RESEARCH REPORT

STATE OF CHINA'S WATER

Dajun Shen and Ruiju Liang

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RESEARCH REPORTS

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- Increasingly many of the emerging water problems and their solutions will come from outside the water sector and the water profession.
- Implementable solutions have to be case specific. For example, solutions that are feasible in France, Germany, UK or USA may not be applicable in China, India, Egypt or Mexico, because of differing climatic, physical, economic, social, environmental, legal and/or institutional conditions.
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The Centre welcomes comments on its activities, outputs and publications.

Asit K. Biswas
President

ABOUT THE AUTHORS

The late Professor Ruiju Liang was the former director of the China Institute of Water Resources and Hydropower, and former president of Hohai University. He acted as the first chair of Global Water Partnership, China Technical Advisory Committee.

Dr. Dajun Shen is a senior engineer in China Institute of Water Resources and Hydropower Research, working on water resources management. He has over 30 publications in his field of specialisation, and currently is the Programme Coordinator of Global Water Partnership, China. He is the member of the “Next Generation of Water Leaders”.

Dr. Shen took part in "The Social and Economic Development Planning in the Middle Reach of the One River and Two Branches Region in Tibet", investigated hydraulic engineering in Middle Stream of the Yaluzangbu River, Mount Everest Reserve and Changshuo Development Zone in the reserve, and designed the hydraulic engineering of four farms of Tibet Army District. He acted as the Executive Secretary of "IGU Study Group on Regional Hydrological Response to Climatic Change" and edited and published four issues of Newsletter of the Study Group. He was member of the expert group on "Circumstance, Trend and Countermeasures of China's Water Shortage", one of the 21st century strategy researches of Chinese Academy of Sciences, and finalised the chapter of "Retrospect and Projection of China's Water Shortage" in the report. Dr. Shen took part in the research program of "Effects of the Middle Route of China's Water Transfer Project on the Downstream of the Danjiangkou Reservoir". The study analysed the influences of the different water transfer scales on the downstream of the water sources, including agricultural water use, navigation, hydropower and flood control, and the different compensation engineering, developed the best water transfer scale from a view of the downstream effects and compensation. Environmental analyst and plan specialist in the ADB TA project "Strategic Options for the Water Sector, PRC" (TA-2817, PRC*)*, and water pricing expert in and responsible for the "Water Pricing Study" in the project "China An Action Program For The Water Sector" funded by the World Bank, team leader of "Water Pricing Theory and Practices for Sustainable Development" funded by Natural Science Foundation of China; "Water Pricing Methodology and Practices for Sustainable Development" funded by Natural Science Foundation of China resent; "Water Pricing Methodology and Practices for Sustainable Development" funded by Natural Science Foundation of China, at present Dr. Shen is responsible for the following projects: "the State of China's Water Resources" of International Water Resources Association. Dr. Shen is currently taking the national coordinator in "Water Resources Demand Management" of the DFID project "Water Sector Development Programme".

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1. Geographical Aspects

China, in the southeast of Eurasia, faces the Pacific on the southeast, stretches northwestwards to the interior of Asia and borders South Asia subcontinent on the southwest. As the world's third largest country in area, China has a vast territory which spans about 62 degrees in longitude from E135°5' to E73°40' and about 50 degrees in latitude from N4°15' to N53°31', covers an area of 9,600,000 km^2, about 1/15 of the total area of the global land surface (Figure 1).

Fig 1, The Administrative Map of China
Sources: http://www.china.com.cn/e-Internet/GQ/HTM/zgdxt.htm

The general tendency of the topography of China is higher in the west and lower to the east and it may be divided into three terracing grades from west to east, which should have pronounced influence on the distribution of precipitation and water resources (Figure 2).

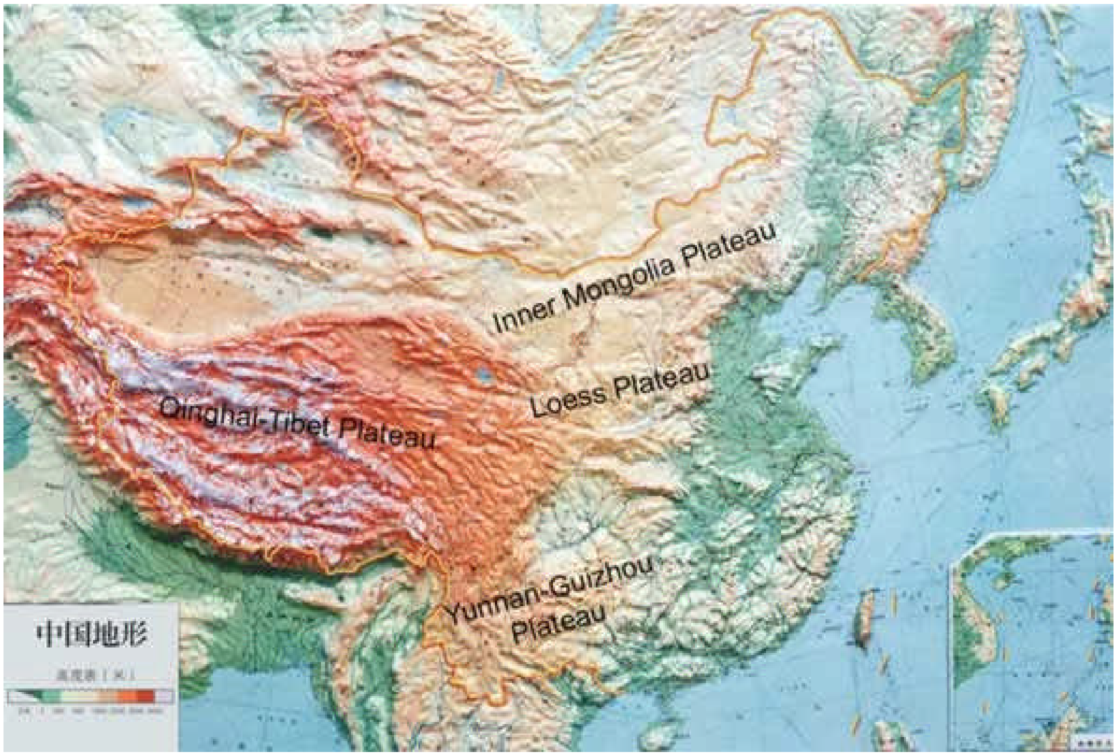

Figure 2, China Topography Map

The highest step is Qinghai-Tibet Plateau having contours generally over 4000m with a series of parallel ridges and valleys and numerous snowy peaks, such as the Kunlun, the Karakorum, the Altun, the Qilian, the Tanggula, the Gangdise and the Himalayas and the Hengduan mountains, as well as a lot of lakes. The elevation of the highest mountain peak, Everest of the Himalaya Plateau is 8848m, which is the highest peaks in the world. On the Qinghai-Tibet Plateau, due to the higher elevation the atmosphere is very thin and the precipitation is scare. At the border districts of the plateau due to intensive upward motion of the air torrent the precipitation becomes more.

The areas to the north of the Qinghai-Tibet Plateau and the eastern part of Sichuan Province with elevation 1000-2000m constitute the second step, including highlands such as the Inner Mongolia Plateau, the Loess Plateau, the Yunnan-Guizhou Plateau and the mountains of Altay, Tianshan, Qinling etc, and large basins such as the Junggar Basin, the Tarim Basin, the Sichuan Basin etc. The northern edge of the summer monsoon may reach the areas, so annual precipitation is obviously higher than that in the Qinghai-Tibet Plateau.

The vast area extending from east of the Da Hingganling Mountains, the Taihang Mountains, the Wushan Mountains and the Yunnan-Guizhou Plateau to the coast is the third step with interlocking distribution of hill lands and plains. The elevation of most hills are below 1000m and the elevations of the coastal plain areas are below 50m. In this step, the summer monsoon prevails and the precipitation is plentiful.

In China, the mountainous areas account for nearly 33% of the total territory, the plateau areas make up 26% of the total and the hilly areas area 10%, the intermountain basins are 19% of the total and the plain areas account for only 12% of the total.

Monsoon climate is the predominant feature of the climate in China, which, with its most part under the influence of southeast and southwest monsoon, has the characteristic of the humid and ample in rainfall around the southeast while dry and scarce in the northwest. It is also typical that prevailing wind directions shift abruptly from winter northerly to summer southerly and precipitation mostly in the warm half-year with high temperature appearing in the same period. The vast area of the East China and most areas of the South China are controlled by the eastern Asia monsoon. Generally, in summer these areas are affected by the oceanic air current, but in winter they are controlled by the continental air current. These results in dry winter and wet summer, however in these regions even in dry season there is also some precipitation. The southern part of Tibet and the most areas of Yunnan Province belong to the southwest monsoon climate zone in summer, and the rainy and dry seasons can be distinguished obviously.

Owing to the winter monsoon from Seberia and Mongolia Plateau, in most part of China, the winter temperature is 5-18 centigrade lower than the places of the same altitude. Due to the oceanic and continental influences, the humidity varies greatly with the distance to the sea. From southeast to northwest, the humid, semi-humid, semiarid and arid zones distribute accordingly. In the southeast coastal area, the annual average comparative humidity is 77-78%, while in the inland area in Xinjiang, it is only 40%.

According to the regionalization of China, the whole country can be divided into nine climatic zones plus the Qinghai-Tibet climatic zone. (Figure 3) In the eastern China, from south to north, distributed are south, medium, north tropic zones, south, medium, north subtropic zones and south, medium, north temperate zones. The heat decreases from south to north. The south tropic zone is mainly the islands in the South China Sea with plentiful heat resources and annual average temperature higher than 25 °C and without winter. The north temperate zone locates at the north Da Hinggaling Mountain, with annual temperature of -5°C and without summer. So the climate in the south and in the north is clearly different.

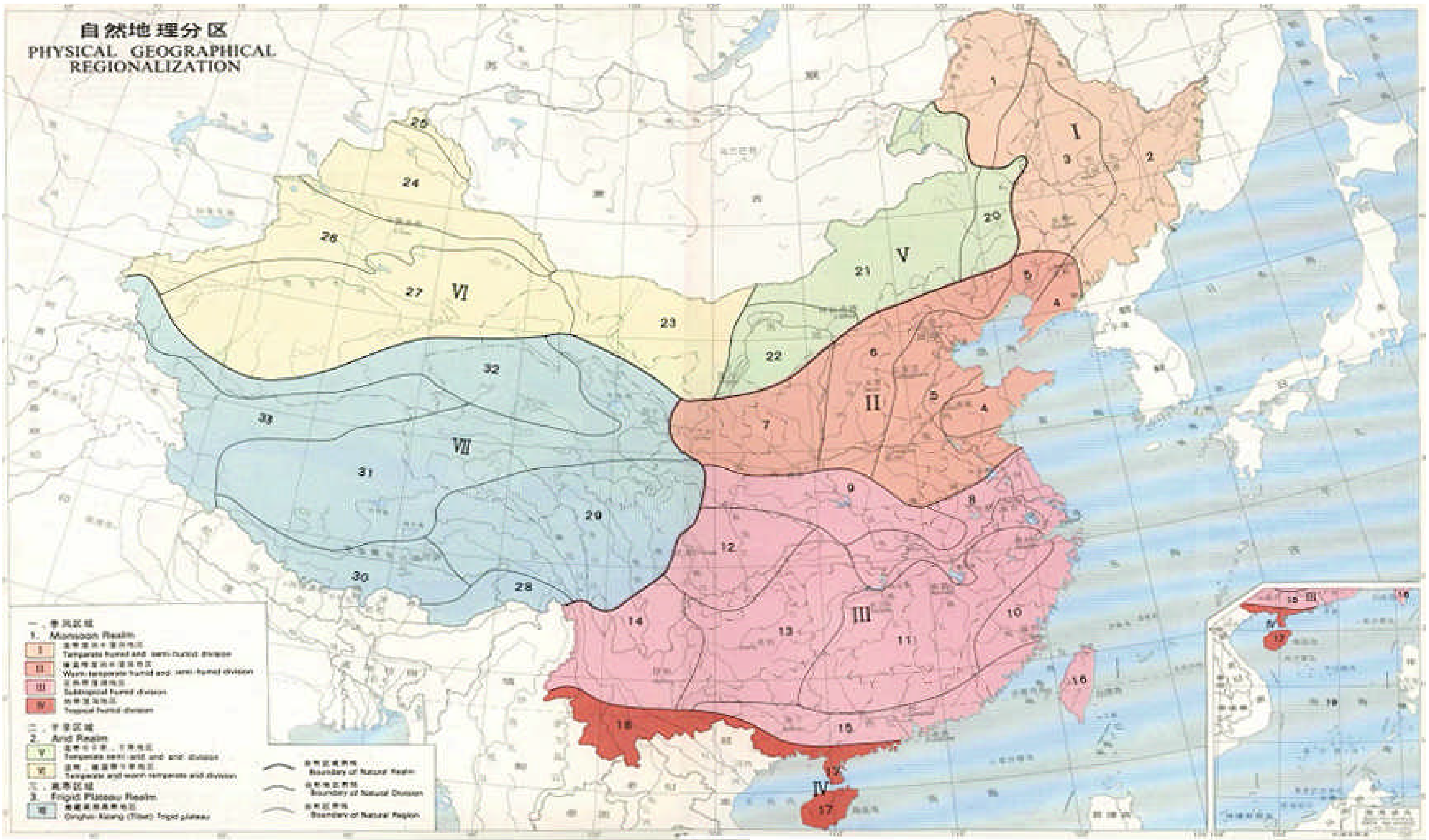

Figure 3, Physical Geographical Regionalization of ChinaSource: Drinking water atlas of China, 1989, China Cartographic Publishing House

China is a country having a great number of rivers, there are more than 50000 of them with catchment over 100 km^2, and about 1500 of them each over 1000 km^2. Owing to the influence of topography and climate, the distribution of rivers over the country is very uneven as the overwhelming majority of them occur in the eastern part where monsoon climate produces abundant rainfall, while the minority exist in the arid northwest interior, where, with vast drainless areas, precipitation is deficient due to continental climate. The majority of rivers are fed by rainfall, some are fed by snow melt in spring and rainfall in summer and autumn. In addition, there are some rivers partly fed by glacier melting water.

The west foot of the Da Hinggaling, Yinshan, Helan, Qilian, Bayan Har Shan, Nyaingentangha, Gangdise mountains and ends at the western border of the country consist of the line between the outflowing and inland riverbasins. All rivers on the east and south of this line have outlets and run into the Pacific and Indian oceans, while those on the west and north belong to the inland except the Ertix River flowing into the Artic Ocean. The total drainage area of outflowing rivers occupies about 65.2% of the country's territory, in which 58.2% belong to the drainage of the Pacific Ocean and 6.4% to the Indian Ocean, only 0.6% to the Arctic Ocean; while that of inland rivers occupies about 34.8% of the country's total area.

Among the outflowing rivers, those originating in the Qinghai-Tibet Plateau, such as the Yangtze River, the Yellow River, the Lancang River, the Nujiang River and the Yarlung Zangbo River etc, are the main great rivers having distant sources and long courses with huge amounts of runoff and tremendous potential of hydropower resources. The rivers of the Helongjiang, Liao, Hai-Luan, Huai, Pearl, Yuanjiang etc, are the main ones takeing sources in the Inner Mongalia Plateau, the Loess Plateau, the west Henan mountains and the Yunnan-Guizhou Plateau; while the Tumen, Yalu, Qiantang, Oujiang, Hanjiang etc. rivers, are the main rivers, with sources in the eastern coastal mountains, having rather rich runoff and hydropower potential in spite of their shorter length and smaller catchment areas. (Figure 4)

The country's inland rivers may be grouped into five major regions, i.e. the inland riverbasins of Xinjiang, Qinghai, Hexi, Qiangtang and Inner Mongolia and each of them includes several systems. The common feature of the inland rivers is that the runoff is produced in the mountains and exhausted in hillside plains. Within inland riverbasins, there are about 1600000 km^2 drainless areas.

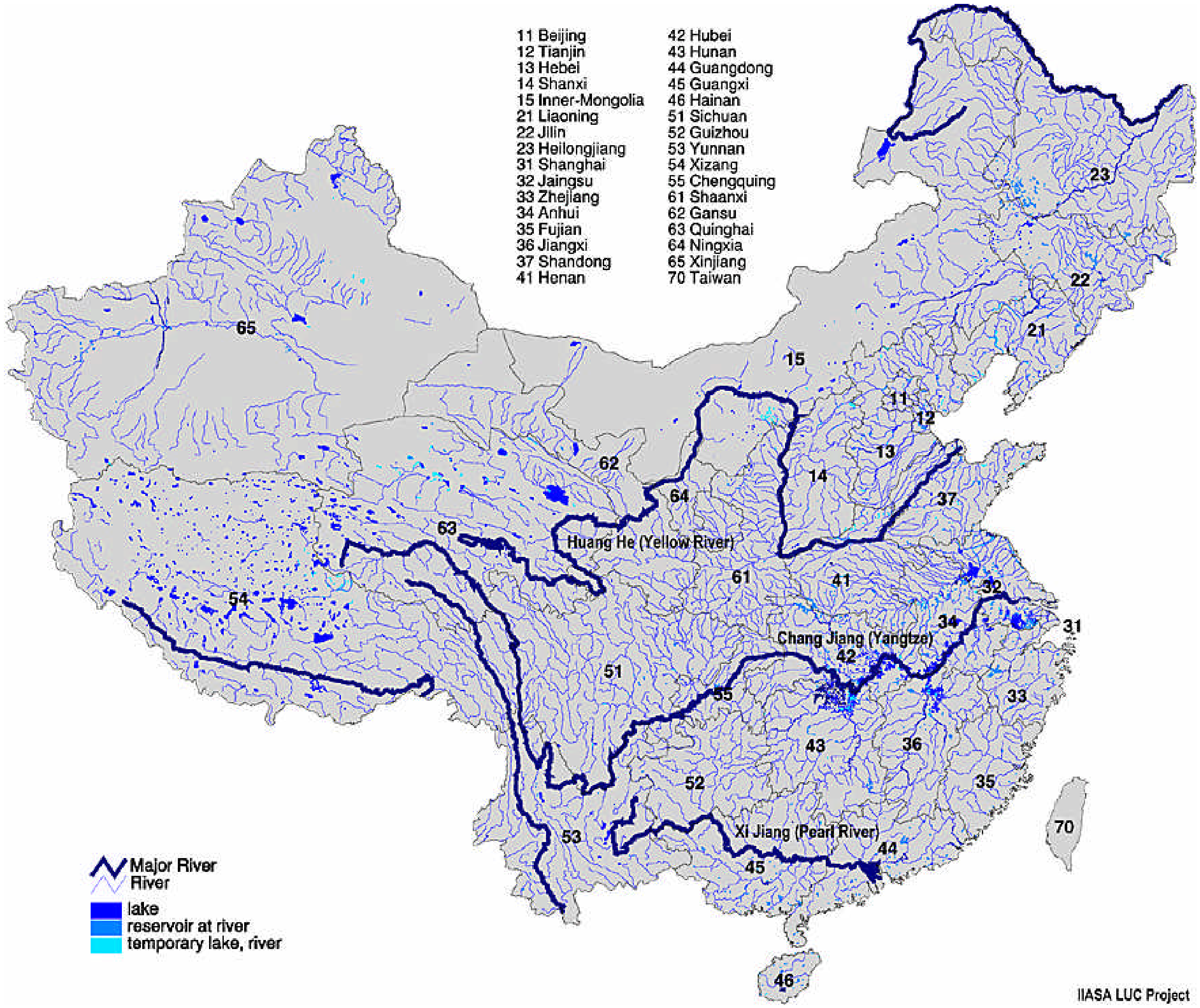

Figure 4, China River Systems
Sources: http://www.iiasa.ac.at/Research/LUC/ChinaFood/data/maps/rivers/riv1_res.htm

Of the rivers related to other countries, some flow along boundary line, e.g. the Ergun River, the main course of the Heilongjiang River and the Wusuli River, the Tumen River, the Yalu River. Some have their lower reaches entering into neighboring countries, such as the Heilongjiang River, the Ertix River, the Ili River, the Nujiang River, the Lancang River, the Yarlung Zangbo River etc.

Additionally, China is a country having numerous lakes. There are about 2300 lakes with areas larger than 1 km^2, the country's total lake area is around 71787 km^2, and the total lake storage is about 708.8 km^3, of which the freshwater portion is 31.9%.

China is one of the countries with most amounts of mid- and low-latitudinal mountain glaciers in the world too. Modern glaciers occur extensively over the country's northwestern and southwestern regions. The total glacial area is about 58651 km^2, the storage is around 5100 km^3, and the amount of mean annual glacier melt water is about 56 km^3.

Always China is grouped into nine water resources regions, the Songliao, Hai, Huai, Yellow, Yangtze, Pearl, Southeast Coastal, Southwest and the Inland riverbasins and 83 second level water resources sub-basins. (Figure 5)

The mean annual volume of precipitation in the whole country is 6188.9 km^3, and the mean annual depth of precipitation is 648 mm, less than both in the mean precipitation (800 mm) over global land surface and the mean precipitation (740mm) over the land surface of Asia.

