure must be compared to estimated losses from pollution quoted at as much as 8% of the GDP in the same source (with air pollution accounting for most of the damage).

In rural areas, particularly in the western provinces, increasing pressures on land and forests has led to catchment degradation. Soil erosion is widespread, desertification occurs, soils are becoming more saline and pasturelands are overgrazed. These conditions endanger not only the western regions but have an effect on water quantity and quality in the country’s major river systems; they have consequences for dams and related infrastructure, as well as aggravating flooding and waterlogging. Costs and benefits of the same order as those expected from environmental improvement in urban areas can probably be expected from catchment and floodplain management programs. Addressing environmental concerns cannot be regarded as a luxury: in fact, government expenditure on sustainable development, based on these estimates, would earn substantial economic returns.

2.8 Current and Future Uses of Water

2.8.1 Trends in Water Use

Table 2.5 shows that domestic and industrial water use have been increasing rapidly, whereas agricultural use has risen slowly. The table also indicates a growth in rural uses other than irrigation (forestry, animal husbandry & fisheries). The low growth in the number of diversions for irrigation suggests a marked improvement in the unit productivity of irrigation diversions. The rate of increase in urban domestic use has been rapid whereas rural domestic use has increased only modestly. Total diversions have risen broadly in line with growth in population but at rates well below growth in GDP. In 1997, total water use was equivalent to about 20% of the total water available in the PRC.

Surface water continues to be the dominant source for withdrawals for consumptive use, accounting for 81% of total diversions in 1997. Exploitation of groundwater has increased at a more rapid rate. This has had damaging effects, especially on the North China Plain, where water tables have declined alarmingly. Reuse of wastewater, especially for irrigation, increased significantly from negligible use in 1980 to 3% of total supplies in 1993.
Table 2.5: Consumptive Use and Withdrawals: 1980-97

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consumptive Use:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic (urban/rural)</td>
<td>27</td>
<td>47</td>
<td>53</td>
<td>6.2</td>
<td>8.5</td>
<td>9.4</td>
<td>4.36</td>
<td>0.86</td>
</tr>
<tr>
<td>Industrial</td>
<td>46</td>
<td>89</td>
<td>127</td>
<td>10.4</td>
<td>17.0</td>
<td>22.6</td>
<td>5.21</td>
<td>9.30</td>
</tr>
<tr>
<td>Agriculture (irrigation)</td>
<td>370</td>
<td>382</td>
<td>392</td>
<td>83.4</td>
<td>73.2</td>
<td>69.8</td>
<td>0.25</td>
<td>0.65</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>443</td>
<td>522</td>
<td>562</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>1.27</td>
<td>1.64</td>
</tr>
<tr>
<td><strong>Withdrawals for Cons.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Water</td>
<td>381</td>
<td>422</td>
<td>457</td>
<td>86.0</td>
<td>80.8</td>
<td>81.2</td>
<td>0.79</td>
<td>2.01</td>
</tr>
<tr>
<td>Groundwater</td>
<td>62</td>
<td>87</td>
<td>103</td>
<td>14.0</td>
<td>16.7</td>
<td>18.3</td>
<td>2.64</td>
<td>4.31</td>
</tr>
<tr>
<td>Reuse &amp; Other</td>
<td>...</td>
<td>13</td>
<td>3</td>
<td>...</td>
<td>2.5</td>
<td>0.5</td>
<td>N/A.</td>
<td>N/A.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>443</td>
<td>522</td>
<td>562</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>1.27</td>
<td>1.64</td>
</tr>
</tbody>
</table>


Table 2.6 illustrates water use in 1997 by river basin. Table 2.7 provides comparable data on withdrawals for consumptive use. As would be expected, use as a proportion of the water available is well above average in the Hai-Huang-Huai basins (3-H Plain). In the Hai-Luan basin, use exceeds sustainable yield, reflecting groundwater mining and other factors. In the Huang and Huai basins, use as a proportion of sustainable yield is lower although still high. For the Huang (Yellow) River, consumptive use is limited by the need to pass silt through to the sea. Use as a proportion of the resources is intermediate in the Songhua-Liao and Inland basins, and markedly lower in the Yangtze and other southern basins. In the case of the southwestern basins, it is no more than 2%. In all regions, irrigation is by far the largest user. Of particular note is groundwater use. In the Hai-Luan basin, groundwater accounts for 60% of total use, and in the Huang and Huai basins it supplies in the order of 30% of total use. These high rates reflect the severe pressures on surface supplies and the depletion of the groundwater resource on the 3-H Plain.

Table 2.6: Estimated Water Use: 1997

<table>
<thead>
<tr>
<th></th>
<th>Domestic</th>
<th>Industrial</th>
<th>Agriculture</th>
<th>Total</th>
<th>Unit Use¹</th>
<th>% Net Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BCM</td>
<td>M³/head</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Songhua-Liao</td>
<td>4.9</td>
<td>12.7</td>
<td>44.4</td>
<td>61.9</td>
<td>524</td>
<td>32</td>
</tr>
<tr>
<td>Hai-Luan</td>
<td>4.7</td>
<td>6.7</td>
<td>31.9</td>
<td>43.3</td>
<td>353</td>
<td>103</td>
</tr>
<tr>
<td>Huang (Yellow)</td>
<td>2.9</td>
<td>5.9</td>
<td>31.4</td>
<td>40.3</td>
<td>389</td>
<td>55</td>
</tr>
<tr>
<td>Huai</td>
<td>6.0</td>
<td>9.6</td>
<td>50.0</td>
<td>65.7</td>
<td>331</td>
<td>66</td>
</tr>
<tr>
<td>Chang</td>
<td>18.6</td>
<td>49.2</td>
<td>106.0</td>
<td>173.7</td>
<td>414</td>
<td>18</td>
</tr>
<tr>
<td>Zhu (Pearl)</td>
<td>10.8</td>
<td>19.4</td>
<td>53.2</td>
<td>83.4</td>
<td>565</td>
<td>18</td>
</tr>
<tr>
<td>SE Rivers</td>
<td>3.1</td>
<td>6.6</td>
<td>19.4</td>
<td>29.1</td>
<td>429</td>
<td>11</td>
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<tr>
<td>SW Rivers</td>
<td>0.7</td>
<td>0.4</td>
<td>7.5</td>
<td>8.6</td>
<td>450</td>
<td>2</td>
</tr>
<tr>
<td>Inland Rivers</td>
<td>0.9</td>
<td>1.5</td>
<td>48.3</td>
<td>50.6</td>
<td>1 961</td>
<td>39</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>52.5</td>
<td>112.1</td>
<td>392.0</td>
<td>556.6</td>
<td>450</td>
<td>20</td>
</tr>
<tr>
<td><strong>% of Total</strong></td>
<td>9.4</td>
<td>20.1</td>
<td>70.4</td>
<td>100.0</td>
<td>N/A.</td>
<td>N/A.</td>
</tr>
</tbody>
</table>

Sources: China Water Resources Bulletin, 1998


Table 2.7: Withdrawals for Consumptive Use – Surface Water, Groundwater, Other: 1997

<table>
<thead>
<tr>
<th>Water use: BCM</th>
<th>% of Water Use</th>
<th>% of Resource</th>
<th>Net Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surface</td>
<td>Ground-water</td>
<td>Re-use/ Other</td>
</tr>
<tr>
<td>Songhua-Liao</td>
<td>35.4</td>
<td>26.6</td>
<td>...</td>
</tr>
<tr>
<td>Hai-Luan</td>
<td>16.9</td>
<td>26.4</td>
<td>0.1</td>
</tr>
<tr>
<td>(Yellow)</td>
<td>26.9</td>
<td>13.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Huai</td>
<td>47.9</td>
<td>18.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Chang (Yangtze)</td>
<td>165.0</td>
<td>7.3</td>
<td>1.5</td>
</tr>
<tr>
<td>Zhu (Pearl)</td>
<td>79.2</td>
<td>4.1</td>
<td>0.2</td>
</tr>
<tr>
<td>SE Rivers</td>
<td>28.1</td>
<td>0.7</td>
<td>0.1</td>
</tr>
<tr>
<td>SW Rivers</td>
<td>8.5</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Inland Rivers</td>
<td>48.8</td>
<td>5.9</td>
<td>...</td>
</tr>
<tr>
<td>Total</td>
<td>456.6</td>
<td>103.1</td>
<td>25.7</td>
</tr>
</tbody>
</table>


2.8.2 Future Outlook for Demand/Supply Balances in Different Basins

Each of the major river basins in China faces different prospects. A common theme though is increasing competition for available water between nature and human uses, and between individuals, different sectors of the economy and provinces. Section 3 discusses the emergence or re-emergence of River Basin Commissions as a means to integrated planning and management at the basin level, and Section 4 provides an illustration of some of the strategic considerations for interbasin transfers which China is contemplating.

Song-Liao Basins

Urban and industrial demands in the northeast already account for a relatively high share of consumption and are expected to rise at rates somewhat slower than the national averages. However, since water is not seriously constrained in this region, rising irrigation demand can also be accommodated based on new irrigation and associated land reclamation. The northeast can thus be expected to develop into an increasingly important source of agricultural products. Total water use in the northeast is expected to rise relatively rapidly, with groundwater contributing an increasing share of the total. By 2050, 39% of available resources are expected to be used, with 33% of this total coming from groundwater.

Hai, Huai and Huang Basins

Shortages faced in these basins will contribute to a reduction in irrigation use, with declines moderating after 2020. Even so, irrigation is expected to remain the dominant use, accounting for more than 50% of the total in 2050. Whether this proves feasible remains to be seen, but this analysis indicates that preservation of irrigation will depend critically on transfers from the Yangtze. These transfers are expected to meet almost 30% of total demand in 2050, with reuse meeting a further 10%. An important aspect of the projections is the shift from groundwater to surface supplies. Accordingly, groundwater in the Hai-Luan basin in 2050 would provide 50% of total use compared to 70% in 1993 (and an actual figure of 61% in 1997, see Table 2.7). Total water consumption is projected to be equivalent to almost 70% of available supplies, with the balance presumably flood flows that are not stored or devoted to instream and environmental purposes.

This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
Yangtze, Pearl and Southeast Basins
Given limited potential for expansion of the irrigated area, the share of irrigation in the total is expected to decline from more than 70% to less than 45% (35% in the Zhujiang basin). However, urban and industrial demands are projected to rise rapidly and, apart from the southeastern basins, total demand is expected to rise more rapidly than the national average. Given the relative abundance of water, and allowing for $5 \times 10^9 \text{ m}^3$ transferred to the north, total use is set to remain under 30% of available supplies and groundwater will remain of only local significance. Given the limited potential for additional storage relative to the high levels of total discharge, uncontrolled surface flows will continue to be very high and flood protection works are likely to remain a high priority.

Southwest Basins
Given the present low level of water services and irrigation coverage, consumptive use is projected to rise at almost double the national average. Supplies are abundant, and consumptive use will account for a minimal share of what is available. Funds and implementation capacity will be the dominant constraints, with hydropower a continuing development opportunity. The year-round assimilative capacity of the rivers suggests that pollution will not be a major issue other than locally or as a result of an international treaty.

Inland Rivers
Issues facing inland basins differ widely. At first sight, it would appear that the water resource would remain under-utilised given the widespread aridity and the land potential that characterise these basins. But conditions are very variable, with acute shortages in some populated basins co-existing with other resources in sparsely inhabited zones. Irrigation is expected to remain the dominant user, its share declining from 89% in 1993 to 80% in 2050. Conjunctive use has potential and increasing recourse to groundwater is expected.

These projections suggest that, provided appropriate policies and strategies are adopted and implemented, and the south to north water transfer project is implemented, emerging imbalances between supply and demand can be contained and the water sector will thus be able to support overall national goals of sustainable development. However such programs are highly controversial and hotly debated as discussed in section 4.1.1. Pressure on the water resource will nevertheless be very great. To provide for increasing urban and industrial demand water available for irrigation will need to be reduced. If greater efficiency of water used for irrigation is not achieved through appropriate management and technology food production will be affected.

2.8.3 Water Supply and Demand Management
The distinction between demand and supply management is not an absolute one, and there is considerable overlap between the two. The issues related to each are discussed below, taking into consideration the prevailing conditions in the PRC:

Mobilising Uncommitted Supplies
The potential for mobilising new supplies varies greatly from region to region. In southern PRC, water is generally abundant and the potential for irrigation expansion is limited. Thus there are typically uncommitted natural flows that can be mobilised to meet rising urban and industrial demands. In northern PRC, however, most obvious developments of surface-water supplies have been constructed and groundwater is over-developed. Moreover, any new storage must have the reliability characteristics needed to satisfy rising urban and industrial demand.

In addition to developing new supplies, there may be potential for managing existing supplies more productively. In principle, reservoir operations and bulk water deliveries should be in line with water-allocation priorities and water rights. In practice, not only are provincial water and other allocations unspecified, but dams are owned and operated by many different national, provincial, and local entities; there is seldom one resource manager responsible for all bulk water deliveries; and lack of
basin co-ordination can lead to a failure to optimise multipurpose operations. Unification of basin management under one resource manager (e.g., a RBC), or at least unified control and monitoring of bulk water operations, could be supported by system studies designed to optimise total benefits.

**Water Allocation**

The Water Law provides the government with broad powers to allocate water to meet economic, social and environmental objectives, subject to meeting domestic requirements. In practice, reallocation already occurs. Reservoir operating rules generally implement priorities at the project level. Within irrigation, scheme-level managers can shift water between farmers (e.g., to serve high-return crops). With regard to transfers out of irrigation, urbanisation automatically releases water if it is at the expense of irrigated agriculture since consumptive use per ha in urban areas is substantially less than in irrigation. However, additional transfers may be needed to satisfy growing domestic and industrial demands. Such reallocation can be highly inequitable, and have unexpected consequences if it is administered unpredictably and/or with inadequate compensation.

Transfers out of irrigation are controversial since they raise issues of food self-sufficiency and the rural-urban balance. It must nevertheless be recognised that relatively small transfers out of irrigation can meet large proportional increases in domestic and industrial demand.

All major studies of water resources by the government appear to indicate that south-north transfers are essential. They suggest that if the transfers are delayed, reallocation out of irrigation will necessarily accelerate in the north. If transfers are brought forward, reallocation can be contained. The justification for the South-North Transfer project is thus largely determined by how much irrigated land is to be retained in northern PRC and over what time schedule. This is clearly a multi-sectoral issue that will require careful consideration and planning at the highest levels of government.

Water use allocations can be handled administratively (e.g., in the way a multipurpose facility is operated, or through supplies given to an irrigation scheme) but water use permits provide a more predictable mechanism for regulating water use. In principle, permits reflect allocation priorities, provide the basis for real-time management, and clarify the rights and obligations of the users who face known risks on which to base investment and production decisions. In practice, however, the expansion of water use permits will call for a clear definition of inter-provincial allocations, specific rights for in-stream users, and procedures at times of shortage. A priority in the PRC is for the water permit system to be consolidated and for the enforcement system to be made more effective.

**Productivity per unit of water**

In all developing countries increasing the productivity of water within any particular use has major potential. Opportunities include a mix of short-term measures and measures which may be practical in the longer term such as: crop varieties that provide increased yields for each unit of water consumed or the same yields with fewer units of water; crop substitution by switching from high-water-consuming to less-water-consuming crops with higher economic or physical output per unit of water consumed; deficit, supplemental or precision irrigation to improve water control and increase the returns per unit of water; technologies and standards that minimise use for specific domestic purposes; and industrial processes that recycle water or reduce the amount of water used. Numerous associated demand-management measures can be considered in the PRC context. Many have already been tested or introduced in one way or another by sub-sector agencies in the PRC.

One mechanism for increasing the productivity of water is to impose a fee that reflects the economic value of water (e.g., by increasing the resource fee). Users who are billed realistic fees for water will use the resource more sparingly and for higher return uses than if water is subsidised. In urban systems, consumers might use water to meet demands they truly wish to satisfy (effective demand) rather than for convenience (unconstrained demand). In industry, users might recycle water or adopt processes that consume less. In irrigation, they might switch crops or adopt practices that increase...
returns per unit of water. However, price mechanisms need to be carefully designed if they are to reflect real economic values. Long-run marginal cost (LRMC) pricing has a strong rationale in economic theory since it provides incentives consistent with optimisation of new investment.

There is a widespread belief in the PRC that water use is inefficient, and first priority must undoubtedly go to ensuring that no water is wasted. To this end, a National Water Savings Office has been created in the Ministry of Water Resources (MRW), and a Water Savings Program in Northern PRC has been adopted for which World Bank support has been requested. This initiative will strive to increase irrigation delivery efficiencies by canal lining and piped distribution, and irrigation application efficiencies through sprinkler, trickle, drip and micro-sprayer technologies. These will be complemented by incentives and other measures designed to increase the productivity of water. Comparable programmes have been adopted by the Ministry of Construction to reduce unaccounted-for-water in urban systems, and by the Ministry of Industry to curtail water use through process investments and adapting industrial processes so as to conserve water.

2.9 International Watersheds and Conventions

Several major international rivers originate in the PRC, notably the Mekong River, the Irrawadi, the Red River and the Tumen River. Annual discharge of the international rivers is estimated at 350 billion m$^3$.

The Mekong Committee was created by the four lower Mekong countries (Cambodia, Laos, Thailand and Vietnam) in 1957 to deal with water-related issues relating to that river. Initially the Mekong was conceived to co-ordinate hydropower development. A new treaty creating the Mekong River Commission (MRC) was signed by these nations in 1995. The PRC and Myanmar, also an upper basin country currently hold the status of dialogue members.

The government considers that most promising sites for hydroelectric development are in the Upper Yangtze and the Upper Mekong (the Lancang River). Among the sites already developed are Ertan (2 300 MW) in the Upper Yangtze, and Manwan (1 500 MW) on the Lancang. Water stored on the Lancang, when released in the dry season would alter the flow at the head of the Mekong Delta. Dams on the Lancang would not affect the seasonal flood pattern in the Tonle Sap and the upper delta. No formal treaty exists with respect to the Irrawady River between the PRC and Myanmar, or to the Red River between the PRC and Vietnam.

Other international rivers flow from the western region, and no formal treaty exists with respect to them. However, an agreement on the Tumen River was concluded in 1994 between the four riparians (the PRC, Russia, Mongolia and North Korea), establishing the Tumen River Commission and Secretariat.

The PRC is one of 118 signatories to the Ramsar Convention on Wetlands, having signed the international treaty in July 1992. The Ramsar Convention covers all aspects of wetland conservation and wise use, and recognises wetlands as ecosystems that are extremely important for biodiversity conservation in general and for the well being of human communities. The PRC presently has seven sites covering a surface area of 588 380 ha designated as “Wetlands of International Importance”: Dongdongtinghu in Hunan; Dongzhaigang in Hainan; Mai Po Marshes & Inner Deep Bay in the New Territories, Hong Kong; Niaodao (“Bird Island”) in Qinghai; Poyanghu in Jiangxi, Xianghi in Jilin; and Zhalong in Heilongjiang.

This section of the paper describes the evolving policy environment and institutional framework for water and electricity development and management in China. It then considers the changing institutional roles and responsibilities in the planning, design and operation of water resource projects, including those of China's seven main River Basin Commissions operating under the control of the Ministry of Water Resources.

The larger picture that emerges is that China has developed a very comprehensive body of policies and legislation considered by most observers to be adequate to manage all aspects of water and energy resource development, including the environmental and social aspects. These policies, legislation and regulations are being continuously updated and adapted to the socialist market transformations. One central tenant of law in China is that the people own land and water resources collectively, and the state is to manage it on behalf of its citizens. Local governments, communities and individuals have no rights of ownership in a property sense, though they have rights of use for living and economic activities. Urban land belongs to the State, while rural land belongs to the collectives, except those areas stipulated by law as State land. Water facilities including dams, reservoirs and irrigation systems can now be owned privately. Permits and licenses are required for abstraction of water from rivers and lakes, and more recently groundwater aquifers.

At the same time as the policies are evolving on water and energy development and management, the environment and social resettlement aspects, there is tremendous existing institutional capacity at the central and provincial levels, that remains focused on building and operating large dams. This capacity built half the world's large dams. The current policy and institutional reforms appear to reflect and reinforce this direction of development – that is continued emphasis on large-scale public works to address drought and flood management problems and to meet expanding energy requirements, while improving the associated practices in managing environmental and social effects. The emerging policies nevertheless do foster and leave considerable room for more decentralised and integrated approaches to planning, implementation and management.

There is, for instance, an increasing orientation to co-ordinated river basin development, and much higher awareness of the growing threat and need for environmental protection and adoption of sustainable development principles in water and energy development, so as not to impede other sectors of the economy and the gradual social transformations. This awareness is growing throughout all levels of Chinese society. At the same time, China has already the capacity in place at the provincial and local levels for developing alternatives, which is one of the main issues in the dams debate. This is clearly demonstrated by the fact that China, apart from having the largest dam building programme in the world, also has the world’s largest programme and experience with small-scale alternative technology use in water and energy development in rural settings.

With the increasing pace of decentralisation of decision making - that is devolution of state level planning, budgeting and control function to provincial, municipal levels, “company-levels” and the private sector and individuals - operating within a socialist market economy, some of the means for achieving the national and local development goals, and the institutional roles, may be expected to be reshape over time. Policies and plans and studies of large projects are also increasingly required to go through more open public discussion, not restricting such debates exclusively to government officials with some local representation.
3.1 National Governance System and Development Goals

The structure of government for the 1.25 billion or more inhabitants of the PRC consists of four levels: national, provincial (including municipalities directly under the central government and autonomous regions), county/city and township/village. Prefectures may exist for administrative purposes intermediate between province and county, but only in autonomous regions do prefectures have formal governmental status. Excluding Hong Kong, Macau and Taiwan, there are 22 provinces, four municipalities directly under the central government (Beijing, Chongqing, Shanghai and Tianjin), and five autonomous regions (Guangxi, Inner Mongolia, Ningxia, Tibet and Xinjiang). Approximately 2000 counties and 50 cities have county status, with an average population of about half a million inhabitants.

The basic long-term goals for national economic and social development are set out in fifteen-year objectives plans and five-year development plans, as well as the various legislation and policy statements, the most significant of which are submitted to the full session of the National People's Congress.

These development goals are broadly summarised as follows:

- to maintain continued rapid and sound national economic development;
- to promote transformation of the pattern of economic growth;
- to develop the country by scientific and educational means;
- to place agriculture at the forefront of national economic development;
- to alleviate poverty;
- to reform state-owned enterprises as the central link in the reform of the economic system;
- to carry out an opening policy by actively participating in international economic co-operation and competition, and by fully utilising domestic and foreign resources and markets;
- to implement co-ordinated regional economic development to reduce the economic gap between the regions;
- to fully co-ordinate ethics and culture with economic and social development.

To support these goals, the government promises to:

- promote institutional reform and market competition to optimise performance and allocation of resources;
- exploit the potential of existing infrastructure and enhancing the benefits of investment;
- increase the contribution of scientific and technical progress and enhancing the quality of labour;
- promote conservation and multipurpose use of resources, and enhancing the efficiency of resource use;
- optimise enterprise organisation to meet the needs of socialised large scale production and obtain economies of scale;
- accelerate trade reform and circulation efficiency; and
- design planning and industry policy to promote shifts in the mode of economic growth.

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19 As noted in Annex 2, the Fifth Plenary Session of the National People's Congress on April 3, 1992 was asked to consider a resolution to proceed with the Three Gorges water resources project, the largest of its kind in the world. It is intended to provide flood management in the middle and lower reaches of the Yangtze, one of China three first level economic development zones. For an undertaking of this magnitude, significance and controversy, the approval was by no means automatic in Chinese political terms. The vote was 1767 in favour, with 664 deputies abstaining and 177 voting against. The yes vote was thus just 12 clear of the minimum of 1755 or two-thirds of the electorate required to proceed with development of the scheme and came after much internal debate in China about the relative merits of the project.

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The 9th National People's Congress (NPC) (March 1999) also recognised a more prominent role for the private sector in national development.

### 3.1.1 National Development Regions (4) and Zones (12)

Superimposed on the provincial political boundaries are four larger development regions and twelve tiered development zones. The strategic directions for water and energy resource development must also be viewed in the context of the development programmes for the regions and zones.

#### Key Strategic Regions

The concept of a "key strategic region" has been adopted by the government as a basis on which to frame China's regional development strategies and catalysts in the strategic development of China. Funds, resources and talents in these regions are to be allocated in the expectation that this will promote rapid and balanced national economic and social development. With growing urbanisation and all the implications, major cities are at the heart of the strategic regions. Emphasis is also to be given to the many smaller cities within key regions, and more widely, so as to distribute the benefits of development and avoid over-concentration of economic activity in a few mega-cities.

