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INTRODUCTION

The world today is facing three major problems, population, nature resources, environment. Water belongs to natural resources and is closely related to the other two problem. It becomes an important topic with universal significance all over the world. Alongside the increase in population, the development of the economy and the raising of both material and cultural living standard of human beings, there is an ever increasing demand for water by human society. At the present, as a crisis in water resources has appeared in various degrees in quite a number of countries and districts, water resources becomes day by day a very serious problem parallel with the problems of energy resources and food deficiency and restricted factors of the social economic development at a lot countries of the world.

This paper intents to discuss the water resources development policy of China in connection with the characteristic of water resources, present status of water development and utilization, strategies for sustainable development

PRECIPITATION AND WATER RESOURCES

China is situated in the southeastern part of the Eurasian Continent, having a territory of 9.6 million km^2. There are a large number of rivers in China, among which the Changjiang(Yangtze), Huanghe(Yellow), Zhujiang(Pearl), Huaihe, Haihe, Liaohe and Songhua river are the seven main rivers (see Fig.1).

The climate of China is characterized by monsoon. It is cold with little precipitation in winter, and is warm and humid with abundant rainfall in summer. Obstructed by the plateaus and mountains, about 45% of the northwest inland area is arid with slight precipitation and the development of agriculture depends completely on water resources projects. Affected by the ocean, the southeastern part of China is humid with abundant rainfall, being a main

agricultural area of country. However, over 90% of the population and cultivated land of the country concentrates in the eastern monsoon areas.

According to recent estimation made by the Bureau of Hydrology, Ministry of Water Resources in 1984, the total amount of mean annual precipitation of China is about 6190km^3, equivalent to an average of 648 mm, being 20% less than the world average. About 56% of the precipitation is consumed by evapotranspiration and 44% become river runoff.

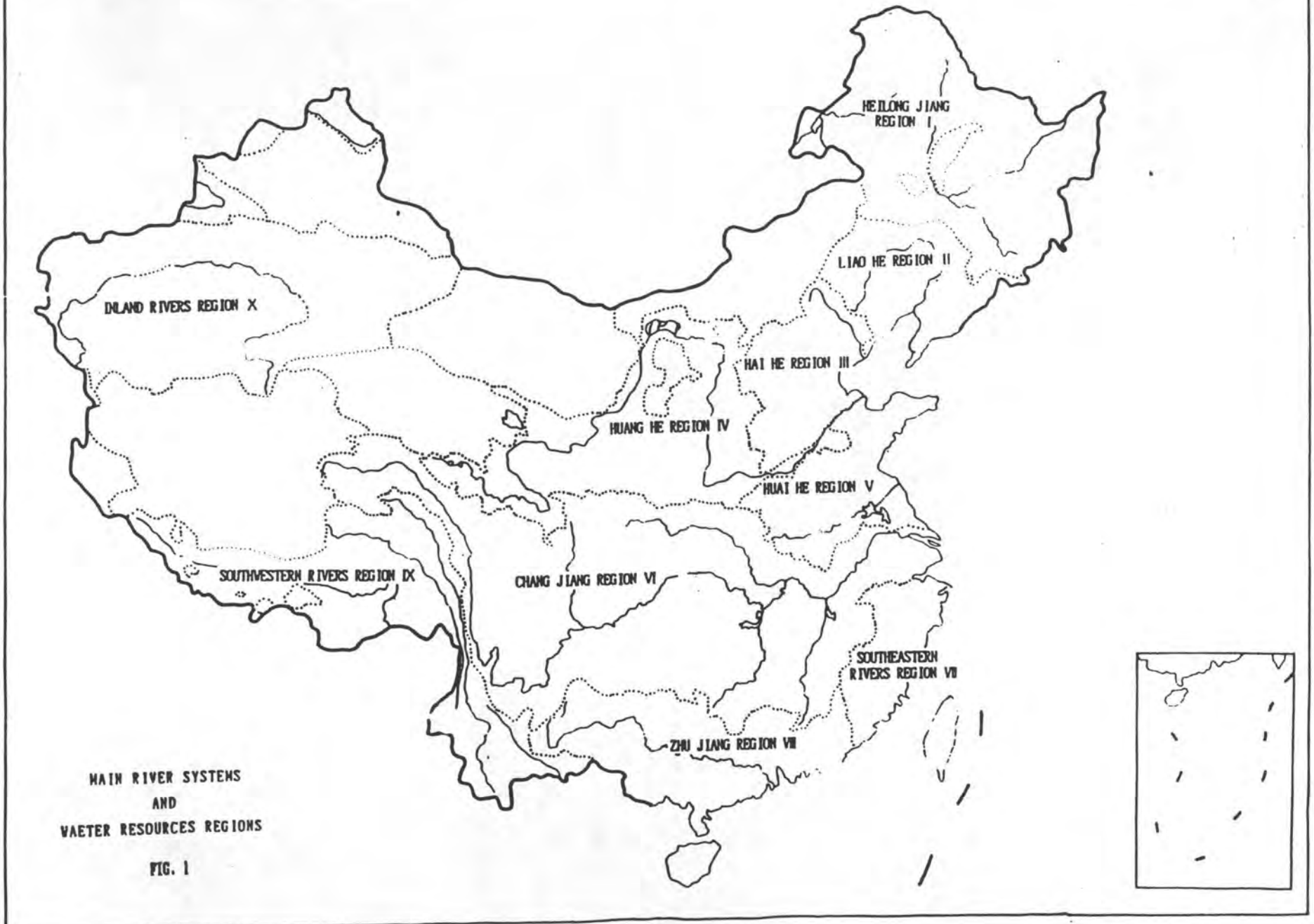
The total amount of the mean annual runoff of all the streams in China is about 2710 km^3, equivalent to a depth of 284 mm, of which the discharge from groundwater is about 678 km3, and from melting snow and glaciers are about 56 km^3. The mean annual amount of water flowing into the ocean and out of the boundary is 2456 km^3. the others is consumed inland.