The general tendency of the regional distribution of annual precipitation is descending from southeast to northeast. In the coastal areas of the southeastern part of the country and some regions of Southwest China, the mean annual precipitation depths are higher than 2000mm and in some places near the eastern sector of the China-India boundary the annual precipitation depths may be higher than 5000mm. The annual precipitation depths for other regions are: to the south of the middle and lower reaches of the Yangtze River,

>1000mm; in the region of Qinling and Huai Riverbasin, 800-900mm; in North China Plain, Northeast China, most part of Shanxi and Shaanxi provinces, Gansu Province, southeast part of Sichuan Province and the eastern part of Tibet, 400-800mm; in the western part of Northeast China, Inner Mongolia, and the vast area to the west of Gansu Province, <400mm; and in some other places, <200mm. At the western ridge of Tianshan Mountain, the annual precipitation is more than 800mm.

Except for some small specific areas, China has the largest precipitation in summer, which is mainly in the form of storms. The whole country except for the northeast part of Taiwan has the smallest precipitation in winter. In spring and autumn, the volume of precipitation lies between those in summer and in autumn, but it varies from place to place, at some places the rainfall in spring is larger than that in autumn, at other places in vise versa. The ratio of the successive maximum precipitation in four months to the annual is 0.6-0.8 in most regions, higher in the north, and lower in the south. The successive three month minimum precipitation for most regions occurs from December to next February. In the south China, the successive three month minimum precipitation makes up 10% of the annual, but in north China it is only 5% of the annual. The concentration of precipitation in summer and the inadequacy of it in winter are more predominant than in other regions of the same latitude in the world.

Figure 1-1 Water resources regions in China

Source: China's Construction in four decades (1949-1989), IX , water resources development in China, 1990, Coastal International Investment Consultant Co., Ltd; Information Research Center of water Resources and electric Power, MOE, MWR.

The time and duration of the rainy season in the country are on a whole consistent with the movement of the summer monsoon. Guangdong, Guangxi, the major part of Taiwan, and the southern part of Fujian are affected by frequent landing of the typhoon until August or September, so the rainy season may last for 7 months, even 8 months in some parts of Taiwan, the Hainan Island, and the Leizhou Peninsula. In southwest China, precipitation is as long as half a year, and there is obvious difference between the wet season and the dry season. In the southern area in the middle and lower reaches of the Yangtze River, the rainy season generally lasts 4-6 months. In the area to the north of the Huai River, summer rainfall constitutes the main part of annual precipitation and it is concentrated within 2-3 months. In the eastern part of Northeast China, the rainy season is slightly longer, 3-4 months, and precipitation is mainly of summer rain and autumn rain. (Table 1)

Owing to the influence of monsoon, the interannual variation of precipitation is significant, moreover bringing continuous wet and dry years. The variation coefficient Cv of annual precipitation in a various places of China presents:

- Along Lanzhou-Qinling Mountains area and southern part of the Yangtze River, Cv of annual precipitation is less than 0.25.
- For the Huai Riverbasin, North China and most part of the Yellow Riverbasin, Cv of annual precipitation ranges between 0.25 and 0.35. For both sides of Beijing-Guangzhou railway to the south of the Yanshan Mountains, Cv may reach 0.40 or more.
- For the northeast China, Cv is, on a whole, low in the east and high in the west. The Da Hingganling Mountains, the Xiao Hingganling Mountains, the Zhangguangcai Mountains and the Changbai Mountains is generally about 0.20. For some areas in the west, the value ranges from 0.25 to 0.30, or above 0.30 for local areas.
- As for vast area in the Northwest China, Cv exceeds 0.40 for most areas, except the Tianshan Mountains, the Altay Mountains and the Qilian Mountains where Cv is comparatively low. The value of Cv may reach 0.70 for dry basins.

The ratio (Ka) of the maximum annual precipitation to the minimum in the country appears with certain regularity, generally, the smaller the mean annual precipitation, the larger the value of Ka. The maximum value of Ka occurs in Northwest China (except the mountainous area in northwest Xinjiang), exceeding 8. The value is generally 4-6 for North China, 3-4 for Northeast China, 2-3 for South China and below 2 for Southwest China.

Table 1, Distribution Normal per Station

Province	Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Beijing	**Tongxian**	3	5.5	7.8	17.7	34.3	77.2	212.2	191	49.4	20.2	9.2	3.9
Tianjin	**Tianjin**	3.1	3.8	7.9	19.3	30	63.1	181.6	156	43.2	17	11.2	4.1
Hebei	**Chengde**	2.7	4.2	7.1	16.9	45.8	87.1	155.8	132	49.4	22.4	8.4	1.7
Hebei	**Baoding**	2.9	5.8	6.7	14.5	29.6	59	166.6	159	38.2	18.3	11.9	4
Shanxi	**Taiyuan**	4	5	10.5	21.3	31.3	49	119.4	107	58.5	24.2	11.8	3.6
Shanxi	**Changzhi**	4.1	7.4	15.3	33.4	36.5	78.6	168.1	136	63.1	44	17.8	5.8
Inner Mongolia	**Hailar**	3.4	3.7	4.4	12.9	23.4	50.8	91.1	73.6	42.2	11.9	4.9	3.8
Inner Mongolia	**Hohhot**	2.6	5.6	7.2	15.1	27.4	48.6	107.2	117	52.9	22	6	2.1
Liaoning	**Shenyang**	5.7	6	15.5	33.9	62.7	88	179.7	162	76.5	41.7	20.9	8.8
Liaoning	**Dalian**	9.8	7.8	14.4	29.2	43.2	61.5	174.5	145	80.2	32.2	24.1	11.9
Jilin	**Changchun**	5.1	5	12.7	21.6	48.1	100	181.4	129	58.3	35.5	14.6	5.4
Jilin	**Yanji**	3.8	4.7	10.9	20.9	48	79.7	96.1	119	66.8	29.7	13.9	5.7
Heilongjiang	**Harbin**	3.7	4.7	10.1	22.9	41.6	88.5	159.7	111	59.4	29.2	9.7	4.9
Heijiangjiang	**Heihe**	4	3.5	7.2	21.2	43	92.8	125.6	115	70.1	21.7	9.7	5.2
Shanghai	**Xujiahui**	47.9	61.4	83.2	95.2	104	176	144.2	133	136	68.9	52.6	39.1
Jiangsu	**Yancheng**	27.7	35	45.8	71.2	74.6	118	219.8	170	115	44.2	36.1	32.6
Jiangsu	**Zhenjiang**	36.3	48.2	68.1	88.8	88.4	166	185.1	121	104	51.5	46.3	32.5
Zhejiang	**Hangzhou**	65.9	93.3	118.9	133	160	221	131	157	165	81.4	66.4	62.1
Zhejiang	**Wenzhou**	49.5	85.9	128.6	147	198	258	194.7	249	206	88.8	57.6	44.3
Anhui	**Bengbu**	21.2	40.8	50.6	61.3	65.8	112	192.5	131	73	36.1	31.8	21.9
Anhui	**Anqing**	40.2	75	110.2	159	195	238	158.5	104	80.3	56	50.1	39.6
Fujian	**Xiamen**	36.9	69.9	89.2	130	157	189	140.7	155	103	37.8	30.3	29.6
Fujian	**Shilian**	54	96.1	165	196	308	294	146	139	114	64.9	46.9	43.4
Taiwan	**Taipei**	87.8	134	188.3	167	222	294	227.5	316	230	119	61.6	71.9
Taiwan	**Taidong**	36.8	44.4	64.3	71.4	170	198	326.7	280	267	173	61.3	36.2
Jiangxi	**Nanchang**	58.7	105.5	163.8	236	298	316	142.3	115	76.2	56.4	59.4	56.1
Jiangxi	**Ganzhou**	53.2	85.1	152.9	201	240	221	119.5	140	82	68.9	57.1	46.3
Shandong	**Huantaiqiao**	6.6	9.1	12.5	27.4	35.2	72.6	205.9	163	62.1	29	19.4	9.9
Shandong	**Qingdao**	10.7	11.7	21.2	36.9	43.1	83.3	162.3	156	92.3	39	25.6	14.5
Henan	**Xixian**	29.3	40.6	57.3	99.8	99.5	133	183.3	119	79.7	51.5	45.6	28.4
Hubei	**Yichang**	20.2	30.3	56.4	102	131	160	223.9	173	107	74.3	37.9	19.7
Hubei	**Hankou**	41.5	55.3	95.4	147	165	215	159.3	107	71.2	71.7	48.1	31.4
Hunan	**Changsha**	52.3	90.8	138.5	176	217	210	122.8	118	62.4	77.5	65.3	46.9
Hunan	**Shaoyang**	54.8	75.2	118.5	193	232	192	111.1	126	59.2	81.8	73.2	46.5
Guangdong	**Longchuan**	46	83	135	175	266	268	162	181	136	55	34	38
Guangdong	**Guangzhou**	40	61	91	166	266	278	239	238	153	63	40	30
Hainan	**Haikou**	23	30	48	92	176	212	200	213	275	171	86	45
Guangxi	**Guilin**	51.1	83.1	123.1	262	360	349	217.7	178	74.5	81.8	65.8	49.2

Guangxi	**Nanning**	**37**	**45.5**	**53.7**	**87**	**185**	**234**	**197.2**	**213**	**122**	**84.6**	**38.5**	**32.2**
Sichuan	**Zipingpu**	**17.3**	**30.2**	**56.9**	**100**	**115**	**129**	**367.8**	**346**	**196**	**103**	**43.4**	**16.5**
Chongqing	**Chongqing**	**17.6**	**21.1**	**39.5**	**94.7**	**152**	**175**	**143.5**	**119**	**138**	**103**	**49.4**	**21.4**
Guizhou	**Sinan**	**22.7**	**24.7**	**52.5**	**118**	**184**	**193**	**143.3**	**123**	**99.2**	**101**	**55.1**	**23.9**
Guizhou	**Guiyang**	**19.5**	**24.7**	**38.6**	**102**	**192**	**212**	**183.6**	**135**	**111**	**99.2**	**49.6**	**23.6**
Yunan	**Caijiacun**	**12.1**	**11.5**	**18.5**	**20.1**	**82.2**	**171**	**207.8**	**186**	**97.9**	**78.6**	**37.6**	**11.7**
Yunan	**Xiaguan**	**18.8**	**29.3**	**31.2**	**24**	**66.7**	**184**	**199.6**	**194**	**138**	**127**	**36.1**	**15.9**
Tibet	**Baxika**	**54**	**98.9**	**139.4**	**274**	**468**	**967**	**975.6**	**620**	**585**	**261**	**31.5**	**22.5**
Tibet	**Lhasa**	**0.2**	**0.7**	**2.5**	**6.1**	**24.6**	**84.4**	**134.4**	**133**	**55.9**	**8.6**	**1.5**	**0.6**
Shaanxi	**Yulin**	**2.5**	**4.2**	**8.8**	**21.4**	**26**	**35.4**	**98.3**	**114**	**61.5**	**24.9**	**12**	**2.5**
Shaanxi	**Xi'an**	**6.5**	**10.5**	**23.7**	**48**	**60.1**	**50.5**	**92.4**	**82.8**	**107**	**60.4**	**28.5**	**6.7**
Gansu	**Lanzhou**	**1.4**	**2.5**	**8.1**	**16.1**	**35**	**34.7**	**64.7**	**87.9**	**52.4**	**22.1**	**4.7**	**1.4**
Gansu	**Jiuquan**	**1.3**	**2.5**	**3.8**	**5.1**	**8.3**	**10.6**	**19.4**	**20.6**	**8.4**	**1.5**	**2.2**	**1.6**
Qinghai	**Golmud**	**0.6**	**0.5**	**0.9**	**1.7**	**4.1**	**6.4**	**9.5**	**7.6**	**5.3**	**1.4**	**0.9**	**0.4**
Qinghai	**Yushu**	**4**	**4.6**	**7.1**	**11**	**54.7**	**97.3**	**104.5**	**88.3**	**74.9**	**26.1**	**2.6**	**1.5**
Ningxia	**Guyuan**	**2.9**	**3.4**	**9.1**	**26.1**	**43.7**	**49.9**	**99.8**	**114**	**79.7**	**34.2**	**11.1**	**2.1**
Ningxia	**Yinchuan**	**1.1**	**1.9**	**5.8**	**12.8**	**14.7**	**21.2**	**46.1**	**60**	**27.1**	**12.4**	**4.6**	**0.7**
Xinjiang	**Altay**	**12.9**	**13.3**	**8.8**	**12.9**	**16.2**	**19.2**	**20.3**	**15.5**	**15.9**	**15.3**	**16**	**17.2**
Xinjiang	**Kashi**	**2.3**	**6.8**	**4.6**	**5.4**	**13.3**	**5.7**	**7.4**	**7.2**	**5.4**	**1.7**	**1.5**	**1.6**
Xinjiang	**Hami**	**1.7**	**1.2**	**1**	**2.5**	**2.8**	**6.3**	**6.2**	**4.8**	**2.6**	**1.8**	**1.6**	**34.1**

Source: Department of Hydrology, Ministry of Water Resources, PRC, 1992, Water Resources Assessment for China, China Water and Power Press.

Precipitation is the main sources of river runoff. The volume of river runoff for the country totals up to 2711.5 km^3, 44% of the total volume of annual precipitation, equal to the mean annual runoff depth of 284mm. The general tendency of the annual runoff distribution in the country from the period of 1956-1979 can be drawn that runoff decreases from southeast to northwest. According to the 800mm, 200mm, 50mm and 10mm isolines of annual runoff depth, the whole country is divided into 5 zones. (Figure7, 8, 9,10, Table 2)

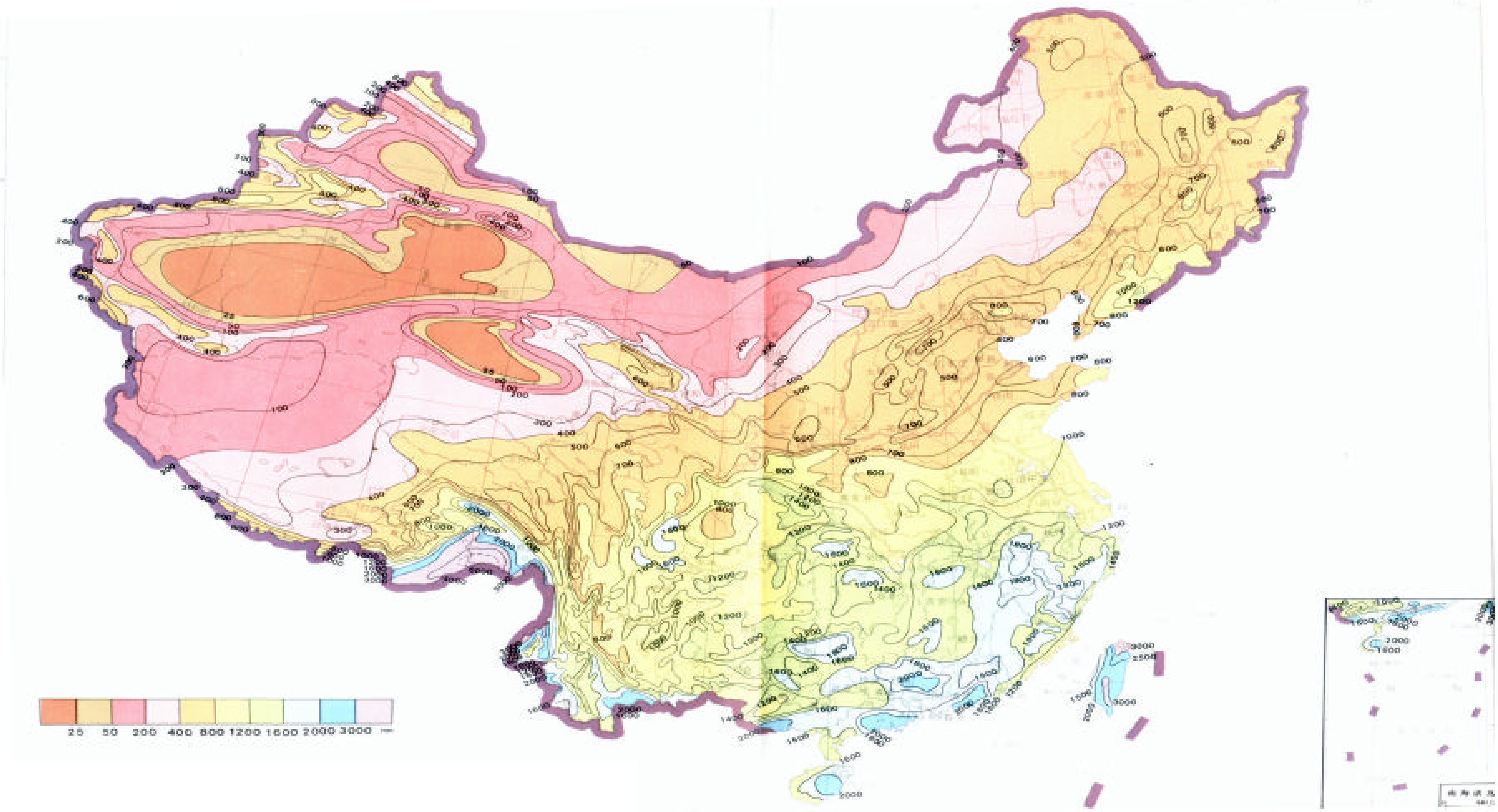

Figure 6, Precipitation Distribution
Source: Department of Hydrology, Ministry of Water Resources, PRC, 1992, Water Resources Assessment for China, China Water and Power Press.

A. The very ample runoff zone

This zone has an annual runoff depth exceeding 800mm. The 800mm isoline starts in the east from the Siming Mountains and Tianmu Moutains of the north part of Zhejiang Province, goes through the Huangshan Mountains and Jiuhua Mountains in Anhui Province, goes along the mountainous area in the east part of Jiangxi Province, extends westward to the mountainous area in the northwest of Guangxi, then turns southward to end at the Shiwan Mountains. The annual runoff generally exceeds 800mm for the zone to the east and south of the line, including the major part of Zhejiang, Fujian, Taiwan, Guangdong, some areas of Anhui, Jiangxi, Hunan, Guangxi, and southeast Tibet and the border areas of southwest Yunnan. For the central mountainous area of Tianwan, the annual runoff reaches 4000mm or more; for the lower reaches of the Yarlung Zangbo River near the China-India border, 5000mm; for main southeast coastal mountains 1600-2000mm; and for the Shiwan Mountains 2500mm, being the largest. The annual runoff coefficient is on a whole above 0.5, for some mountainous areas, it may reach 0.8 or more.

B. The ample runoff zone

This zone has an annual runoff depth ranging from 200mm to 800mm. The 200mm isoline starts from the Changbai Mountains of the east part of the Northeast China, goes southward, passes through Dalian City, turns southwest from Shandong Peninsula, goes through the north part of the Yimeng Mountains, Suxian City, Fuyang City and Zhumadian City, extends along the Funiu Mountains and the northern slope of the Qinling Mountains, turns around the Taizi Mountains of the west Qinling Mountains, continues southwestward by Maqen, Yushu, Nagqu, Lhasa cities in the Qinghai-Tibet Plateau, and finally ends on the China-Nepal border. The vast zone between the 200mm and the 800mm isolines included the east mountainous area in Northeast China, the major part of the Huai Riverbasin, the major part of the Yangtze Riverbasin, the upper Xijiang Riverbasin, the major part of Yunnan, the east part of Tibet, and some parts of the upper and middle reaches of the Yellow River. This zone is vast in area. The annual runoff depth is 300-800mm for most areas in the south, or above 800mm for a few mountainors areas, and 200-300mm for most areas in the north, or above 400mm for some mountainous areas. The annual runoff coefficient is generally 0.4-0.6 for the southern part of the zone, 0.2-0.3 for the northern part, and above 0.4 for mountainous areas.

C. The transitional zone

This zone has an annual runoff depth between 50mm and 200mm, equivalent to the semi-humid zone for precipitation. The 50mm isoline starts from the west side of the Da Hingganling Mountains, turns toward the north end of the Northeast Plain, then goes toward southeast from the east part of the plain, passes by Chifeng City, Zhangjiakou City, Yulin City, Tongguan City, extends westward along the northern slope of the Qinling Mountains, passes through Guide of Qinghai and the headwater areas of the Yangtze River and the Yellow River, and finally ends in south Tibet. This zone covers the Da Hingganling Mountains, part of the Songhua-Nenjiang Plain, the Sanjiang Plain, the plain on the lower reaches of the Liao River, the major part of the North China Plain, the Yanshan and Taihang Mountainous areas, the middle part of the Qinghai-Tibet Plateau, the mountainous area of the Qilian Mountains. The mountainous area in west Xinjiang is also included in this zone. In the zone, the annual runoff depth is 50-100mm for most plain areas, and 100-200mm for mountainous areas. It may exceed 200mm for some local mountainous areas. The annual runoff coefficient is generally about 0.1 for the plain areas, and 0.2-0.4 for mountainous areas.