The disparity in the level of development between the east and west is also part of the concern. Thus, while key regions determine the overall structure of regional development, priority in the allocation of development funds is to be given to resource development and construction of infrastructure facilities in interior and western parts of the country. This strategic priority has significant implications for water and energy resource development and particularly large dams.

Twelve key zones fall into four main regions. Together they account for about 10% of the land area, 34% of the population and 58% of the gross national product. They are further classified into three levels depending on their economic status and influence as shown below:

#### Box 3.1: Twelve Strategic Zones in China

<table>
<thead>
<tr>
<th>First Level: (3)</th>
<th>Chang (Yangtze) River Delta Zone, Beijing-Tianjin Capital Zone, Zhu (Pearl) River Delta Zone;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second Level: (6)</td>
<td>Wuhan Economic Zone, Chengdu-Qongking Economic Zone, Guanzhong (Xian, etc.) Economic Zone, Liaodong Peninsula Economic Zone, Shandong Peninsular Economic Zone and Southeastern (Fujian) Economic Zone;</td>
</tr>
<tr>
<td>Third Level: (3)</td>
<td>Beibu Gulf Economic Zone, Urumqi Economic Zone, and Harbin-Changchun Economic Zone.</td>
</tr>
</tbody>
</table>

The three zones at the first level are to play a leading, dynamic role in the national economy (in the north, centre and south, respectively); zones at the second level are to play a predominant role in their local area, and contribute dynamically to national development; and zones at the third level have been identified as being at the initial stages of development but will play an increasingly important role in the longer term.

#### The Pattern of Regional Development

Table 3.1 shows socio-economic data for the strategic key regions, and Figure 3-2 locates these and shows how they are conceived in terms of north-south and east-west strategic development axes. Broadly, three main axes are envisaged from east to west (along the south eastern-southern coast, along the Yangtze valley, and from Shandong through Xian to the interior at Urumqi), bisected by one main north-south axis from Beijing through Wuhan to Guandong, and a further axis along the southern coast.
To illustrate the purpose of these classifications, major international contacts are awarded and the procedures conceived through the three Level 1 economic regions (Beijing-Tianjin, Shanghai and Guangdong), and the experience and practices will be transferred to other zones such as through Urumqi to Central Asia and Russia and through the Yangtze Valley south to continental Southeast Asia. A carefully managed strategic transition to the market economy and engagement of other such economies in the region is planned. There will still be a large element of central control and direction.

Table 3.1: Key Strategic Key Regions

<table>
<thead>
<tr>
<th>Region and Level</th>
<th>Land Area '000 km²</th>
<th>Population Million</th>
<th>GDP B yuan</th>
<th>Population density Pop./km²</th>
<th>GDP/head Yuan/head</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Yangtze Economic Belt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yangtze River Delta Zone</td>
<td>1</td>
<td>100</td>
<td>74.3</td>
<td>1,164</td>
<td>15,673</td>
</tr>
<tr>
<td>Wuhan Economic Zone</td>
<td>2</td>
<td>70</td>
<td>47.5</td>
<td>344</td>
<td>678</td>
</tr>
<tr>
<td>Chengtu-Qongking EZ</td>
<td>2</td>
<td>120</td>
<td>70.8</td>
<td>352</td>
<td>591</td>
</tr>
<tr>
<td>Total</td>
<td>290</td>
<td>192.6</td>
<td>1,860</td>
<td>665</td>
<td>9,656</td>
</tr>
<tr>
<td>2. Bohai Gulf Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beijing-Tianjin Capital EZ</td>
<td>1</td>
<td>52</td>
<td>33.0</td>
<td>427</td>
<td>635</td>
</tr>
<tr>
<td>Shandong Peninsular EZ</td>
<td>2</td>
<td>73</td>
<td>38.0</td>
<td>441</td>
<td>521</td>
</tr>
<tr>
<td>Liaodong Peninsular EZ</td>
<td>2</td>
<td>77</td>
<td>30.0</td>
<td>318</td>
<td>388</td>
</tr>
<tr>
<td>Harbin-Changchun EZ</td>
<td>2</td>
<td>96</td>
<td>38.1</td>
<td>241</td>
<td>294</td>
</tr>
<tr>
<td>Total</td>
<td>298</td>
<td>129.1</td>
<td>1,427</td>
<td>433</td>
<td>11,053</td>
</tr>
<tr>
<td>3. Southeast Coastal Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearl River Delta Zone</td>
<td>1</td>
<td>48</td>
<td>28.2</td>
<td>550</td>
<td>510</td>
</tr>
<tr>
<td>Fujian EZ</td>
<td>2</td>
<td>41</td>
<td>20.8</td>
<td>238</td>
<td>282</td>
</tr>
<tr>
<td>Beibu Gulf EZ</td>
<td>3</td>
<td>77</td>
<td>21.6</td>
<td>117</td>
<td>130</td>
</tr>
<tr>
<td>Total</td>
<td>165</td>
<td>70.6</td>
<td>904</td>
<td>428</td>
<td>12,805</td>
</tr>
<tr>
<td>4. Northwest Inland Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guanzhong EZ</td>
<td>2</td>
<td>51</td>
<td>20.9</td>
<td>101</td>
<td>407</td>
</tr>
<tr>
<td>Urumqi EZ</td>
<td>3</td>
<td>150</td>
<td>5.3</td>
<td>53</td>
<td>35</td>
</tr>
<tr>
<td>Total</td>
<td>201</td>
<td>26.1</td>
<td>154</td>
<td>130</td>
<td>5,890</td>
</tr>
<tr>
<td>5. Four Economic Regions:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>954</td>
<td>418.5</td>
<td>4,345</td>
<td>439</td>
<td>10,383</td>
</tr>
<tr>
<td>% of National Total</td>
<td>9.9%</td>
<td>33.9%</td>
<td>58.1%</td>
<td>340%</td>
<td>172%</td>
</tr>
<tr>
<td>6. Country Total:</td>
<td>9,600</td>
<td>1,236.3</td>
<td>7,477</td>
<td>129</td>
<td>6,048</td>
</tr>
</tbody>
</table>

Source: The Institute of Spatial Planning and Regional Development, 1999
3.1.2 Strategic Development and water and energy considerations

There are many direct and indirect implications for water and energy development that derive from these strategic plans and policies. Energy is considered to be a primary constraining factor to development in the south and in the north. In the interior and west, and more generally with respect to Level 3 economic regions, the constraining factor is regarded to be the overall lack of all types of strategic infrastructure. As transport, urban and related infrastructure – including water infrastructure – improves in the Level 3 regions, economic development is expected to spread rapidly into the interior, up the Yangtze Valley into the Yuan (Red) and Lancang (Mekong) valleys, and via the Silk Road towards Central Asia.

In envisaging interactions with regional development policy and the water sector, both top-down and bottom-up issues need to be considered. With regard to top-down issues, water resources development must always meet the needs of economic and social development. However, there are also (bottom-up) ways in which development of the economy itself will have to adapt to water realities. For instance, water shortages in the north and in arid inland areas will impose limits on the irrigated area and should be reflected in limits on water-intensive industries. This can be directly accounted for in investment decisions, for instance by limiting irrigation or by locating thermal power stations along the coast so that seawater can be used for cooling.

In the market economy setting, however, regulation and incentives are the primary instruments for influencing industrial location decisions, and if these reflect economic realities, appropriate industrial location decisions will follow. Implementation of the water-permit system and the adjustment of incentives to reflect external effects in resource use are two obvious mechanisms the government intends to use to achieving regional development objectives.

In addition to macro-considerations, important interactions exist between water and regional and urban planning at a local level. These interactions are predominantly managed through land-use planning and associated regulations. For instance, social and environmental concerns should be taken into account the location of polluting industries (groundwater, water and airshed and land pollution impacts). Another important area of concern relates to floodplain management. Flood-risk mapping is not yet widespread and deserves greater attention as an aid to planning.
3.2 National Water Resource Policy Priorities

Industry policies for the water sector published by the State Council in December 1997, detail the PRC’s current water policies. These represent the most current guide for implementation of the Water Law and related laws. The policies pertain to all levels and categories of government entities, enterprises, the private sector, and to individuals.

The provisions broadly indicate:

- water resources are owned by the State, and are to be developed and utilised at its discretion. Control is to be exercised through a water-rights system covering the consumptive use of both groundwater and surface water;

- a unified administration of water resources is to be adopted throughout the country. This corresponds to the national level for international and inter-provincial water systems, the provincial level for systems lying wholly within the jurisdiction of a province, and a lower level for local resources and facilities;

- development and utilisation of all water resources (surface and groundwater) is to be integrated with water quality protection;

- comprehensive planning is to take full account of the potential for multiple uses as well as of impacts, in order to achieve maximum benefits;

- water charges are to be levied on all consumptive uses of water (both surface and groundwater) and water service fees are to be levied by service entities so as to achieve cost recovery;

- water conservation is to be achieved using advanced technologies and mechanisms to reduce consumption, generate water savings and promote reuse and recycling.

Implementation procedures, in particular relating to the charging for water services, were also clarified by the Industry Policies for the Water Sector. In general, the policies set out are consistent with the "user pays" and "polluter pays" principle, while allowing ongoing subsidies for social purposes, subject to all users being accountable for efficient water use and for environmental protection.

More specific goals for the water sector can be summarised as follows:

**Flood control**

- strengthen the capacity for flood control for major rivers and lakes (by altering the control structure’s design to withstand increased frequency of the maximum probable flood discharges);
- improve the flood-control system for the key cities of the nation;
- establish a safe construction system, as well as adequate communications and management systems for flood storage and discharge.

**Water supply**

- increase the country’s water supply capacity to 700 billion m³;
- increase the irrigated area by 10 million ha and expand the area by a further 10 million ha by increased efficiency;
- increase the number of domestic water supply facilities (implement 30 000 additional township facilities) and improve the quality standard for potable water.
Extend soil conservation and water resources protection
- increase the controlled soil erosion area (mainly in middle and upper areas of the Yellow and Yangtze) by 700,000 km²;
- protect the sources of potable water for the entire country;
- improve the water quality of all major water sources up to Classes II and III of the national standard;
- alleviate and solve groundwater mining, as well as overexploitation.

Increase the installed hydropower capacity
- increase the country’s hydropower capacity by 20,000 MW;
- expand the rural electrical network (to cover 600 additional counties).

Develop science, technology and education
- develop the water sector by scientific, technological and educational means;
- promote staff technical skills and abilities through education and training.

3.3 China's Legislative and Regulatory Framework for Water Resources Use and Development

The 1982 Constitution of the People's Republic of China established the fundamental resource principles that must be complied with by all central and local government laws, policies and regulations. Deviation from the Constitution is not permissible, although a re-interpretation of the Constitution in response to changing conditions may allow a certain flexibility of its provisions. In several instances, the Constitution has been amended to reflect changing conditions of the country, technology and globalisation. This has not been the case with water and other natural resources. However, the 9th NPC (March 1999) adopted an amendment to the Constitution requiring the application of the "rule of law" to implement the Constitution and all laws of the nation. It also recognised a more prominent role for the private sector. This may enable an adjusted and more flexible interpretation of the principles to fit the needs for good water and related resources management.

Constitutional Provisions on Ownership of Land and Water Resources:
The Constitution contains three articles that specifically address natural resources. Article 9 provides that "all mineral resources, waters, forests, mountains, grasslands, unreclaimed land, beaches and other natural resources are owned by the state..." except for forests, mountains, grasslands and unreclaimed land and beaches owned by collectives by law, and further provides that the "state ensures rational use of natural resources...." Article 10 provides the fundamental principle that "land in cities is owned by the state," but "land in the rural areas and suburban areas is owned by collectives," including house sites and privately farmed plots of cropland and hilly land, except land that belongs to the state under the law. The Constitution further provides in Article 26 that "The state protects and improves the environment in which people live and the ecological environment. It prevents and controls pollution and other public hazards" and "the state organizes and encourages afforestation and the protection of forests."

3.3.1 Water, Energy, Environment and Other Resource Legislation

Until the early 1980s the main focus of China's policy, legislation and regulations was the construction and management of dams and other structural approaches to flood control, irrigation and drainage issues. Starting in 1979 significant and broader changes occurred in how development was perceived in China. Consequently, a broader definition of water and energy management started to emerge and a comprehensive body of new laws and regulations were introduced. In 1981, water laws began and several individual laws and regulations followed. The umbrella Water Law was approved in 1988 and subsequently the Laws for Water and Soil Conservation (1991), and the Law for Flood...
Control (1997) were approved. In parallel a large number of pollution, environment management, health and social development, electricity sector, banking and finance, economic management laws and regulations were developed and approved as part of China's transformation which had cross-sector implications for water resources development.

It is beyond the scope of this paper to provide a full description of the related policies, laws, regulations and decrees at the central level, and their provincial implementing regulations. Generally, it is considered that the body of laws is adequate to manage water and energy resources, and they are constantly being updated, and adapted to changing circumstances of China's social and economic transformation. Central issues in the dams debate may relate more to the capacity to implement the laws that exist, and the strength of the steps to ensure compliance by all the government bodies, "corporations", the private sector and individuals involved or affected.

The following is a brief summary of a few key laws, as they apply in this context.

**Water Law**

The 1988 Water Law is the fundamental and “umbrella” law for water management in the PRC. It was passed on January 21, 1988 and came into force on July 1, 1988. The stated purposes of the Water Law are: to co-ordinate and standardise all activities for the comprehensive development, utilisation and protection of water resources, harnessing of rivers, control of water-related disasters and the basic law to adjust all the social and economic activities and relationships related to water. The Water Law consists of seven chapters and 53 articles. In summary, it:

- declares that water resources (surface and groundwater) are the property of the state, except that water in ponds and reservoirs owned by agricultural collectives is collectively owned;
- establishes that the state shall take effective measures to protect and preserve water resources and the ecological environment;
- sets out a system of centralised and integrated water management from central down to county levels;
- requires data surveys and preparation of comprehensive (basin and regional) plans and professional (specific water issues) plans, involving all relevant levels of government and taking into account the upstream/downstream interests;
- specifically addressing the nature and problems of groundwater extraction;
- identifies priorities of use (domestic, irrigation, industrial, navigation in that order) and specifies the need for multipurpose development;
- establishes a water-permit system for diversions and extractions of water (except small-scale household uses);
- requires levying water charges for water uses; and,
- pays considerable attention to flood-prevention measures, standards and plans, and remediation of flood conditions.

The MWR is charged with implementing the water law, adopting further ministerial and inter-ministerial guidelines for implementation, and overseeing implementation by the provinces and local governments.

Comprehensive and integrated planning and management of inter-provincial river basins is provided for in the Water Law, and more recent measures the ensure better adherence to basin and area plans have been identified. These aspects include working out water allocations in the basin, water quality

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20 There are reportedly over 25 laws at the central level and over 300 laws and regulations at the provincial level that directly or indirectly concern water resources and the water sector.

21 The chapter titles are: General Provisions; Development and Utilization; Protection of Water, River Basins and Water-Related Projects; Management of Water Utility; Prevention and Fight Against Floods and Inundations; Legal Responsibility; and Supplementary Provisions.
improvement and pollution control and the identification of environment effects and management plans. Reportedly not all the River Basin Commissions (RBCs) have submitted such plans as yet.

**Law on Water and Soil Conservation**
The 1991 Water and Soil Conservation Law recognises the inter-relationship between water resources and soil (land) conditions. The primary purposes of this law is to set out the need and ways to prevent and control soil erosion, protect and rationalise the utilisation of water and soil resources, mitigate disasters from floods, droughts and sandstorms, and improve the ecological environment and development of production. The law complements the Water Law in an effort to ensure sustainable development and utilisation of the nation’s land and water resources in a manner that is consistent with protecting the environment. In summary, the law:

- provides for the policy of “prevention first” in undertaking water and soil conservation through overall planning, comprehensive prevention and control, adoption of measures suited for local conditions, strengthening management, and placing emphasis upon beneficial results;
- clarifies responsibilities of governments at all levels for water and soil conservation;
- requires preparation of water and soil conservation plans in co-operation with other departments and the incorporation of these plans into the plans for national economic and social development; mandates governments at all levels to carry out soil and water conservation under specific guidelines, and sets restrictions and conservation requirements on the cutting of forests, cultivation, and construction of rail, highway, water, mining and hydro projects;
- requires rehabilitation of soil erosion in water, wind, and soil-eroded regions.

**Flood Control Law**
The 1997 Flood Control Law is the first law for the prevention and control of natural disasters, and thus fills a gap in the water-legislation system. It requires a unified and integrated planning approach with comprehensive river basin plans prepared by the river basin commissions and at administrative levels of local government, specifically including urban areas. The law introduces the important mechanism of designating “planned reserve zones/areas” in which special rules may apply on the use and activities with the area. It further provides for the operation of reservoirs and other hydraulic works; for multiple-use considerations in river-course realignments and lake embankments; and for a flood impact assessment for any projects in flood-prone areas.

**Water Pollution Control Law**
The first Law for Water Pollution Control was passed in 1984. In the more than ten years since the law was adopted, it was clear the provisions were inadequate for several reasons: water pollution continued to increase; the targets of water pollution control changed greatly; and the legal measures for the control of point sources were unable to stop the decline of water quality.

The law was revised and reissued in 1994. The revised law retained the provision for pollution prevention and control of surface and groundwater through the setting of water-environment quality standards and pollutant-discharge standards. Relevant to the water sector, the new provisions that emphasise unified river basin management; preparation of river basin or regional water-pollution prevention and control plans under the direct control of, or guidance by, the central agency (ie State Environmental Protection Administration [SEPA]) in co-operation with related central and provincial/local agencies. More stringent requirements for protecting receiving waters based on the total quantity of discharges and specific provision for agricultural chemicals and provisions that establish the power to designate protected zones for surface-water sources of domestic and drinking waters were incorporated. A number of administrative regulations have been promulgated on quality standards and pollution control. The SEPA is primarily responsible for implementing this law by setting water-quality standards and issuing water-discharge permits.
Environmental Protection Law
The 1989 Environmental Protection Law is designed to protect and improve the “people’s environment and ecological environment”, prevent and control pollution, and safeguard human health. The law requires that plans for environmental protection are to be incorporated into national economic and social development plans; the establishment of national standards for environmental quality and for the discharge of pollutants; the setting up of monitoring systems and networks; specific relevance to dams, the preparation of an environment impact assessment and statement for construction projects. The wastewater discharge permit requirements and other provisions of the water pollution prevention and control law are applicable under this law, and a separate fee is to be charged for any discharges in excess of the prescribed standards, which fees shall only be used for prevention and control of pollution. Hazardous pollutants are controlled under the law, and anyone causing damages from such hazardous discharges or uses shall eliminate the condition and compensate those adversely affected. The SEPA is primarily responsible for carrying out this law.

Electricity Law
The Electricity Law (1997) focuses on ongoing reforms of the power sector and influences hydropower development. It has three basic themes: to transform the power sector to a corporate management system; to set a commercial orientation for all operations; and to establish the legal and regulatory framework.

The structure of the power industry in the PRC is progressively changing from a top-down administration with state, regional and provincial levels to a more decentralised corporate system. The Electricity Law clarifies details on the future evolution of the power industry structure. Among other factors, it provides direction on mechanisms for the separation of regional and provincial power industry bureaus and enterprise functions in the regional and provincial power companies. It also clarifies the separation of regulatory responsibilities between state and provincial levels and puts forward a framework for decentralised decision-making, giving more authority to regional and provincial power entities.

Mineral Resources Law
The Mineral Resource Law of 1996 seeks to protect irrigation, navigation, and flood control; prevent loss of water; promote environmental ecological protection; and identify underground water as both a water resource and a mineral resource. The law applies to the exploitation of groundwater, while the Water Law applies to development, utilisation, protection and management of water resources. Both must take into account the requirements of the Water and Soil Conservation Law. In 1998, most jurisdiction over groundwater was transferred to the MWR, thus enabling one ministry to be primarily responsible for all quantitative aspects of the water sector. However, the Ministry of Land and Resources has retained or has dual jurisdiction over planning of land and water use, and over prevention of overdraft and pollution control of groundwater. The Ministry of Construction has primary authority to guide urban water supply, water conservation and sanitation.

Administrative Decrees and Regulations
Numerous administrative decrees and regulations have been adopted at national, provincial and local levels. Of particular interest is the recently issued Industry Policy for the Water Sector which defines the characteristics of different classes and categories of projects, promotes the industrialisation of the water sector, promotes water savings and protection of water resources, clarifies financial issues under the Water Law, and places strong emphasis upon the implementation of a system of paying for the use of water resources and for payment of a water resources fee. In this regard, three important steps are required: (i) water use must be measured; (ii) the national water-drawing permit system is to be implemented in accordance with the Regulations for the Implementation of the Water drawing Permit System; and (iii) according to the class of project, the water-service fees will be set and collected.

Gradual Decentralisation of the Authority
In recent years (1993 onwards), the central government has gradually transferred authority and responsibility to the regional government. Projects of national importance are still under the control of
the central government, but provincial governments evaluate projects that are regional in nature, with final approval coming from the central government (in this case, the Ministry of Water Resources). Provincial governments are also responsible for securing financing for projects. Since most of the potential hydro projects are located in remote provinces, local officials usually do not have much experience dealing with organisations such as the World Bank and Asia Development Bank. The resulting confusion often delays project implementation. There is a clear need for clear lines of authority and for decisions not to be needlessly reviewed or referred to higher authority. There is also a need for local authorities to be adequately resources to handle projects for which they have responsibility.

3.3.2 Land Tenure, Acquisition, Resettlement and Compensation

In addition to the above laws, reforms are ongoing in social legislation and land administration that impact on dams development practices, particularly in regard to planning, participation in planning and resettlement including provisions for compensation, sharing in project benefits and follow-up support to resettled communities to help restore livelihoods.

The Legal Framework section of Annex 4 of this paper, "Shuikou Hydroelectric Project: Findings Of The Resettlement Study" describes some of these legal provisions for resettlement and some of the issues encountered with the implementation of measures under the provisions. Section 5.1.1 also addresses some of the social provisions. Appendix A includes comments on the draft version of this paper, which also provides and much deeper critique of the inadequacies of China's policies and their implementation. This was prepared by international NGOs. Among the concerns expressed are those on human rights and involuntary displacement in China, concerns over the limitations in the scope of the resettlement policies, and concerns about corruption and implementation failure in resettlement and compensation, as reported in the Chinese media.

These laws and regulations nevertheless state and include broadly:

**Land Tenure:** According to China's 1982 constitution, urban land belongs to the State, while rural land is owned by collectives, except those areas stipulated by law as State land (Article 10). These provisions formed the basis of the 1986 Land Administration Law, which also included detailed provisions on land usage. Under these provisions both State and collective-owned land may be allocated to be used by individuals for their own use. The use and management of rural land may also be contracted to collectives or individuals. In both cases, individuals and collectives have the responsibility for protecting and managing the land and making rational use of it in accordance with the terms of the allocation or contract. Because of the nature of collective ownership, a village losing some land through state requisition is able to redistribute its remaining land holdings among village members so that none will be left without land to farm. The ability to redistribute remaining land resources among villages greatly facilitates the resettlement process in China.

**Land Acquisition** National land requisition regulations were also issued in 1982. These regulations affirm the right of the State to requisition land from collectives for construction, define the procedures for land requisition and resettlement and the responsibilities of the parties. Compensation rates for cultivated land are specified to be within the range of three to six times of the average annual output value in the past three years. Provincial governments have the responsibility to stipulate standards of compensation for other types of land with reference to the standard for cultivated land. In addition to land compensation, the regulations provided for a resettlement subsidy to finance provisions for restoration of production. This subsidy is paid on a per capita basis based on the “agricultural population to be resettled’. This is calculated by dividing the area of cultivated land requisitioned by the average amount of cultivated land per person of the collective, before land requisition.

The regulations further provided that if land compensation and resettlement subsidies are still insufficient to restore farmers living standards to previous levels, the resettlement subsidy may be
further increased, with the approval of the provincial government, provided that combined land compensation and resettlement subsidy shall not exceed 20 times average annual output value of the cultivated land requisitioned. As in the case of compensation standards, provincial governments have the responsibility to stipulate standards for resettlement subsidies for other types of land (orchards, fishponds, pasturelands etc.) with reference to the standard for cultivated land.

Under the regulations, all compensation and resettlement subsidies, except for compensation for individually owned property on the land and non-harvested crops from land being contracted to an individual, are to be paid to the collective to finance the development of a new production base, find jobs for surplus labourers, and provide subsidies for those who cannot be employed. Funds shall not, in any circumstances, be diverted for other purposes. The Land Administration Law further specifies that compensation funds received are shared equally by all village members and may be used individually or collectively to either develop new production systems or improve existing production capabilities.

**Provincial Regulations**

The national land requisition regulations delegated specification of detailed measures in several areas to provincial governments.

**Resettlement for Water Conservation and Hydroelectric Projects**

The land requisition regulations provided that methods for relocating and resettling people in these projects would be stipulated separately by relevant national agencies. Regulations lay down the following basic principles for reservoir resettlement:

- the government advocates and supports resettlement with development and adopts the approach of giving compensation in the early stages of resettlement and providing rehabilitation assistance after displacement;
- benefits to the nation, communities and individuals should be considered in an integrated manner;
- resettlement shall be synchronized with resource development, soil and water conservation and economic development in the reservoir area;
- all displaced persons shall be assisted to improve or at least restore their former living standard in steps;
- resettlement should be planned taking full consideration of local conditions and available resources;
- if conditions allow, displaced people should be resettled as near as possible Otherwise alternatives such as reclamation of wasteland, land re-consolidation and moving to other areas should be considered.

More specific compensation and resettlement subsidy standards are also specified within the ranges laid down in the general land requisition regulations. However, they do provide that for large scale flood control, irrigation or drainage projects (not hydropower), land compensation standards could be reduced, with detailed standards negotiated between MWR and concerned departments.

Supplementary benefits to resettled people, beyond compensation and resettlement subsidies, are also stipulated:

- government to establish a reservoir construction fund to finance resettlement site maintenance and production development;
- communities affected by hydropower plant construction to be electrified, with preferential tariffs for irrigation and drainage;
- priority to be given for displaced persons to use water surface and reservoir drawdown areas;
- priority to be given to resettlement communities in government budgetary support for agriculture, communications, culture, education and health care, and to employment in government construction projects;
government support to economic rehabilitation efforts to extend for five to ten years after displacement.

3.4 Power Policies and Sector Reform

China's electric power industry is now the third largest in the world. Long-range planning by government has identified targets of between 650 000 MW and 670 000 MW of installed capacity by 2010 and upwards of 1.1 GW by the year 2020. The broad thrust of the national strategy for new capacity additions is threefold, with simultaneous pursuit of:

- mine-mouth, coal-fired generation in the north of the country;
- hydro plants in the south and central and western areas; and
- nuclear along the heavily populated southern and coastal areas.

Power development plans of individual provinces and regional power supply companies will also take advantage of co-generation and other opportunities with the energy resources available locally. Regional interchange of power similar to power pooling practices in Europe and North America are expected to evolve after main regional power groups are strongly interconnected with adequate HV transmission facilities.

In view of the growing supply requirements, laws to permit independent generation were initially introduced in the mid 1980s by the Central Government. While the policy on private sector participation is in transition, some reports indicated that half the new generation in the longer term may be expected to come from independent generation, also involving the private sector participation in BOT, BOOT and BOO schemes.

As noted in the Electricity Law 1997, the structure of the power industry in the PRC is progressively changing from the vertically integrated, three tiered administration with state, regional and provincial levels to a more decentralised corporate system. Sectoral reforms started in the 1980s accelerated in the 1990s. Some measures have been introduced as part of broader market and state-enterprise reforms; other measures which have been introduced, or in the process of being introduced through MOEP, include:

- decentralisation of decision-making to give greater autonomy to regional and provincial power entities, with a corresponding increase in accountability;
- conversion of regional and provincial-level Power (Industry) Bureaux to Power Companies, with the aim to separate administration and regulatory functions from the management of the commercial functions in the new companies;
- implementation of improvements in management systems in the new power companies and their subsidiaries, to speed the adoption of commercial practices in the industry;
- introduction of more commercially-based relationships, including contracts, between industry participants, competition, external investment and diversification of ownership in power generation, and;
- preparation of the legal and regulatory framework necessary to support the new industry structure, and diversification of ownership and investment.

In February 2000 it was announced that the policy would be to eventually provide up to 40% of electric supply from hydropower, up considerably from the 19% overall. More recently it has been suggested that policies are being considered to set quotas for the minimum generation of from renewable sources at 5% for each province. The government sees this is one part of a more comprehensive strategy for
power sector reform, to reduce dependence on coal-based generation accounting for 80% of power generation, to significantly reduce air pollution and GHG emissions in the Chinese economy, and to promote sustainable energy development in China and the East Asia region. Some critics internationally suggest the policy is a justification only to build more large hydropower dams, and that more emphasis and funding than is currently provided should be allocated for demand-side management and efficiency measures and small-scale and decentralised renewable energy development.22

3.5 Institutional Framework for Water and Energy Resource Development

The overall institutional arrangements for the planning, design and operations of large dams and the management of river basins is undergoing change in China. Some of the changes are to adapt to the devolution of powers from the centre accompanying the transformation to a market economy. Other changes are to address strategic development priorities such as poverty alleviation, problem areas seen as impediments to growth overall, water scarcity and competition for water, floods and the accelerating deterioration in the quality of the environment (especially water and air quality as it threatens the health and livelihood of people), and threats to the ecosystem which may have more profound implications for China, its development prospects and quality of life in the longer term.

3.5.1 Roles of different levels of Government

The highest administrative authority is the State Council. Functional organisations such as committees and ministries fall under the State Council (e.g. the MWR, the State Development and Planning Commission [SDPC]). Comparable entities are also found at the provincial, prefecture (administrative and autonomous) and county/city levels. Township/village entities are supervised by county governments. In addition to the technical ministries and departments, two other lines of authority have a crucial bearing on water resources administration. These are the civil administration and the Communist Party.

The National People's Congress, State Council and its various ministries, most of which report to it, dominate central government functions in the area of water resources. The provinces have no inherent powers other than those delegated by the Central Government, but with the increased level of delegation apparent in recent times, they have come to exercise substantial power within the evolving political system. In contrast, the autonomous regions have an inherent autonomous status within the framework of the Law.

According to Article 9 of the PRC’s Water Law:

- the National People's Congress, through its State Council, provides the national focus, policy plans and budget, and directs national programs, most of which are oriented directly or indirectly towards meeting the country's national goals. On behalf of its citizens, it is the trustee for ownership and utilisation of the country’s water resources;
- the MWR directly manages major river basins and inter-provincial bulk services;
- the SDPC has major review and approval roles concerning programs and projects;
- other ministries with direct or indirect responsibilities that bear on water resources management include the following ministries: Construction, Geology and Mineral Resources, Energy, Finance, Public Health, Forestry, Agriculture and Civil Affairs;

22 Troubles Ahead for China Dam Project, Stratfor.com's Global Intelligence Update October 2000, [http://www.stratfor.com/asia/default.htm](http://www.stratfor.com/asia/default.htm) noting that: "Environmental regulators will soon require each Chinese province to supply 5.5 percent of its power from renewable resources. This is most likely a means of subsidizing hydropower stations in the country's slow-growing inland provinces, where electricity buyers are harder to find. It's also a way to redistribute coastal wealth to China's interior and help reduce economic disparities between regions of the country."
the SEPA, under the State Council, manages environmental protection work throughout the country. It is required to establish a system for monitoring compliance to be effected by respective departments of the central government and parallel entities at the local levels.

Local governments – provincial, county and township/village – focus on the immediate and specific needs of their residents and the economy of their respective jurisdictions. Provincial governments play a lead role as the decentralised trustee of the nation's water resources within their boundaries. Local government is most heavily engaged in local planning, oversight and providing services that increasingly dominate government functions at these lower levels.

Provinces and local governments may adopt additional standards in areas not covered by the national standards, which can also be more stringent. Local governments are responsible for designating and protecting areas of local and national interest according to classifications in the law. Soil conservation receives special attention, and Environmental Impact Statements are required for all activities that may affect the environment.

3.5.2 Roles and Functions of State Ministries

The following table describes the functions of the various water-sector institutions in the PRC at the central or state level.

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<th>Ministry of Water Resources (MWR)</th>
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<tr>
<td>- Has the highest administrative responsibility for managing the nation's water resources</td>
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<td>- Formulates policies and develops mid- to long-term plans and strategies for the water sector; drafts related laws and regulations; oversees their implementation and enforcement</td>
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<td>- Implements integrated water administration throughout the entire country; formulates national and trans-provincial long-term water supply-and-demand plans, as well as water allocation plans; monitors their implementation; organizes flood-control and drought-fighting studies; monitors flood-control work; implements the water-extraction permit and fee-collection systems</td>
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<tr>
<td>- Gathers hydrological data and issues the national bulletin for water resources</td>
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<td>- Formulates policies and plans for water conservation; organizes and monitors water-saving works</td>
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<td>- Organizes national water and soil conservation activities; formulates engineering measures; monitors soil erosion</td>
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<td>- Formulates plans for water resources protection; organizes the control of waste discharge to water bodies; monitors surface-water quantity and quality</td>
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<td>- Organizes and supervises law enforcement; arbitrates water-related conflicts among sectors and provinces</td>
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<td>- Formulates economic regulation measures for the water sector, including macro-regulations for fund and diversified economic activities; conducts studies on economic regulations such as pricing, taxation, credit loans, finance, etc.</td>
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<td>- Reviews feasibility studies for large- and medium-sized water projects; organizes studies for important research projects; formulates standards and codes for water works and oversees their implementation; organizes and manages the construction of important or transprovincial projects; monitors dam safety</td>
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<tr>
<td>- Organizes and coordinates construction of farmland irrigation and drainage facilities, rural hydro-electrification and township water supply</td>
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<td>- Manages international river affairs</td>
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<td>- Manages the water sector's scientific activities; guides its human-resources development and capacity building;</td>
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<td>- Provides technical guidance to provincial water resources bureaus and departments</td>
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<td>- Chairs the National Water Resources Coordinating Group</td>
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<tr>
<td>- Through the RBCs, organizes water allocation on inter-provincial rivers among the provinces (with the State Council making the final decisions).</td>
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Ministry of Construction
Oversees urban water supply and conservation; guides the development and use of groundwater in urban areas

Ministry of Civil Affairs (MCA)
Resettles and compensates displaced populations

Ministry of Finance
Administers governmental financial allocations for capital construction and operating expenses

River Basin Water Resources Commissions (RBC)
- Monitor safety of RBC dams and major river levees
- Assist local government with implementation of the Water Law
- Manage flood-control facilities and programs
- Prepare basin-water resources strategies and multipurpose development of the resources
- Resolve water-related conflicts among provinces and sectors.

3.5.3 Roles of River Basin Commissions (RBC’s)

As noted in the discussion on the Water Law (1988), and more recently the Industrial Policy for the Water Sector, reconfirm and make provisions for integrated planning and management of trans-provincial rivers. It is increasingly recognised within the government and professional communities in China that the scope and scale of the water management problems is such that it threatens overall economic development and growth, and now with some urgency requires basin level actions. There is also a need for reconciliation of competing interest of different sectors of the economy, of nature and the provinces. Accordingly, seven river basin commissions (RBC) have been set up as units of MWR: (a) Yangtze, (b) Yellow, (c) Huanhe, (d) Haihe, (e) Pearl, (f) Song-Liaohe and (g) Taihu (lake). Some have existed for several decades. The Yellow River RBC was originally set up in 1918 and the Yangtze in 1922 and the Pearl in 1929. However, it is clear that the RBCs have not taken or been permitted to take a leading role in planning and management as envisaged in the legislation that led to their establishment.

Stemming from the 1988 Water Law the roles of the RBCs are tailored, within a framework, to the individual basins. Common responsibilities include: (a) to aid local government with implementing the Water Law; (b) to manage flood control facilities and programmes; (c) to prepare basin-water-resources plans and multipurpose development of the resources; and (d) to resolve water conflicts among provinces and sectors. The RBCs prepare the basis for allocating water among provinces from common sources, help local governments with data collection, resources evaluation and environmental monitoring and house MWR’s specialised Water Conservancy Commissions. Some RBCs have real-time water project operations responsibilities for major multipurpose facilities and flood-control operations during the event. During most flood events, the Ministry retains control for operations.

There is still debate and uncertainty over the future role of basin entities. In particular, should their power be increased or should more power be given to the provinces? The RBCs' role is defined in the provisions of the Flood Control Law. The RBC’s are said to be more active in flood protection and have developed and managed some multipurpose water resources project. The general scope of their authority appears to be planning and co-ordination and some have prepared basin water strategies. There are nevertheless serious inconsistencies between the basin and other plans and local
governments may ignore its provisions. Water allocation among rural and urban entities is uncoordinated and split between two central ministries. In turn, these activities conflict with basic responsibilities for resources management, stewardship and services assigned to the provinces.

As with national plans, basin planning efforts to date have largely been a consolidation of provincial plans. Most basin plans are complete to the extent that they exist and inter-provincial allocations remain uncertain except for general allocations on the Yellow. However, the central government has aided in securing agreements to allocate water among riparian provinces in several small basins.

The jurisdictional issues are getting more complex given the various intra- and interbasin transfers planned in the Ninth Five year Plan on the Yellow and Da rivers to Shanxi province and from the Bi to Lian province.

It is not immediately apparent to outside observers how China will resolve these complications and contradictions due to the many jurisdictions involved. However, government resolve to move in the direction of greater integration in basin planning and management appears clear.

3.6 Institutional roles in planning, development and operation of large dams in the PRC

This MWR has responsibility for irrigation, flood management and other multipurpose dams, together with its oversight of the RBCs, while the power authorities have jurisdiction over single purpose hydropower dams. The national and provincial and water departments are responsible for enforcement of regulations at their respective levels.

3.6.1 Planning and Design of Dams

Specialised design institutes under MWR and the provincial design institutes, and the parallel bodies in the power sector, plan and design most of the dams in the PRC. For large externally financed dams, these institutes usually team up with international consulting firms and there is usually an independent consulting panel.

The power companies do system planning which provides the context for the feasibility study of hydropower dams, while the RBCs, ostensibly, and together with the provincial agencies would provide the planning context for the feasibility study of dams for other purposes. These bodies focus almost exclusively on problems associated with the dam itself and give little attention to induced social and infrastructural problems.

The Environment Protection Law requires that EIA and SIA studies be conducted for large-scale water resources projects such as dams. By law they are required to be undertaken as part of the project evaluation and justification studies. In the design phase, the EIA and SIA must be performed and the results incorporated into the project design. The MWR has a social and environmental unit and affiliated institutions that would lend support on these aspects, and design institutes are generally acquiring more capacity in these areas, but thus can vary widely. As noted in Section 5 of this paper, the various provincial departments may also be involved in both preparation and review of the project studies for all water and energy resources projects, including dams.

Among the stated objectives of the Water Law are greater participation in the planning and management of water resources projects. It is noted that public participation in encouraged in all stages of planning and review of projects. Professional associations are encouraged, however, except for the Three Gorges Project there is no clear information on extensive public and local participation in design review or project approval processes, with the exception of the resettlement and environmental mitigation programmes.
3.6.2 Construction of Dams

Specialised construction teams usually carry out construction of locally financed dams. In the past, contracts were negotiated with the bureau that were branches of the infrastructure ministries (e.g., MWR and Energy), but national competitive bidding is now the norm. Large externally financed dams are built under contracts procured through international competitive bidding and often involve joint venture for civil works as well as electrical and mechanical. It is China’s policy to ensure international technology transfer. Thus for the Three Gorges Project, while the initial units will be manufactured and supplied from outside China, subsequent units will be produced locally under technology transfer schemes.

Lengthy construction periods were common in the past on locally financed projects, in part because of a shortage of funds and wide fluctuations in annual budgets, and in part because of weaknesses in project organisation and construction management. A problem for projects in the PRC has been the lack of a clear separation of the roles and responsibilities of the owner, the engineer and the contractor. This has in past lead to conflicts of interest when construction was in the hands of an entity controlled by the owner, and the owner sets up a unit to act as the engineer.

On externally financed projects, responsibilities are now defined and this practice is increasingly being adopted on projects with no external finance.

3.6.3 Operation and Maintenance of Dams

Dams are owned and operated by provinces, prefectures or irrigation districts. For large dams of special importance, semi-autonomous agencies are set up to be owners and operators. The MWR and RBC usually set operating rules for large dams for the basin where the dam is located. In some basins such as the Hai and Huai there are many medium to small sized dams operated primarily for flood control and they simply follow a rule curve which keeps the pool level down until the end of the flood season.

Dam operation in the PRC covers a wide range of practices that reflect the varying regional capabilities, objectives, and the conditions faced by the various dam owners. The smaller owners – such as cities or counties, which typically run one dam of small to medium size – operate on the basis of the inflow and the season of the year. They do not have sophisticated planning and management tools to help them determine the optimal release taking into account demands and predicted conditions. Some dam management units do not have a flood forecasting capability to optimise management of the reserves. Under these conditions, many operators are obliged to rely on conservative operation rules that favour safe reservoir levels but may unduly penalise the dam’s productivity. The larger owners may possess management units equipped with highly experienced personnel assisted by forecasting and management systems.

In general, the PRC’s dams, especially in the small to medium category, are operated individually rather than within a river basin system. The management of dams and reservoirs belonging to different owners is usually not co-ordinated along hydrological boundaries, and jurisdiction on dams follows provincial or county borders rather than river basin limits. The potential benefits to some river basins, in terms of the optimal integrated management of the basin’s resources, are thus not realised. Dam safety management and evaluation is also not usually integrated within a hydrographic basin. Flood Control Headquarters are an exception to this rule in that they co-ordinate the management of flood events along hydrographic lines during the flood season.

Maintenance, in general, covers the essentials, but many provinces report a considerable backlog of work to upgrade the older dams, especially the need to increase spillway capacity. Some reservoirs have lost capacity through sedimentation and where possible the dams will be raised. As noted in
Most of the dam management units in the medium to large size categories are equipped with flood forecasting systems based on watershed modelling. These models provide information on the inflow to the reservoir calculated from measured rainfall throughout the basin. This approach provides a warming lead-time that depends on the watershed’s lag time. In a medium-sized basin, the advance warning is of the order of a few hours.

Operation and maintenance is carried out by resident personnel of the dam management units, which typically have a maintenance program tied to the dates of the flood season, including a mandatory check on the gates and gate operating mechanisms before the flood season. Most of the dam management units in the medium- to large-size categories are equipped with flood forecasting systems based on watershed modelling. These models provide information on the inflow to the reservoir calculated from measured rainfall throughout the basin. This approach provides a warming lead-time that depends on the watershed’s lag time. In a medium-sized basin, the advance warning is of the order of a few hours.

### 3.6.4 Dam Safety

Regulatory requirements for surveillance and inspection dams are embodied in the “Regulations for Dam Safety Management” issued by the State Council in 1991. Regulations concentrate on the methods of data interpretation and the calculation methods used to evaluate safety from measurements or instrument readings.

The Ministry of Water Resources (MWR) has broad responsibility for the safety of dams and flood levees throughout the country. There are two National Dam Safety Centres. The centre for concrete dams is located in Hongzhou; the one for earth and rockfill dams is in Nanjing. The MWR has issued numerous dam safety guidelines and regulations: Safety Management of Reservoir Dams; Flood Control Criteria; Evaluation Procedures for Reservoir Dams; and the 1991 Regulation of Dam Safety Management. The regulation, Law of Flood Control for PRC (January 1998), requires that emergency-preparedness plans be established for each dam that is above a certain size. Plans list people to contact and actions to take in an emergency.

Chinese sources describe some notable dam failures in the PRC. In August 1975, a typhoon created a maximum 24-hour rainfall of 1 005 mm and a three-day rainfall of 1 605 mm in Henan Province. This unprecedented event caused the failure of the Banqiao Reservoir on the upper reach of the Ruhe River. The flood caused by the typhoon combined with the dam failure inundated more than one million ha of land, over 100 km of the Beijing-Guangzhou railway line was damaged, and more than 20 000 lives were lost. In 1993, the Gouhou Dam in Qinghai Province failed when the concrete slab on the rockfill ruptured and 1 200 people died.

The recent Dam Safety Management and Monitoring Project (1999) recommended the establishment of a Dam Safety Regulatory Agency to assume responsibility for dam safety management. Its proposed tasks include advice and assistance to the MWR in drafting regulations, taking responsibility for enforcement for dam safety and overseeing the production of guidelines and standards for inspection and safety appraisals. Recommendations included the need for new regulations and guidelines to cover the areas of owners’ responsibilities, frequency of inspections, record-keeping requirements, qualification of personnel, etc. Approval of these recommendations is anticipated. The present action plan sets a date of completion of the regulations and institutional arrangements for the end of 2003.

The main weakness observed in medium and small dams is the insufficient analysis and interpretation of inspection results and instrument readings. In some dams, inspection records are either unavailable or not readily usable; in other cases, vital design information is unavailable at the site.
Regulatory requirements for surveillance and inspection dams are embodied in the “Regulations for Dam Safety Management” issued by the State Council in 1991. Regulations concentrate on the methods of data interpretation and the calculation methods used to evaluate safety from measurements or instrument readings. The frequency of inspection and the requirements for personnel and record keeping are not covered in detail.

The most important limitation on management in many cases is the lack of experienced and qualified personnel. Installation of automatic instruments, such as an Automatic Data Acquisition System (ADAS) to continuously monitor the behaviour of the dam, increase the need for qualified personnel. The number of people available to the dam management units is sufficient, even excessive; however, additional personnel (estimated at around 6,000) trained in surveillance, data validation and interpretation functions, regular inspections, and flood forecasting and reservoir management are needed. It is expected that, as manpower costs escalate in the PRC due to economic changes, the trend towards automatisation will grow in the future, emphasising the need for training in the fields of telecommunications, data processing and interpretation. Financial resources are required for manpower training, purchase of automated equipment, and to maintain adequate institutional arrangements for the proper discharge of responsibilities.

3.6.5 Basic Data Collection and Management

Hydrological data is collected, and to varying degree analysed, by several entities in the PRC. Responsibility for basic surface-water hydrology rests with MWR, Department of Hydrology (DH). Differing from other MWR departments, DH has staff in the seven RBCs and at the provincial level and below. All entities report directly to departmental headquarters – not the respective levels of government. Thus, there is the framework of a national agency following uniform procedures and utilising a countrywide network of monitoring sites. These units gather stream channel stage and more limited information on discharge and water quality.

Separately, MWR-linked departments are responsible for groundwater data in all areas; however, these departments focus on rural areas, while MGMR is responsible for groundwater data – and review of allocations – in the urban areas. However, MGMR-linked units also collect information in the rural area, and in greater detail than MWR. The groundwater data include water levels, quality, and limited information on extraction. Some units have constructed groundwater models for critical management areas, but few cover entire groundwater basins. There is no enforced co-ordination or exchange of information among the agencies, even those working on the same groundwater basin.

A provincial committee composed of representatives of the departments of water resources, geology and mineral resources and environment is to co-ordinate activities among these agencies, but results demonstrate inherent ineffectiveness and conflicts among the departments. The constraints imposed by the ranking system seem to prevent even provinces from assigning departmental responsibilities to bring order to the administration of these critical functions.

Except during flood emergencies, all users of both surface and groundwater hydrologic information must pay for the data. As a result, critical resources-management actions are based on little or marginally current data. Planning agencies depend on this source of information, but have limited budgets. Without assured funding, they cannot contract data-collection entities for long-term data programs. With rare exception, local governments allocate groundwater and use licenses without reference to adequate, if any, data – or water plan - even though they have a need for more localised information. Some collect data in the course of their operations that are not readily available to others without payment.

The State Meteorological Administration, independent of any ministry, gathers precipitation, temperature, evaporation and related data. However, only weekly forecasts are issued free to the press. Charges are levied for all other information. Yearbooks on daily data were free of charge until
the mid-1980s. Now no yearbooks are prepared and charges are made for all data, regardless of its nature or use, based upon the number of numerical characters in the request. "Privatisation" has frustrated efforts to improve agency functions; indeed, the functions have deteriorated.

The deficiencies in data quality, the limited coverage, and lack of timely analysis and distribution of findings only to those who can pay are serious shortcomings that directly affect the PRC's responsible resource development. The policy to charge government agencies for these data ensures poor planning, poor operations and poor, extremely costly decisions. It ensures uncertain budgets for the data agencies for what should be a continuing stable program. Implementation of sound national policies, from planning to reality will be hampered until the matter of funding data programmes and removing charges is reviewed.
4. Perspectives on Dams and Alternatives for Providing Water and Energy Services in China

This section considers some of the options that China has for providing water and energy services and some of the issues it faces in deciding among options – which may or may not involve large dams. Clearly it is not possible to list, or even begin to describe the full nature and the advantages and disadvantages all the options that are available to satisfy needs for improving or expanding water and energy services in China. Rather the intention here is to convey an impression of the strategic choices and challenges China has to face.