D. The low runoff zone

This zone has an annual runoff depth ranging from 10mm to 50mm. The 10mm isoline starts from the east side of the Hulun Buir Plateau, goes southwestward, passes through the southeast part of the Inner Mongolia Plateau, then turns southward from the area of the west of Baotou City, goes through the southeast part of the Erduosi Plateau, extends along the northern slopes of the Qilian Mountains and the Kunlun Mountains, turns around the Tianshan Mountains, and finally ends on the southern slope of the Altay Mountains. This zone covers the middle part of the Songhua-Liao Plain, the upper reaches of Liao River, the southern end of the Inner Mongolia Plateau, the major part of the Loess Plateau, the north part of the Qinghai-Tibet Plateau, and some hilly and low mountain areas in the west. The annual runoff depth is generally 10-25mm for plain areas and 10-50mm for the Loess Plateau. In some mountainous areas, the value exceeds 50mm. The annual runoff coefficient is about 0.1, for some areas it is less than 0.05.

Most areas in this zone are poor in water resources. The west edge of this zone lies on the line of sand-driving wind, so desertification is becoming more and more serious. The hilly areas of the vast Loess Plateau are seriously short of water, and soil erosion there is severe. In many areas, of the limited water resources, flood water in summer constitutes about half of the annual runoff. Moreover, the sediment concentration of the water is very high, which brings further difficulties to the development and utilization of water resources. On the upper and lower reaches of the Yellow River, the degree of mineral concentration in water of some tributaries is quite high, which brings great difficulties to the supply of drinking water for people and livestock.

E. The dry zone

This zone has an annual runoff depth below 10mm. In some areas, surface runoff is not available. This zone includes the plain areas of Inner Mongolia Plateau, the Alxa Plateau, the Hexi Corridor, the Qaidam Basin, the Junggar Basin, the Tarim Basin and the Turpan Basin. In this zone, the river network has not developed, intermittent flows predominate, the runoff is very low, and the course of flow is short. In the denuded hilly areas, the runoff is generally below 5mm, and the runoff coefficient is 0.01-0.03. In the vast desert hinterland, there scatter wet land and small shallow lakes, which are the special forms of surface water bodies in desert and are of great significance to the development of livestock husbandry in those areas.

The distribution of the values of the variation coefficient (Cv) of annual runoff over the country is on a whole like this: the value is below 0.50 for the hilly areas in the Yangtze Riverbasin and the Huai Riverbasin and the areas to the south of the Qinling Mountains, of which for the vast area to the south of Poyang Lake Basin and the Dongting Lake Basin except the coast area of Fujian and Guangdong the value ranges within 0.3-0.4; for the mountainous area in west Hubei, the major part of Guizhou and the north area of Guangxi the value is below 0.30; and for the middle part of Yunnan and the Sichuan

Basin, the value generally exceeds 0.50. The value of Cv ranges between 0.60 and 0.80 for the major part of the Huai Riverbasin; it may exceed 1.0 for the North China Plain, which make the plain area with the largest Cv of annual runoff in the country. For the mountainous areas in Northeast China, Cv of annual runoff is generally below 0.50, the value for the Songhua-Liao Plain and the Sanjiang Plain is larger, reaching 0.80 or more. For the Yellow Riverbasin, the value is generally below 0.60, except for the north part of Gansu, Ningxia, and Inner Mongolia for which the value is larger. For the wind-driven sand area in north Shaanxi the value is below 0.30 because of the relatively large volume of groundwater supply. Among the inland riverbasins, the value of Cv for the west section of the Tianshan Mountains and the Qilian Mountains is the smallest, about 0.20, the value of Cv for the Altay Mountains and the east part of the Inner Mongolia, the Qaidam Basin, it is around 0.60. For the Tarim Basin and the Junggar Basin, it exceeds 0.80. For the west part of the Inner Mongolia Plateau, Cv is generally above 1.0, with the maximum reaching 1.20, thus, this is the area with the largest Cv of annual runoff among the inland river areas.

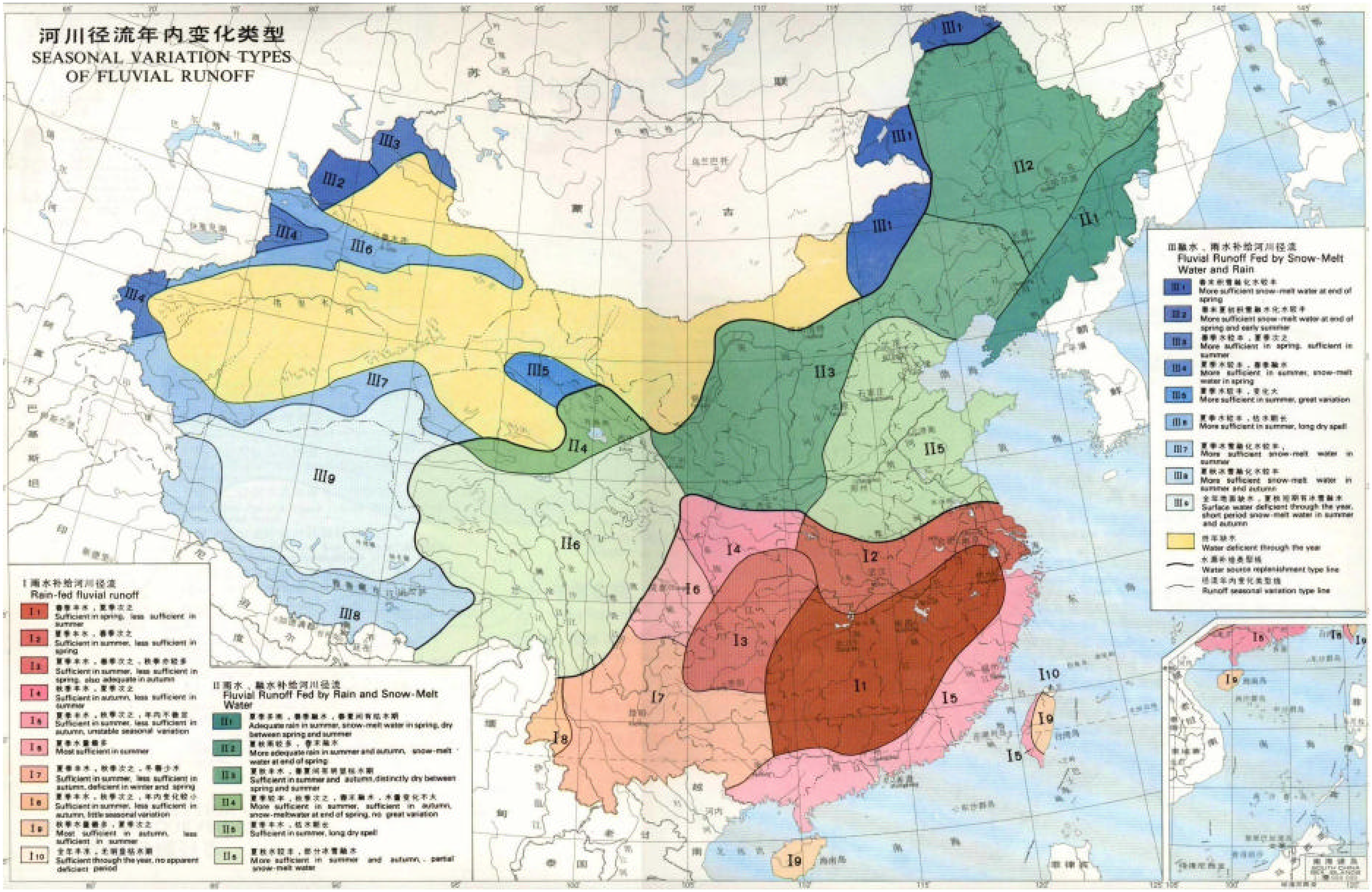

Figure 7, Distribution Type of Precipitation

Sources: Drinking water atlas of China, 1989, China Cartographic Publishing House.

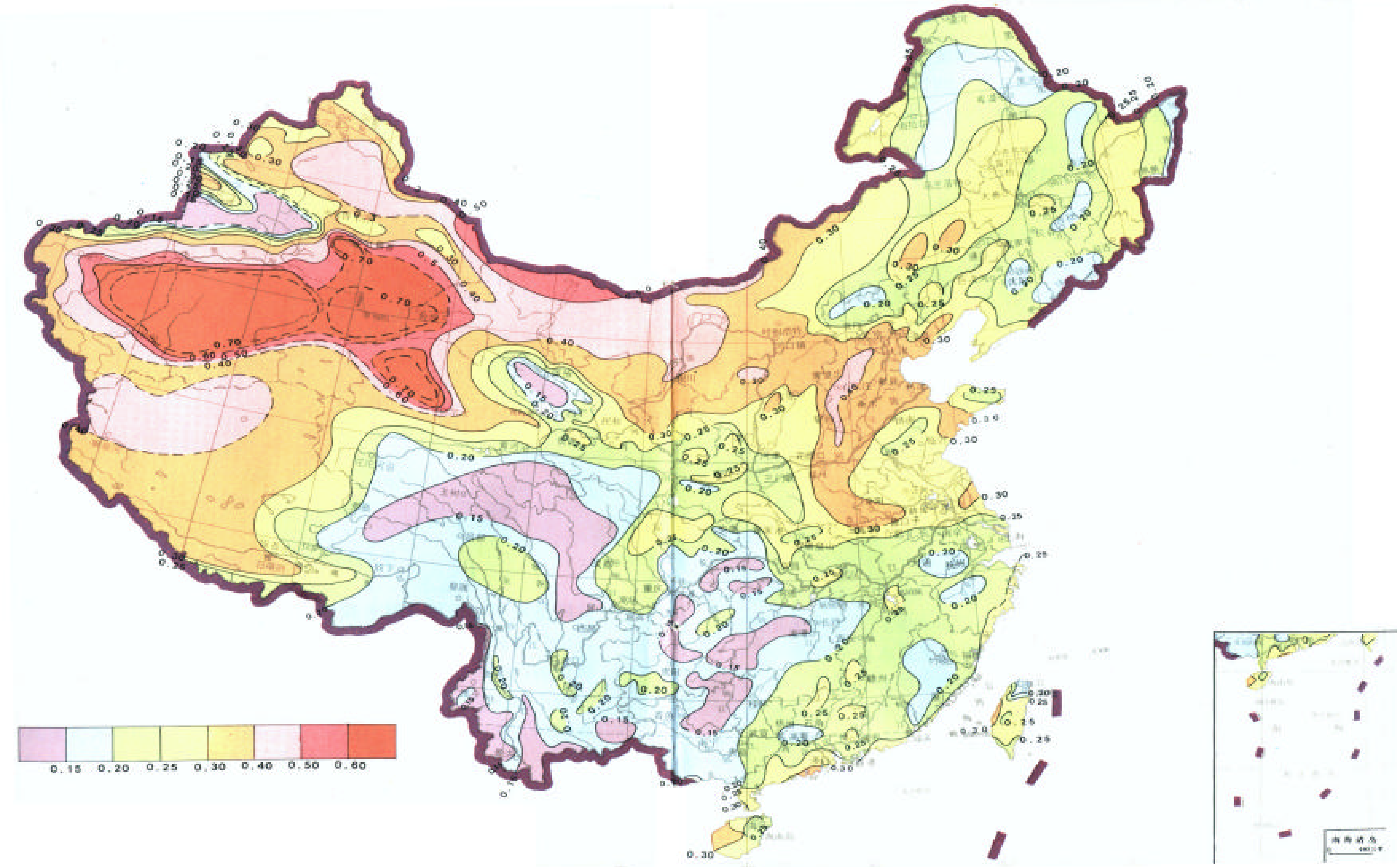

Figure 8, Variation coefficient of annual precipitation in China. Source: Department of Hydrology, Ministry of Water Resources, PRC, 1992, Water Resources Assessment for China, China Water and Power Press.

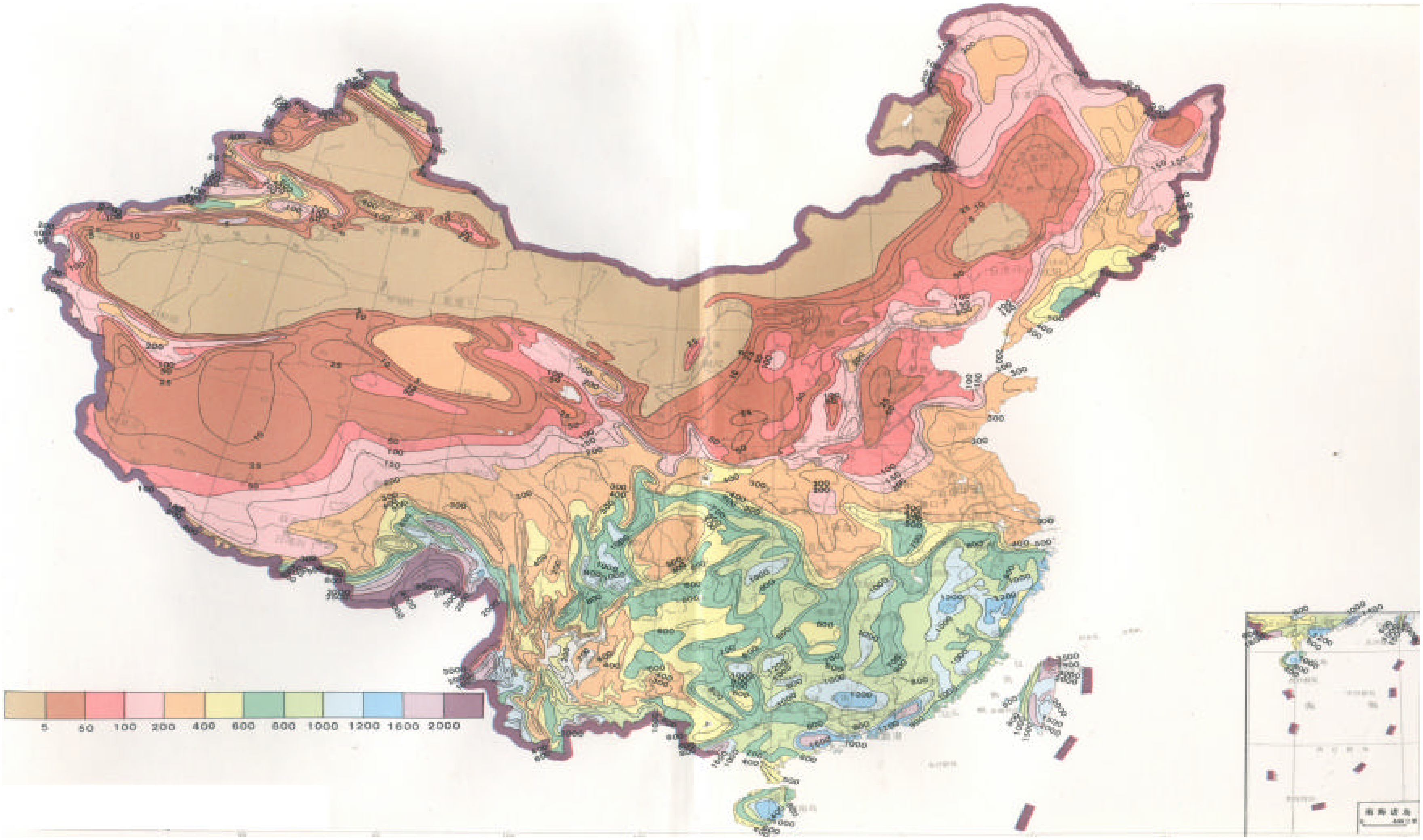

Figure 9, Runoff Depth in China. Source: Department of Hydrology, Ministry of Water Resources, PRC, 1992, Water Resources Assessment for China, China Water and Power Press.

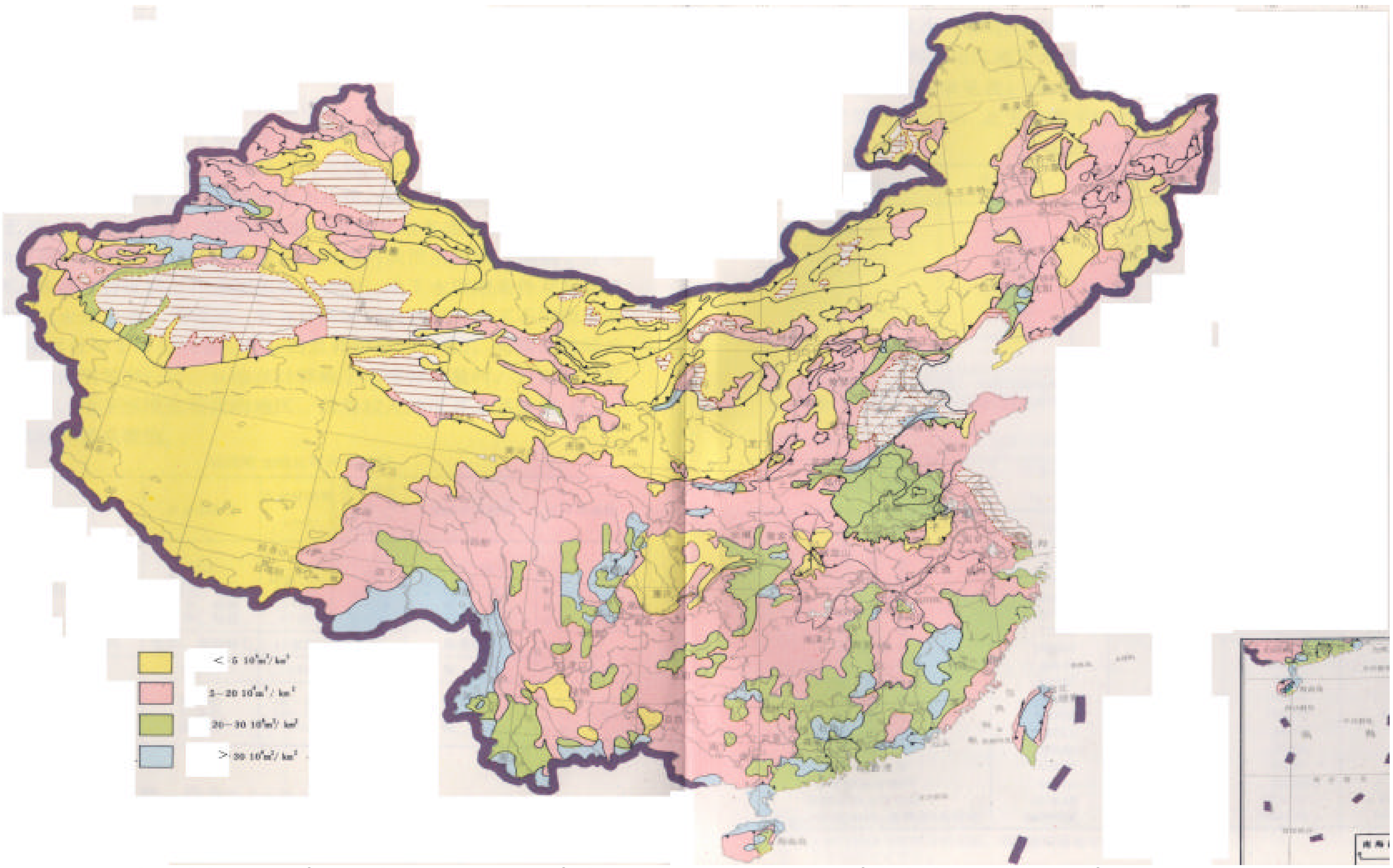

Figure 10, Regional modulus map of groundwater resources of China. Source: Department of Hydrology, Ministry of Water Resources, PRC, 1992, Water Resources Assessment for China, China Water and Power Press.

The regional difference in annual runoff in China is even larger than that in annual precipitation. The mean annual runoff depth in southern China (including the Yangtze, the Southeast Coastal, the Pearl, and the Southwest water resources regions) reaches 650mm, while in the northern China (other five water resources regions), the corresponding depth is only 74mm. The total area of the southern China only occupies 36.5% of the total area of the country, but the annual runoff occupies 83.4%. Of the 9 water resources regions, the largest annual runoff depth occurs in the Southeast Coastal water resources regions, reaching 1066mm; the Pearl water resources region takes the second place, the annual runoff depth there being 807mm; the smallest annual runoff depth happens in the Inland water resources region, being 32mm, with the Yellow water resources region (83.2mm) and the Hai water resources region (90.5mm) following it.

Among the 33 provinces, autonomous regions, municipalities and specific administrative region, Taiwan has the largest annual runoff depth (1770mm), Hong Kong takes the second place (1240mm), and Guangdong, the third (996mm). The smallest annual runoff depth occurs in Ningxia, being 16.4mm, Inner Mongolia (32.2mm) and Xinjiang (48.1mm) follow it.

It can be seen from the analysis of water balance that the values of hydrological elements and runoff coefficients are quite different between the outflowing area and the inland area, and also between the southern part and the northern part of the outflowing area. The depth of the mean annual precipitation of the southern China of the outflowing area is 1204mm, of which 46% is consumed in the form of land surface evaporation, 54% contributes to the river runoff. As for the northern China in the outflowing area, the depth of the mean annual precipitation is 546mm, of which only 23% forms the river runoff, 77% is lost in evaporation. The depth of the mean annual precipitation in the inland area is only 154mm, of which 79% is lost in evaporation, the annual runoff depth is only 32mm, and there is a large non-contributing area. The mean runoff coefficient of the whole country is 0.44.

On the basis of recharge and discharge computation for both mountainous area and plain area, and in consideration of duplication deduction, the groundwater resources are obtainable for various catchment regions, provinces, autonomous regions, municipalities and the whole country.

The total area for the whole country of China, involved in groundwater resources computation is 8774708 km^2 and the total average annual groundwater resources is 828.8 km^3.