4.1 Two Strategic Challenges

Two issues are used to illustrate challenges and the context for deciding among options. These two issues are almost at opposite ends of the water management spectrum. The first is the water scarcity situation on the north China plain, which has suffered a rapid decline in ground water levels and a drying up of the main rivers and lakes in the region. This area was subject to an intense drought in 1999, and produces as much as 40% of China's grain. The second issue is flood management in the Yangtze River, the world's third largest river and host to intense monsoon storms, including the devastating 1998 floods.

4.1.1 Water-Scarcity on the North China Plain

Water is scarce in the 3-H basins of north China (Table 4.1). Scarcity is most acute in the Hai basin (which includes Beijing) and somewhat less severe in the Huang (Yellow) and Huai basins. A few relatively small countries in the Middle East and North Africa face greater scarcity, but no other region in the world has anything like the same population dependant on so little water. For instance, per capita supplies in Egypt and Morocco, countries often said to be water-scarce, are double those in the 3-H region. However, and despite this scarcity, water use in the 3-H region is still high by international standards. This is so for agriculture (270 m³/hd) and even more so for domestic and industrial uses (57 m³/hd). Withdrawals are equivalent to about two-thirds of renewable supplies and those in the Hai basin now exceed sustainable yield. Most rivers run dry for long periods, including the Yellow River for up to 180 days or more, and groundwater extractions are well beyond their sustainable yield, again especially in the Hai basin. With minimal dry season dilution capacity, water pollution and environmental degradation are pervasive.

Table 4.1: Water Availability: 3-H Basins, Yangtze Basin and all-China

<table>
<thead>
<tr>
<th>Basin</th>
<th>Population: million</th>
<th>Net renewable resources m³/hd</th>
<th>Availability net of transfers: m³/hd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hai</td>
<td>130</td>
<td>330</td>
<td>375</td>
</tr>
<tr>
<td>Yellow</td>
<td>110</td>
<td>680</td>
<td>600</td>
</tr>
<tr>
<td>Huai</td>
<td>210</td>
<td>460</td>
<td>500</td>
</tr>
<tr>
<td>3-H</td>
<td>450</td>
<td>475</td>
<td>485</td>
</tr>
<tr>
<td>Basins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yangtze</td>
<td>440</td>
<td>2,190</td>
<td>2,180</td>
</tr>
<tr>
<td>China</td>
<td>280</td>
<td>2,200</td>
<td>2,200</td>
</tr>
</tbody>
</table>


In contrast to north China, water is abundant in the Yangtze basin where availability per head is similar to the all-China average. Limited transfers are already made from the Yangtze to the Huai basin, and the option of much larger transfers via the south-north transfer scheme has been under detailed study for more than thirty years. Prima facie there is a clear rationale for such a project and...
some detailed studies have implied that it could be economically attractive\textsuperscript{23}. Three alternative routes have been designated which together could transfer up to 50-60 bcm per year, equivalent to 5%-6% of renewable supplies in the (exporting) Yangtze basin, but 23%-28% of those in the (importing) 3-H basins. In practice, if the project goes ahead, construction would be staged and the final amount could fall well short of this total. Most attention has been given to the middle route, taking off by gravity from an existing reservoir on the Han river and subsequently crossing the Yellow River towards Beijing; and the eastern route, starting at an existing pump station and requiring successive lifts that would inter-connect lakes, rivers and canals, again with a possible extension across the Yellow river\textsuperscript{24}.

Estimates made by the government in 1993 suggested costs at about 40 billion yuan and 20 billion yuan for the middle and eastern routes respectively (US$7 billion and US$3.5 billion, respectively, at the then exchange rate). However, not all items seem to have been included and costs have risen considerably since 1993. The project could thus be enormously expensive, of the same order of magnitude as the Three Gorges Dam (the costs of which were estimated at 90 billion yuan, also in 1993). Moreover, social and environmental concerns have been raised, in particular relating to the basins of origin. Difficult questions remain, therefore, concerning the project's phasing and justification.

**Water Transfers and the Regional Economy**

It would be unreasonable to attempt to second-guess the comprehensive studies that have evaluated the opportunity cost of water on the North China Plain and the implied justification for the South-North Transfer scheme. But no matter how competent such studies are, major uncertainties will always remain. In the last resort, the decision whether or not to go ahead will be political and in many ways will have to be an act of faith. Above all it will depend on a strategic choice between two visions of the future development of the regional economy of north China.

Despite acute water constraints, and rapid urban and industrial growth, the 3-H region remains rural in character relative to that of the economy of China as a whole. Thus, they account for about 40% of China's gross agricultural output and 42% of the irrigated area but for only 31% of industrial output and 23% of the urban population. Reflecting its rural character, income per head is marginally below the national average, with the region accounting for 35% of China's population but for only 33% of its GDP. The poor inland provinces of the Yellow River basin depress the regional average. Beijing, Tianjin and the coastal provinces raise it.

Since 1978, agricultural output and regional GDP have lagged in the poor inland provinces of the Yellow River basin, but on the North China Plain have risen at rates that are equal to or even exceed the national average (Table 4.2). This may seem surprising given that rainfall is a low 700-900 mm and that the 3-H basins account for just 15% of China's land area and 7.5% of renewable water. Even so, there are few indications that agricultural output growth is slowing. In Hebei, for instance, which comprises more than 50% of the Hai basin, gross agricultural output between 1990-97 rose at current prices by more than 60% compared to less than 40% for China as a whole. Thus, though the Hai basin has long faced "physical water stress" as defined by IWMI\textsuperscript{25}, robust agricultural growth continues and there have been few signs of the setbacks to agricultural growth and food-grain output that some observers have anticipated\textsuperscript{26}.


\textsuperscript{24} Ministry of Water Resources: "Brief Introduction of the Planning for South-to-North Water Transfers", Beijing, 1996.


\textsuperscript{26} e.g. Lestor Brown: "Who will feed China? Wake-up call for a small planet". New York, W.W. Norton & Company, 1994.
One obvious explanation is that North China is living on borrowed time. There has been an explosive growth in groundwater extractions which now account for some 60% of withdrawals in the Hai and 30% in the other two basins. Deep confined aquifers are exploited especially for city supplies and shallow aquifers, especially for irrigation. Dams have been built on many rivers, but storage in the Hai, Huai and lower Yellow basins is primarily reserved for flood protection. Intermittent surface supplies and recharge from canals and drains have underpinned the shift to groundwater, which provides local control and supports high return agriculture. The result has been unsustainable use. Though exploitation of shallow aquifers is in principle self-regulating, they are vulnerable to pollution and the impacts associated with confined aquifers can be irreversible leading to consolidation, loss of storage capacity and seawater intrusion.

Unsustainable use by definition cannot be sustained. But it is important to recognise how it will come to an end. It will not happen suddenly. Rather there will be a process of attrition as ground-water yields decline, pumping heads become uneconomic, city managers find alternative if higher cost sources, farmers respond in their cropping practice and investments, and operating holdings consolidate. Agricultural water use per head is surprisingly high by world standards and water will of necessity shift out of irrigation in some locations, indeed this is already happening due to urban spread and a few market-like transfers (e.g. Qingdao in Shandong province). Agricultural activities that can support higher water costs will tend to survive, low-return or poorly situated irrigators will revert to rainfed farming or go out of business. The more rapidly irrigation supplies contract, the more rapid will be this process of rural restructuring. Employment outside agriculture and migration to the cities will relieve pressures in rural areas, and both promote and complement rural restructuring by providing markets for commercial and diversified farming.

What seems to be happening is that farmer responses have been more than adequate to offset the increasingly restricted water supply and so the value of output has continued to increase (Table 4.2). There is no reason why these offsetting pressures should not continue indefinitely. No doubt the balance will change as water constraints bite more sharply. But agriculture still accounts for more than 70% of all water use, even in the Hai basin, and provided economic expansion and structural change continue at a rapid pace, there appears to be room for continued growth in agricultural value-added even as this share declines. In some areas (e.g. in the southern Huai basin) additional supplies

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**Table 4.2: Gross Farming Output Provinces in 3-H Basins and all-China**

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Provinces more in Hai Basin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beijing</td>
<td>100</td>
<td>493</td>
<td>87</td>
<td>195</td>
</tr>
<tr>
<td>Tianjin</td>
<td>100</td>
<td>426</td>
<td>90</td>
<td>343</td>
</tr>
<tr>
<td>Hebei</td>
<td>92</td>
<td>525</td>
<td>845</td>
<td>230</td>
</tr>
<tr>
<td><strong>Provinces more in Yellow Basin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shanxi</td>
<td>100</td>
<td>418</td>
<td>227</td>
<td>174</td>
</tr>
<tr>
<td>Shaanxi</td>
<td>65</td>
<td>441</td>
<td>321</td>
<td>224</td>
</tr>
<tr>
<td>Gansu</td>
<td>32</td>
<td>408</td>
<td>223</td>
<td>225</td>
</tr>
<tr>
<td>Qinghai</td>
<td>21</td>
<td>306</td>
<td>31</td>
<td>177</td>
</tr>
<tr>
<td>Ningxia</td>
<td>78</td>
<td>427</td>
<td>49</td>
<td>228</td>
</tr>
<tr>
<td><strong>Provinces more in Huai Basin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shandong</td>
<td>100</td>
<td>677</td>
<td>1,117</td>
<td>253</td>
</tr>
<tr>
<td>Henan</td>
<td>84</td>
<td>578</td>
<td>1,105</td>
<td>253</td>
</tr>
<tr>
<td>Anhui</td>
<td>48</td>
<td>560</td>
<td>701</td>
<td>241</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>62</td>
<td>769</td>
<td>1,085</td>
<td>231</td>
</tr>
<tr>
<td>China</td>
<td>n.a.</td>
<td>497</td>
<td>13,867</td>
<td>230</td>
</tr>
</tbody>
</table>

could be mobilised but elsewhere little water reaches the sea and the potential for real improvements in physical irrigation efficiency is very limited. Economic efficiency, however, will rise as farmers respond to water constraints, and drip irrigation could spread rapidly where it proves financially attractive. Those who anticipate physical resource limits to agricultural growth in the region may fail to take fully into account how resilient farmer responses can be.

Moreover, as already indicated, urban and industrial use is also very high for a country at China’s stage of development and income levels. Estimates made in the context of a recent study\(^{27}\) suggest that average city tap water use in the 3-H region in 1997 was 530 l/c/d (of which domestic use was 192 l/c/d and industrial/commercial use was 299 l/c/d) compared to 280 l/c/d for a sample of forty Asian cities. Again, industrial GDP/m\(^3\) of industrial water use was put at US$5 compared to much higher figures in many other Asian countries, including Indonesia, Korea, Thailand and Japan. There are definitional issues that need clarification but demand management and pricing is already slowing the growth in urban demand and further progress in this direction could be considerable.

**A Strategic Role for the South-North Transfer Scheme?**

The implications are that, even without the south-north transfers, agricultural growth in the 3-H region would continue and the impact of water constraints on overall economic performance would be less adverse than sometimes claimed. Nevertheless, such an outcome would be associated with major problems. Rural restructuring would have to be faster than if such transfers were provided; inequities would be greater; and rural-urban migration would be accelerated. Moreover, though regulatory measures could in principle address issues of groundwater and pollution management, these would inevitably further constrain irrigation supplies and would be extraordinarily difficult to implement in practice. In the long term, and if economic growth is sustained, most of these issues could no doubt be tackled (as they have been in the wealthy countries). But in the meantime the process would be that much more difficult to manage and the burden on society would be very great.

These difficulties could be greatly moderated if additional supplies could be brought via the South-North Transfer scheme. Water could be directed towards high priority city purposes, meeting additional needs and easing pressures on the deep confined aquifers. Environmental flows in the rivers could be augmented without the need to deprive irrigation. And, since existing irrigated areas could without question absorb any water in excess of that required for other purposes, the constraints on irrigated agriculture could be reduced and assets (sunk costs) that might otherwise have had to be abandoned could remain in use. However, it must be recognised that the real impact of the south-north transfers would be to greatly ease management problems associated with transferring water out of agriculture, and at the margin would tend to preserve agricultural activities that would otherwise have had to cease or change. In other words, and no doubt with important exceptions, the main real benefits of the transfer scheme would be to preserve the least profitable agricultural activities.

It is not possible to state categorically whether or not the marginal agricultural and management benefits are sufficient to justify the enormous expenditures associated with the South-North Transfer scheme. No doubt competent analysis could further clarify the weight of the arguments. But, as already suggested, studies of such enormous complexity seldom provide conclusive justification and a decision must ultimately take on some of the characteristics of a strategic act of faith. And in this context, there are four further arguments that could well help point in a positive decision:

- regulatory and management constraints are compounded by the differing interests of and disputes between the provincial governments, and within the provinces between localities. For the Yellow River, in particular, upstream irrigation development has had damaging downstream impacts. Constructive agreement between different jurisdictions would be greatly eased if the question was

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how to share additional supplies rather than to redistribute existing shortages (recognising also
that additional issues would arise related to the basin of origin);

- China's hectic development and reform process is being accompanied by decentralisation to, and
  increased autonomy at, the provincial and local levels. Each of China's provinces has a population
equivalent to a medium-sized country and each faces staggering institutional and management
challenges. Incentives incorporated within the planning and financing of the South-North Transfer
project could in principle provide an important mechanism for helping promote provincial water
sector and associated reforms consistent with the transition to a market economy;

- the risks associated with climate change are incalculable. But, given the enormous size of the
  population concerned, the precautionary principle suggests that the Chinese authorities would be
  wise to guard against the possibility of a significantly adverse impact on the natural water
  resources of the 3-H basins; and,

- finally, US$10 billion may be a huge sum but it should be put in perspective. The population of
  the 3-H basins exceeds that of every country in the world other than the two Asian giants, India
  and China itself. Such a sum is equivalent to no more than about US$20 per citizen to be invested
  over a period of years. Put this way, the cost does not appear excessive and it is greatly exceeded
  as a matter of routine in comparable projects in almost every other country in the world.

These arguments, and those discussed earlier, do not provide conclusive proof that the South-North
Transfer scheme is justified. Despite the apparent necessity for the south to north water transfer, a
detailed study of the full consequences of such diversion must be undertaken before a final decision
on the project is made. Apart from the economic consequences of resource diversion and associated
changes in power and influence, there are considerations related to the ecology and biodiversity of the
basins involved; and considerations related to the water chemistry, hydrology, rates of erosion and
sediment loads. It will also be important to consider the implications for further dam building on the
major rivers such as the Yellow. With multiple political jurisdictions involved, the potential for
disagreement on water allocation between basins in times of drought are real. It is imperative that
inter-basin transfers of water be very carefully thought out before they are initiated.

The Chinese government has long studied the possibilities of a south to north water transfer project
to balance the uneven distribution of water between land north and south of the Yangtze. Several
possible routes have been identified and studied. These are:

- West Route: From the upper Yangtze to the upper Yellow River. Dams would be built on the
  Tongtianhe, Yalongjiang and Zumuzuhe rivers. A tunnel would link the Yangtze and Yellow
  basins.

- Middle Route: In the early stage, water would be diverted from the existing Danjiangkou
  reservoir on the Hanjiang River. Later, water would be diverted from the main stem of the
  Yangtze to increase the quantity of water transfer. The main gravity flow canal has a length of
  more than 1 200 km. A 142 km-long canal leading to Tianjin City is to branch from it north of
  Baoding. The feasibility study report for the Middle Route transfer project has been approved
  by MWR. Preliminary design for the project is presently being carried out by CWRC
  (Changjiang Water Resources Commission).

- East Route: There are two possible routes for this option. One possible route originates at
  Yuxihe, Fenghuangjing and Shentanghe within Anhui province and would divert/pump 4 bcm
  water annually from the lower Yangtze to the Huaihe basin. Another route, beginning at
  Sanjiangying in Jiandou county, Jiangsu province, would run along the Beijing-Hangzhou
  Grand Canal.
If inter-basin transfers are initiated it is imperative that both the receiving and exporting basins undertake careful monitoring of the factors mentioned above. Receiving basins must monitor for the introduction of alien species, particularly water weeds and predatory fish species. They must also monitor for changes in water chemistry, which may affect both agricultural crops and industrial processes. Changes in suspended solids and bed load of streams and rivers must also be checked. Exporting basins should monitor ground water recharge as a matter of routine to ensure that excessive amounts of surface water are not exported. Monitoring of sediment build-up in the rivers and streams of the exporting basin is also essential to ensure that adequate discharge is maintained for the proper hydrological and ecological functioning of the basin from which water is being diverted.

Finally, political structures and agreed processes must be put in place to enable problems that might arise to be addressed and rectified.

4.1.2 Flood Management in the Yangtze Basin

The 1998 Yangtze floods hit the world's headlines, and the media were filled with images of a vast throng battling to close the temporary breach in the Jinjiang main dyke. Some 14 million people were affected, three thousand lost their lives and perhaps 4 000 km\(^2\) (40 M ha) were inundated.

The event was portrayed as a world-class disaster so it may come as a surprise to learn that by past standards it was not in fact an exceptionally large flood. It is true that flow at Yichang peaked at 63 600 m\(^3\)/sec. This is a huge quantity but then the Yangtze is the world's third largest river with a catchment subject to intense monsoon storms. To put it in perspective, the 1998 flood corresponded to a 1 in 40-year event at Ichang and was exceeded on three other occasions in the twentieth century alone (in 1931, 1954 and 1981). In 1931, when China's population was a third of its present level, 29 million people were affected and 145 000 lost their lives. A flood on record occurred in 1870 when the flow is said to have peaked at an astonishing 105 000 m\(^3\)/sec, corresponding to a return period considerably greater than 1 in 100 years. If a flood of this size had occurred in 1998, there would have been no way to avoid massive breaches and the lives that would have been lost and the damage that would have been caused are incalculable.

No one can foretell when a flood equal to that of 1870 will re-occur. Perhaps next year, perhaps not for hundreds of years. Global warming may affect its probability. But what is certain is that it will re-occur. Any responsible government must plan for this eventuality. How then should China plan and view the alternatives? This was part of the challenge faced by the government when it was faced with the decision on The Three Gorges Project, which was put to a vote by the full Congress and it was decided to go ahead after a comparatively close vote - in Chinese political terms.

The Mississippi and the Yangtze - Similarities and Differences

Much has been written on the virtues of "software" solutions as an alternative to investment in dams and dikes. Discussion on these issues has intensified since the 1993 flood in the upper Mississippi basin which was "an event without...precedent in the United States" (ICOLD-CIGB, 2000). This flood exceeded all records. The peak flow at St. Louis reached 29 700 m\(^3\)/sec and had a return period in excess of 1 in 100 years, that is it approached the return period of the 1870 Yangtze flood. Even so, and despite its size, the human impact was much lower than from the relatively less severe 1998 flood on the Yangtze. In total, about 50 000 people had to be moved, 35 lives were lost and perhaps 250 km\(^2\) of land behind the dikes was inundated. But this was sufficient to encourage a fundamental re-appraisal of the US approach to flood plain management, leading solutions away from relative emphasis on physical investments and towards more ecosystem-friendly approaches. Similar directions are being pursued in Europe, as noted in the WCD thematic paper on Flood Management options.

The Yangtze is much the larger river and its huge, populated floodplain is far more vulnerable than the narrower river valleys of the upper Mississippi and its tributaries, which helps explain why the
The impact of the 1998 flood was so much greater. The Yangtze valley below Ichang comprises two huge inter-connected bowls centred respectively on Dongting Lake and the city of Wuhan in the (larger) upper reach and Poyang Lake and the city of Jiujiang in the lower reach. Numerous other lakes and wetlands dot the flat landscape. Below Jiujiang, the valley narrows where mountains close in prior to the river emerging into the long estuary reach some 700 km from the sea. Under natural conditions, the river and its tributaries in the mid-Yangtze valley would spill onto the surrounding plain, periodically changing course as silt deposition gradually raised the land surface. Humans have intervened by constructing dikes that confine the rivers and by reclaiming wetlands for agriculture. Silt is increasingly deposited on the riverbed rather than the now-constricted wetlands so that the dikes must be progressively raised if the surrounding land is to receive the same protection. Extensive detention basins have been delineated for inundation in the event that this is needed to protect urban and other priority areas. But behind their dikes, even the detention basins are densely inhabited - there is literally nowhere else for the vast population to go.

Dikes (levees) have also been constructed along the Mississippi and its tributaries and during the 1993 flood several were breached, some deliberately to protect St. Louis and other cities. This suggests similarities between the Yangtze and Mississippi. But there are also great differences. Rural America is sparsely populated, farm sizes are large, the population is rich and mobile, and it would be quite feasible in many places for habitation to move up off the valley floor. Reserving areas in the flood plain for ecological purposes would require minimal sacrifice in terms of the US's huge land resources, while the intermittent flooding of agricultural land to safeguard the cities would entail few costs once occupation, buildings and infrastructure had been moved out of harm's way. In the Yangtze valley, such options are not available on the same scale, given the huge population, the prior occupation of most of the flood plain due the protection afforded by centuries of raising levees, the subsequent incremental raising of flood levels above the surrounding land, and the limited range of alternatives open to its inhabitants.

Another crucial difference lies in the protection afforded by flood control dams. Seventy-six dams have been constructed in the upper Mississippi basin with an aggregate volume of 49 bcm, of which 25 bcm is available for flood storage. In absolute terms, these volumes are very similar to those that will be available in the upper Yangtze after completion of the Three Gorges dam (about 50 bcm, with Three Gorges providing 40 bcm of which 22 bcm for flood storage). But even with Three Gorges, total storage will amount to little more than 10% of mean annual flow at Ichang compared to 30% of the flow of the Mississippi at St. Louis. Moreover, given the monsoon climate, monthly flows on the Yangtze at Ichang are considerably more variable than on the Mississippi. Mean flow in the peak month (July) is almost nine times that in the low flow month (February). By any reckoning, flood protection standards on the Mississippi are far superior to those on the Yangtze.

Estimates quoted by ICOLD-CIGB suggest that the damage avoided in 1993 due to dams and levees was US$19.1 billion or 25% more than the actual damage to property and agriculture (US$15.6 billion). Of US$11.5 billion avoided due to works in the Missouri basin, US$7.5 billion (65%) was attributed to dams and the balance to levees. No breakdown is given for the Mississippi itself but "upstream reservoirs ...reduce flood peak stages at St. Louis by nearly two meters. Inasmuch as the flood crested within one meter of the top of the floodwall...the value of these reservoirs...is obvious" (ICOLD-CIGB 2000). Damages from the 1998 Yangtze flood have been put at 250 billion yuan or US$30 billion. It is not known if this estimate is strictly comparable with those for the Mississippi flood, nor is there an estimate of the damage avoided due to flood control works. However, dams played essentially no role in moderating the 1998 flood and any protection available was almost wholly dependent on the dikes. It remains, however, the case that if Three Gorges had been in existence, the flood would have been a perfectly manageable event. No doubt inflows below the dam site would still have caused some damage but peak flows in the main river would have been appreciably reduced, total damages would have been much lower, and the flood would have barely merited a footnote in the world's press.
Flood Plain Management

A major report following the 1993 Mississippi flood\(^{28}\) recommended that, wherever feasible and reasonable, dikes should be retired and occupation of the floodplain should be modified to "preserve and enhance the natural resources and functions of the flood plain". Equally, however, the report reiterated the need to "reduce the vulnerability of the nation to the dangers and damages that result from floods". There is no question of foregoing protection where this is justified. On the contrary, protection standards are to be enhanced. No one, for instance, seriously suggests that dams and dikes in the upper Mississippi should ever be abandoned. It is therefore in essence a question of balance.

What may not be so widely known is that a similar re-assessment took place in China as a result of the 1998 Yangtze flood. It has been concluded that agricultural encroachment onto lakebeds and other wetlands, though entirely understandable, has gone too far, reducing natural storage, forfeiting non-agricultural benefits and environmental values, and exposing communities to unreasonable risks. A decision has therefore been taken to move upwards of a million people, some onto higher land in the same vicinity, others to completely new settlements away from the flood plain. This amazing decision reflects the scale of China's problems - even after they have moved, the overall situation will not be that greatly different. The decision was taken at the highest level of government, with detailed planning and implementation by local government and communities. This is characteristic of China's governance. That it has failed to attract the attention of the international media and NGO community is in remarkable contrast to the furious controversies that have accompanied resettlement of a comparable number of people from the site of the Three Gorges reservoir.