The mountainous area of the whole country involved in the present evaluation is 6790906 km^2, being 77.4%, where, the average annual groundwater resources is 676.2 km^3, making up 81.6% of the total. The average annual value of baseflow amount equals to 659.9 km^3, i.e. 97.6% of groundwater resources in mountainous areas. 3545455 km^2 of mountainous area is located in northern China, where average annual groundwater resources equals to 141.1 km^3, in which baseflow amount is 124.8 km^3, making up 88.5% of the total in this area. 3245451 km^2 of mountainous regions is distributed in southern China, where the average annual groundwater resources is 535.1 km^3 wholly constituted by baseflow.

Table 2, Runoff and ground water recharge per administrative regions (km^3)

Regions	Mean annual surface water	Mean annual ground water
Beijing	**2.53**	**2.62**
Tianjin	**1.08**	**0.58**
Hebei	**16.7**	**14.58**
Shanxi	**11.5**	**9.46**
Inner Mongolia	**37.1**	**24.83**
Liaoning	**32.5**	**10.55**
Jilin	**34.5**	**11.01**
Heilongjiang	**64.7**	**26.93**
Shanghai	**1.86**	**1.2**
Jiangsu	**24.9**	**11.53**
Zhejiang	**88.5**	**21.33**
Anhui	**61.7**	**16.66**
Fujian	**116.8**	**30.64**
Jiangxi	**141.6**	**32.26**
Shandong	**26.4**	**15.42**

Henan	**31.1**	**19.89**
Henan	**31.1**	**19.89**
Hubei	**94.6**	**29.13**
Hunan	**162**	**37.48**
Guangdong	**180.1**	**46.67**
Hainan	**31**	**7.92**
Guangxi	**188**	**39.77**
Sichuan	**313.1**	**80.16**
Guizhou	**103.5**	**25.89**
Yunnan	**222.1**	**73.8**
Tibet	**448.2**	**109.43**
Shaanxi	**42**	**16.51**
Gansu	**27.3**	**13.27**
Qinghai	**62.3**	**25.81**
Ningxia	**0.85**	**1.62**
Xinjiang	**79.3**	**57.95**
Taiwan	**63.7**	**13.87**
Total	2711.52	828.77

Source: Department of Hydrology, Ministry of Water Resources, PRC, 1992, Water Resources Assessment for China, China Water and Power

The total plain area of the whole country involved in the present groundwater evaluation is 1983802 km^2, being 22.6% of the total studied area. The value of average annual plain groundwater resources equals to 187.3 km^3 (deducting the duplicative amount, i.e. 34.8 km^3 from mountainous regions, making up 18.4% of the total groundwater resources), in which 105.6 km^3 is derived from infiltration recharge of precipitation, constituting of 56.4%; and 71.1 km^3 from seepage recharge of surface water bodies, occupying 38%.

The plain area in northern China involved in the groundwater assessment is 1799898 km^2. The corresponding average annual groundwater resources is 146.8 km^3, making up 78.4% of the total plain groundwater resources, in which 76.4 km^3 is derived from infiltration recharge of precipitation, constituting 52%; 59.8 km^3 from seepage recharge of surface water bodies, occupying 40.7%.

The plain area in southern China involved in groundwater resources evaluation is 183904 km^2. The corresponding average annual groundwater resources is 40.5 km^3, making up 21.6% of the total in plain, in which 29.2 km^3 is derived from infiltration recharge of precipitation, making up 72.1%; 11.3 km^3 from seepage recharge of surface water bodies, occupying 27.8%.

The main features of groundwater resources distribution in China are:

- the general groundwater resources distribution is rich in the South but scarce in the North, being the same as that of surface water resources; computation area in northern China is 5345353 km^2, making up 60.9% of the national total computation area, but the average annual ground water resources is merely 255.1 km^3, constituting 30.8% of the total amount; in contrast, the computation area in southern China is only 3429355 km^2, making up 39.1% of the total area, but the average annual ground water resources reaches to 573.7 km3, constituting 69.2% of the total.
- as contrasted with the surface water resources, the modulus of groundwater in plains are usually greater than those in their surrounding mountainous areas. The average annual modulus of groundwater resources, with the deduction of duplicative amount, is 63000m^3/km^2 in plain of northern China, while 40000m^3/km^2 in mountainous area. In southern China, the modulus of groundwater resources, with deduction of duplicative amount, is 209000 m^3/km^2 in plain, while 165000 m^3/km^2 in mountainous region;
- the major part of plain groundwater resources is stored in aquifers lain in northern China, while that of mountainous groundwater resources in southern China. The northern plains occupy 91% of the total studies plain area, and 78% of the total plain groundwater resources of the country distributes in the northern plains. 79% of the total mountainous groundwater resources occurs in southern mountainous regions, accounting for 48% of the total studied mountainous area.

For the whole country, the long term mean annual volume of surface water resources is 2711.5 km^3 and that of groundwater resources is 828.8 km^3, the duplicative volume is 727.9 km^3, so the long term gross mean annual volume of water resources is 2812.4 km^3. For the northern China, the gross mean annual volume of water resources is 535.8 km^3, 19% of the gross volume for the country. For the southern China, the long term gross mean annual volume of water resources is 2276.6 km^3, 81% of the gross volume for the country.

The long term mean annual precipitation of the country is 648mm, of which 44% forms the river runoff, 56% is lost in the evapotranspiration from surface water bodies, plants and soils and the phreatic water evaporation. The long term mean annual river runoff depth for the whole country is 284mm, of which 25% is supplied by groundwater. The long term mean annual volume of evaporation and transpiration for the country is 364mm, of which only 3% is the phreatic water evaporation in the fresh water areas of the plains, and is usable by means of groundwater withdrawal. The long term mean annual of water yield (gross water resources) in the whole country is 2812.4 km^3, equivalent to water depth of 295mm, constituting 45% of the total precipitation of the country, of which the base flow and the phreatic water evaporation in the fresh water areas of the plains is comparatively easily exploited, its volume being about 780 km^3, 28% of the gross water resources; the remaining 72% being the volume of surface runoff, varying widely within a year and from year to year, and being able to be controlled and utilized only when regulation facilities are provided.

The values of the water budget elements and their relations are obviously different for different regions. For the southern China, the mean annual precipitation is 1204mm, the mean annual depth is 650mm, being 1.9 and 2.3 times as large as the mean values for the whole country respectively. For the northern China, the mean annual precipitation is only 330mm, the annual runoff depth, 74mm, 51% and 26% of the mean values for the country. (Figure 11)

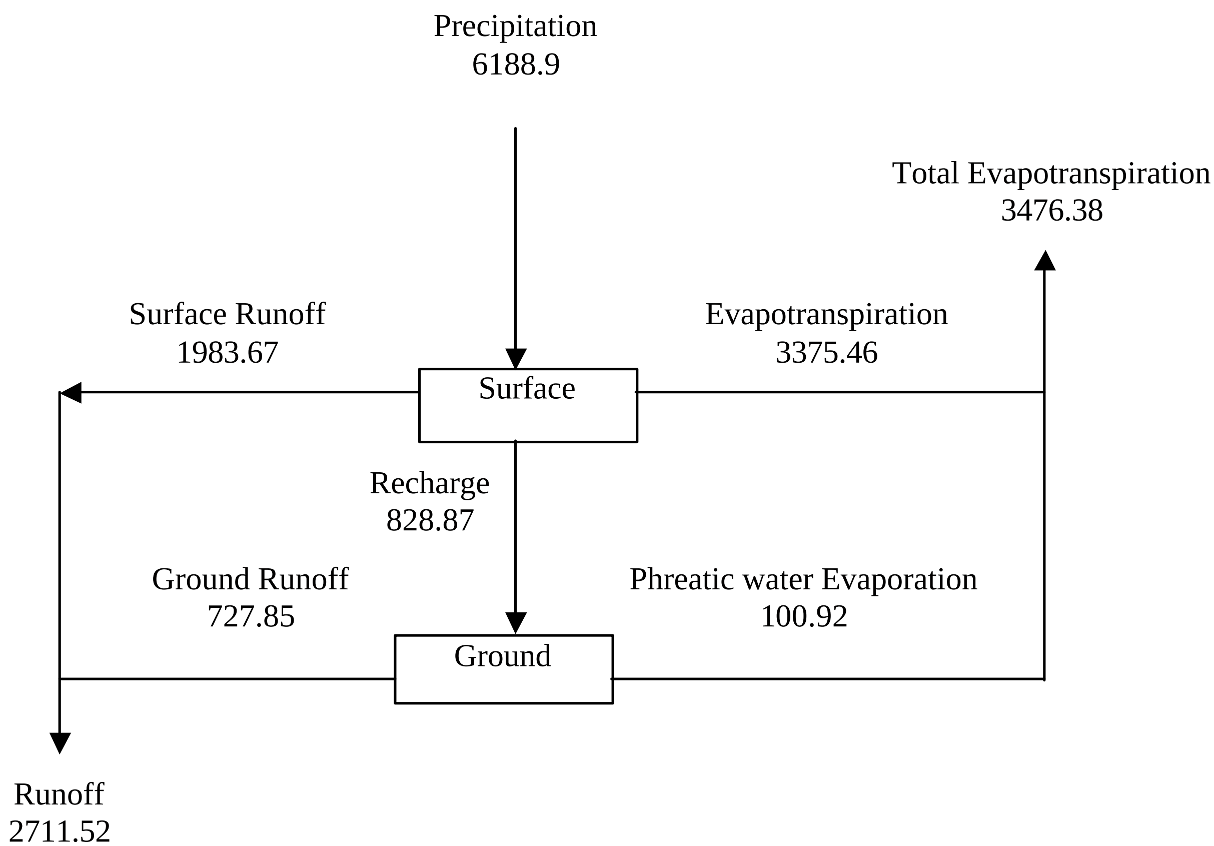

Figure 11, Hydrological Balance at the National Level (Km^3/year)

2 Present Status of Social and Economic Development

Since 1949, China has passed through a great shift in demographic, economic and social situation. The total population in China at the end of 1952 was 574.2 million, and reached 1276.26 million at the end of 2001(Figure 12). China had a high natural growth rate in 50s and 60s, especially at the middle of 60s, reaching 2.838%. After the implementation of family planning program in 70s, the population growth rate gradually dropped. In 2001, it was 0.695%. The percentage of age older than 65 year increases and the percentage of age younger 14 year decreases. According to the basic statistics on national population census, in 2000, the percentages of age less than 14 year old, 14-65 year and older than 65 year were 22.89%, 70.15% and 6.96% respectively. Changes are found in the percentage of rural and urban population. From 1952 to 2001, the percentage of urban population of the country increased from 12.46% to 37.66% and the percentage of rural population decreased from 87.54% to 62.34%. (Figure 13, 14)

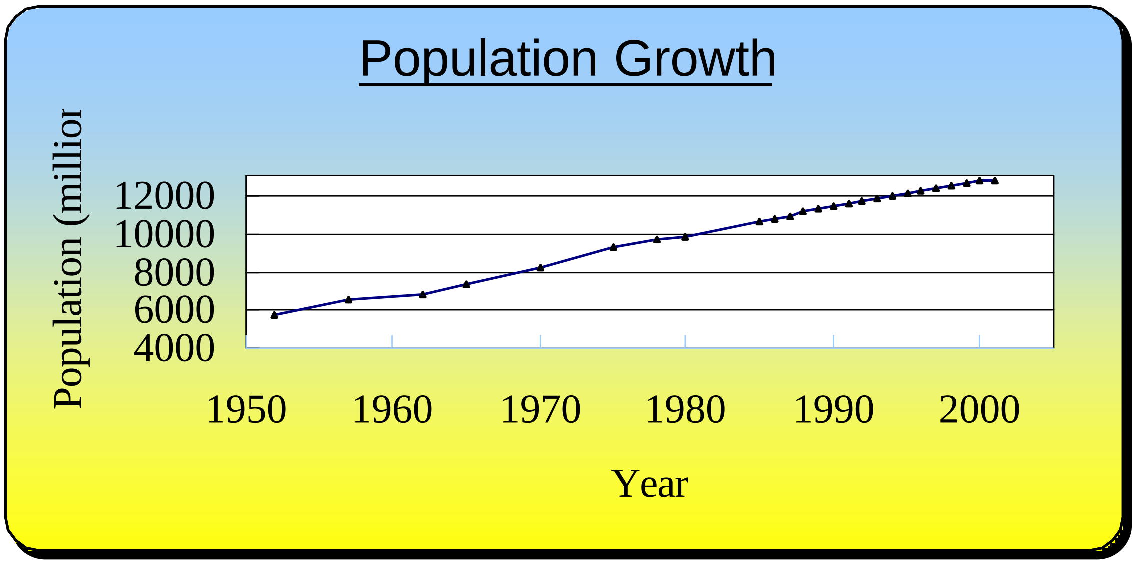

Figure 12, Population Growth in China

The ratio between male and female in China in 2000 was 106.0:100 (Figure 15). China is gradually shifting to the aged society. In 2001, the percentage of the population older than 60 was 10.45%, of which female occupied 5.36%, and was growing in the recent year. Due to the family planning program since 70's, China is shifting to a country with low birth rate, low growth rate and low death rate. Also due to this program, the family size is small. In 1995, the no of people living in the individual housing which was less than 4 was 74.62% and which was larger than 6 was 10.93%. From 1949, great increase happened in the life expectancy. The life expectancies in 1996 were 68 and 71 for males and females respectively.

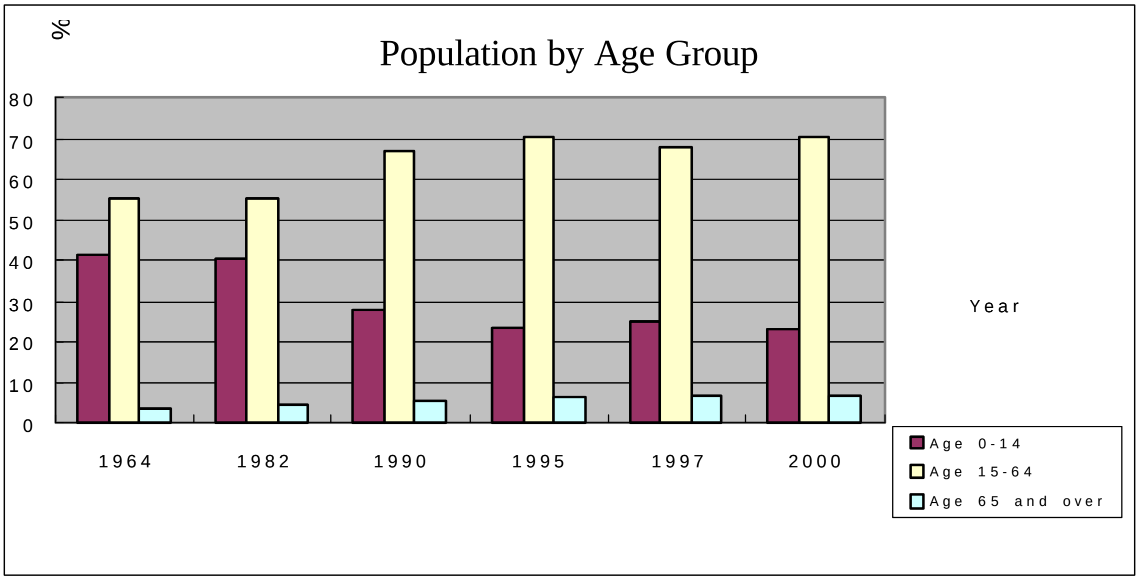

Figure 13, Population by Age Group

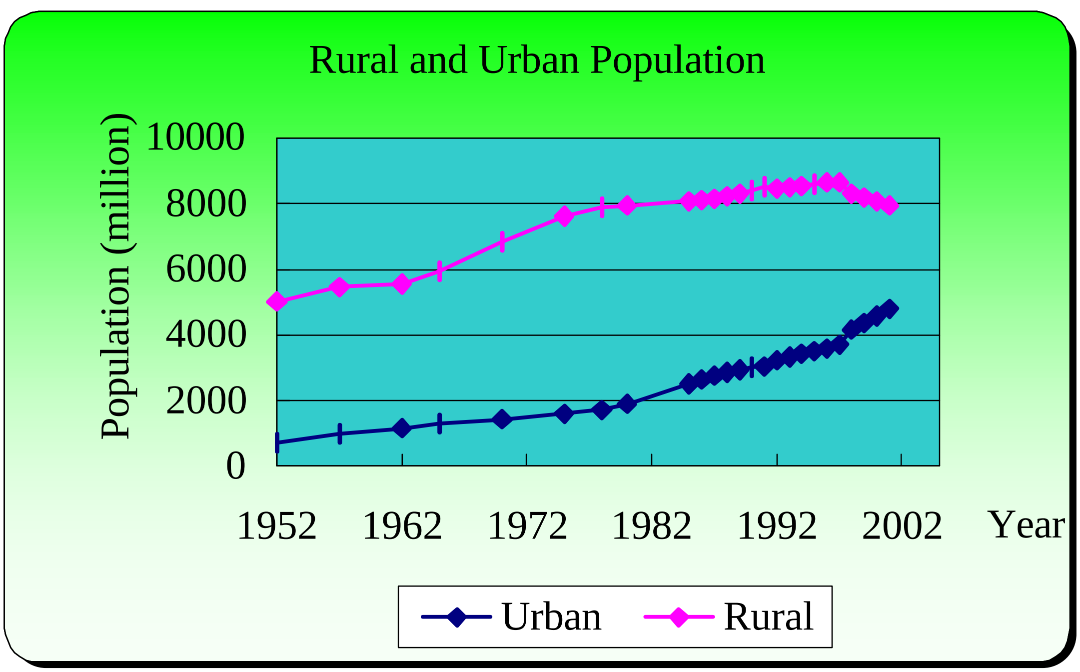

Figure 14, Rural and Urban Population

The spatial distribution of the population in the country varied greatly. In 2001, the average population density was near 134 persons per square kilometer; among the 31 provinces, autonomous regions and municipalities calculated, the densest administrative region is Shanghai, which reached 2350 persons per square kilometer in 2001; the second densest region is Tianjin (843 persons per square kilometer) and Beijing with the population density of 738 persons per square kilometer ranked the third. The scarcest three administrative regions are Tibet with only 2 persons per square kilometer, Qinghai with only 7 and Xinjiang with only 11.

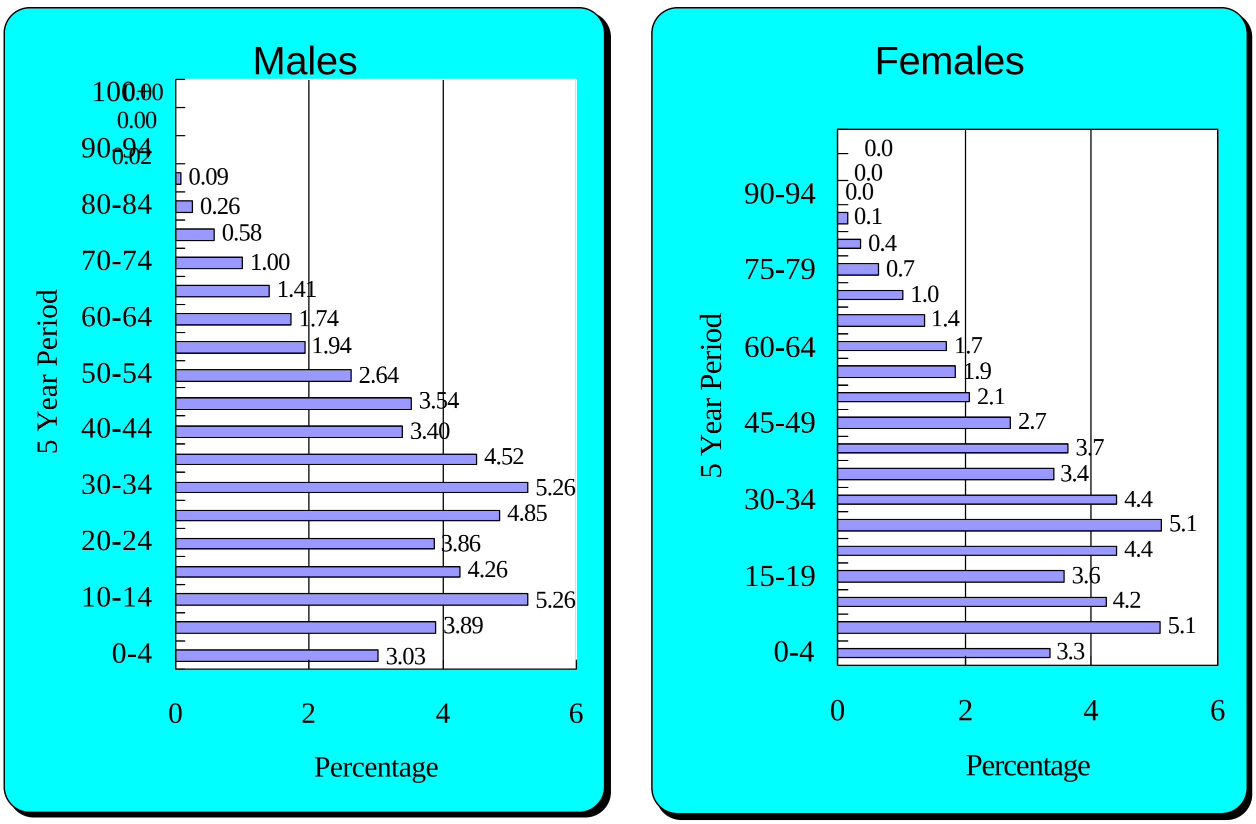

Figure 15, Composition of Population by Age and Sex, 2000

Table 3, Spatial distribution of population by administrative regions

regions	population (million)*	density (hab/km^2)	Areas*(10000km^2)
Beijing	12.4	738.1	1.7
Tianjin	9.53	843.4	1.1
Hebei	65.25	343.4	19.0
Shanxi	31.41	201.3	15.6
Inner Mongolia	23.26	19.7	118.3
Liaoning	41.38	284.0	14.6
Jilin	26.28	140.5	18.7
Heilongjiang	37.51	80.0	46.9
Shanghai	14.57	2350.0	0.6
Jiangsu	71.48	696.7	10.3
Zhejiang	44.35	435.7	10.2
Anhui	61.27	440.8	13.9
Fujian	32.82	273.5	12.0
Jiangxi	41.5	249.1	16.7
Shandong	87.85	574.2	15.3
Henan	92.43	553.5	16.7
Hubei	58.73	313.4	18.74
Hunan	64.65	307.9	21
Guangdong	70.51	379.1	18.6
Guangxi	46.33	379.1	23.63
Hainan	7.43	379.1	3.4
Chongqing	30.42	379.1	8.2
Sichuan	84.3	379.1	48.8
Guizhou	36.06	379.1	17
Yunan	40.94	379.1	39.4
Tibet	2.48	379.1	122
Shaanxi	35.7	379.1	20.5
Gansu	24.94	379.1	45
Qinghai	4.96	379.1	72
Ningxia	5.3	379.1	6.64
Ningxia	17.18	379.1	160
Ningxia	1236.26		

Sources: the population data is from China Statistical Yearbook, 2002.
* The military personnel were included in the national total population, but excluded in the regional total population.
The national total population excluded the population of Hong Kong, Macao and Taiwan.
The areas are from China, 1998 New Star Publishers, Beijing. The area was not included Hong Kong and Taiwan.