What does this imply for the future? There are various views on this. One view is that China has enough dams now and that new dams should be considered as a last resort only - or not at all. Conventional flood defences cannot provide long-term sustainable solutions - they are simple expensive alternatives that may at best buy time until the real problem has to be faced, and at the same time cause irreversible social and environmental damage. At the opposite end of the spectrum is the view that additional storage is the only viable option China has given all the circumstances and magnitude of the problem.

As anywhere, others see that it is a question of achieving the proper balance suitable to the circumstances. In this view, land use plans and other non-structural measures cannot substitute for structural measures such as levees and dams; they are complementary. The relative roles of each - and of flood forecasting and preparedness, flood proofing, compensation and insurance schemes, ecological management, resettlement and a host of other possible measures - can only be determined in the context of integrated flood plain planning and management for the basin concerned. As societies grow richer and populations more vocal, they typically demand greater security against floods while also giving increasing weight to ecological values. Moreover, underlying natural conditions are never constant and what is feasible changes in response to technical and financial prowess, administrative and community capacity, and scientific understanding. Over time, the balance of solutions appropriate in a basin invariably evolves; integrated flood plain management is a never-ending process.

In the particular case of the Yangtze, the characteristics of the basin and its floodplain foreclose radical solutions that aim to return more than very limited areas of the flood plain to their natural state. No doubt decisions taken as a result of the 1998 flood point the way toward a long-term vision that includes some combination of: secure protection of cities, industries and other priority areas; emergency refuges, flood proofing and flood preparedness for that part of the rural population that cannot move out of harm's way; intermittent flooding of agricultural areas and detention basins with appropriate compensation arrangements; and the enhancement of ecosystem values. Elements of these objectives are being incorporated in present plans and pilot projects such as the WWF "Partnership for

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a Living Yangtze" need to be given high priority. Nevertheless, full attainment of such a vision is a very long way off and how best to move toward it will be a drawn-out, complex and difficult process.

Moreover, it is undoubtedly true that the basin's population enjoys current levels of protection that fall far behind those that would be deemed necessary in richer countries and, as China develops, it is entirely understandable that there should be policy that these standards should be enhanced. Whether this justifies the Three Gorges dam is another matter. Flood protection is undoubtedly the driving force for the dam's construction, but numerous other factors must also enter into the equation, notably the huge costs of the dam itself, controversial and important resettlement and humanitarian issues, complex upstream and downstream environmental impacts, and the enormous power, navigation and other benefits. But past emphasis on the raising and strengthening of dikes has clear limits, and it is hard to escape the conclusion that - as in almost all other protected basins worldwide - flood storage dams will have to play an important role in any balance that proves acceptable over the foreseeable future.

As for any river, no amount of protection can rule out damage during truly extreme events. The very size of the Yangtze rules out more than moderate levels of overall protection and the valley below Ichang will remain vulnerable to the impact of direct storms on the plain. Moreover, protection works of all types have a universal tendency to promote complacency and to encourage inappropriate development. Land use planning controls and flood preparedness will thus continue to have a crucial role in containing potential loss of life and damage. Nevertheless, even in extreme events, as illustrated by the 1993 Mississippi flood, damage can be much reduced by appropriate works. Competent integrated flood plain planning and management can only establish what is appropriate and what should be the balance in any particular context.

4.2 Flood Control and Sediment Control

The previous sections illustrated some of the circumstances and challenges China faces in deciding its flood management strategy and whether existing or additional dams are to play a role. China is also facing questions on the role and use of larger check dams for sediment management and control

4.2.1 Flood Control

Generally the literature and science indicates that a broader approach to flood management is necessary. There is need to look outside the river channel to minimise the cause and effects of floods. This includes retaining rainfall for longer periods in the catchment before it reaches the river and allowing the river itself to vent the effects of floods, while capturing the beneficial aspects such as natural water purification.

Once the more fundamental priorities for flood management are established, the elements of a flood management strategy can include: (i) reducing run-off by managing the water flows; (ii) reducing the vulnerability of people and infrastructure to damage by floods by physically separating water and people; and (iii) planning a comprehensive strategy for coping with exceptional flood events when they do occur. These are summarised in Table 4.3. Dams can play a key role in the first component of this approach, that is, reducing the scale of the threat. No option is likely to be free of risk, whether it is the risk of exceeding the design floods for dikes or for dams, or the institutional failure of alternative management strategies.

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This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.

Table 4.3: Complementary approaches to flood management

<table>
<thead>
<tr>
<th>Reducing the scale of flood</th>
<th>Isolating the threat through:</th>
<th>increasing coping capacity through:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Better catchment management</td>
<td>• flood embankments</td>
<td>• emergency planning</td>
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<tr>
<td>• Controlling runoff</td>
<td>• flood proofing</td>
<td>• forecasting</td>
</tr>
<tr>
<td>• Detention basins</td>
<td>• relocation</td>
<td>• warnings</td>
</tr>
<tr>
<td>• Dams</td>
<td>• limiting floodplain</td>
<td>• evacuation</td>
</tr>
<tr>
<td>• Wetlands</td>
<td>development</td>
<td>• compensation</td>
</tr>
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Source: WCD Flood Management Options Thematic

China now has a total storage capacity of some 360-493 billion m$^3$ in 119 large reservoirs and 2,653 medium reservoirs. It uses the strategy of storing floodwaters to reduce outflows and attenuating peak flows. Most large, medium and small reservoirs in the PRC are operated for flood control but the percentage of the reservoir capacity reserved for flood storage varies. Except for dams specifically designed for flood control the operator would aim to keep the volume of dedicated flood storage to a minimum. This is because in most years the flood storage will not be used, and water that otherwise could have been used for irrigation and power is not stored. Xiaolangdi and Three Gorges are special cases of large dams where a significant part of the reservoir will be dedicated to flood control.

In the Hai and Huai basins there are numerous medium-sized dams that are operated primarily for flood control. It is difficult to estimate to what extent these dams have reduced flood damage in the past, especially when inundation has often come from intense and direct rainfall on the land and communities, but officials in the Basin Commissions report they have had a significant effect.

In the case of large dams the impact on floods can be predicted with some accuracy. For example, the benefits of the Three Gorges and Xiaolangdi dams are expected to be less frequent flooding of detention basins. (A detention basin in China is a low-lying area along the river that is populated and cultivated; but is designed to be flooded to reduce the flow in the main river.) Xiaolangdi is also expected to reduce the frequency of flooding of cultivated land between the main levees. Critics suggest that the benefits will be short term only and that sediment build-up will rapidly reduce the benefits. Moreover, people will be lulled into a false sense of security. Unless parallel measures are taken to increase the coping capacity and exceptional flood event, when it occurs, will cause more damage overall. This debate is similar to those throughout the world on strategic approaches to flood control where severe damage experienced on some of the world's great rivers has thrown into question the performance of conventional flood control works and the strategies underlying their design. Rivers should not be confined because this prevents the flood plains from acting as natural flood attenuating mechanisms. Whatever the pros and cons of the option of leaving floodplains undeveloped, the view is that this option was foreclosed centuries ago for many water courses in the PRC. The levees in place on most of the country’s rivers protect vast areas of land every year from annual floods – protection against extreme floods is not their only purpose.

As noted, following the 1998 floods, China initiated a program of non-structural measures for flood management. These include measures to reverse human encroachment into floodways and wetlands with concomitant loss of flood handling ability. People and facilities situated in these areas will be relocated. Buildings in detention basins and floodways will be moved. People will also be moved from dangerous locations if they cannot be safely evacuated in the event of a flood. Other measures include improvement of flood warning and forecasting models; siting of public buildings away from high-risk areas; and the design and construction of public infrastructure to be flood resistant.

4.2.2 Sediment Control

The Yellow River carries more sediment than any of the world's large rivers. For example, it carries three times the sediment load of the Brahmaputra-Ganges with only 8% of the annual flow. The
source of the sediment is the wind-deposited material covering 430 000 km$^2$ in the Loess Plateau. Much of this sediment inflow is deposited in the river channel and this causes the bed to rise above the surrounding land at a rate of about one metre every ten years. In order to keep the river within its channel during floods China has periodically raised 700 km of flood embankments, strengthen 1 000 km of levees, and reconstruct and repair over 5 000 river training spurs.

The Xiaolangdi Dam will intercept sediment during its early years of operation and is expected to defer the raising of the levees in the lower reaches, until the sediment storage space in the Xiaolangdi reservoir will fill, in about ten years, after which the process of deposition in the river’s lower reach will begin again. Critics view the construction of large dams for sediment control as an expensive short-term remedy for a problem that needs to be addressed through long-term measures alternative land-use practices to reduce silt load.

Although sediment runoff per unit area from the Loess Plateau is remarkably high, the conditions for sediment control are considered to be unusually favourable in comparison with other Chinese river basins. There are several reasons for this. First, the deeply incised gullies of the plateau provide numerous sites for the small dams needed to intercept and store the sediment near its source. Two, the gullies are virtually uninhabited and so no resettlement is required. Three, the cost of dams is low because the loess soil, ideal for earthfill dams, is abundant near the dam sites. Fourth, there is considerable experience in the planning, design, and construction of sediment control dams in the Loess Plateau.

These small sediment control dams are homogeneous earthfill dams from 15-30 m in height. A local benefit of the dams is the valuable farmland formed by the deposited sediments once the dam is filled. Thousands of sediment control dams have been built and many more are planned. Design standards have been improved in recently years. Some dams built in the 1970 did not have sufficient flood storage capacity and failures occurred after extreme storms. Fortunately, the dam break floods were of short duration and were largely confined to the uninhabited gullies.

4.3 Irrigation and Water Supply

Irrigation and municipal and industrial water supply are competing consumptive uses of water in China. Surface water is the main source of fresh water in China. On a national average China's rivers, human made reservoirs and natural lakes are the source of about 83% of the fresh water supply, ground water, 15.5%, and water recycling, 2.5%. Irrigation is the largest single use of fresh water resources (about 74% of total use) followed by industry, rural and urban uses at about 14.4%, 4.6% and 3.5%, respectively.\footnote{ADB, Strategic Options for the Water Sector, 1999} The proportions for both supply and use actually vary widely among provinces.

In Chinese Law water for people, commerce and industry has priority over irrigation. Between 1980 and 1993, the share of irrigation dropped from 80.7% to 73.8%, according to government statistics. In the water short areas, as these demands and the competition for water grows, farmers will get less water, and it is anticipated that the response will be a shift to crops that produce more value per unit of water, gradually changing the structure of agriculture in many areas.

As noted in section 3 of this paper, because of the rapid pace of reforms and higher standards of living, and greater freedom for farmers to make production choices, total water demands have been growing sharply in the last few decades. Supply constraints are now being encountered and supply problems are also increasingly compounded by growing pollution and water quality problems for both surface and ground water resources. The water stress that is encountered, coupled with market reform and decentralised decision-making has and will in many cases stimulate the attention to demand management, efficiency and an expanded number of supply options being considered. An important
aspect in deciding the options is that many sectors of the economy (irrigation, industry, domestic) now use water inefficiently. Therefore, demand management options and improvements in the efficiency of water use have the potential to reduce competition for and stress on available supplies of fresh water particularly in the short to medium term.31

4.3.1 Irrigation

China has the world’s 3rd largest agriculture area (after USA and India) and is second to India in area irrigated. Irrigated area doubled in the last 40 years (from 27 M ha in 1957 to 51 M ha today) and is about half of the cultivated area (124 M ha).32 Agriculture land under pressure from other urbanisation and other land uses fell by 5% in the last 20 years, though average yields increased.

It is not possible to explore all the many complexities of agriculture and food supply and security in China in this paper. China does rely heavily on irrigated agriculture and dams and other surface water schemes of all scales provide a large portion of this. The need for irrigation nonetheless varies among regions. The lands north of the Yangtze River, and especially the areas north of the Yellow River suffer from wide variations in rainfall between years and within a year. North of the Yellow River, the most widespread crop, winter wheat, is planted in the low rainfall months of the late fall and harvested in the late spring before the onset of the summer rains. Without irrigation a farmer is faced with low yields if rainfall is low and in some years a crop failure, whereas with irrigation, there will be no crop failure and yields may be two to three times rainfed yields. Farmers growing summer crops such as maize and cotton also benefit from irrigation. In the land along the north bank of the Yangtze, a longer growing season gives farmers a wider range of options, but double cropping depends on irrigation. The peak demands for irrigation come in the fall and spring when the rivers are at their lowest. Therefore, the need is to store the abundant flows in the wet season and release water in the dry season, which is the main function of most of the smaller dams in China.

Restructuring agriculture practices and the agriculture economy to accommodate more competition for water between sectors and provinces will entail shifting to reliance on more water-efficient crops and improving the efficiency of existing and planned new supply. There are various well-known techniques to raise the efficiency of water use in irrigation and the concerns relate to applicability and affordability plus experience. Canals are lined to reduce seepage, farmers can switch from flood irrigation to sprinklers, crops with low demands can replace high water users, and new varieties with shorter growing seasons can be adopted.

However, if farmers are to adopt such water-saving techniques in market economy situations there must be a financial incentive, or water must be so scarce that there is no alternative. In places where groundwater is an alternative, raising water charges for surface water can have the perverse effect of overexploitation of aquifers.

There also have been articles in the media and reports that China, because of its water-stress and inability to adapt quickly to change agriculture practices may be forced to significantly increase food imports.33 Current thinking is that such a view may be over stated and within China, national food security is still considered as a major rationale for irrigation dams, especially where groundwater levels are rapidly declining due to over exploitation.

4.3.2 Municipal and Industrial Water Supply

Various sources estimate that 250 to 300 of China's 617 largest cities, or about half, already face water shortages. As noted in section 3, meeting demands and using water more efficiently coupled with

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32 52 million hectares (42% of total cultivated), from FAO 1999.
33 Ibid; and World Bank, Food Security for the World, 1999
improving water quality is a major policy objective of government. Within cities there is considerable scope for more efficient use of water by upgrading supply systems (leaks are a major source of inefficiency), and pricing at levels that encourage conservation.

Water from many reservoirs in the PRC is being used increasingly for municipal and industrial use, and more will be used for this purpose in the future. Groundwater accounts for about 70% of domestic water supply in rural areas. Some dams, such as the one forming the Miyun Reservoir that serves Beijing, were built solely for water supply. Reservoir water will become increasingly important for cities and industries as groundwater declines in quantity and quality. This problem is particularly acute in north China and is likely to get worse as the number of urban places is increased under the next five-year plan.

In many major urban centres, China has initiated demand management programmes. There are media and public information programmes. Unaccounted water loss is low in China (about 11%) compared to other Asian countries (typically 25% to 50%). There is a great variation in water charges for domestic and industrial users in China and often tariffs only cover operation costs. The potential for water saving in industry is regarded as the highest. For example, statistics suggest it requires 23 to 56 m$^3$ of water to produce one tonne of steel in Chinese industry versus about 6 m$^3$ in western countries; one tonne of paper consumes 450 m$^3$ in China where it generally requires less that 200 m$^3$ with modern equipment and processes. A mixture of incentives, pricing measures, and technology improvements will be required in future to address the challenge. One perspective is that China will restructure its industry to become more competitive in world markets, and in doing so, there will be a window of opportunity to address the water efficiency issues.

4.4 Electric Power Services

As noted in sections 2 and 3 of this paper, China has the third largest electric power system in the world with some 277 000 MW of installed capacity producing about 1157 TWh of electricity per year (1998). The context is that per capita electricity use in China is about 928 kWh/year, about half the world's average and one-tenth that of OECD countries. About one-third of the power produced is consumed in rural areas where 70% of the population live, and about 83.5% of this rural consumption was supplied by the grid. In some provinces such as Heilongjiang in the northeast close to 98% of all the households are served by the grid, while in western regions the proportion is much smaller. At present about 80% of the power is produced in coal-fired generation power stations with considerable impacts on local and urban air quality in China and regional GHG emissions.

The policy is generally to meet the demand with new capacity and optimising the use of existing assets, improve the efficiency of the electrical system, including demand management, and increase the proportion of renewable energy generation. The latter primarily means increasing the percentage of hydropower generation that is currently about 19% of supply. Some policy statements have suggested the target is 40% hydropower. While the rate of demand growth was close to 8-9% for most of the 1990s, the restructuring of the economy has seen the closure of many power-intensive industries and the conversion of other industries to different production. As a consequence, demand growth has slowed and many regions have experienced over capacity. This is regarded by government to be a short term phenomenon. China's complex power pricing system has led to distortions in purchase policies from existing and new power stations, as marginal cost pricing and market-based pricing has not been achieved as yet in all provinces.

China has many options for electric power generation in grid and off-grid situations of all scales and sizes. Indeed China also has one of the most widespread dissemination programmes of rural

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35 Li Shidong, China's Water resources and hydropower development policy, Hydropower and Dams, Issue 4, 2000.
renewable energy technologies in the world. On the grid, various conventional and renewable options are possible and are being pursued depending on the energy resource base of the province and possibilities for import or export of power to other regions of China. Options for improving and expanding electrical services include supply-side efficiency (power stations, transmission and distribution systems, and demand side management). From many perspectives, the critics of dams and large-scale infrastructure suggest it is best to start with demand management options before pursuing other options, while other views suggest demand management and supply options initiatives must proceed together.

**4.4.1 Improving Energy Efficiency**

**Demand Side Management**

A number of power supply companies have instituted demand management programmes as a means of dealing with capacity constraints and reducing the rate of growth of peak power demands and longer term energy consumption. This is done with pricing incentives for off-peak use to lower peak demands, by raising tariffs in general, and by helping large users with energy audits. Although the PRC’s per capita use of 928 kWh per capita is low compared to Europe and North America, there is still wasteful use particularly in the older industrial plants. Cuts in energy use through conservation and demand-management are desirable and there remains considerable scope for improvement. The view of planners in China and the power industry is that these measures would delay, but not eliminate, the need for new capacity such as hydropower given the low per capita demand in China and the implications of raising standards of living for power demand in future.

As noted in the box below, some studies have indicated 20% savings in current consumption could be reasonable with demand management programmes. The timeframe over which such efficiency improvements can be realised would be linked to the rate of turnover and replacement of energy using equipment in China (industrial and commercial, motors, pumps, lighting systems, domestic appliances etc.). Electric motors, which tend to have long replacement cycles, are estimated to account for up to 60% of the electricity end-use demand in China (the corresponding figure in the USA is about 50%).

**Box 4.1: Strategic Planning involving DSM**

**Southern China Strategic Energy Planning Project, 1995-1998**\(^\text{37}\). This project compared a number of planning “scenarios” for meeting southern China’s future electricity needs. Electricity demand was estimated using MEDPRO, an end-use based computer model that separately models macro-economic variables, technology shares and technology efficiency. Electricity supply options included coal, hydro, nuclear and a set of DSM programmes covering all sectors. These programmes were analysed for viability and market penetration using a spreadsheet based model. Environmental and social impacts were estimated for each scenario. A “multi-attribute approach” was used to evaluate scenarios by attaching weights to costs and impacts. The DSM option was shown to have the lowest cost, it was able to meet up to 20% of future electrical needs, and it was a major component of all favoured scenarios under the multi-attribute analysis.

Source: Electricity Options Thematic WCD

At present, due to the restructuring of industry power policy generally recognises that demand-side efficiency improvements will be of fundamental importance if the electricity demand-supply gap over the long term is to be fully closed. It is recognised that demand-side efficiency improvements can help offset needs for investment in new supply and help improve environmental quality. With higher tariffs resulting from transition to market-orientation tariff practices, it can be expected that consumers will pay

\(^{36}\) WCD Electricity Supply and Demand Management Options Thematic Paper

much greater attention to the efficiency of electrical appliances and end-use equipment. Gradually the older inefficient stock of appliances will be replaced by more efficient equipment. However, experience in other south Asian and western countries indicates action needs to be taken by equipment and appliance manufacturers and government to promote consumer awareness of options. Programmes ranging from industrial energy audit programs to appliance efficiency standards and labelling programs will be needed.

**Supply Side Efficiency:**

Government has stressed the need for supply-side and demand-side efficiency in power sector development to help mitigate supply requirements. Supply-side efficiency approaches include rehabilitation and modernisation of older inefficient power plant, expansion of capacity at existing power stations when feasible, and loss reduction in transmission as technology evolves, particularly in the EHV areas, and overburdened distribution systems are relieved.

There were no statistics available of the potential for technical and non-technical loss reduction in China. However, with the experience in other Asian countries that have experienced rapid growth, it is expected there is considerable potential in improving the efficiency in generation, transmission and distribution with modernisation of equipment and practices.

**4.4.2 Alternative Power Sources**

In China as in many developing countries, the rural population depends on traditional biomass energy for the bulk of their energy needs, largely because of the unavailability or expense of grid-based energy services. Many more rely on kerosene lanterns or, when available, expensive gas- and diesel-burning electric generators. China itself has the most widespread dissemination programme of rural renewable energy technologies in the world.

China's experience with more than 25 000 village micro-hydroelectric (<100 kW) installations, 150 000 household scale wind turbines, 120 million improved cook stoves, and tens of millions of small-scale biomass coal, and waste-powered boilers (ISTI, 1995; Lu, 1993) is largely unknown and certainly under-studied outside China. Many of the successes in China have been achieved through an enlightened mix of national standards and R&D support coupled with efforts to encourage local innovation, heterogeneity, and entrepreneurial competition. Studies of energy in China have generally paid relatively little attention to non-fossil fuel energy issues. This is due to language barriers and the lack of an internationally oriented literature (for important positive examples, illustrating the benefits of disseminating this information, see Smith, et al, 1993 and Byrne, et al., 1998). Those who wish to learn about China's renewable energy efforts can often only do so through interactions with national bureaucracy in China, where connections and contacts with a particular set of agencies and individuals are needed. The barriers to learning about China institutional programs and capacity compounds the problem of a widespread assumption within the renewable energy community that Chinese experiences are so unique that they cannot provide useful lessons for those working in other countries. In fact, China provides a wealth of information about topics such as effective low-subsidy dissemination approaches, institutional arrangements to promote market formation, local technology development strategies, and many other areas relevant to renewable energy dissemination (Lu, 1993).

At present, the government sees development of the PRC’s large and small hydroelectric resources as an attractive alternative to exclusive development of large-scale, coal-fired and gas-fired power plants. Many of constituencies in the dams debate see small-scale hydro and other decentralised renewable energy options as one of the major options for China that would fit well with and build on
current capabilities, and provide a sustainable basis for future electricity supply. Dam critics suggest that investment in such programmes will reduce the requirement for large hydropower schemes to meet rural electricity needs met by centralised grid supply.

4.4.3 Conventional Generation Alternatives

In addition to small-scale decentralised alternative energy sources described above, conventional sources of energy and conversion systems such as coal-fired, nuclear, pumped storage, gas turbines using natural gas, advanced power generation technologies and adding capacity to existing hydro facilities are options for grid supply. These are briefly described below in the context of China's power system.

Large Scale Options:

a) Coal-Fired Thermal
Coal has been the main source energy for electrical generation in the PRC reflecting the fact that the country has the world’s largest coal reserve \((86 \times 10^{10}\) tonnes). Coal-fired thermal energy accounts for over 80% of the country’s energy supply. Conventional coal power stations are well suited for generating base load energy, but highly inefficient for peak and operational reserve purposes. Over 50% of the thermal units in the PRC are comparatively small units for centralised grid supply (less than 200 MW) and are considered inefficient, obsolete and highly polluting. They are also characterised by lower fuel efficiency (from 500 g/kWh of standard coal for units under 50 MW to 420 g/kWh for units between 100 to 120 MW, as compared with 350 g/kWh for newer 300 MW units) and lower operation reliability, as indicated by the lower total hours of operation/year.

Figure 4.1: Size Mix of Thermal Units (1996)

World Bank data (1999 World Development Indicators, World Bank) indicates that CO\(_2\) emissions in the PRC increased from \(1.4768 \times 10^9\) tonnes in 1980 to \(3.3635 \times 10^9\) tonnes in 1996 (second only to the USA). Sulphur dioxide emissions are also a problem and can be controlled only at considerable cost. Ash disposal and thermal pollution of water sources are also major problems at coal-fired plants. Some of the PRC’s largest cities are switching to natural gas from coal-fired heating plants due to their contribution to air pollution and health impacts. Acid rain from coal burning is also believed to reduce agriculture yields.

A report on China's power sector prepared by the Battelle Institute in the USA recommends that the PRC continue using coal-fired thermal, with added sulphur-control equipment, at a cost of

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approximately $150/kW. It does not address the differences between base load and peak load requirements. Adoption of this recommendation means that coal-fired thermal power will continue to be used in the PRC, although it cannot be considered as an alternative to hydropower for peaking purposes.

One issue is that new power stations are being built that do not have the best or most advanced energy efficiency ratings and which cause more air pollution that is necessary. The incremental cost of "super-critical" coal technology and other measures add about 5% to the cost of the power station. One challenge for China, perhaps with international co-operation, is to ensure that when a decision is made to build a coal power station, only the most efficient technologies are used.

b) Nuclear Energy
The Daya Bay Nuclear Power Plant, located approximately two hours north of Hong Kong on the seacoast, was the PRC’s first commercial nuclear power plant. The plant has two Framatome (French) nuclear units. Each generates 900 MW. The facility provides power to Guangdong province and Hong Kong. The PRC has also purchased two CANDU units from Canada, to be installed in Zhejiang Province. Purchase contracts have also been signed with the USA and Russia for other nuclear units.

At a time when nuclear energy in the Western world is on the decline, the PRC and its neighbours (Korea and Taiwan) are buying into nuclear power, with heavy promotion from Western nuclear-equipment manufacturers. Basically, nuclear energy is similar to coal-fired thermal, but uses a different method of heating water to create steam. It suffers from the same inability to follow peak load or act as a stand-by reserve. Nuclear energy is also very expensive (~$4,000 per kW), and, from the experience in USA, has a relatively short economic life.

Figure 4.2

Take the Trojan Nuclear Power Plant as an example. “The power plant is on the Columbia River near Rainier Oregon, just upstream from Longview/Kelso, Washington. It was operated by Portland General Electric Co. (PGE) from May 1976 to November 1992 and permanently closed in January 1993 for a variety of reasons, including potentially high operating costs, defective steam generators, and energy market conditions.” (Washington’s Role In Decommissioning The Trojan Nuclear Power Plant, Washington State Department of Health Fact Sheet, September 1998). In the 1990s, over 70 nuclear power plants were decommissioned in the USA, with only four licenses for new plants being granted, the last one in 1996 (Watts Bar). At the same time, Ontario Hydro (the largest power utility in Canada) has had to close about 20 nuclear power plants and replace them with old coal-fired thermal plants, due to concerns from environmental lobby groups.

The total cost of decommissioning 20 stations is estimated at $18.7 billion (Ontario Hydro press release, 1997$). In addition, it does not appear that the USA and Canada have found a politically acceptable permanent solution to decommissioning nuclear plants and spent fuel. Therefore, on the grounds of operational efficiency, economy and environmental concerns, nuclear power plants cannot be considered as an alternative to hydropower for peaking purpose.
c) Pumped Storage Hydropower Plants

Pumped storage becomes an attractive option to traditional hydro plants in supplying peaking energy when there is excess base load energy (from coal-fired thermal or nuclear power plants). Hydro plants utilise the off-peak excess energy from these plants to pump water from a lower reservoir to an upper reservoir. Water from the upper reservoir can be released to generate electric energy in a very short time during peak-demand periods or during a sudden outage in the system. The PRC already has experience with pumped storage facilities. The oldest pumped storage station is Gangnan, built in 1968. The 2 000 MW Guangzhou Pumped Storage Projects I & II (completed in 1996 for peak regulation of Daya Bay Nuclear Plant) and the 2 052 MW Tianhuanping Pumped Storage Project (completed in 1998 as peaking supply for the load centres of Shanghai and Ningbo) are some of the world’s largest. No less important is the 800 MW Shisanling Pumped Storage Project that was completed in 1997 and is located only 40 km from the load centre of Beijing. Since no large reservoir is needed, there is flexibility in locating the structure to avoid settlements, and no obstruction of river flow if the project is developed downstream of an existing dam; pumped storage appears to be less controversial for most environmental groups.

Energy losses occur when energy is transformed from one form to another. The final result is a loss of efficiency of about 40% (20% in pumping and 20% in generating). E&M equipment (motor/generator and reversible pump/turbine) is more expensive than the traditional hydro E&M equipment. The civil work cost for the power station will also be higher than the traditional hydro plant because of the very deep setting (the distance between the centre line of the pump/turbine and the tailwater) required by the pump/turbine during pumping. Two dams will be required, one for the upper reservoir and one for the lower reservoir. This higher capital cost, together with cost of off-peak energy and loss of efficiency, makes pumped energy much costlier than traditional hydro energy. Since there is no large reservoir in pumped storage, there are no benefits associated with large reservoirs (e.g., irrigation, flood control, and water supply).

d) Gas Turbines Using Natural Gas

Natural-gas production in the PRC was estimated at 15 billion m³ in 1997. Gas reserves totalling 230 billion m³ have been confirmed in the central part of the Shaanxi-Gansu-Ningxia region, as have gas reserves of 200 billion m³ in the eastern part of Sichuan. In the Xinjiang Uygur Autonomous Region, total gas reserves of 160 billion m³ have been verified, and a group of new gas-bearing structures has been discovered. In the Xibei area of Northwest PRC's Qinghai Province, a gas field with proven reserves of 50 billion m³ has been found. (Figures for gas reserves are from Alexander's Gas & Oil Connections.) At this time, most of the gas is used for fertiliser production and domestic cooking and heating. It is worth noting that with the exception of Xijiang Uygur Autonomous Region, the areas with natural gas reserves mentioned above are also rich in coal and hydro reserves.

The Battelle Report recommends that “China can meet up to one-third of its future power generation needs with natural gas for less total cost than using coal if it begins manufacturing gas turbines domestically and develops low-cost natural gas sources.” The Report also predicts that “power demand will increase four-fold by 2020: China’s power demand will reach 4,000 terawatt-hours (TWh) by 2020”. However, the authors do not take into consideration the complexities of developing cost infrastructure to deliver sufficient gas from remote gas fields to the coastal load centres by 2020. Moreover, gas reserves will only last for 50 years at the present rate of consumption.

A cost comparison between a pipeline to deliver gas and a transmission line to deliver hydroelectricity shows the transmission line option will come out cheaper. The initial capital cost for a gas turbine generating unit is about $1 000–1 500 per kW (30% of which is for the E&M equipment), but the economic life of the high-speed gas turbine is much shorter than that of hydro turbines. While gas turbines are fast acting and could meet the peaking requirement of the daily load variation, high fuel, operation and maintenance costs make gas turbine energy the most expensive of all the alternatives (see DOE data). This is why most power utilities prefer to use gas turbines as a temporary source of
power until other sources can be found. Gas turbines do not come with a reservoir; those associated benefits are absent. This means that gas turbines could be a real alternative to hydropower as a source of peaking energy, but would offer fewer benefits.

**Advanced Power Generation Technologies**

A number of reports promote the idea of using advanced power generation technologies such as grid-scale wind power, fuel cells, gasification processes (biomass and coal-bed gasification) and photovoltaic technologies as future sources of energy for the PRC. The accumulated experience in wind generation in Europe, and to a lesser extent in the USA suggests that there is considerable future potential for wind-generation in China, which due to its varied topography has many regions with suitable wind regimes. In China as in Europe wind-generation can displace existing thermal generation, which then is used as back up when the wind is not available.

Wind power and photovoltaic (solar power) cannot reliably meet the requirement of peaking energy demand without some form of energy storage device. On a small scale, such devices can take the form of storage batteries. Fuel cells are a new, unproven technology that require hydrogen-rich gases, usually produced by fossil fuels and using energy from other fossil fuel plants. A process such as this can only result in loss in efficiency. Advanced power generation technologies may be ideal for small, remote communities but their implementation in the PRC would be extremely challenging in the near term.

**Adding Capacity to Existing Hydro Facilities**

Existing hydropower facilities in the PRC were primarily built for base load energy production. These facilities can be adapted to provide 2-3 times the present capacity, thereby complementing the base load from coal-fired thermal.

Longyangxia, Lijiaxia, and Liujiaxia, the three stations on the Yellow River cascade, provide a good example of this adaptability. Longyangxia, the first project of the cascade, was built in remote Qinghai in 1989, with a dam height of 178 m, a reservoir capacity of 27.63 x 10^9 m^3, and installed capacity of 1 280 MW. Lijiaxia is in Qinghai, downstream of Longyangxia. Lijiaxia was built in 1996, with a dam height of 165 m, a reservoir capacity of 1.65 x 10^9 m^3, and installed capacity of 2 000 MW. Liujiaxia is in Gansu, downstream of Lijiaxia. Built in 1969, Liujiaxia has a dam height of 147 m, a reservoir capacity of 5.7 x 10^9 m^3, and installed capacity of 1 160 MW. Since these three projects are in the same cascade, the same amount of water passes though each of them. The height of Lijiaxia’s dam is similar in height to the other two stations on the cascade, but has almost double the installed capacity with the same annual energy output (55.8~59.4 x 10^6 kWh, see Figure 4.2). This means Lijiaxia is operating differently from the other two projects. If additional peaking capacity is needed, it is feasible to add 1 000 MW capacity each to Longyangxia and Liujiaxia without adding reservoir capacity, that is by increasing the dam height.

Transmission facilities will have to be added since most of the existing hydro facilities are in remote areas away from the load centres. Financing of such expansions will be facilitated by government recognition of the difference between peaking and base load energies, and subsequent price adjustment. In a recent speech on the future trends of hydropower development in the PRC by the Minister of Water Resources, Mr. Wang Shucheng, the use of hydropower for peak regulation was recognized, as was the fact that energy price will control the future rate of hydro development. Similar views have also been expressed by the vice-general manager of the State Electricity Corporation.

This option does not add to the benefits, or the cost and adverse impacts, associated with new dams or reservoirs. The number of suitable sites for adding generating units is also limited. However, until such sites are exhausted, this may be considered to be one of the most efficient and most environmentally acceptable alternatives for the immediate future, providing the incremental environmental and social impacts are low and acceptable to Chinese society.
5. Social and Environmental Management of Large Dams in China

This section of the paper looks broadly and briefly at some of the social and environmental management issues and effects of the development of large dams in China. In doing so, it highlights suggestions that have been made by external observers and in various reports on the possible ways forward for China to strengthen management practices and reduce future adverse social and environmental effects. There are issues related to the management and operation of China’s existing 22,000 plus large dams, and for the planning, decision making, and implementation of new water and energy resource projects.

Clearly, a thorough assessment of the full range of social, cultural, and ecological effects of large dams would require baseline information, detailed project-specific monitoring and studies, access to project-affected people, and considerable research within China involving Chinese scientists and government officials.

5.1 Resettlement and Social Consequences of Dam Construction

No country in the world matches the scale of the PRC’s involuntary resettlement for its public infrastructure, especially since the founding of modern China in 1949. Table 5.1 provides an estimate of the number of people resettled for different types of infrastructure development projects in the past five decades. It may be seen that reservoir projects are seen to account for about 27% of the total with urban expansion as the primary reason.

Table 5.1: Estimated Number of People Resettled (Million)

<table>
<thead>
<tr>
<th>Type</th>
<th>1950s</th>
<th>1960s</th>
<th>1970s</th>
<th>1980s</th>
<th>1990s</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoir</td>
<td>4.6</td>
<td>3.2</td>
<td>1.4</td>
<td>1.0</td>
<td>2.0</td>
<td>12.2</td>
<td>27</td>
</tr>
<tr>
<td>Transportation</td>
<td>2.5</td>
<td>0.9</td>
<td>2.7</td>
<td>1.3</td>
<td>2.0</td>
<td>9.4</td>
<td>21</td>
</tr>
<tr>
<td>City Construction</td>
<td>1.5</td>
<td>1.3</td>
<td>2.6</td>
<td>8.5</td>
<td>9.6</td>
<td>23.5</td>
<td>52</td>
</tr>
<tr>
<td>Total</td>
<td>8.6</td>
<td>5.4</td>
<td>6.7</td>
<td>10.8</td>
<td>13.6</td>
<td>45.1</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: NRCR, Hohai University, Nanjing

By these statistics, the 85,000 reservoirs that have been built in the period, which involved some 22,000 dams higher than 15 m., have caused the displacement of an estimated 12 million people—an average of 240,000 per year. There is no accurate means of retroactively counting the total number of people or families displaced in different regions and periods, such as during the cultural revolution, when China was actively building large dams while there was a large social upheaval and largely undocumented movement in the country. As noted in section 2 of this paper, the available statistics suggest that China is now building fewer, but larger dams than it was in the 1950s through 1970s. The Three Gorges dams (Hubei province), which is exceptional in terms of the size of affected population, will displace at a minimum some 1.1 to 1.2 million persons, depending on the estimates; some critics suggest the total may be higher.

Like most countries, the more recent the project, the more accurate and available the figures on resettlement are likely to be.

Five large multipurpose dam projects with a total installed capacity of 7,040 MW have been supported by World Bank loans since 1985. These are Shuikou, Daguangba, Xiaolangdi, Ertan and Jiangya. They have inundated about 25,000 ha and displaced some 343,000 people. The Asian Development Bank is also assisting with dam projects in the PRC. Projects include Lingjintan (240 MW), which affected 4,000 persons, and Mianhuatan (600 MW), which affected 36,000 persons.

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5.1.1 Resettlement Laws, Regulations and Policies

There are numerous laws, administrative regulations and rules pertaining to land acquisition, demolition of buildings and infrastructure and resettlement in the PRC. The laws, rules and regulations most affecting involuntary resettlement are:

- Constitution of the People’s Republic of China, first adopted in 1982 and revised in 1999 – states that land in urban areas belongs to the State and land in rural areas and in city suburbs belongs to the collectives; house plots also belong to the collectives;
- Law of the People’s Republic of China on Administration of Real Estate, adopted in 1994;
- Regulations on the Protection of Basic Farmland, adopted in 1998;
- Regulations Governing Urban House Demolition and Relocation of 1991;
- Regulations for Land Acquisition and Resettlement for the Construction of Large and Medium-sized Water Conservancy and Hydroelectric Projects, adopted in 1991 – local governments are empowered to formulate their own local regulations;

Annex 4 provides an illustration of the resettlement programme for the Shuikou hydroelectric project where some 67 000 people were displaced. It provides an illustration of the application in practice of the laws and regulations applicable to all large dam projects and lessons learned about good practice.

The most recent government initiative is the Land Administration Law of the People’s Republic of China, which became effective on January 1, 1999. It ensures the need not only to compensate affected people but also to provide for adequate subsidies to re-establish their livelihoods. Article 51 requires that the State Council should approve the standards of compensation for the construction of medium or large-scale water conservancy projects. The Law requires provincial and local governments to obtain comments and suggestions on compensation and resettlement subsidies from the public. Regulations for Land Acquisition and Resettlement for the Construction of Large and medium-sized Water Conservancy Projects set out the principles and methods for restoring the livelihoods of the affected people.

The important policy implications of the above laws and regulations are to:

- give the government overall responsibility for all resettlement;
- launch social mobilisation to convince people of the project benefits;
- encourage self-reliance among the resettled population;
- restrict the use of agricultural land for construction purposes as far as possible;
- restore the original living standards of the affected people;
- compensate and provide employment to affected people if no land is available;
- extend developmental assistance for up to ten years after resettlement implementation is completed;
- foster support for the affected people from the general population;
- include all compensation and resettlement costs in the project budget;
- ensure government approval of the land acquisition and resettlement plan;
- allow agricultural displaced people to resettle on land;
- enable urban affected people to choose houses in alternative locations or get cash compensation;
- ensure that affected villages sign contracts for compensation and resettlement;
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- enable disputes to be settled through grievance redress mechanisms.

In addition to these provisions, the PRC has adopted preferential policies for a number of dam projects. Of particular importance are the policies adopted for the Xiaolangdi Multipurpose Dam Project and the Three Gorges Project. These special policies include additional provisions to:

- ensure mutual acceptance of displaced people and hosts,
- restore infrastructure to improved service levels,
- consult with the affected population,
- establish effective institutional arrangements to implement resettlement,
- use revenue from power generation to rehabilitate affected people,
- invest land tax revenues for the welfare of affected people,
- make electricity available to the reservoir area on a priority basis,
- develop the affected areas on a preferential basis.

The foregoing lists are clearly idealistic and need to be translated into actions that are felt by those subject to resettlement. The change in institutional culture that will be required to give effect to these policies and regulations should not be underestimated. There is much criticism in the Chinese media and from international NGOs and civil rights groups about an apparent lack of follow-up in implementing and observing the spirit of the laws and regulations. Concerns ranging from lack of experience and institutional capacity, and under funding to corrupt practices, are expressed in the media of by outside observers.

5.1.2 Institutional Responsibilities for Resettlement

The Ministry of Land and Resources provides laws, policies, standards, regulations and methods for land use planning. The objective is to ensure that the designated owners properly use land resources and to deal with any disputes. In land acquisition and resettlement, it provides laws and regulations dealing with compensation, land transfers and resettlement plan reviews.

The MWR has a Resettlement Management Bureau that is responsible for resettlement and rehabilitation in new reservoir projects. It also manages the remaining problems arising from resettlement in water conservancy projects built before 1985. It is highly significant that China recognises such remaining problems as there are few other Asian countries that formally and commonly recognise that there may be many specific and legitimate grievances expressed by displaced families. The Sector of Electric Power of the State Economic and Trade Commission is responsible for resettlement in the electric power sector. For the Three Gorges Project, its own Resettlement Bureau deals with all resettlement matters.

In foreign funded projects, the project owner's responsibility is to review the resettlement plan, control funds, and to guide and supervise the implementation of resettlement. The project owner must also co-ordinate implementation, resolves conflicts, monitors progress and takes appropriate action to make the necessary adjustments.

According to the Regulations on Land Acquisition and Relocation in Large and Medium-Sized Water Conservancy and Hydropower Projects, resettlement bureaus at provincial, city, and county level have responsibility for the implementation and management of resettlement. In rural areas, the township government and village committees also play an important role in resettlement. Specifically, they contribute to the resettlement plan in such areas as land allocation, location of housing, common property, compensation for land and income generating activities. On a countrywide basis, there are 740 000 village committees comprising 233 million households.

Water conservancy projects, including hydropower projects, are required to prepare resettlement plans at the design phase and at the implementation phase. Provincial design institutes of the MWR, the

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Involuntary resettlement on the scale that is undertaken in the PRC constitutes significant social engineering. A common view expressed by resettlement professionals outside China is that in situations where ethnic minorities are affected, particular care needs to be taken to ensure that minority views are canvassed and recorded in a manner that allows free and open expression of opinion and aspirations.

5.1.3 Human Resources and Training

In the PRC, the central and provincial design institutes have extensive experience in resettlement planning and in some cases are over worked. However, their resettlement/social staff, numbering about 500, generally lacks deeper expertise in important areas such like archaeology, anthropology and sociology. While they do rely on social scientists, many of the government and agency personnel involved in resettlement programmes have physical sciences background and training. Indeed this is understandable given that the Chinese education and university system has in past emphasised the physical sciences disciplines. This also applies at middle and senior management levels where the dominant "organizational culture" is engineering and has in past been related to promotion and advancement.

One consequence of this has been greater emphasis on the physical aspects of resettlement, estimating areas inundated, cost estimates, logistics concerns etc. than on the social consequences of resettlement. This approach to resettlement planning has been largely influenced by MWR directives issued in 1984 and 1985 that stressed impacts on land, houses, structures and population. In the water conservancy sector, 26 out of the 31 provinces have resettlement offices with 3 000 staff trained in engineering, finance and management. Again there is very limited expertise in the social sciences. This is a serious shortcoming that needs to be addressed over time in the training of social and environmental professionals for resettlement in China. The social dimensions of water resource projects in a country that has as many ethnic minorities, such a shortage of arable land and so many people living in poverty are daunting. As China embraces a free-market and more open society the potential for social tension resulting from water resource allocations may well increase, unless serious consideration is given to the social implications of water related projects.

Hohai University in Nanjing and the Wuhan Water Conservancy and Power University are the only institutions offering resettlement courses. The Resettlement Management Bureau of the Ministry of Water Resources has established a training centre at Lintong City in Shanxi province where over 800 persons have been trained to date.

5.1.4 Chinese Performance in Resettlement as a Consequence of Dam Construction

The performance in resettlement will vary from project to project depending on the circumstances and the capacities and experience of the leaders and key personnel involved. The following is a list of favourable trends, unfavourable trends, and directions for improvement that have been suggested in various reports and studies.

Favourable trends in Chinese resettlement procedures are:

- national and provincial leaders increasingly recognise that resettlement should be seriously dealt with in the context of rapid infrastructure development;
• resettlement policies are being continually improved at the national level;
• compensation standards are improving and livelihood restoration is being recognised as a component in many resettlement projects;
• efforts are being made to minimise land acquisition;
• resettlement is viewed as a development opportunity;
• socio-economic surveys and impact identification are improving;
• resettlement offices have been established at provincial, city and county levels;
• village representatives and affected people confirm and sign off on land matters;
• flexibility is being built into implementation and budgeting;
• economic development is providing opportunities for project-affected people to move out of agriculture;
• environmental conditions in potential host areas are investigated before deciding to relocate people;
• a fraction of hydropower revenues is used to improve conditions of affected people around the reservoir;
• monitoring and evaluation are given more attention.

Less-favourable trends include the following:

• because of scarcity of natural resources, affected people are being resettled at longer distances from their place of origin, which raises the question whether they are being given a real choice;

• the shift for a market economy has led to hard-pressed state-owned enterprises not being able to absorb any displaced people from the agricultural sector;

• corrupt practices in resettlement implementation are being reported with greater frequency. These practices are involving large amounts of money and as a result the affected people end up poorer as funds earmarked for them are being diverted;

• resettlement frequently results in a period of lower standard of living for those involved. Livelihoods usually only improve after a number of years. This loss of quality of life is not being recognised as an issue.

Areas where further improvement is needed are:

• project feasibility studies should clearly demonstrate how resettlement was avoided/minimised;
• clear procedures properly grounded in social science are needed to ensure that affected people fully participate during all stages of the resettlement process. Surveys and studies must ensure confidentiality and freedom from intimidation;
• compensation criteria and levels must be sufficiently flexible to accommodate the rapidly changing economic and social conditions in the PRC;
• the choices open to communities must be clearly and fairly stated and must not be misleading;
• the guidelines for conducting baseline surveys and preparing resettlement action plans must pay more attention to human aspirations, informed choice, and socio-economic considerations. (The current emphasis is largely on inundation impact measurement and is largely confined to estimation of material losses);
• consistency is required in the application of resettlement policy regardless of the source of funding for the project—internationally funded projects appear to receive preferential treatment;
• specific efforts are needed to promote integration of displaced people and host populations;
• procedures for the redress of grievances should be clearly communicated to the people;
• the wide variability in the quality of resettlement action plans prepared by the different organisations has to be reduced, and minimum standards should be made mandatory for all dam projects;
• staff from design institutes who prepare resettlement plans should also have the opportunity to participate in implementation so that they can improve their planning capabilities based on lessons learned;
• special attention should be paid to vulnerable groups and ethnic minorities;
• separate strategies are needed where significant numbers of ethnic minorities are affected;
• roles and responsibilities, including accountability of various agencies for specific components of the resettlement action plan, should be clearly identified and funded;
• inconsistencies in compensation among different provinces/counties for people affected by the same project should be avoided;
• agreed indices should be developed to objectively and independently assess if the planned livelihood restoration strategies are achieving the anticipated results;
• overstatement of the amount and quality of land available for agricultural resettlement must be avoided and the expectations should not be raised unduly;
• choices and issues relating to possible alternative livelihoods must be addressed earlier in the resettlement process;
• the policy of moving households higher up the reservoir slopes should receive serious re-examination;
• consultation practice should be both formal and professional. Ad-hoc informal consultations by untrained personnel must be stopped;
• systematic follow-up on monitoring results should be made a duty of the resettlement offices;
• institutional capacity to implement resettlement at the local government level should be strengthened;
• income restoration and improvement is still poorly planned and executed, especially in the absence of replacement land;
• in the final analysis, resettlement success should be measured on the basis of the views expressed by the affected people; there is a dearth of this type of information.

Although the PRC has considerable experience in resettlement, it is clear from the problems outlined above that there is much room for improving procedures to ensure that the comply fully with the new policies and regulations that are emerging. A necessary first step appears to be the need to engage or develop a cadre of professional social scientists with experience in social impact assessment to plan and implement resettlement schemes.