The income in China is low, especially in the rural areas. In 2001, the urban household income per capita is 6907 RMB, while the rural household net income per capita was 2366 RMB; the percentage of the rural households with annual net income less than 1000 RMB was 13.32%, those between 1000 to 3000 RMB was 59.23%. In the urban area, the situation was a little bitter better, in 2001, the income of the 10% highest income household was 15220 RMB, and was the 10% lowest income household was 2835 RMB; the 20% middle income household was 6406 RMB. (Figure 16)

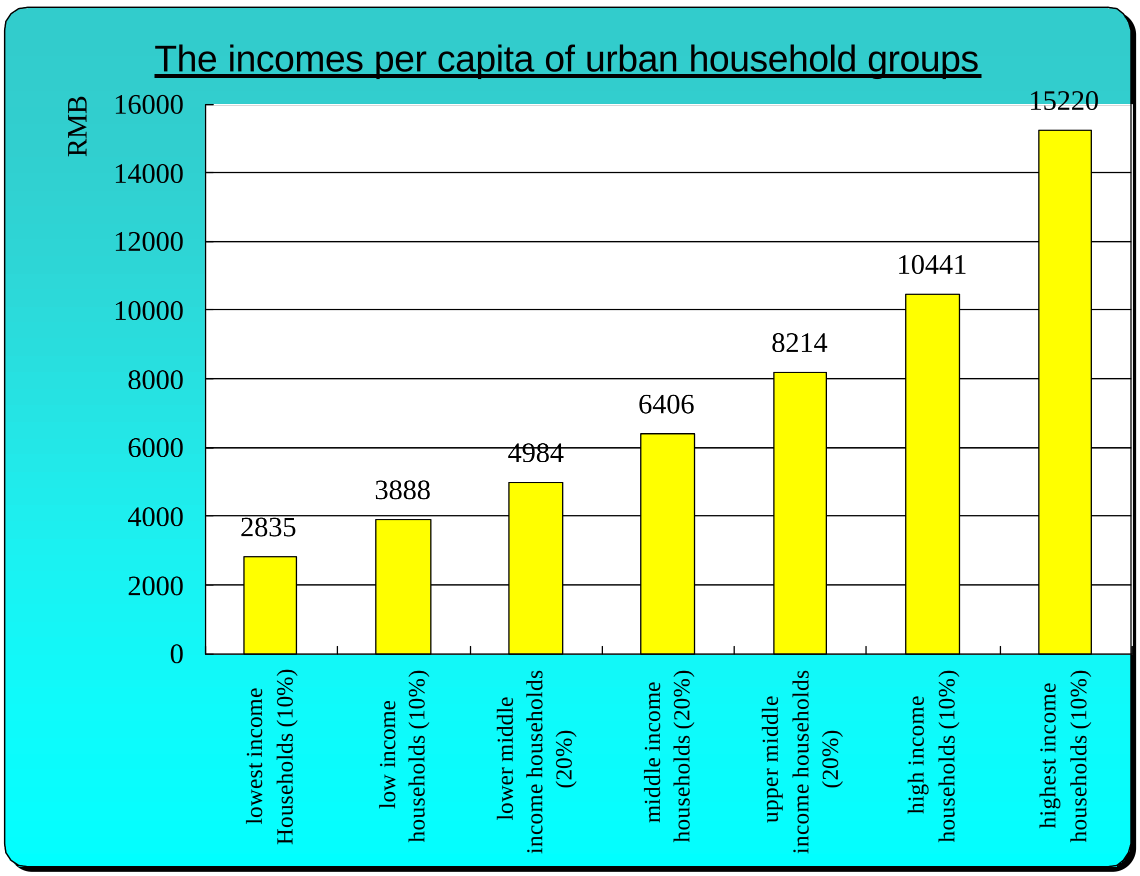

Figure 16, The Incomes per capita of Urban Household Groups

From 1949, a swift growth occurred in GDP both in the total and per capita in China. From 1952 to 2001, GDP was increased from 67.9 billion RMB to 9593.33 billion RMB, and GDP per capita increased from 119 RMB to 7543 RMB, especially from 1978 when China implemented its opening policy. Per capita GDP growth averaged about 8-9% annually from 1978. In GDP, the agriculture, siliviculture and fishing sector contributed to 15.2%, the industry contributed 51.1% and the services contributed to 33.6% in 2001. (Figure 17).

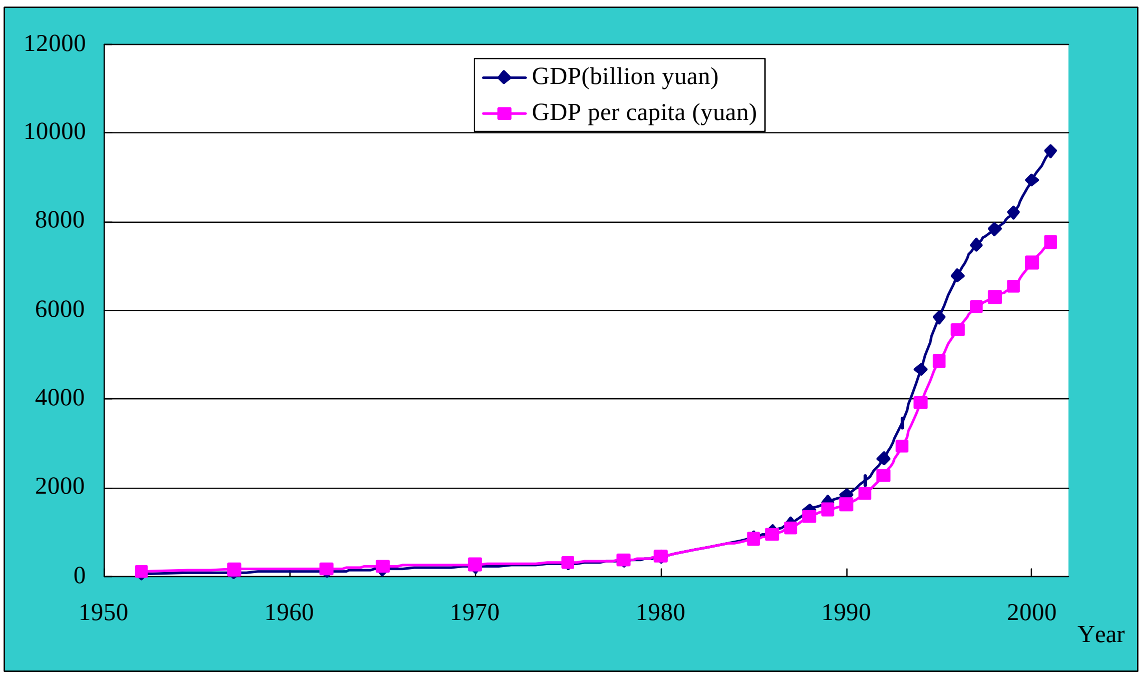

Figure 17, GDP and GDP per capita in China

In terms of land resources, China only presented to 7% of the cultivated land in the world. The cultivated land in China was among 94.91 to 1300.39 million ha among 1978 to 2001 (Figure 18). The rural population increased from 791.04 million to 795.63 million at the same period. So the cultivated land per capita in China will continue decreasing due to the increment of the population. In terms of the employed population by area of activity, with swift growth came rapid structural change. The percentage employment of the primary sector gradually decreased from 83.5% in 1952, to 70.5% in 1978 and 50.0% in 2001; while the secondary sector increased from 7.4% in 1952, to

17.3% in 1978 and to 22.3% in 2001; the tertiary sector increased from 9.1% in 1952, to 12.2% in 1978 and 27.7% in 2001. (Figure 19)

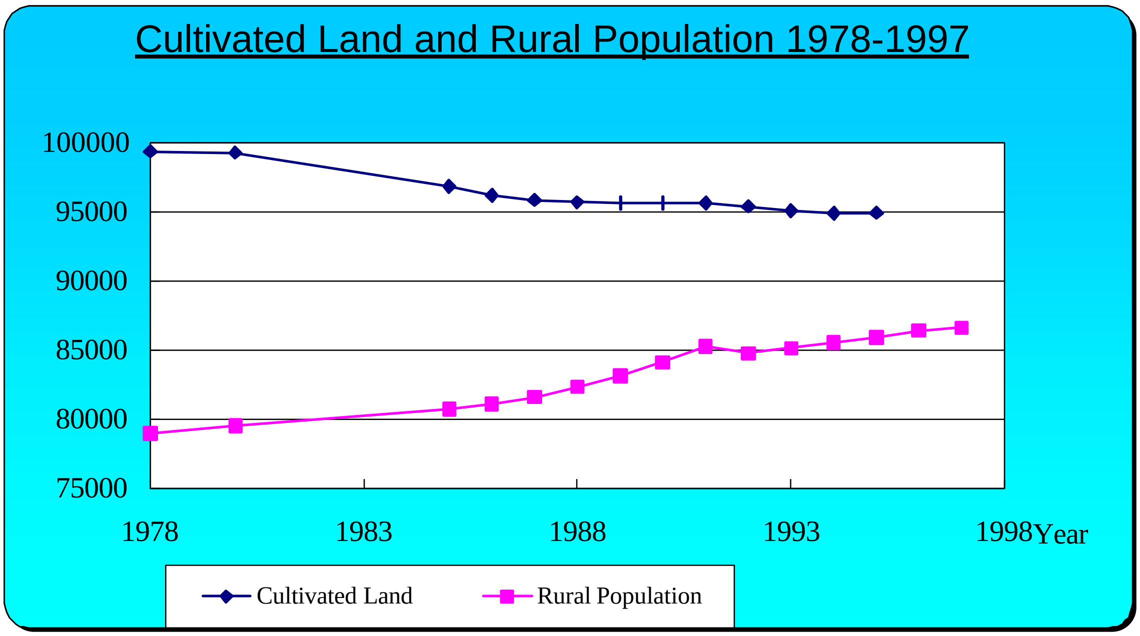

Figure 18, Cultivated Land and Rural Population

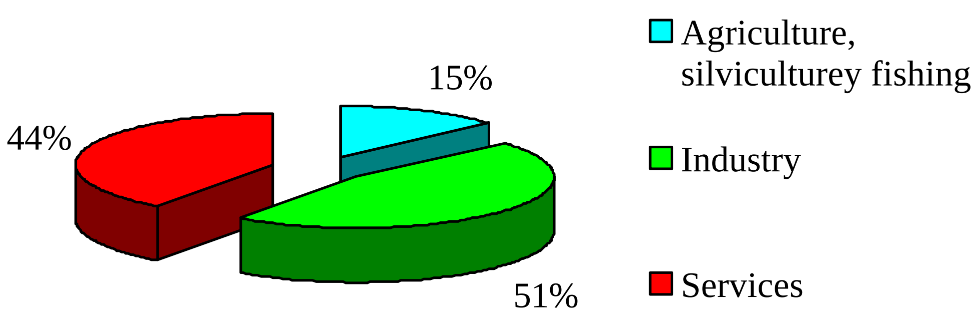

Figure 19, Participation of the different economic sectors in GDP in 2001

3 Situation on Water Use

In 2001, the total water supply of China was 556.7 km^3, of which 445.1 km^3 was from surface water, equivalent to 79.9% of the total; 109.5 km^3 was from groundwater resources, equivalent to 19.7% of the total; 2.2 km^3 was from the other sources (wastewater reuse and rainwater utilization etc.). Additionally, the seawater direct usage was 15.0 km^3. The interbasin water transfer volume was 15.0 km^3.

In terms of water resources regions, in 2001, the Songliao water resources basin supplied 59.6 km^3, of which 54.3% was from surface water; the Hai water resources region supplied 39.2 km^3, of which 31.4% was from surface water; the Yellow water resources region supplied 39.5 km^3, of which 64.7% was from surface water; the Huai water resources region supplied 60.8 km^3, of which 67.5% was from surface water; the Yangtze water resources region supplied 174.3 km^3, of which 94.7% was from surface water; the Pearl water resources region supplied 83.9 km^3, of which 94.9% was from surface water; the Southeast water resources region supplied 31.3 km^3, of which 96.7% was from surface water; the Southwest water resources region supplied 10.0 km^3, of which 95.9% was from surface water; the Inland water resources region supplied 58.3 km^3, of which 84.6% was from surface water. The water transfer between these regions were: 3.87 km^3 was diverted from the Yellow to the Hai, 7.96 km^3 and 1.59 km^3 were diverted from the Yangtze and the Yellow to the Huai respectively, 1.32 km^3 was diverted from the Yellow to Shandong Peninsula.

In 2001, the total water use of China was 556.7 km^3, of which 382.6 km^3 (of which 91.1% was used for agricultural irrigation) was used for agricultural use (including irrigation water use, forestry, husbandry, fishery water use); 114.2 km^3 was used for industrial water use (including thermal power, urban and rural industrial water use); 52.5 km^3 (of which 47% was for urban domestic use) was used for domestic water use. (Table 4)

Table 4, Water use per consumption-activities by riverbasin (km^3)

Riverbasin	agriculture	industry	domestic	Total
Total	382.6	114.2	60.0	556.7
Songliao	41.6	12.9	5.1	59.6
Hai	27.8	6.2	3.4	39.2
Yellow	30.6	5.5	6.9	60.8
Huai	44.1	9.7	20.9	174.3
Yangtze	101.8	51.6	3.9	29.7
Pearl	54.6	15.8	11.7	83.9
South-east	18.6	17.6	4.1	31.3
South-west	8.5	0.6	0.9	10.0
Inland	55.0	1.6	1.8	58.3

As a result of the rapid socio-economic development starting from the end of 1970s, total water demands for various sectors is increasing sharply. From 1980 to 2001, total water use has increased by about 20%. During this period, water use of the domestic sector has increased by near 100% and of the industrial sector has increased about 150%, while the agricultural sector water use increased only about 5%. It is estimated that the industrial water demand will continue increasing rapidly in the early of the 21st century.

In terms of water consumption, in 2001, 305.2 km^3 was consumed, 55% of the water used, of which 79.8% was consumed by the agricultural activities, 9.2% was consumed by the industrial activities and 11.0% was consumed in the domestic use.

In views of national water availability, with the increase of population, water availability per capita will decrease greatly. In 1952 the water availability per capita was 4893 m^3, and 3389 m^3 in 1970, only 2460 m^3 in 1990, and only 2204 m^3 in 2001. It is estimated that this amount will decrease to 2009 m^3 in 2010, 1875 m^3 in 2030 and 1785 m^3 in 2050 when population in China reaches 1.6 billion. (Figure 20)

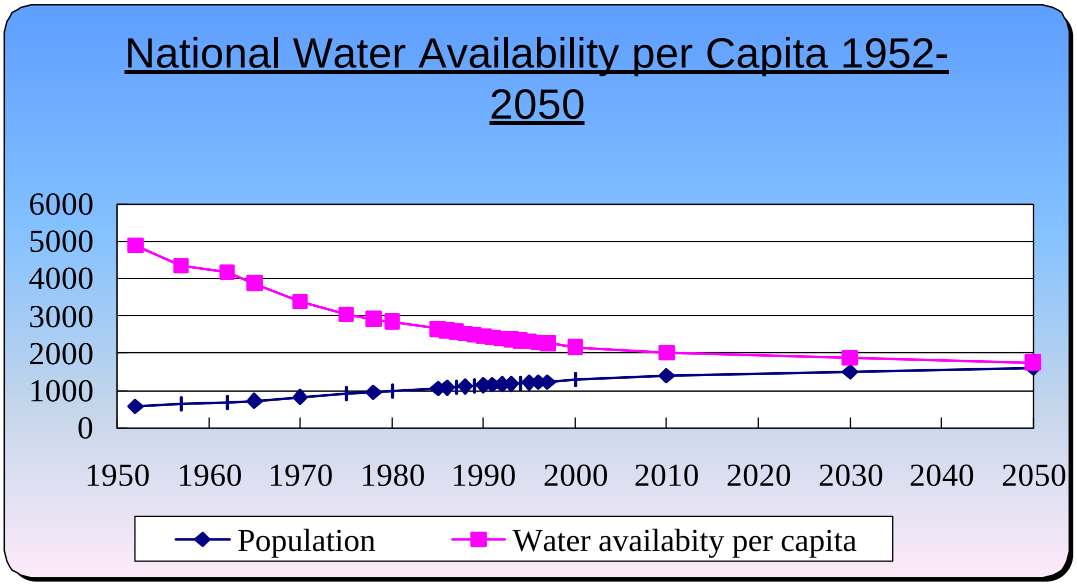

Figure 20, National Water Availability per Capita

In the hydro-cycle, in the total precipitation of 6189 km^3, 56.20% is evaporated, and 32.80% becomes the surface runoff, and 11.00% recharges to the ground water. In the total surface runoff and recharge of 2812 km^3, 19.79% had been used and 80.21% was without use. In the total consumptive uses of 556.7 km^3, agriculture occupied 68.7%, the industry used 20.5% and 10.8% contributed to the domestic sector in 2001.

In the nine riverbasins, water resources conditions differ greatly. The Yangtze Riverbasin occupies 35% of the water resources of the state, while the Hai Riverbasin only present 1.5%. In terms of the water per capita, the Southwest Riverbasin is 31914 m^3 (the population data is in 1993, hereinafter in this paragraph), while the Hai and Huai riverbasins were only 357 m^3 and 507 m^3 respectively, less than one-fourth of the national average of 2342 m^3. In terms of water per ha, the Southwest Riverbasin is the highest with 346350 m^3, and the Hai Riverbasin is the lowest with only 3870 m^3. (Table 5)

Table 5,Water Distribution, population and Economic Activities

Riverbasin	Percentage of the State (%)				Water per capita	Water per ha
	Water resources	Population	Arable land	Industrial Output	(m3/person)	(m3/ha)
Songliao	7.0	9.7	20.2	9.8	1704	9915
Hai	1.5	10.0	11.3	12.3	357	3870
Huai	3.5	16.2	15.2	15.0	505	6555
Yellow	2.7	8.5	12.9	6.0	749	6000
Yangtze	35.0	34.3	23.8	35.8	2388	41925
Pear	17.1	12.1	6.7	12.1	3327	72630
Southeast	7.0	5.5	2.5	7.8	2962	80175
Southwest	21.3	1.6	1.8	0.2	31914	346350
Inland	4.7	2.1	5.7	1.0	5270	23850
Total	100.0	100.0	100.0	100.0	2342	28500

In the urban areas, water supply services covered 225.5 million population in 1997, while in the rural areas, water supply services only covered 168.22 million population. In rural water supply by sources, 17.4% was from the tap water, 4.7% was from the rivers and lakes, 3.3% was from pools, 65.5% was from wells and 9.1% was from other sources.

In 1997, 307 water treatment plants had been under operation, with the total treatment capacity of 12.921 million m^3/day. The average treatment rate was 25.84%. Among the various administrative regions, Shanghai had the highest treatment rate of 71.4%, while in Tibet, without any treatment facility.