5.1.5 Social, Cultural and Socio-economic Consequences of Dams

There are also significant social and cultural impacts associated with dam construction and operation that overlap the resettlement planning and environment impact assessment activities. Clearly, even if a project had no or very little resettlement, a social management plan and related investments would be needed. For example, there may need to be agreement on measures to ensure that the communities near the project are not adversely affected by the influx of a large construction work force, or prepared for the boom and bust cycles in employment, or changes in the river flow resulting from the dams and their access to water or fisheries resources.

Other social measures may need to be considered to avoid situations where:

• established communities that must be resettled are disrupted;
• communities which must host those being resettled are strained;
• competition for land and natural resources is increased in resettlement areas;
• resettled communities must necessarily change their means of livelihood;
• resettled communities suffer material hardship particularly if they are poor;
• ethnic minorities are marginalised;
• the wealthy and those in power benefit at the expense of the poor and marginalised;
• affected communities may suffer a perceived decrease in quality of life;

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• the loss of cultural and historic relics; and
• the loss of landscape features cherished by local communities and in Chinese culture and important to tourism.

More emphasis is also be needed (with appropriate financing by sharing in the project benefits) to ensure that the local development benefits are maximised due to the presence of the project in terms of non-agriculture job opportunities, education, skills development and rural credit to start local enterprises.

Increasingly the human and social dimensions associated with dam building in China are being recognised. Social studies are being undertaken and affected persons are being consulted as to the options that they would prefer following involuntary resettlement. Such studies do, however, appear to be focused on minimising social disruption caused by structural solutions to water related problems. They have not yet progressed to a stage in which affected populations are drawn in to discussions of non-structural solutions in water resource management that may in some situations avoid the need for construction of the dam.

5.2 Environmental Consequences of Dams

Information on the actual consequences of dams and other water related infrastructure on the country’s natural systems is limited. Despite the unprecedented scale of the activity there appears to be a lack of accessible documentation on the effects, both positive and negative, that water related projects have had individually or on a cumulative basis. Some information may be held by national, provincial or local government agencies, or by individual dam operating authorities. Numerous indicators of pollution and environmental quality for rivers, lakes, ground water and watersheds as well as land and air resources have become increasingly available that together paint a larger picture of the state of the environment in China. But there are few comprehensive reviews of the actual environmental effects of dams and related infrastructure.

Based on experience elsewhere and in China some of the main physical and ecological concerns centre on the loss and fragmentation of land, habitat and species, and the loss or degradation of many of the ecosystem functions that natural rivers provide. The ecosystem functions are numerous and depend on the river system. They include wetlands functioning as carbon sinks, nutrient recycling and water purification. The extent to which dams and reservoirs improve or reduce water quality is a major concern in the Chinese context. But generally China's dams permit storage and abstraction of water from rivers so that there is less water in rivers available to sustain natural functions and the ecosystem balance changes. The discussion in section 4 and in Annex 4 on the drying up of the Yellow River for most of the year is one illustration.

As government policy statements indicate the direction of thinking in China is increasingly that the construction of water resource development projects must be harmonised with sustainable social and economical development, and with adequate protection of the ecology and environment.39 Critics contend that while the general awareness and the situation is improving, there is still considerable distance to move to translate policy into regular practice.

5.2.1 Environmental Laws, Regulations, and Institutions

The PRC’s Environmental Protection and Natural Resources Conservation Committee of the State Council, first formed in 1993, oversees national environmental legislation and regulation. In 1998, the National Environmental Protection Agency, an administrative entity under the State Council, was

elevated to ministry-level status and renamed the State Environmental Protection Administration (SEPA). SEPA is responsible for formulating national environmental rules, methods and standards, and oversees but is not directly responsible for their implementation. Also, each industrial ministry has an environmental protection department, office or division that oversees and issues approvals for development activities within their jurisdiction. Locally, provincial environmental protection agencies, as well as county and municipal environmental protection bureau (EPBs), deal directly with the regulated community and enforce both national and local environmental statutes, regulations, rules, methods and standards.

The PRC’s first major environmental statute, the Environmental Protection Law (EPL), was enacted by the State Council in 1979 and revised in 1989. This law brought environmental management within the PRC’s legal system and laid the foundation for future environmental legislation. Between 1979 and 1998, the National People’s Congress enacted 16 laws dealing with pollution control and natural resource conservation (Table 5.1), and the State Council issued more than 20 related regulations. In turn, SEPA, other ministries and agencies under the State Council issued well over 100 environmental rules and methods, and 350 standards. In 1998, it was anticipated that the 1998-2003 Environmental Legislative Plan would propose new laws addressing clean production, industrial waste recycling, environmental impact assessment, and renewable energy.

Locally, the congresses of provinces, regions, and special municipalities formulate local environmental protection regulations based on the national statutes while addressing local social and economic conditions. Local EPBs and commissions can also enact rules, methods and standards not covered by their national counterparts, and may set more stringent standards. Since local authorities are bearing the brunt of the PRC’s most severe environmental problems as a consequence of China’s rapid economic development, local legal and regulatory systems are being required to play an increasingly important role in protecting and improving environmental quality. Many cities, towns and villages nevertheless lack the capacity to protect the environment. They neither have the trained staff, or the financial resources to do so. At the same time, local economic development goals and other pressures may lead to environmental protection being afforded low priority by towns and villages intent on poverty reduction and meeting output quotas.

Article 13 of the EPL provides the basis for the environmental impact assessment of certain projects. Along with the EPL, the Management Methods for Environmental Protection in Construction Projects, the Management Procedures for Environmental Protection in Construction Projects, and the Technical Guidelines for Environmental Impact Assessment incorporate the components of EIA regulation. Generally, SEPA is responsible for examining and approving EIAs for large projects (over US$ 24 million) that must be approved by the State Development Planning Commission. Local EPBs can approve EIAs for smaller projects. The Planning Commission or its local counterpart should not approve a project until the EIA is approved. Local EPBs are responsible for ensuring implementation of whatever environmental monitoring and management measures are specified in EIAs approved at any level. Generally, the administrative aspects of the PRC’s newer environmental regulations, such as approvals and permitting subsequent to EIAs, are enforced more stringently than older regulations. Despite this framework of environmental laws and regulations the use of EIAs to inform planning and influence decisions is limited. China has few environmental professionals adequately trained to undertake EIAs; environmental assessments are undertaken only after key decisions have been made and serve more to formulate mitigation mechanisms than to enable a choice to be made between alternatives. The political will to give environmental protection precedence over economic growth also appears to be lacking.

While the PRC is clearly committed to improving the legal and regulatory basis for sound environmental management, there are considered to be some significant difficulties to overcome in reaching this objective. Among them are:

- some vaguely drafted legislative provisions especially those allocating responsibility and liability;
• capacity limitations in human and financial resources;
• culture- and development-related difficulties related to varying concepts of ownership;
• low environmental awareness among the people;
• slow acceptance and implementation of the relatively new concept of an advanced legal system that can work independently of central government directives;
• revising the environmental management framework to introduce market-based rather than command-and-control environmental protection mechanisms;
• sporadic enforcement of legislation;
• fragmented enforcement power among many administrative entities with often conflicting environmental protection and development goals; and
• traditional aversions to the use of law to contest authority.

Table 5.2 lists the main laws and regulations by date, and provides an indication of the increasing emphasis on environment management measures.

Table 5.2: Environmental Laws in the PRC, 1979-1998

<table>
<thead>
<tr>
<th>Law</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Protection Law</td>
<td>1979</td>
</tr>
<tr>
<td>Marine Environmental Protection Law</td>
<td>1983</td>
</tr>
<tr>
<td>Water Pollution Prevention and Control Law</td>
<td>1984</td>
</tr>
<tr>
<td>Grasslands Law</td>
<td>1985</td>
</tr>
<tr>
<td>Fisheries Law</td>
<td>1986</td>
</tr>
<tr>
<td>Mineral Resources Law</td>
<td>1986</td>
</tr>
<tr>
<td>Land Administration Law</td>
<td>1987</td>
</tr>
<tr>
<td>Air Pollution Prevention and Control Law</td>
<td>1988</td>
</tr>
<tr>
<td>Water Law</td>
<td>1988</td>
</tr>
<tr>
<td>Wildlife Protection Law</td>
<td>1989</td>
</tr>
<tr>
<td>Solid Waste Prevention Law</td>
<td>1996</td>
</tr>
<tr>
<td>Noise Pollution Control Law</td>
<td>1997</td>
</tr>
<tr>
<td>Water and Soil Conservation Law</td>
<td>1997</td>
</tr>
<tr>
<td>Energy Conservation Law</td>
<td>1998</td>
</tr>
<tr>
<td>Flood Prevention Law</td>
<td>1998</td>
</tr>
<tr>
<td>Forestry Law</td>
<td>1998</td>
</tr>
</tbody>
</table>

5.2.2 Environmental Assessment and Management

Since it was first introduced in 1970, environmental assessment (EA) has evolved internationally from being an evaluation tool to being, in best practice, a planning tool. In the initial “evaluation” model, EA was undertaken for fully planned and designed projects, engineering and environmental professionals did not work as a team (or even meet), and there was virtually no chance for the EA work to influence the project plan. Many of the best opportunities to reduce environmental and social impacts are only available before major siting and design decisions are made, and, in the initial evaluation model, were missed. The more recent “planning” model is characterised by engineering and environmental professionals working as a team right through the project cycle – from concept, through preliminary and detailed design and construction, to operation. At each step, both the environmental and technical costs and benefits of different project alternatives are considered in refining and detailing the project plan, and opportunities to improve the project in terms of its environmental and social performance are evaluated before they are missed.

Worldwide, every country that uses EA is somewhere along this evolutionary path. The PRC appears to still use EA more as an evaluation rather than as a planning tool. Nonetheless, the quality of EA work in the PRC has improved substantially in the past decade, is as good or better than elsewhere in the region (7,8), and is meeting World Bank and ADB requirements for projects in which these organisations are involved. Several late 1990’s submissions for loans in the water sector – including

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• experiences such as those on the Yellow River where the physical cumulative effect of dams and abstractions associated with dams is clearly evident.

Additionally there appears to be a revival of plans for intra and inter-basin transfers of water as discussed in section 4. Cumulative impacts must be viewed and studied on a basin level.

The PRC appears to be moving toward managing the environmental aspects of dams within the context of integrated river basin management. This is an important initiative. Authorities responsible for the development of the Jiangya Dam in Hunan Province are actively working with the Tennessee Valley Authority in the USA to develop their capabilities in this area. Worldwide, integrated river basin management is being promoted and adopted. Experience in the Lancang River basin in PRC (Yunnan Province) demonstrates the severe environmental, social and economic impacts that can result from the lack of such an integrated approach, especially on poor people, and especially when they are not active participants in the overall management effort. The PRC should be encouraged to develop its interest, capacity and commitment to integrated river basin management, and to disseminate lessons learned with the Jiangya project throughout the country.

Performance Assessments

An indication of the PRC’s capacity for the environmental management of dams is provided in a recent comparison of four ADB-funded dam projects in the PRC (Lingjintan), Malaysia (Batang Ai), Indonesia (Singkarak), and Lao PDR (Theun-Hinboun). The ADB review was based on the examination of project documents and site visits in 1998/99. The Lingjintan Dam, a 240 MW run-of-the-river project, was under construction at the time of the review mission, and is the most downstream of 17 proposed hydropower developments on the main stem and tributaries of the Yuanshui River in Hunan Province. The ADB study found:

• communication and consultation with project-affected people was satisfactory to good on Lingjintan (much better than the other projects), but all projects performed poorly in providing opportunities for these people to participate in the design of mitigation measures, project implementation, and monitoring;
• formal channels for affected people to settle disputes were absent or ineffective on all projects;
• weaknesses in baseline data collection led to the misidentification and analysis of project impacts, especially concerning fisheries and heritage resources. On Lingjintan, for example, there was no description of riparian vegetation or rookeries;
• EIA reports tended to define the project to exclude associated infrastructure (e.g. transmission lines, access roads, audits, etc.) and project changes subsequent to the EIA studies. On Lingjintan there were no environmental documents prepared for the transmission lines. Thus, project-related activities having a high potential for causing adverse impacts were left out of the environmental management framework;
• the use of environmental and social scientists was limited during project planning, resulting in a lack of timely and adequate attention to some mitigation measures;
• some mitigation measures have been successfully implemented. However, overall success was hampered by lack of clear specification of the required measures, lack of clear assignment of implementation responsibility, inadequacy of funds, absence of support from local agencies, and inadequate enforcement capacity. There was also confusion about what mitigation measures were binding on the proponent. On Lingjintan, for example, barriers to fish migration were documented in the EIA studies but were not mitigated, and a prescribed study on migratory fish was not carried out;
• compliance with environmental clauses in construction contracts has not been satisfactory for reasons which include ambiguous and modest contract language, lack of incentives, lack of penalties and accountability, poor oversight, and conflicts with schedule and budget;
most projects did not have a formal means by which impact-monitoring information is translated into changed mitigation or operation.

- quality control by agencies that approve EIA reports was inadequate, and the review role provided by social and environmental institutions has been less than satisfactory. Even where supervision responsibility was institutionalised (Lingjintan and Singkarak), there was little evidence of serious scrutiny or oversight. On Lingjintan, the Provincial Environmental Protection Agency (SEPA) did not act as a regulatory body and reported monitoring findings to project management. The reasons for weak supervision are: (i) absence of effective laws and regulations; (ii) lack of technical strength and depth to provide meaningful oversight; (iii) pressure on professional staff in oversight agencies not to follow up on favoured projects; and (iv) paucity of funds to carry out supervisory functions;

- although agencies responsible for the environmental and social management of dams are largely in place, their capabilities to fulfil their responsibilities are generally weak due to: (i) lack of funds; (ii) poor communication and co-ordination between agencies; and (iii) fragmentation of responsibilities. As well, many environmental units are made up of engineers with limited knowledge about environmental and social issues; the units were low in priority for receiving support, staff, and facilities; and the units were managed and operated by local staff with little influence over project management.

From the ADB study it is evident that although the PRC is taking steps to introduce appropriate environmental legislation and regulations there is a great need for the consequences that flow from environmental assessments to be incorporated into planning, decision making, construction management and operational procedures. It is in the interests of all concerned that environmental management of water resource projects be placed on a firmer foundation of political will, resource allocation and meaningful influence in planning and decision making.

### 5.2.3 Future Outlook for Environmental Management of Water Resource Projects

The areas where environmental assessment and management apply in relation to large dams include the basin level and project level.

**Project Level**

The stages in the project cycle where environmental management is important include planning, design, constriction and operating stages. The activities that would be split between the dam owner and the regulator or government agency include the actual assessment or implementation work, and the review, monitoring and compliance roles.

It appears that the PRC’s capacity to evaluate the environmental effects of large dams through the use of EA is improving, but suffers from a lack of reviews on completed projects. The PRC should be encouraged to undertake several reviews of the actual environmental performance of its dams and associated infrastructure to better inform the planning, evaluation and decision-making for future dams both in China and worldwide. Such reviews should focus not only on the severity of the biophysical and resource use effects of dams but also, more importantly, on the limitations in planning and management processes, institutional arrangements, professional/technical capacities, and budget allocations which allowed those effects to occur. The reviews should also begin the process of applying environmental economics to estimating the economic value of the environmental benefits and costs of water resource projects.

It would be very beneficial for these reviews to be widely disseminated throughout Chinese ministries, EPBs, and research institutes involved in the planning and management of dams as well as to international development agencies such as the World Bank, Asian Development Bank and African Development Banks.

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While the use of EA appears to be improving, the translation of EA results into effective environmental management of dams at the construction and operation stages in the PRC appears to be weak. As mentioned above, this is a difficult task. Jurisdictions with advanced EA experience are now placing far more emphasis on project designs that avoid impact, and then on robust environmental monitoring and management systems that can respond effectively to anticipated impacts as they begin to manifest themselves. The PRC would benefit from moving quickly to adopting this approach to strengthening its environmental management capabilities for dams.

**Basin Level or Sectoral Level Strategic EAs**

The PRC would do well to begin initiating EA much earlier in water resource planning so that EA can contribute to integrated river basin management and to improving project planning and design. This, of course, will require political commitment at the highest levels to encourage the transformation of the dam building “culture” in the PRC, and to ensure the required funds are allocated. Reviews of the environmental performance of existing dams will help in this regard. Initiating EA much earlier in the project cycle will not eliminate or even minimise the adverse effects of dams. It will, however, ensure that, at each step in the cycle, decision-makers are aware of the trade-offs they are making among power production, flood control, irrigation, navigation and environmental and social benefits and costs.

There also needs to be an accelerated move to basin-level and sector level EAs. There is much need and scope for this in China and the River Basin Commissions are well positioned for this responsibility, and indeed partly mandated for it. Given China's challenges, experience and large number of dams that can be optimised together (to improve system level performance as well as reduce adverse impacts) there is a need to move beyond strictly project-level EAs to basin, sectoral or strategic EAs. This will help to scientifically bridge the gap between policy level goals and project-level implementation.

Finally, the PRC’s investigation into managing the environmental and social effects of the Jiangya Dam within the context of integrated river basin management is an important and promising initiative. The PRC should be encouraged to develop its interest, capacity and commitment to integrated river basin management, and to disseminate lessons learned with the Jiangya project throughout the world.
Appendix I: Comments received on the Initial Desk Study

Attached are comments received on the initial desk study version of the paper that was circulated in March 2000 and available for the WCD Forum meeting in Cape Town in April 2000. Preceding the comments is the summary note sent to stakeholders and interested parties within China and externally requesting comments and information the material in the desk study.

1. Note Requesting Comments

Attached is the summary of a paper (desk study) on dams in China for your information and comment. It is 15 pages. The full desk study or scoping paper is 125 pages with the summary, main text and annexes. It can be downloaded from the WCD’s Internet WEB page at http://www.dams.org. The objective of the full paper will be to provide an overview of the past experience and emerging issues in water and energy resources development in the China, with particular reference to large dams and the river basin context.

It is important to emphasize that this paper was prepared by Consultants. It does not represent the views of the Commission or of the People’s Republic of China. It is simply the first step (scoping stage) in a 2-step process to prepare a review paper on China. The final paper will form part of the larger WCD knowledge base of 11 case studies and country reviews, 17 thematic reviews, 4 regional consultations and several hundred submissions supporting the Commission process. Thus at this point, the paper may be viewed as a basis for initiating dialogue on some of the experiences and lessons to be learnt from China.

The rest of this note provides background on the process for completing the China Review Paper and where it fits in the WCD process. The review process is completely open. Questions that might provide guidance for the reviewers are as follows. The questions are by no means exhaustive but simply indicate potential lines you may wish to take in commenting, either at a strategic or directional level, or of a detailed nature.

Such as: in your view -

1. is the information contained in the scoping paper accurate and balanced?
2. Which parts of the paper (executive summary, main text or annexes) need to be expanded, reduced or re-oriented to produce the final paper? – and along what lines?
3. what other central points need to be covered? Essentially what is absent from the scoping paper that should come into the full review paper?
4. are there key sources of information or data you could point to which should be reflected in the final review paper (can you indicate how to obtain the information, or can we obtain a copy from you)?
5. Are there important influences on China’s current practices that should be mentioned in the final review paper, or areas China has influenced or shaped in other countries?
6. what do you feel should be principle lessons or points about China’s experience and future direction, which the final review paper might spotlight?
7. what principle experiences from China may be beneficially shared with other countries, which the final review paper might spotlight?
8. what are the key topics where the WCD process (knowledge base or recommendations) may be particularly of interest to or helpful to modern and rural China, which the final review paper might spotlight?

In keeping with the mandate and independent nature of the Commission, each study commissioned by the WCD has a stakeholder review process. Stakeholder participation helps to capture the full range of views and perspectives. With this objective in mind, the China paper was sent to authorities in China to advise them of the progress of this work and other elements of the WCD’s global work program,
and to invite their comment. At the same time this paper was given to the multi-stakeholder WCD Forum consisting of approximately 60 members from around the world. The Forum recently gathered in Cape Town with the Commission to review and comment on all the WCD work in progress. The results of that Forum meeting are reported on the WCD web page. While awaiting comments on the China paper, it has also been place on the WCD’s web page. And it is now being circulated more widely by e-mail to interested and knowledgeable parties such as yourself, who reside both inside and outside China.

Comments on this paper will be collected until the end of the first week of May. Comments may certainly be received after that date, or at any time, but we cannot guarantee that they will go directly into the next version of the paper.

2. Comments Received

The following were comments received on the first desk study and many have been taken in to account in addressing gaps, revisions and other information for the final version of the paper. Otherwise they provide a source of additional information and perspective.

| a) Ian Fox | ADB |
| b) Jean-Luc Rahuel | “Songhua River Flood and Wetland Management Project” ADB TA |
| c) Rob Crooks | World Bank |
| d) Warren A. Van Wicklin | World Bank |
| e) Qingfeng Zhang | |
| f) Jostein Nygard | |
| g) Sophia Woodman | Human Rights in China |
| h) Doris Shen | International Rivers Network |
| i) Rolf Schaumann | ABB |

a) Comments by Ian Fox, ADB

The paper is well written and presents a fairly comprehensive overview of the dam scene in PRC. It is spot-on in the identification of the conflicts of interest, which arise when construction is in the hands of an entity directly controlled by the owner, and the owner also happens to be the engineer via another unit under his control. These incestuous arrangements are highly inefficient, and lead to all kinds of abuses.

To my mind, however, the paper is remarkable for what it does not say. For example, there is no development of the particular Chinese disposition to pursue grandiose engineering projects in favor of more benign solutions. The summary paper mentions, almost in passing, the proposed transfer of water between river basins (the south-north transfer) as though it is perfectly normal to shift water between river basins. Apart from the enormous cost of such schemes and their highly dubious economics, there are many environmental and social costs which, I am sure, have not been considered (often because they are simply too hard to evaluate).

In flood control, also, PRC tends to ignore the potential for non-structural solutions which are relatively inexpensive, and which have the exceptional benefit of not exacerbating the flooding. Non-structural flood management options are mentioned in the paper, but again only in passing. China will have to come to terms in the near future with more modern approaches to flood management (as part of overall natural resources management) to get out of the vicious circle of increased flood protection setting the conditions for increased flood damage leading to even greater incentive to augment the standard of flood protection.
b) **Comments by Jean-Luc Rahuel, SOGREAH, France**

"Songhua River Flood and Wetland Management Project" ADB TA

**Flood Control 5.1.2**

In the section "Floods" I think you should make it clear that continually raising the dykes all along the river course, as is the current trend in China, is not the appropriate solution for fighting floods. One must accept that if some highly vulnerable parts of the river flood plain must be protected with a high flood return period, other less vulnerable part of the river flood plain must in turn be protected with a much lower flood return period.

c) **Comments by Rob Crooks, World Bank**

**Section 1.1.1:**

Para. 3 .... it has now been acknowledged even by the Bureau of Census and Statistics that the figure for cultivated land of 95 million ha. is an under-estimate. As indicated by various satellite surveys done both by Chinese organizations (e.g. Academy of Sciences) and foreign (e.g. USDA), the actual figure is around 133 million ha. (various estimates range from 129-140 million) ..... probably only need to make a marginal note that this is actually the case.

Para.10: " ? "consequently, most water resources had a low success rate ?."". This seems a bit strong and contradictory to the statement in the previous para. to the effect that irrigation increased from 16 Mha in 1949 to 52 Mha in 1997. Obviously something worked. It would be more reasonable to say that most water resources developments have not been as efficiently developed as they could have been; O&M requirements are higher than otherwise due to poor construction, water losses are higher, etc..

**Section 3.1.2:**

Again, need to add the note about the statistical inaccuracy regarding cultivated land area.

**Section 3.1.4:**

p.22 second para? Check the erosion figures ?.. the land susceptible to erosion hasn't changed. The figure quoted (3.67 M sq. km) is the area suffering from moderate to severe wind and water erosion (about half and half). Regarding salinization, most recent estimates of the area of salinized land in China range from 81 Mha to 100 Mha of which, as stated, only about 7 - 8 Mha is located within cultivated land. According to data compiled by the Ministry of Water Resources, the area of salinized cultivated land increased by about 10% over the 20 years to 1996 but the rate of increase declined quite noticeably during the late 1980s (when the trend may have been reversed) and into the 1990s.

**Section 3.1.6:**

First para.  Might note that the low river flows in the Three-H are due mainly to over-abstraction for consumptive uses pointing to one of the key issues in integrated river basin management and no provision for environmental flows?