4 Agricultural Sector

According to the result of 1:1000000 land resources assessment, China has a total arable land of 139 million ha (different from the cultivated land due to different statistical calibrate), of which 57.47 million ha is high in productivity, 48 million ha is medium, 28.5 million ha is in low, and 5.07 million ha is unsuitable for cultivation. There are 33.93 million ha potential agricultural land, of which 3.1% is in high productivity, 48.9% with medium productivity and 48.0% with low productivity. (Figure 21)

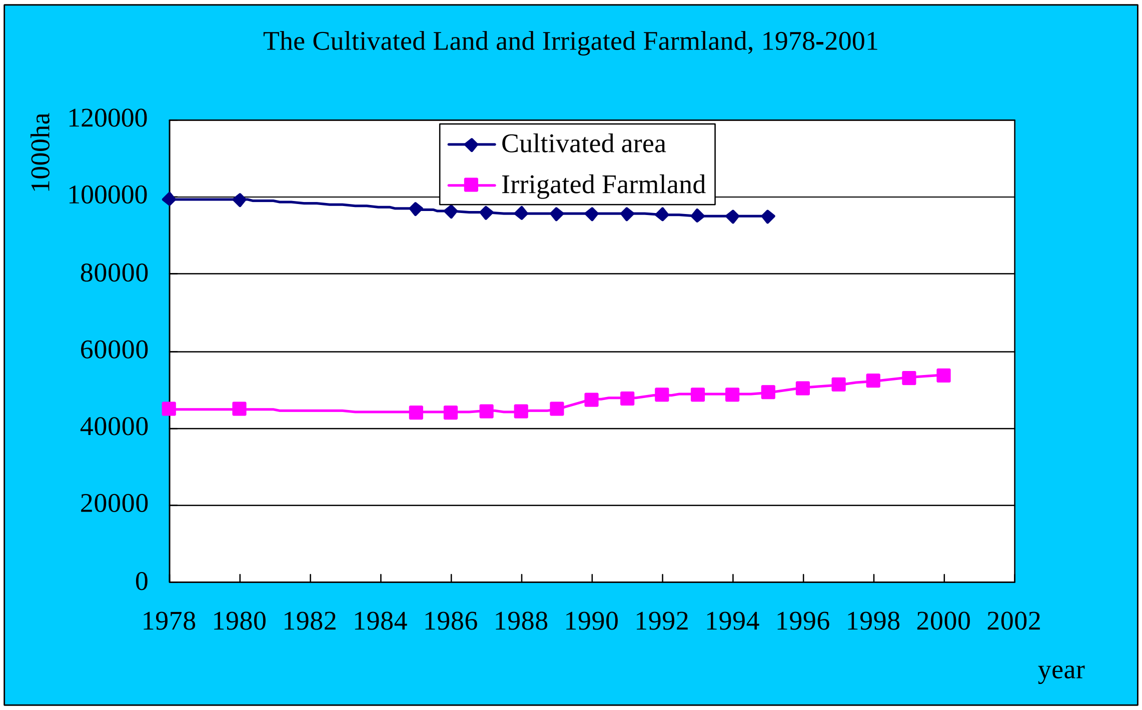

Figure 21, The Cultivated Land and Irrigated Farmland in China

China is stable in the irrigated farmland. In 1978, there was 44965.3 thousand ha irrigated farmland, and in 2001 it reached 54249.4 thousand ha. According to the size of irrigation district, 29733.62 thousand ha irrigated farmland was in the irrigation districts less than 667 ha; 13225.14, 2861.9 and 6408.1 thousand ha was in the irrigation districts of 667-20000ha, 20000-33333ha and larger than 33333ha respectively in 1997.

According to the statistics of Ministry of Water Resources, in 1997, in the total irrigated area, 93.42% was farmland, 1.66%, 2.59%, 1.50%, 0.84% were forestry, orchard, pastry and other respectively. In the administrative regions, Shandong Province had the largest area of irrigated area.

In 1995, there were 20201.93 thousand ha low yield area, of which 3471.13 thousand ha was due to the waterlogging, 2428.67 thousand ha was due to marshland, 2194.67 thousand ha was due to salinity, and 8856.67 thousand ha was due to water shortage.

In 1997, 18105 thousand ha was covered by water saving works, of which 12000 thousand ha had the lined canals, 4700 thousand ha was equipped with low pressure pipes, 1270 thousand was fixed by sprinkler, and micro-irrigation/drip was installed in 135 thousand ha.

In terms of water sources, in 1997, 85% of irrigation water were from surface water, and 15% was from ground water. In the total 392 km^3 water used in the agricultural sector in 1997, the Yangtze water resources region used 106 billion m^3, the Southwest water resources region only used 7.5 billion m^3. The Songliao, Hai, Yellow, Huai, Pearl, Southeast and the Inland water resources regions consumed 44.4, 31.9, 31.4, 50.0, 53.2, 19.4 and 48.3 km^3 respectively.

In 1997, China had 84387 reservoirs, of which 397 were large reservoirs each with capacity of large than 100 million m^3 and with the total capacity of 326.72 km^3, 2634 were medium reservoirs each with capacity between 1 to 100 million m^3 and with total capacity of 72.9 km^3, 81806 were small reservoirs each with capacity less than 1 million m^3 and with total capacity of 57.72 km^3.

5 Electric Sector

China is rich in hydropower resources. The theoretical hydropower potential is 676000 MW, and the annual potential power generation is 592 trillion Kwh, of which 378000 MW can be developed with annual power generation of 192 trillion Kwh.

China has a very rapid growth in the power sector. From 1949 to 1996, the total power generation increased from 431 million Kwh to 1079.4 billion Kwh. The total installed capacity in 1996 was 236541.6 MW.

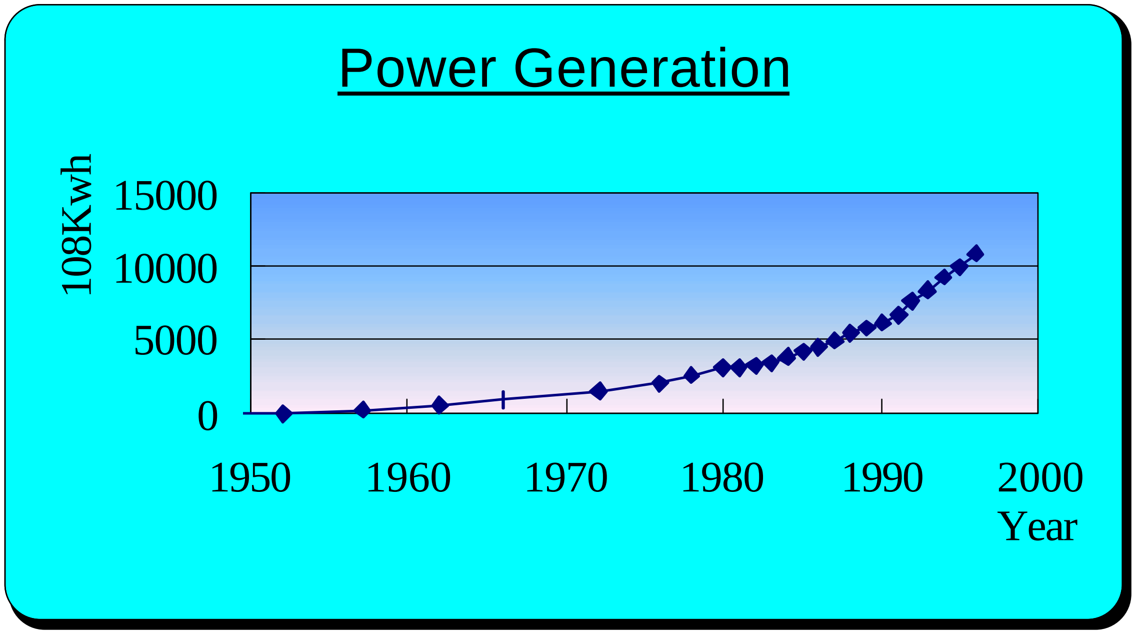

Figure 22, Power Generation Increase in China

In terms of hydropower, the hydropower installed capacity in 1996 was 55581 MW, 2.74 times of that in 1980. The hydropower generation increased from 109.2 billion Kwh in 1980 to 201.3 billion Kwh in 1996. In the rural area, the small hydropower has an important role. In 1996, the installed capacity of small hydropower was 17740 MW with annual generation of 57.3 billion Kwh, 46.28% of the total installed capacity and 48.15% of the annual generation in the rural power sources. (Figure 23)

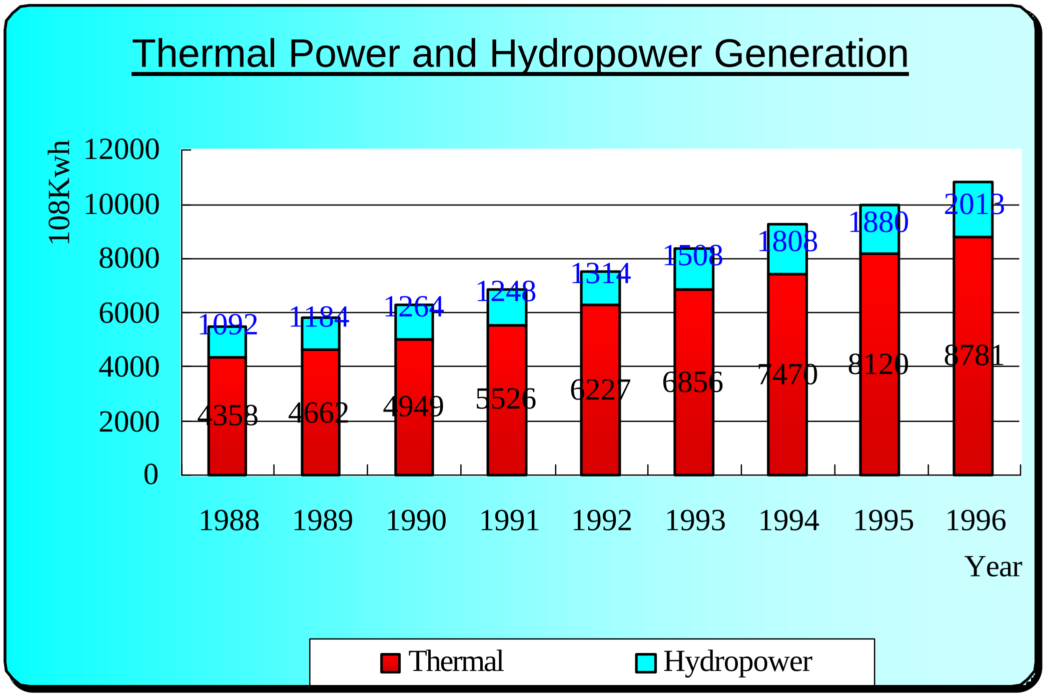

Figure 23, The Composition of Thermal Power and Hydropower Generation
Note: in 1995, 1996 thermal data included 2.1 million kw nuclear power

It is projected that in 2000, the installed capacity will reach 290000 MW, of which hydropower will occupy 62900 MW and in 2010 the installed capacity will be 500000-550000 MW.

In terms of hydropower water use, it is estimated that in 1980, the daily hydropower water usage is about 1.8 billion m^3. In 1988, under the installed hydropower capacity of 3269.1 MW and power generation of 109.2 billion Kwh, the hydropower water use was 486.01 billion m^3, of which 435.11 billion m^3 was from the storage engineering, 50.90 billion m^3 was from water divert projects.

6 Water Quality

According to the analyses for the observed data of river sediments in China, about 3.5 billion tons of sediments are eroded every year in average and transported by rivers from mountainous regions and hilly areas, of which approximately 1.85 billion tons are transported directly into the sea, about 0.25 billion tons are transported out of the boundaries, and 0.2 billion tons of sediments per annum are carried away from the mountainous and hilly areas for inland rivers, approximately 1.2 billion tons of sediments are deposited in the channels, lakes and reservoirs on the middle and lower reaches of the rivers for outflowing areas, or diverted into irrigated areas and flood diversion areas. (Figure 24)

Of the nine riverbasins, the Yellow River takes the first place in the sediment discharge, the mean annual sediment discharge, the mean annual amount of sediments it carries into the sea make up 53% and 60% the total values for the country respectively; and the Yangtze River takes the second place, 21% and 26% respectively.

The seasonal variation of river sediment in China is quite high, which is on the whole corresponding to that of runoff. For most rivers in China, high sediment contents appear mainly in flood season, particularly for the northern rivers. The 4 consecutive months' maximum sediment discharge of the northern rivers in China constitutes about 80% the annual value. Another feature in seasonal variation of sediment concentration is that the larger the yearly variation. In the south of the country the river sediment contents are usually low. The rainy season is long and the seasonal variation in river sediments is relatively small.

The interannual variation of river sediment content is very large in the country. Usually interannual variance of sediment discharge depends on variance of sediment content and annual runoff, so large variation occurs on the Yellow River, the Hai River and the Liao River etc. The interannual variation of sediment contents of rivers in the south of the country is usually smaller than that of hyperconcentrated rivers in the north.

In terms of regional distribution of modulus of sediment discharge, on the whole the regions with high sediment discharge modulus in the country are distributed from southwest to northeast, over the low mountainous and hilly areas between the second step and the third step. Based on the analyses of the observed sediment data, the area with mean annual modulus of discharge over 1000t/km^2 reaches 625000 km^2, occupying 6.5% of the total area of the country. The areas with most serious soil erosion in the country are mainly distributed over the Loess Plateau in the Yellow Riverbasin. There is area about 10000km^2 with the annual modulus of sediment discharge over 10000 t/km^2 in the basin. The areas with the sediment discharge modulus below 100t/km^2 in China are mainly the Northeast Plain, the Inner Mongolia grassland, the North China Plain, the plain on the middle and lower reaches of the Yangtze River, the coastal plains of Southeast China and South China, coastal plains of Hainan Island, the major part of the Tibet Plateau, the Da and Xiao Hinggaling Mountains, the mountainous region of the Changbai Mountains, the mountainous limestone areas of Guangxi and Guizhou, the middle part of Qilian Mountains, the Altay Mountains, the middle part of Taishan Mountains, etc.

The regional distribution of degree of mineralization of river water in China varies contrary to that of precipitation and runoff. Except for some coastal rivers influences by intrusion of sea water, the degree of mineralization increases from less than 50 mg/L for the southeast coastal rivers to more than 1000 mg/L for rivers in the Northwest, showing clearly zonal distribution. The area with the value below 300 mg/L accounts for about 54% of the total area of the country, mainly distributed over the Yangtze River, rivers in Zhejiang, Fujian and Taiwan, the Pearl River, rivers in southwest and the Heilongjiang River etc. The area with degree of mineralization below 500 mg/L accounts for about 74% of the total area of the country. Except for inland rivers, the Yellow River and the Hai River, the proportion of area with the value below 500 mg/L is about 80% for all other basins. Therefore, on the whole, in most parts of the country the degree of mineralization of river water is not high and can thus satisfy the needs for domestic and agricultural water use, and for industrial water use in general as well. The area with the degree of mineralization over 1000 mg/L occupies about 13% of the area of the country and is mainly distributed over the inland riverbasin. The total hardness of a water body has a close relation with degree of mineralization. Generally, the former will increase with the increase of the latter. (Figure 25, 26)

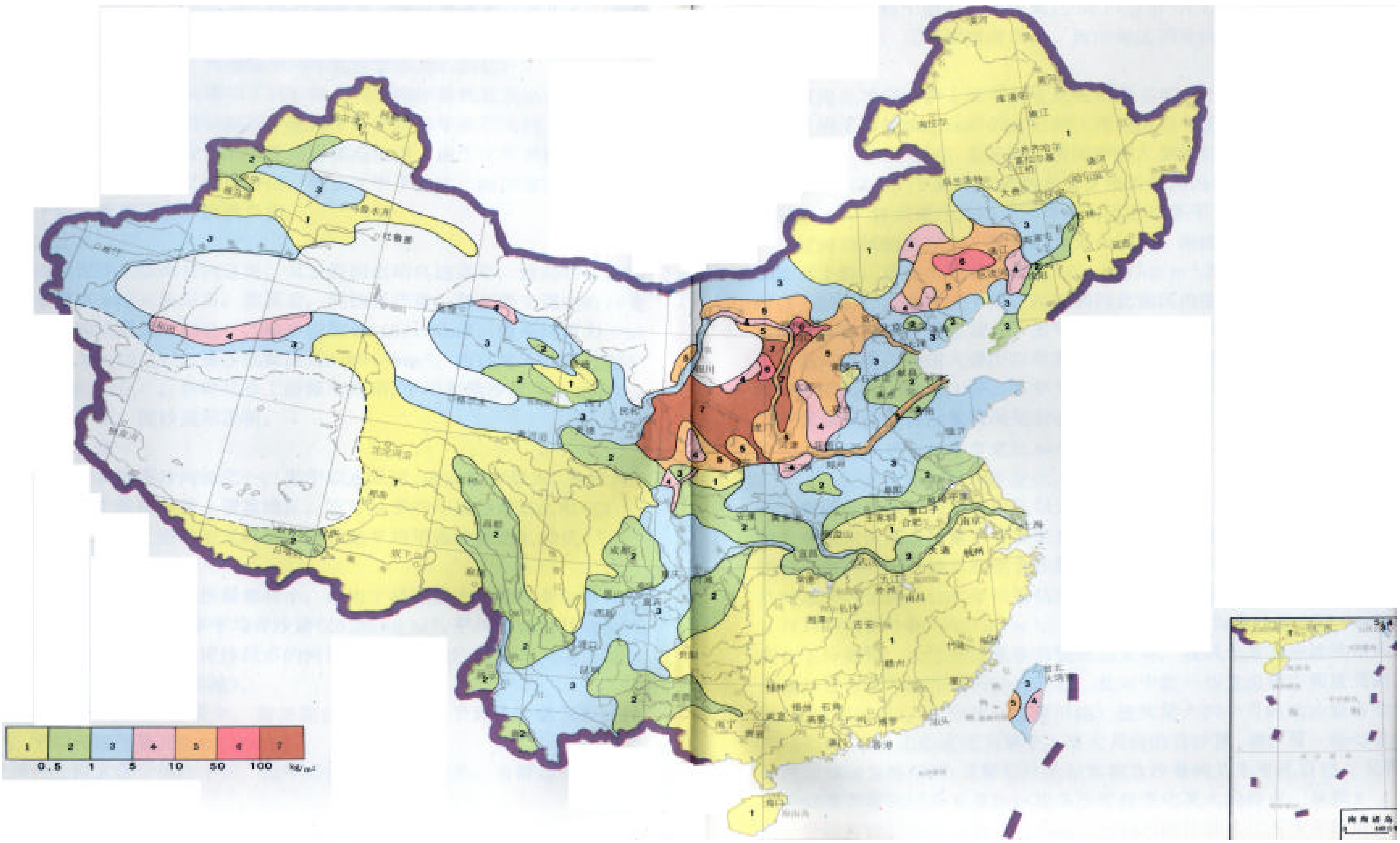

Figure 24, Long-term Mean Suspended-Sediment Concentration of the rivers in China. Sources: Department of Hydrology, MWR, 1992, Water Resources Assessment for China, China Water and Power Press

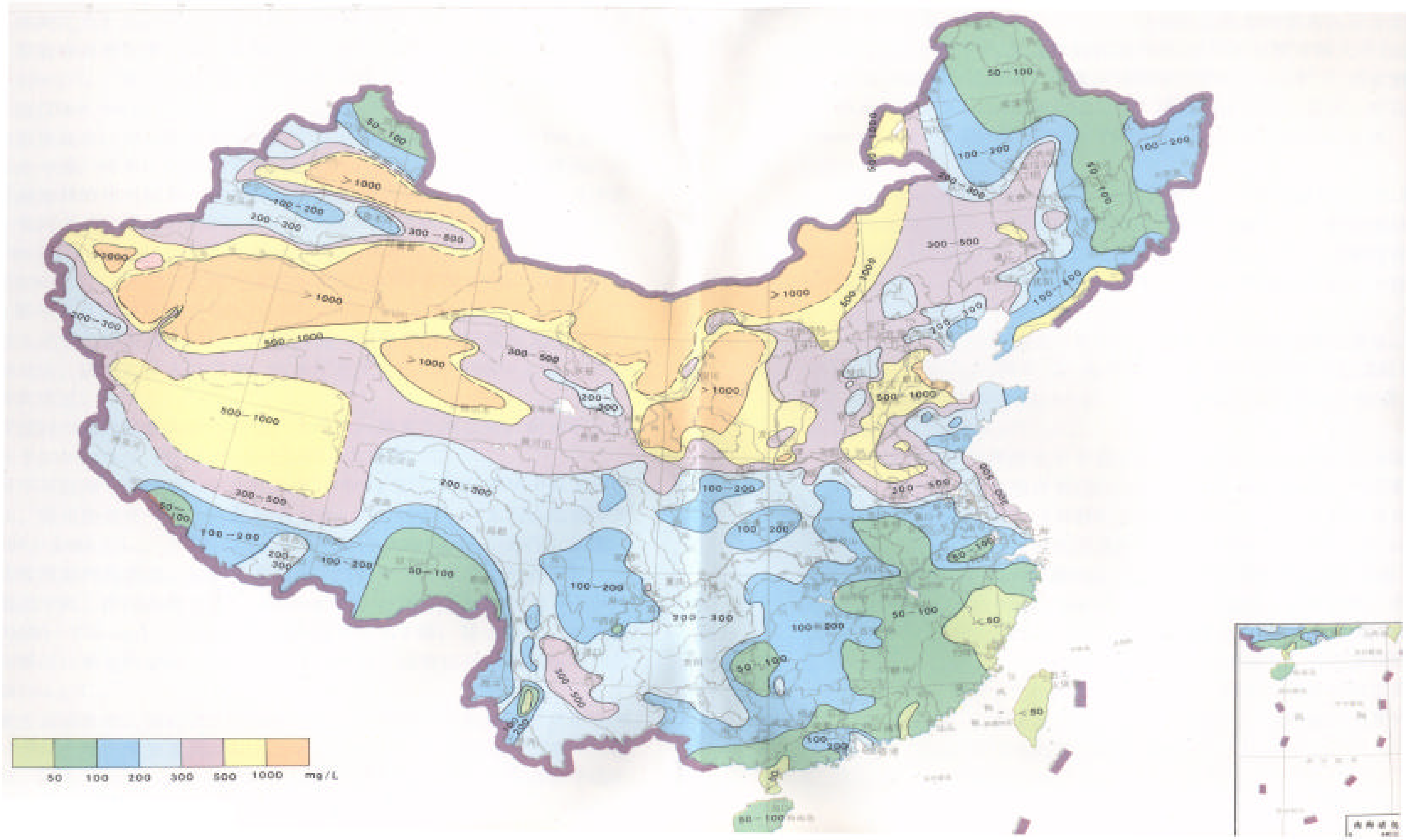

Figure 25, Distribution of Degree of Mineralization of River Water in China. Sources: Department of Hydrology, MWR, 1992, Water Resources Assessment for China, China Water and Power Press

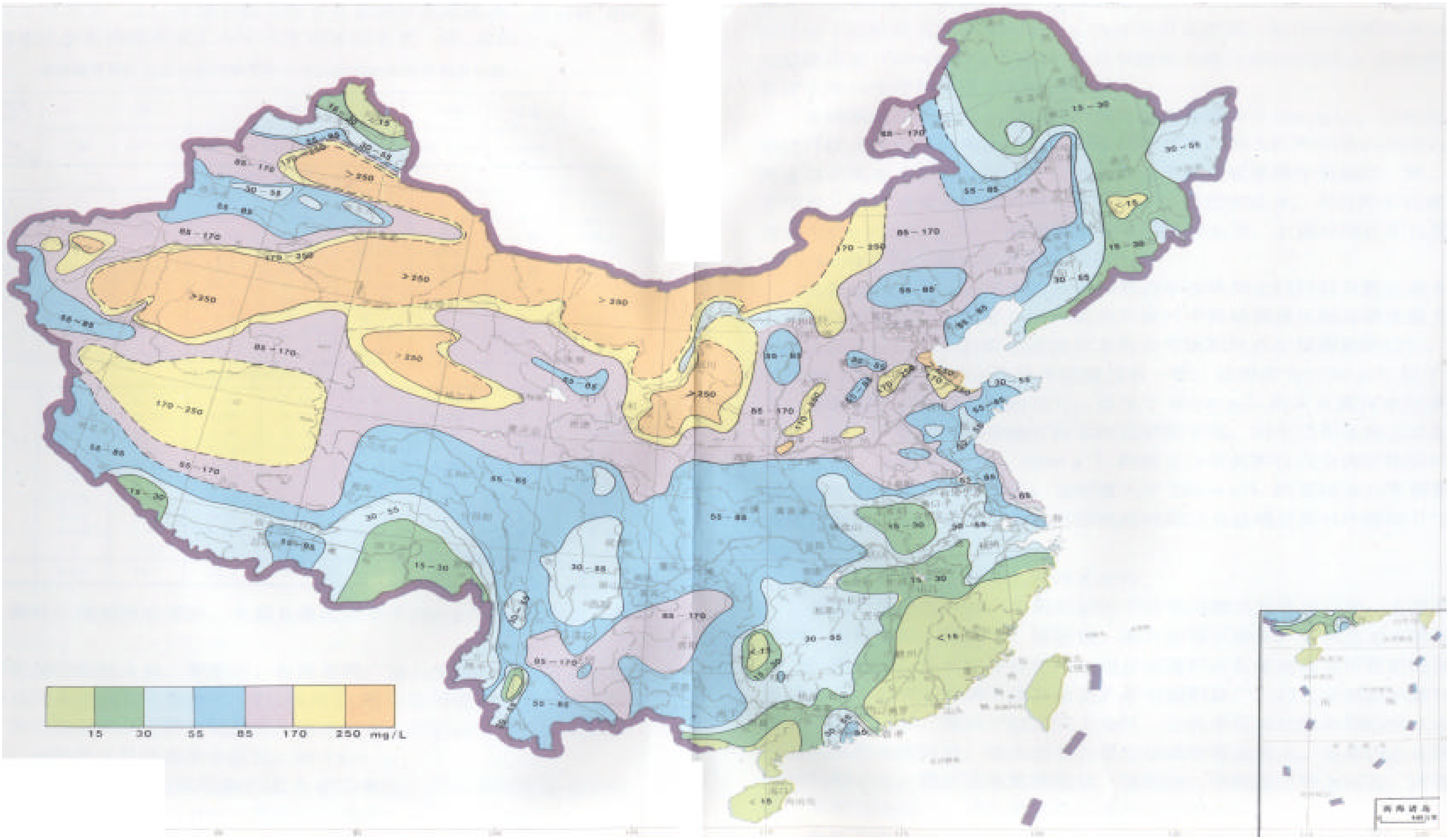

Figure 26, Distribution of Total Hardness of River Water in China. Sources: Department of Hydrology, MWR, 1992, Water Resources Assessment for China, China Water and Power Press

China's past two decades of rapid economic growth, urbanization, and industrialization have been accompanied by steady deterioration of the environment. The concentrations of water pollutants are among the highest in the world, causing damage to human health and loss in agricultural productivity.

In China quality of surface waters is largely determined by pollutant discharges. The proportion of wastewater discharged to surface has been increasing with a resulting decrease in quality of waters. In 2000, the total wastewater discharge was 41.5 billion tons, of which 19.4 billion tons were industrial wastewater and 22.1 billion tons municipal wastewater. In the case of industrial wastewater, industries at the county-level and above discharged 15.3 billion tons, while town and village enterprises discharged 4.1 billion tons. Industrial treated wastewater at the county-level and above was 31.4 billion tons, the treatment ratio was 95.0%. Industrial wastewater discharge meeting the discharge standard at the county-level and above was 12.6 billion tons.

In 2000, in wastewater discharges COD represented 14.45 million tons, made up of 7.05 million tons from industries and 7.40 million tons as domestic wastewater; of the COD discharged with industrial wastewater, 4.50 million tons were discharged by industrial enterprises at the county-level and above while 2.55 million tons were discharged by town and village enterprises. (Figure 27, 28, 29)

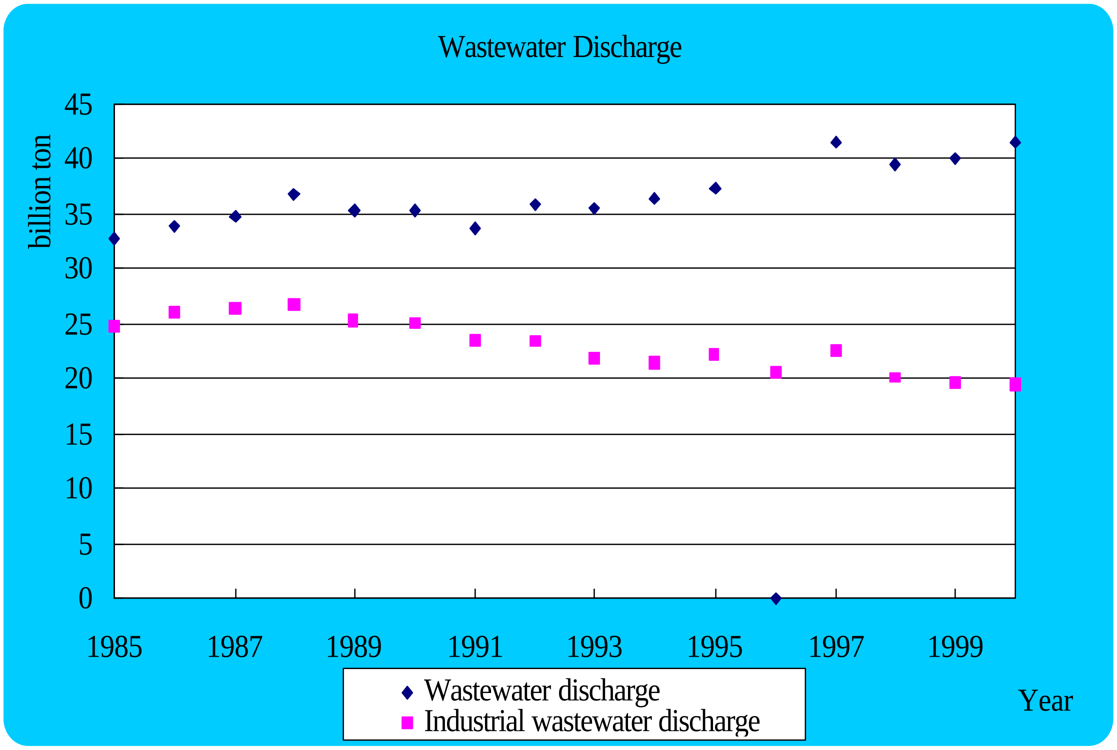

Figure 27, Wastewater Discharge in China

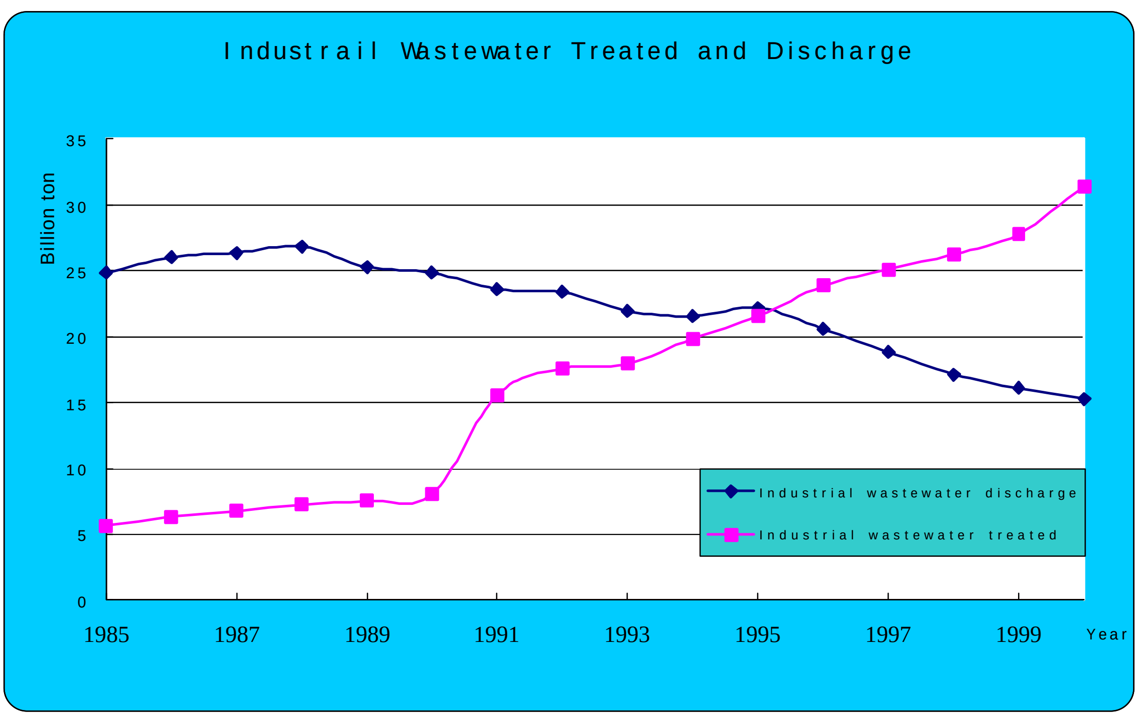

Figure 28, Industrial Wastewater Discharge in China

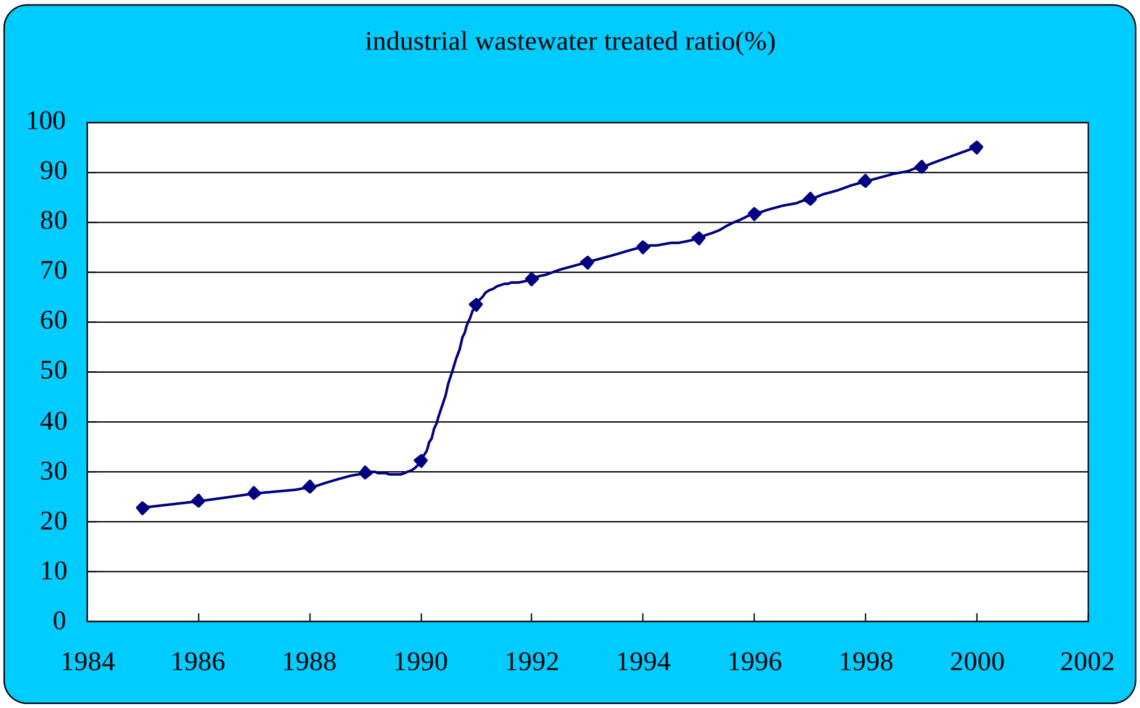

Figure 29, Industrial Wastewater Treated Ratio in China

The raw chemical materials and chemical products sector was the largest industrial wastewater discharge sector among 19 sectors in 2000, followings were the smelting and pressing of nonferrous metals sector, the papermaking and record medium reproduced sector, and electric power, gas and water production and supply sector. The least industrial wastewater discharge sector was plastic products sector.

Generally, in the recent decade, with the great increment of industrial output, the industrial wastewater discharge does not increase; the ratio of industrial wastewater discharge and the ratio of industrial wastewater discharge meeting the discharge standards raise up greatly; the discharge of poisonous materials, such as mercury, cadmium, lead, arsenium, chromium, phenol and cyanogen etc. in the industrial wastewater are decreasing. Except for a few waters, the water pollution induced by heavy metals and poisonous materials in the industrial discharge, which had been the major reason polluting the water related environment and is not now, has basically been controlled. At present, the major pollutants are organic pollutants, which come from high concentration organic wastewater from chemical, petrochemical, paper-making, food, tan and textile industries, and untreated urban domestic wastewater. The urban wastewater discharge increases gradually, as well as COD in wastewater. The reason that aggravates the pollution in the water bodies near cities is the lower treatment rate of urban wastewater and discharge of untreated wastewater. Besides the urban wastewater, the losses of nitrogen and phosphorus from chemical fertilizers and pesticides exacerbate the lake eutrophification.

In the nine river basins, the main streams of the Pearl, Yangtze, Yellow and Songhua rivers have a better water quality, but the streams through the urban regions are polluted heavily. In 2001, in 121000 km river length assessed of the state, 5.0% was in Class 1 and 2 of "The Surface Water Quality Standard" (the same below), 27.6% was in Class 3, 28.8% was in Class 4 and 7.8% was in Class 5, 16.6% was surpassed Class 5. So the river length polluted (including Class 3, 4, 5 and surpassed Class 5) was 61.4% in 2001. In the nine riverbasins, the Songliao, Hai, Yellow and Huai were heavy polluted with the polluted length percentages of 65.6%, 60.7%, 56.3% and 63.1% respectively. The Southwest Riverbasin had only 6.7% polluted river length and the Inland Riverbasin had only 8.9% polluted.

In the large fresh lakes, there were a wide pollution of total phosphorus and total nitrogen. The total mercury polluted heavily in some lakes. The water quality in the large reservoirs was good and the main pollutants were total phosphorus and total nitrogen. But the organic pollution had a slight increase. The eutrophications in the lakes and reservoirs assessed was 19.4%, 34.0%, 22.2%, 24.3%, 0.10% by area according to the poor, medium, medium plentiful, plentiful and heavily plentiful five eutrophication categories respectively.

The urban groundwater quality was good, but the total hardiness had a slight increase. The over-exploitation of groundwater in middle and large cities was very common. At least 14 cities existed heavily over-exploitation of groundwater.

According to groundwater quality assessment results from 69 cities in the northern five provinces and regions (Xinjiang, Gansu, Qinghai, Yinxia and Inner Mongolia), there was no city whose groundwater quality is in Class 1, those in Class 2 are 10, 22 in Class 3, 37 in Class 4 and 5. The surpassed parameters are total hardness, $N\text{-}NO_2^-$, SO_4^{2-}, $N\text{-}NH_3$, $N\text{-}NO_3^-$, Cl^-, etc.

The water quality assessment for 2015 wells in the Hai Riverbasin showed that: two-thirds of the investigated wells did not meet the drinking water quality demand. The pollution parameters were total hardness, mineralization degree, Mn, Fe, F^-, Cl^-, SO_4^{2-}, violate phenol, lead, $N\text{-}NO_3^-$, mercury etc; 1411 wells meet the irrigation water quality demand, the pollution parameters are pH, Cl^-, mineralization degree, F^-, Cd^{2+}, lead, mercury etc. According to results assessed by GB/T14848-93, only 22.0% of wells were under Class 1 to 3.

This indicated that, groundwater in the northern five provinces and regions were polluted more or less, no matter in the rural or urban areas, shallow groundwater or confined groundwater. In some localities, groundwater pollution is severe and become worse and worse gradually.

7 Environmental Sector

There are a number of environmental issues that transcend the water sector and impact on other sectors of the environment. Soil erosion, deforestation, and damage to wetlands and grasslands have resulted in deterioration of China's national ecosystems, pose a threat to future agricultural sustainability, and contribute to the overall pollution of the water resource in China. The water and wind erosion area occupied 38% of the total territory. The dry-up in rivers in northern China is more popular. The Yellow River dried up every year in 90s, with the annual average of 107 days.

The protection of the marine environment has been strengthened. By the end of 1996, the number of marine natural zones had reached 61, among which there were 15 national level and 46 local level sites covering an area of 142 million hectares. The departments responsible for sea areas management had approved and selected 16 temporary dumping areas, issued 441 permits and approved 7810 million cubic meters of dredged materials to be dumped. The branch bureaus responsible for management of South China Sea and North Sea had conducted a comprehensive examination on the application of oil-dispersal agents handled by operators on the sea and approved 14 plans for oil spill emergency response.

At present, wetlands in China cover over 25 Mha, representing 2.6 percent of the country's entire area. The wetlands of China consist of marshes (11 Mha); natural and artificial lakes (12 Mha); shoals (12 Mha); and salt marshes (2.1 Mha). Approximately 80 percent of the wetlands in China (20 Mha) are fresh water. Of China's 217 recognized wetlands, 95 have been declared nature reserves. Despite such efforts to protect wetlands, it is estimated that 40 percent of China's important wetlands have been disturbed by human activities and face moderate to serious threats of deterioration. These threats are pollution, excessive fishing and hunting, and conversion of wetlands into farmland.

China's wetlands suffer from both anthropogenic and natural effects. Natural influences are generally limited to climactic changes, whereas human influences include such activities as land reclamation for cultivation purposes and dam construction with associated reservoirs. As a result of such activities, China's wetlands have been shrinking steadily. In the early 1950s, there were 24880 natural lakes of various dimensions in China, with a total area of 83000 km^2. Over the past thirty years, lake area has decreased by more than 12000 km^2.

Converting lakes and marshes into agricultural land is the main reason resulting in the decrease of wetland. In the Dongting lake region, water conservation works undertaken since the 1950s have resulted in the expansion of farmland from 400000 ha to 580000 ha. In addition to creating additional farmland, draining marshes contributes to a reduction of disease due to less mosquito habitat, etc. However, large scale lake-shore and marshland conversion for cultivation purposes has also caused a rapid reduction of both the area and the number of lakes and marshes.

8 Health Sector

In 1993, there were more than 50 million populations and 30 million stocks that do not have access to safety water in the rural regions in the north and northwest China. Due to water shortage, some areas, especially the north and coastal regions, have to over-exploit groundwater. At the same time, according to the investigation on drinking water in 1988, drinking water of 82% population in China comes from shallow wells or rivers, of which 76% drank water which was heavily polluted or where bacteria surpassed the drinking water standard. The populations which drank organic polluted water were160 million and which were lack of drinking water were 47 million.