As to the pollution load statistics suggest the authors contact Jostein, who is in the process of compiling a fairly authoritative account of pollution loads and compliance levels. Regarding the issue of non-point (third para. Last sentence), I don't think it is possible to say how they stack up against other sources overall but there have been studies done in certain lake catchments (e.g. Dianche and Chao) which show that ag non-point is contributing a high proportion (60 - 80%) of total nutrient loads in those locations. The picture is different for other pollutants (e.g. COD) however. The picture for livestock emissions is even less well defined. However, I have just done a "back of the envelope" calculation which suggests that the current intensively housed pig population in China produces a COD load equivalent to that of 200 million people!!!
Fourth para. ?? occurrence of fluoride is not a pollution problem. A lot of the non-compliance registered in these surveys is naturally occurring poor quality groundwater.

Section 3.2 (e)
China is far more highly urbanized than the figures suggest ?.. their comment on the large peri-urban areas is correct ... suggest they talk to Songsu Choi and/or Geoff Read of EASUR for more data if they want to pursue it.

Section 3.4 (Water Demand Projections)
They should note that IHWR never takes account of price elasticity of demand in its projections and hence it tends to chronically over-estimate demand. It should also be pointed out that nearly all water use sectors in China use water very inefficiently - because water is rarely priced at its marginal cost – and there is much potential for significant efficiency gains.

Here are some interesting comparisons between the China paper industry and world average figures (from HHH Water Pollution Study commissioned by Daniel) which sort of demonstrate the point:

<table>
<thead>
<tr>
<th></th>
<th>China Average</th>
<th>World Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill production capacity (pulp)</td>
<td>4,000 tpa</td>
<td>150,000</td>
</tr>
<tr>
<td>Labor productivity (t/person/yr)</td>
<td>10.5</td>
<td>200-500</td>
</tr>
<tr>
<td>Avg water consumption (cm/t)</td>
<td>350</td>
<td>20-50</td>
</tr>
</tbody>
</table>

**d) Comments by Warren A. Van Wicklin, World Bank**

Social Section 6.2-6.6

It is a bit difficult to review this study because it is a meta-review, that is a review of other reviews. The sections I read were mainly lists of composite findings from other sources, not an assessment of case studies. Since no case studies are presented, it is difficult to verify the accuracy of these findings. My overall impression, however, is that the summary findings are fairly accurate, listing failures as well as successes.

6.5.3 Failures

I would suggest adding the following bullets to the list. There could be others. Emphasis tends to be given first to relocation, with the focus on economic rehabilitation done after relocation. This leads to postponed income restoration, and a short-term income gap, although long-term income restoration appears successful. Some local authorities have not invested resettlement funds wisely, therefore creating local discrepancies in resettlement performance. Resettlement budgets do not provide for inflation, which often necessitates later supplements to the resettlement budget. This causes some problems with the timing of resettlement activities.

6.5.4 Issues

Curiously, this section is somewhat understated. China has by far the most extensive legal and policy framework for reservoir resettlement of any country I know, which has a direct impact on resettlement performance. This does not really come through in the paper.

I also believe that resettlement of ethnic minorities has been a bit of an issue, mainly in Daguangba, but I do not know the details. It was not an issue in Yantan, so maybe I am wrong. Check with someone that worked on Daguangba.
Another issue that is not addressed is the changing nature of the Chinese economy, particularly towards a more market based approach, could potentially undermine the existing planning approach to resettlement. As township and village enterprises (TVEs) are restructured, and many shut down or down-sized, that will reduce the ability of that instrument to create employment for resettlers. The current level of inconsistency in resettlement performance can be expected to increase as the center has less control over local government units.

6.5.5 Future Directions

The list of proposed measures are very general and come across more as a set of good intentions.

6.6.1 Socio-Economic Impacts of Dams

This brief section is so superficial and brief that it really does not cover the subject adequately. It's a good start, but not really sufficient to be considered complete.

In summary, the paper has the problem of sounding a bit general at times because of the absence of specific cases. The paper reads more like a summary of a paper, with all the lists of bullets. I kept wishing there were more specificity and depth. That said, I think the paper does a good job of summarizing the Chinese experience, even if that picture is painted with very broad brush strokes.

Chapter 6-7 Environmental and Social Safeguards

Robert Crooks

As to the main question of tone - I don't think any of us found anything potentially offensive to the Chinese in this report and, in fact, I think there would be plenty of people in China, particularly in SEPA and many of the leading universities, who would agree with many of the problems and weaknesses outlined in the report …. particularly as it relates to the use and effectiveness of EA. I think also that the report is fairly balanced insofar as it acknowledges that EA and environmental management are developing fields in all countries and there is always room for improvement. It might have gone a little further in pointing out that, in comparison to most other developing countries, China is fairly well along the road on EA/environmental management, but, on the other hand, maybe this is becoming a tired argument. The other way to look at it is that environmental problems in China are so monumental, that it really needs to lift its game substantially... up to developed country standards ... obviously, it is quite capable of doing it if it decides that is what has to be done.

e) Comments by Qingfeng Zhang

1. General Comments: These chapters (6 and 7) already grasped the general weaknesses existing in China's environmental safeguards practices at the same time they also indicated the positive efforts the government made to improve the current situation. The suggestions made in the chapters are realistic, and could be taken up by the government if it wanted, particularly those relevant to the reviews of the actual environmental performance of the dams (this is a general criticism for many aspects of environmental management.... there needs to be much more effort put into "audits"," reviews of experience", etc. to feedback lessons of experience into regulatory and management procedures).

2. However, given the great disparity between the small & medium-size dams and larger ones in terms of environmental performance, it seems to me that the discussions may need to go further and make the arguments more specifically.
For example:

2.1. Environmental economic analysis: (page 63): It says in page 63 """"the two EIAs also show no use of methods in environmental economics that supports estimating the economic values of environmental impacts,""", and results in the follow-up suggestions in page 66. I didn't find which EIAs the authors referred to, but the EIAs of some large dams like Three Gorge Dam already employed the environmental economic methods although there were arguments about the analytical results (if they want to contact Qingfeng he will be able to provide some elaboration for them on the general question of the use of environmental economic analysis on large capital developments);

2.2. Institutional arrangement (page 77): With regard to the institutional arrangement of the larger dams, the authors didn't pay attention to the positive change that there already established separate stock-holder company to deal with the issues of dam management and electricity generation. For instance, the Ertan development company has been responsible for the issues of dam construction, dam management, revenue generation and relevant safeguards (also the case on Jiangya). To my knowledge, river basin management commission will play decreasing role in the management of new larger dams.

2.2. Weak supervision of Environmental Management Plan (page 65): General speaking, although the preparation of EIA report has been improved a lot, there are still deficiencies regarding serious supervision. In addition to the reasons listed in page 65, there may exist an institutional reason which also varies between the large dams and small & medium size ones:

a) Normally, local cities or counties are the owners of small & medium size dams. There exists strong conflicts that local governments own and run the dams while simultaneously regulating them in term of environmental safeguards, given the heavy dependent of local EPBs on the governments.

b) Although the separate companies that deal with the larger dam management are largely owned by the government, they already proved to provide more technical staff and funding to handle environmental safeguards as one of their objectives is to make revenue and operate relative independently. Moreover, this kind of market-oriented mechanism gave the environmental authorities more chance to play the safeguard role.

2.3. Integrated River Basin Management (Page 65 & 66) The authors suggested that the government disseminate lessons learned with Jiangya project throughout the country. Given the growing importance of integrated river basin management in China, it is the right time to propose this suggestion. However, it is better for the authors to give more description about Jiangya case since the current toughest aspect for integrated river basin in China is to deal with the trans-provincial issue relevant to the larger dams rather than others (this is an issue that will come up on Jiangya too since parts of the catchment are in Hubei to the best of my knowledge, they have not yet developed an approach for dealing with this problem in fact, they haven't yet dealt with the whole problem of how they can encourage the counties who control the catchment to adopt policies which are consistent with the Hydropower Company's catchment management objectives).

f) Comments by Jostein Nygard

General comment:
The general approach of finding possible shortcomings and providing recommendations to the Chinese EA approach vis-à-vis dams in water and energy resource development is reasonable. As long as the description of the shortcomings are based upon correct facts the criticisms are reasonable.
Some specific comments:

P. 61: Sentence "Each industrial ministry has an ...." In line with the general government restructuring from March 1998 (where, as mentioned, NEPA was elevated to a Ministry becoming SEPA) the former industrial ministries became bureaus and merged under the umbrella of the State Economic and Trade Commission (SETC). At the national level, the environmental protection departments within the former industrial ministries we supposed to be abolished and responsibilities transferred to SEPA. How this is functioning in practice is unclear. Moreover, the restructuring of the government, including clarification of division of labor between the industrial SETC bureaus and SEPA on environmental issues is an ongoing process which has not really commenced at the provincial and local administrative levels.

P. 62: Sentence: "The Planning Commission or its local counterparts will not approve a project until the EIA is approved." This sentence might leave the reader with the impression that SEPA (or local EPB) is executing a strong authority vis-à-vis SDPC by having a kind of "veto" based on the EIA clearance. As far as we know, this is far from the reality. In practice the EIA is often seen as a "formality" and there are indications that many - particularly local EPBs - are not sufficiently powerful to express their possible environmental concerns with the projects and might be overruled by stronger governmental partners in decision making processes.

The point "... traditional aversions to the use of law to contest authority..." It might be put stronger by indicating that enforcement of the law is flawed in many instances. This is not necessary a "traditional" aversion, but simply a reflection of the fact that environmental considerations are not high enough on the political agenda to be in the front rank of decision making concerns which is also reflected in the failure to give responsible authorities sufficient power to enforce the laws and regulations.

Pp. 64-65: "Integrated river basin management (IRBM)": This is a key issue for all Chinese river basins, particularly as it relates to the need to co-ordinate activities of different authorities in jointly abating water pollution. Good experience might be referred to in the example of the Huai River program where an IRBM approach was set up under the approval by the State Council and promulgated by a separate regulation for the river basin (refer to regulation of August 8, 1995). How to apply IRBM is already a strongly focused issue among Chinese leaders, key problem is delegation of authority in a comprehensive intergovernmental IRBM arrangement. (Might strengthen coordination between 4.5 and 6.1 descriptions) (recurring problem for the River Basin Commissions, of course, is that they are essentially departments of MOWR, there is inadequate provision for "stakeholders"(or Provinces) to influence them and, hence, they don't really make much progress).

Overall, Chinese authorities do not need to be encouraged to develop interest, capacity and commitment to IRBM ... there is already a lot of interest. The main issue is how to overcome intergovernmental "battles" in the IRBM arrangements ... the report could be more specific on what parts of IRBM should be strengthened rather than generating general interest and commitment.

Related to "Lingjintan": was SEPA expected to act as regulatory body at the time this project was being developed and EA made (before March 1998)? I assume that the responsible agencies were the Ministry of Water Resources and Bureau of Electric Power? Moreover, is there really an absence of effective laws and regulations or rather flaw enforcement of them?
g) Comments by Sophia Woodman, Research Director, Human Rights in China

Executive Summary, Environment and Resettlement sections (6 & 7)

Overview
While the author of this paper raises some good points about environmental review and regulations, overall in its assessment of resettlement, environmental impact and the procedures for implementing policies in these two areas, I think it presents an unrealistic picture. Part of the problem is that there is a serious shortage of accurate information based on detailed field studies in these areas, but the author fails to give this lack of information sufficient weight. In addition, the author relies too heavily on the promises contained in regulations and policies, and fails to examine the gap between these and their implementation, a deficiency that is an officially admitted feature of most areas of life in China today. Below are some brief comments about critical points that have been omitted or not sufficiently emphasized in the paper.

1. Absence of critical literature

I am disturbed to see that the author does not cite any of the literature produced in recent years by NGOs outside China, or books edited by Dai Qing on the Three Gorges Dam (see list below). A number of these are very pertinent to the whole process of review of dam projects and the climate for discussion of them in China today, and also address more technical aspects, including environmental concerns.

By contrast, the paper relies heavily on studies by the World Bank and the Asian Development Bank. But the banks’ studies of resettlement have generally not been conducted by independent agencies, but by institutions with close links to the Chinese government agencies involved in dam building. Institutions and individuals in China that engage in this kind of evaluation work may be under great pressure to produce results favorable to the government, and there is a lack of independent research institutions and NGOs.

Furthermore, international institutions such as the World Bank and UNDP routinely allow the Chinese government effectively to censor their reports. As an article by Patricia Armstrong shows, it is very clear from the World Bank’s own reports on resettlement in China that it has not applied its own guidelines in a number of areas regarding its work in the PRC. (“Illusions of progress? The World Bank and involuntary resettlement in China,” China Rights Forum, Spring 2000)

2. Context of restrictions on rights

To my knowledge, there is little real public discussion of the “development effectiveness,” or otherwise, of dams in China, although the author of this paper claims that such discussion is increasing. It may be true that such discussion is going on among scholars in scholarly journals, but I have never heard of any such debate in the public mass media. And it is very rare that any criticism of the Three Gorges Project, or any other major project which has been decided by the authorities, can appear in the mass media. Most of the detailed reports regarding corruption and mismanagement of resettlement have appeared only outside China.

The paper also fails to highlight the effects the severe restrictions on freedom of information, expression and association have on such matters as the availability of less-favorable information about dams and dam-building, reports of problems with water projects, independent monitoring of all aspects of hydro projects, the ability of displaced persons to organize to protect their interests and the effectiveness of grievance mechanisms, among other matters.

In addition, the paper takes no account of the effects of the absence of proper mechanisms for public oversight and accountability. Even where there are inspection mechanisms, since they lack
independence, they may not be in a position to act to expose malfeasance, negligence or poorly-conceived projects. There are no independent NGOs that can effectively monitor the work of public and private agencies.

3. No mention of corruption

The paper does not even mention the problem of extensive corruption, which has plagued many large infrastructure projects, contributing to unsafe construction and inadequate provisions for resettlement. Premier Zhu Rongji himself has railed against “tofu construction” projects, and there have been a number of publicized collapses of buildings, bridges and so on. Many commentators have said that one of the reasons for the devastating nature of the floods in China in recent years is that levees and other water control works have not been properly maintained, partly because of corruption, both in that the money has disappeared into officials’ pockets and that because they have paid kickbacks, companies responsible for building such projects have not done a proper job due to incompetence or cutting corners. Another reason for this flooding is the level of clear-cutting of timber.

The author fails to mention the fact that there are serious questions about the reliability of official statistics and reports, a fact that is clearly indicated by a continuing series of news articles in the official Chinese press about the falsification of data by local officials. For example, while the level of flood related fatalities might be lower than in the past, as the author mentions, there are questions about the accuracy of the official figures. They should not be used as a reliable guide, and many commentators have said that the real death toll from the floods is likely much higher than the official numbers, for example.

4. Promises, not reality

The paper focuses too much on written policies and laws, and not enough on practice. The author mentions that there is a shortage of available information on certain issues, but this is not sufficiently highlighted. Given the context of widespread, officially acknowledged failure to implement laws and regulations—particularly when these conflict with other policy goals, such as rapid economic development—it is particularly important to show how the reality compares with the legislative and policy provisions.

As do the World Bank and the Asian Development Bank, this paper tends to exaggerate the extent to which regulations covering resettlement provide “guarantees” to displaced persons. One key example is the idea that these regulations require that the authorities ensure that the income levels of the displaced be restored to the level they were at prior to moving. But there is no such legally-enforceable guarantee. Thus restoring income levels is merely a promise. (For more on resettlement, see our critique of the DRRRD study.)

5. Inadequate grievance procedures

The paper also does not mention a major deficiency of the government’s resettlement policy: the fact that grievance procedures are severely inadequate. Under the land administration law and the regulations governing resettlement for water projects, people who believe they are not being treated as required under these regulations may bring their case before a court. However, if compensation levels as set by local governments are too low, or provisions for resettlement are inadequate, there is little the courts can do, as they may essentially only rule on whether or not the written regulations and provisions have been followed, such as whether the proposed compensation has been delivered or not. In fact the World Bank’s 1993 report on involuntary resettlement in China states that most of the resettlement cases their researchers were aware of that were brought to courts were initiated by the authorities seeking eviction orders.

Even having laws on the books allowing for suits challenging resettlement provisions is no guarantee that individuals can have such cases heard. When the local authorities believe that cases could be too
disruptive or precipitate a flood of similar suits, court administrations in particular areas have been known to order that the courts refuse to hear specific categories of cases, including those relating to resettlement for urban redevelopment. For example, courts in Beijing have been ordered not to accept any cases challenging provisions for compensation for housing expropriated for new developments, although the law allows for such suits. In one recently reported case regarding resettlement for a water project in northeastern China, villagers who were able to sue had to wait eight years to get compensation at levels much lower than they were apparently entitled to.

There are a number of studies of the use of grievance procedures, including the courts, in rural areas, but none that I know of specifically focusing on resettlement for hydro projects. These studies show that villagers have to rely on extra-legal procedures—such as protests and sit-ins—to get their problems addressed. (See Zweig, David, “The ‘externalities of development’: Can new political institutions manage rural conflict?” in Perry and Selden, eds, Chinese Society, 1999; this paper refers to a number of others on related topics. Also see our critique of the DRRRD study.)

The paper cites provisions of the Chinese Constitution and international treaties to which China is a party as among the legal guarantees for the rights of resettled persons. However, there is no mechanism for invoking the provisions of international treaties in domestic courts, and there is no judicial review of constitutional matters available to Chinese citizens.

The paper repeats the nostrum that “consultation” with local communities is required under current regulations. It is more accurate to say that people are “informed” about projects. They generally do not have any opportunity for input in the planning stages, except perhaps in some cases they may have some input into specific aspects of the plans for their own resettlement, e.g. design of housing. But to my knowledge, this kind of real consultation is more the exception than the rule.

6. National situation
The paper does not take note of the possible effects of widespread and growing urban unemployment on resettlement plans involving transfer of farmers to industrial jobs. Since maintaining “stability” in urban areas has consistently been a higher priority for the PRC government than rural development, providing jobs for urbanites is likely to remain a higher priority for the authorities than dealing with resettlement of people in what are often quite remote areas where water projects are being constructed.

This points to a wider problem of discrimination against rural people in the Chinese system which has significant effects on resettlement policies and practices, but is not mentioned in this paper. (See our critique of the DRRRD study for more details.)

Conclusion:

The approach of this paper, assessing China’s situation essentially on the basis of laws and policies and a number of officially-sanctioned and controlled studies, is consistent with the long-term modus operandi of the World Bank and the Asian Development Bank in China. I would be very disappointed to see the WCD endorse this kind of report since it shows no sensitivity for the particular context in which dam building occurs in China, and fails to take account of the available information that might challenge the received wisdom on this matter.

List of references not cited in this paper providing a more critical take on dam-building in China and resettlement for water projects

Barber, Margaret, and Ryder, Grainne, Damming the Three Gorges: What the Dam Builders Don’t Want you to Know, Toronto: Earthscan, 1993.

Dai, Qing and Xue, Weijia ed., *Whose Yangtze Is It Anyway? (Shuide changjiang)*, Hong Kong: Oxford University Press, 1996


**h) Comments by Doris Shen, International Rivers Network**

The paper is shockingly inadequate and does a gross disservice to the WCD. It is largely a synthesis of Chinese government, ADB and World Bank documents and presents only a dam-builders' perspective of dam building in China. There is no reference to the terrible social consequences of resettlement in China or the repression of those who have criticized dam building. The true extent of the 1975 Henan dam disasters is covered up (the fact that the disaster was covered up by the Chinese government is itself covered up) and the overall poor record of dam safety in China ignored. The environmental impacts of dams warrant hardly a mention. The major problem of reservoir sedimentation in China and its worrying consequences for the future are skimmed over (according to Morris and Fan's Reservoir Sedimentation Handbook (1997), China is losing reservoir capacity at a rate of 2.3% per year - compared to 0.22%/year in the US).

The paper fails to adequately convey a sense of how badly China's water resources have been mismanaged and the severity of current shortages (I could not find it mentioned in the paper that the Yellow River is now a seasonal river which is dry for most of the year), of groundwater depletion and pollution. The paper fails to discuss the role of the Ministry of Water Resources and its obsession with dam building in this mismanagement. The treatment of alternatives to dams in the paper lacks any credibility.

The concerns of dam critics are only very occasionally noted, mostly just so that they can be criticized as irrelevant or ill informed. I can find only one reference given to an NGO document (the Oxfam submission for the Hanoi hearing). I can find no reference to any material by Chinese critics of the country's dam building record, such as the 51 scientists, economists and journalists who contributed to Dai Qing's books 'Yangtze! Yangtze!' and 'The River Dragon Has Come' (similar points have been made in the excellent comments by Sophia Woodman from Human Rights in China).

Most of the study is concerned with macro-level generalizations taken from government sources. Without any source of verification the statistics presented are not credible. No information is given on whether or not Chinese dams have met their projected costs, benefits and impacts and there is almost no information on the actual impacts or performance of any specific dams.

This is a working paper prepared for the World Commission on Dams as part of its information gathering activities. The views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission.
There is basically no information on the actual environmental impacts of dams in China (the 108 page paper has 1 page which purports to address this issue). There is no analysis of the history of reservoir resettlement in China other than to note the number of people resettled (12m people according to page vii, 27m according to page 80; no explanation is given for the discrepancy - the 27m statistic may be a misreading of the table on p.67 which states that reservoirs account for 27% of people resettled in China).

While it is more difficult to get information on dams in China than in many other countries there is still a lot of information available. This paper ignores even the WCD's own review of resettlement in China. Why?

Below are a few specific comments. The paper is so poor that I will only comment on a few of its most egregious problems (I will also try and not duplicate comments that have already been made by Ms Woodman).

- p5 the history of dam building section mentions Gezhouba without describing the various design and planning fiascoes which caused its construction period to be increased from an estimated 5 years to 18. Similarly it mentions Sanmenxia without mentioning the massive suffering of the 400,000 people relocated (4 times the original resettlement estimate) nor explaining the massive sedimentation problem, the cost of the measures to deal with this, and the reduced power production of the dam resulting from the sedimentation. (For Sanmenxia resettlement see e.g. Leng Meng, 'The Battle of Sanmenxia', Chinese Soc. of Anthrop., Spring 1999.)

- on p. ix it is claimed that flood control works have 'greatly reduced the magnitude and frequency of flood overflows'. Yet the statistics on p.22 indicate that the floods in 1996 affected more land than any flood in the past 50 years, and the 1998 floods affected an area of similar extent to that affected by the worse floods between 1954 and 1990.

- the description of major flood events on p.22 fails to note the 1975 Henan dam disaster which killed more people than any of the other floods mentioned.

- p36 states without presenting any evidence that all the downstream impacts of the upper Mekong (Lancang) dams will be positive, especially on the delta. This is merely parroting government propaganda and the claim can only be made based on a deep ignorance of the hydrology and ecology of the Mekong, and of the impacts of dams in general (cf various presentations on the Mekong made at the WCD Hanoi consultation).

- p56 and elsewhere mention the Ertan project. No mention is made of recent press articles stating that the project is losing significant amounts of money due to the lack of markets for its expensive power. This is especially important given the several places in the text where it is mentioned (without any substantiation) that hydro is the cheapest of all power sources.

- p56 the mention of flood control in the Huai basin implies that although there is no available evidence, dams have reduced flood damage. In fact the Huai basin was devastated by one of the world's worst ever disasters - the dam collapses of August 1975.

- section 5.2 Alternatives to Dams is derisory - less than 2 pages long and a quarter of a page out of these 2 pages is devoted to large-dam based trans-basin diversion megaprojects (large dams as an alternative to large dams?!).

- the 4 pages of 'Annex 1 Alternative Sources of Energy to Hydropower' at least expands upon the 3 paragraphs on this subject in the main text. The content of the section is however quite pathetic (for example coming to the remarkable conclusions that a disadvantage of all the alternatives is that they don't have reservoirs and that gas-fired power is "the most expensive of all the alternatives").
- the annexes on the Three Gorges Project, Xiaolangdi and Shuikou are just pro-project propaganda. Aside from citing the number of people to be displaced, no information about the project's public health impacts or social impacts are disclosed.

In conclusion, I cannot see how it will be possible to salvage a credible paper from this review given the short time available. The WCD has wasted its money on the consultants who wrote this paper. The only positive aspect of this I can see is that it highlights to the WCD the type of biased fiction which dam industry consultants regularly churn out and which their clients use to justify building more large dams.

i) **Comments by Rolf Schaumann, ABB**

Following issues are very important and seemed not heavily addressed in the summary (maybe due to political concerns) such as:

- How to control and ensure the quality of the projects
- How to improve the decision making process
- How to enhance transparency with the project management
- How to prevent corruption (erection phase, resettlement)

These issues contribute to the major part of risks for dams in China.