Environment is a major factor affecting human health and mortality. In 2001, the total mortality rate for China was 643 per 100000 persons, a slight decrease from the previous year. The mortality rate for the urban population was 558 per 100000 while the mortality rate for the rural population was 690 per 100000. The death rate from cancers in urban areas was 127 per 100000 persons while the death rate from cancers in rural areas was 118 per 100000 persons making mortality rates from cancers approximately 22.7% and 17.1% of the total mortality rate for the urban and rural populations respectively. The death rate from digestive disease in the urban area was 17 per 100000 and 30 per 100000 in the rural area. The incidences of the plague, cholera, viral hepatitis and dysentery were 0.01, 0.22, 65.15 and 39.32 per 100000 respectively in 2001.

An obvious form of pollution on human health is from pollution accidents such as chemical and fuel spills, and uncontrolled wastewater releases. According to statistics for 29 provinces, autonomous regions and large municipalities, there were 65 environmental pollution accidents in 1996, of which 28 were caused by chemical pollutants and 26 by biological pollutants. The number of the people affected by these accidents was approximately 500000, with 4300 reports of illness. Among these, 916 persons suffered from typhoid, 847 from dysentery, 977 from hepatitis, and 1124 from gastrointestinal infections. Ten persons died as a result of the pollution accidents. Of the causes of these pollution accidents, 41% were attributed to pollution from municipal wastewater and 34% to industrial pollution.

9 The Legal and Institutional Framework

Up to 1970s, water legislation of water resources in China focused on construction, and on the management of flood control, agricultural irrigation and drainage. In 1979, the conception of water management started to see changes and the management of water projects moved towards water management in the broad sense.

In 1981, water legislation started and many individual laws and regulations for water were issued. The Water Law was passed and issued officially in 1988, came into effect on July 1. Then, the Law for Water and Soil Conservation was issued in 1991, the Law for Flood Control was issued on August 29, 1997 and came into effect on Jan. 1, 1998. The Law for Water Pollution Control, which was first issued in 1984 and saw significant revision afterwards, was re-issued on May 15, 1996. Later on, in order to promote the rational development and sustainable utilization of water resources and the effective control of floods, water logging and drought disasters and relax the constraints on the national economic development resulting from inadequate water management, the State Council promulgated the Industry Policies for the Water Sector in September 1997, based on the laws mentioned above and the Ninth Five-year (1995-2000) Plan for the Economic and Social Development and the Fifteen-year Objectives Plan. In October 1st 2002, the Water Law was amended and put into practice.

Based on those laws, the State Council has adopted related administrative laws and regulations and MWR has formulated some ministry regulations to support these administrative laws and the State Council decrees. The governments of provinces, municipalities and autonomous regions have formulated local regulations based on national laws. Those laws and regulations can be divided, in terms of the contents, into the categories of water and soil conservation, flood control, drought management, project management and protection, operation and management of water related business, law enforcement, monitoring and administration, etc.

Up to now the State Council and its ministries and commissions have issued more than 70 water related administrative laws and regulations and local governments have issued more than 300 local laws and regulations, thus laying a sound basis for the administration of water by law. MWR is making efforts to establish a complete water legislation system so as to meet the needs by market economy.

Government in PRC is structured at four levels: national, provincial (including municipalities directly under the central government and autonomous regions), county/city and township/village. The highest administrative authority is the State Council. Under the State Council there are functional organizations such as committees and ministries.

MWR, Under the Water Law, is in charge of the unified administration of water resources throughout the entire country. Besides water planning, administration and related matters, MWR has particular responsibility for construction of multi-purpose projects, flood protection, and rural water development, especially irrigation & drainage but also operation of small-scale hydropower. Under the 1998 central government restructuring program, it has also gained most responsibilities for groundwater administration and for urban and coastal groundwater management and protection.

MWR is linked vertically to water resource departments in each of the provinces, which have comparable responsibilities to MWR at the provincial level. However, these departments report administratively to the provincial governments and their links to MWR are primarily those associated with technical guidance and to ensure implementation of the law. The specific structure of, and allocation of functions, to provincial departments varies depending on local decisions and requirements.

There are currently six commissions for inter-provincial river basins (Songhua-Liao, Hai, Yellow, Huai, Yangtze and Pearl) and one Lake Commission (Tai) under the direct administration of MWR but established with the consent of the State Council. Their functions are delegated to them by MWR. Many have been allocated responsibilities that go beyond the particular river or lake basin concerned so they essentially act as regional offices of the Ministry. With regard to their basin responsibilities, in general they are predominantly planning and coordinating bodies with limited management and operational powers. They have been particularly active in flood protection and in some cases have developed and now manage multi-purpose water projects and inter-basin transfers.

10 Investment of the Public Sector

In 2001, the total investment of China in capita construction was 1482.01 billion RMB, of which the agriculture, siliviculture and fisheries presented for 43.46 billion RMB and the electricity, gas wand water accounted for 219.63 billion RMB, which are two sectors related to water resources. From 1978 to 1997, the infrastructure investment on water resources increased rapidly. In 1978, the value was only 3.532 billion RMB and in 2001 it reached 56.07 billion RMB. And it is estimated that in recent years it will increase greatly due to the important role of water resources in the national economy. (Figure 30)

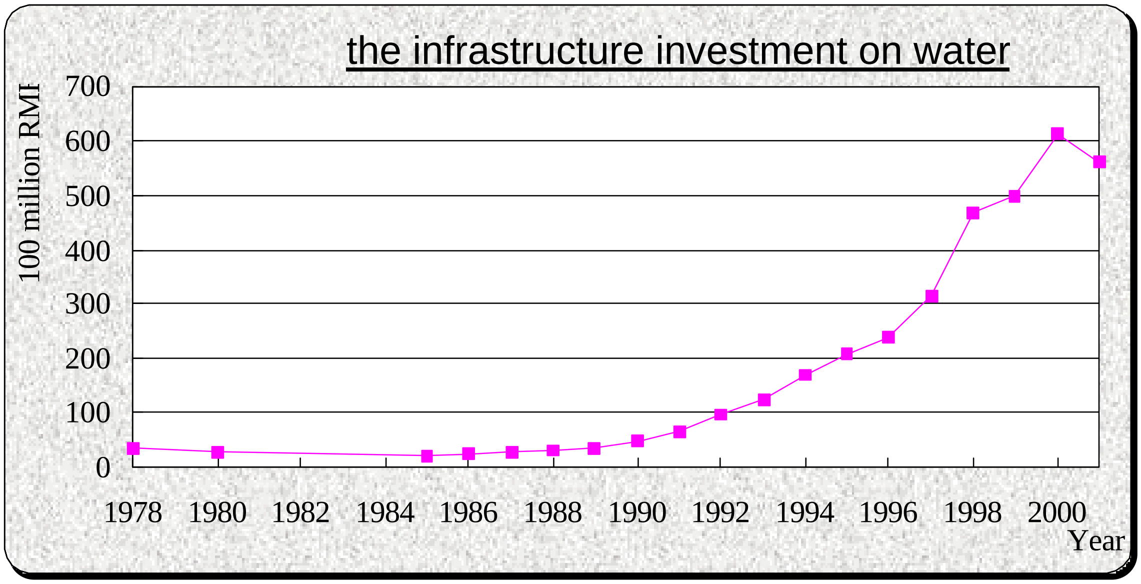

Figure 30, The infrastructure investment on Water

By types of engineering, in 2001, the total expenditures on water resources development were 56.07 billion RMB, of which w 18% was invested on reservoir projects, 9% on irrigation projects, 2% on waterlogging alleviation, 50% on flood control, 12% on water supply projects and 3% was invested on hydropower projects

By sources of capital, in 2001, in total 56.07 billion RMB investment, 28.24 billion RMB came from the government budget, 3.25 billion RMB came from domestic loan, 2.75 billion RMB came from foreign investment, 17.4 billion RMB came from self-collected capita, 2.09 billion RMB came from water resources fund, and 2.17 billion RMB was from other sources.

Annual expenditure on the water-related programs has increased greatly. From 1992 to 1998, the annual expenditure on water resources increased from 9.7 billion RMB to 41.9 billion RMB, with an annual increment of 27.6%. In 1999, the central government will increase another 30 billion RMB investment on water resources.

The investment on wastewater treatment increases quickly too. In 1997, the investment was 7.279 billion RMB, 53.53% increase that in 1996, while in 1991, the total investment on wastewater treatment was only 2.92 billion RMB. (Figure 31)

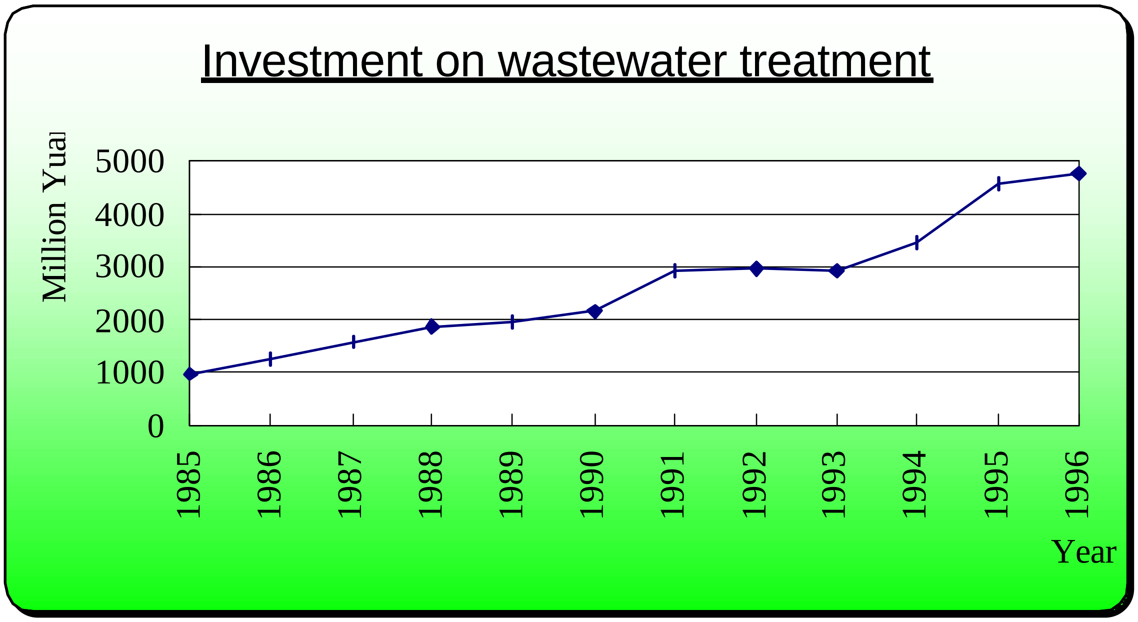

Figure 31, the Investment on Wastewater Treatment

11 Private sector participation

Private sector including national and external investors is encouraged to participate in water resources development and management. The State Council's document on Industry Policy for the Water Sector (1997), specified the sub-sectors in which the government seek the participation of private sector. This includes urban and rural water supply, irrigation and navigation.

In the individual management system, which covers the remaining 25% of the country's irrigated area, farmers build the irrigation system and manage it. Irrigation facilities in this system are owned and managed by individuals. In some irrigation districts, there are villages or water user's associations being organized as non-profit water resources entity owned and managed entirely by farmers. Associations of these local entities have been created in several provinces.

In some provinces, private sector is active in developing and implementing water conservation irrigation system including sprinkler and drip irrigation. In Northeast China, farmers (one household or more) may rent a large irrigated area of around 100 to 200 mu (7 to 14 ha) and install and operate the sprinkler system. In Henan province, around 10% of groundwater wells are owned by private sector (one farmer or more). The farmers pay to the government the well drilling cost (20 000 to 30 000 Yuan), rent the irrigated land from collective or village and install the sprinkler system. In same cases, the farmer, owner of the system, rent the whole or part of the system to other farmers. This type of activity is encouraged as a mean for enhancing the introduction of water saving techniques.

Foreign private sector participation in water industry is still in early stage of development. The private sector participates in the water sector in the form of service contract, management contract, lease, and concession. The first urban water supply BOT project (US $ 100 million) is currently under construction in Chengdu. The project production capacity is 400 000 m^3/day. In Shanghai, two shareholder companies for raw water supply and water treatment plant exist. The government of Shanghai is the majority shareholder of the two companies.

Some provinces are implementing various forms of privatization for water services. The majority of the privatized water services entities (WSE) deal only with water supply and distribution. The new “privatized” companies are organized under the Company Law of 1994. Three types of “privatization” system of WSE currently exists in China including: government investor-owned, non government investor-owned and customer-owned.

12 General Assessment and Outlook for the Future

Water availability

The total runoff in China is 2711.5 km^3, ranking the sixth most plentiful country in water resources in the world. In terms of water availability, the water resources in China is not less. But due to the large population and not less cultivated land, the water availability per capita is only 26% of the world average, ranking 88th in the world; the water availability per ha is only 80% of the world average. Moreover, with the population increase and economic development, more and more areas will occur water shortage. So, water resources in China are not plentiful.

In a view of water resources development, the current water usage per capita is only one fourth of that of America in middle 70s, although the water usage per ha is very high. In terms of water usage per kg of grain, the water usage per kg of grain is 7.6 m^3, less than 30% of the world average.

In views of water resources development degree, in 1997, the ratio between water resources developed and water availability was only 20.2%, not high.

Regional distribution

Influenced by climate, topography etc. natural conditions, the regional distribution of water resources in China is very uneven, and results in the circumstances of more water in the south and less in the north, more in the southeast and less in the northwest. The average runoff depth of the country is 284 mm, of which the Yangtze, the Pearl, the Southeast and the Southwest 4 southern riverbasins are all more than 500mm; in the northern riverbasins including the Huai, the Yellow, the Hai, the Songliao and the Inland riverbasins, the largest is the Huai Riverbasins with only 225mm, and other riverbasins are less than 150mm, in the Inland Riverbasin it is only 32mm, 11% of the average of the state.

Besides of the uneven regional distribution of water resources itself, the regional distribution of water resources is incompatible to the population and land distribution. In the 4 southern riverbasins, with 36.5% territory area, 36.0% cultivated land, 54.4% population of the country, the percentage of water resources is 81%, the water availability per capita and per ha are 1.6 times and 2.3 times respectively of the country. The water availability per capita and per ha are 15 times and 12 times of the country average in the Southwest Riverbasin respectively. While the Songliao, Hai, Huai and Yellow riverbasins, with 18.7% territory area, 45.2% cultivated land, 38.4% population only account for 14.4% water availability of the country. Particularly in the Hai Riverbasin, the water availability per capita and per ha are only 16% and 14% respectively of the country average.

Seasonal distribution and interannual variation

The seasonal distribution of water resources in China is both advantageous and disadvantageous to water resources development. First, the seasonal distribution of water resources is consistent with the heat condition and helpful to crop growth. In the north, northeast and southwest China, the precipitation in summer can present for 30-45% of the year. But in spring in the northern, 10-20% of annual precipitation always can not meet the demand of the crops. Second, most of China is influences by the monsoon, with great variation in the seasonal and interannual water resources, particularly in the arid zones. The flood runoff occupies about 2/3 of the total runoff. The shifts of seasonal and interannual distribution in China are greater than those regions at the same latitude as China. This results in the fluent occurrences of water disasters in China.

Water quality

In general, the natural water quality in the rivers is good. In the southern regions and the northern regions with plentiful runoff, the mineralization degree and total hardiness are lower, as well as the main streams of the large rivers.

In terms of water pollution, with the economic development, the water quality is deteriorating. In the river channels, the urban sect is more polluted than the rural sect; and during the dry seasons, the water pollution is more severe than the flood seasons. In the rivers, normally, the tributary is more polluted than main stream.

Outlook for the future

Major results and assumptions of the central (medium) projection of "The medium and long-term water resources projection" conducted by MWR are stated that in the early half of this century in China:

- *Population*. Population will reach the peak at 1.55 billion in 2040, falling to 1.52 billion in 2050. The rate of urbanization will rise from 29% in 1993 to 40% in 2010, 53% in 2030 and 60% in 2050 by when it will stabilize.
- *Economic growth*. By 2050, China is assumed to reach income levels typical of a middle income country today, with growth in GDP slowing from 9% p.a. between 1993-2000, to 8% p.a. in 2001-2010, 6.4% in 2011-2020, and 5.7% p.a. in 2031-2050. By 2050, GDP per capita is projected to reach US $5100 and gross industrial production per capita US $27,500.
- *Domestic use.* Average daily urban domestic use is projected to increase from 177 L/c/d in 1993 to 285 L/c/d in 2050, and rural use from 89 L/c/d to 154 L/c/d.
- *Industrial use.* It is anticipated that water recycling in industry will rise from 50% in 1993 to 75% by 2050. Allowing also for technological progress and a changing industrial structure, unit water use per 10,000 Yuan of value-added is projected to decline drastically from 159 m^3 in 1993 to 7 m^3 in 2050.
- *Irrigation use.* In order to remain self-sufficient in basic foodstuffs, China should increase its irrigated area from 50.4 Mha in 1993 to 61.3 Mha in 2050. At the same time, improvement in irrigation technology would be needed in order to decrease the unit irrigation water use.
- *Forestry and Husbandry.* Water use per head of population for these other rural purposes is assumed to rise from 14 m^3 to 17 m^3.

Under these assumption, it is projected that in 2020, the total water demand would be 672.3 km^3, of which urban water demand would be 65.0 km^3, rural water demand would be 37.9 km^3, industrial water demand would be 179.5 km^3, irrigation water demand would be 365.4 km^3, and forest, husbandry and fishery water demand would be 25.4 km^3 respectively; in 2050, the total water demand would be 764.5 km^3, of which urban water demand would be 90.6 km^3, rural water demand would be 33.6 km^3, industrial water demand would be 231.8 km^3, irrigation water demand would be 382.5 km^3, and forest, husbandry and fishery water demand would be 26.0 km^3 respectively.

Broad implications by river basin categories can be as follows:

- *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. Water is not seriously constrained in this region so that rising irrigation demand can also be accommodated based on new irrigation and associated land reclamation. The northeast can 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 utilized, with 33% of this total coming from groundwater.
- *Hai-Luan, Huai and Yellow Basins*. The 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, still accounting for more than 50% of the total in 2050. The 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%. The combined impact of transfers from the Yangtze basin and planned conjunctive use would aim to end groundwater mining and arrive at a balanced and sustainable use of surface and groundwater use. For instance, groundwater in the Hai-Luan basin would meet 50% of total use compared to 70% in 1993. Total water consumption is projected to be equivalent to almost 70% of available supplies, with the balance presumably either unutilizeable flood flows or devoted to instream and environmental purposes.
- *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 Pearl basin). However, urban and industrial demands are projected to rise rapidly and total demand is expected to rise more rapidly than the national average. Even so, 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.

- *Southwestern 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 that available. Funds and implementation capacity will be the dominant constraints, with hydropower a continuing development opportunity.
- *Inland Rivers.* The issues facing Inland Basins differ widely with acute shortages in some populated basins coexisting 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 there is expected to be increasing recourse to groundwater.

The projections are based on the premise that a satisfactory balance can be achieved use by the middle of the next century between consumptive demand and withdrawals for consumptive use. It assumes that population can be controlled; that rapid economic growth will continue; and that the institutional and financial means will be forthcoming that are needed to address the whole range of issues in the water sector. So for the water sector, China is facing the following challenges:

- *Population.* If population grows more rapidly, then *prima facie* there will be greater pressure on the resource and it would be more difficult to achieve the projected increase in domestic use per capita, as well as self-sufficient food supply.
- *Economic growth.* The economic growth targets are optimistic despite anticipating GDP per capita in 2050 well below present day levels in developed countries. Other things being equal, a slower rate of growth would reduce pressure on the water resource, notably in industry. However, this would also undermine the economy's capacity to finance investment. The financial shortfalls would make it more difficult to meet the specific targets for domestic, industrial and irrigation use.

- *Domestic use.* The targets for per capita domestic use are reasonable and diversions per head for domestic use in 2050 would still be less than a third the US level in 1995. Even so, they may prove difficult to achieve.
- *Industrial use*. The projections of use in industry are based directly on value-added. If growth is slower than projected, then water demand would be less. On the other hand, the unit rates are optimistic and will require large investments if they are to be achieved.
- *Irrigation use*. Given the predominance of irrigation in total demand, it is this assumption more than any other that would seem problematic. Irrigation will remain the predominant user and a likely scenario would have pressure on supplies for irrigation resulting in some shortfall in food production.
- *Instream use.* The projections are expressed in terms of the balance between consumptive demands and offstream withdrawals to satisfy these demands. This fails to account for return flows and instream uses. Instream use for power, navigation, the environment, pollution management etc. does not always preclude offstream withdrawals. Nevertheless, it may impose timing constraints and can result in flows reaching the sea that reduce its availability or value for offstream uses.

In summary, pressures on water resource will remain very considerable given the water resources condition in China. For the future, opportunities and crises will both exist in the water sector to meet the national demand of sustainable development, and water resources will remain an important issue in the society and economics, just as the role in the present and history.

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