The amount of natural recharge of groundwater is 830 km^3 in average annually; the total amount of water resources, i.e., the sum of river runoff and recharge of groundwater minus the amount of groundwater transformed into river runoff is approximately more than 2810 km^3.

The results of recent estimation for annual precipitation, runoff and groundwater resources of China are listed in table 1.

Table 1 Annual precipitation and water resources in China

Water resources region	Drainage area	Mean annual precipition		Mean annual runoff		Groundwater resources	Total amount water resources
	10^3km^2	mm	km^3	mm	km^3	km^3	km^3
1 Heilong River	903	496	447.6	129	116.6	43.1	135
2 Liaohe and other river	345	551	190.1	141	48.7	19.4	57.7
3 Hailuan river	318	560	178.1	91	28.8	26.5	42.1
4 Yellow River	795	464	369.1	83	66.1	40.6	74.4
5 Haihe and other rivers	329	860	283.0	225	74.1	39.3	96.1
6 Yangtze River.	1809	1097	1936	526	951.3	246	961
7 SE rivers	240	1758	421.6	1066	255.7	61.3	259
8 Pearl River	581	1544	896.7	807	468.5	112	471
9 SW rivers	851	1098	934.6	687	585.3	154	585
10 Inland rivers	3374	158	532.1	34	116.4	86.2	130
Total regions		648	6189	284	2711	829	2812



MAIN RIVER SYSTEMS
AND
WATER RESOURCES REGIONS

FIG. 1

CHARACTERISTICS OF WATER RESOURCES

1. Vast Total Amount and Low Volume per Capita and Unit Area of Cultivated Land

The total amount of annual runoff of China ranks the 6th in the world, next to Brazil, USSR, Canada, USA and Indonesia. Because of the vast land and huge population, however, both the volume per capita and per unit area of cultivated land in China are less than the average of the world, accounting for 25% and 76% of the world's average respectively. In comparison with other countries, therefore, it is most arduous and complex for China to deal appropriately with the mutual relationship between water and human beings.

2. Uneven Regional Distribution and Disproportionate Combination of Water and Land Resources

The depths of precipitation and runoff in China are distributed in descending magnitudes from the coastal areas in the southeast to the inland areas in the northwest(see Fig.2), representing very uneven regional distributions and disproportions with the distributions of population and cultivated lands(as shown in table 2), which is a serious issue encountered in the development and utilization of water resources. Of the water resources in the whole country, 81% concentrates in the Yangtze River basin and the areas south of it where the area of cultivated land is only 36% of that in China; 19% are in the Huai River basin and the areas north of it where the area of cultivated land accounts for 64% of that in China, mainly in the four basins of the Yellow river, Huaihe, Haihe and Liaohe rivers; here, the total area of cultivated lands accounts for 42% of that in China, but the total amount of resources is only about 9%. As a result, while the South has surplus water with less cultivated land, the North has less water with more cultivated land and the deficiency of water is very serious. In order to change such situation, strategic measures must be investigated to divert the surplus water from the south to the water shortage areas in the North in order to reallocate water resources among regions rationally.

3. Uneven Time Distribution and Consecutive Dry and Wet Years

Affected by monsoon, the precipitation in most part of China varies greatly within a year and from year to year. The amount of precipitation and runoff in the months of flood season accounts for 60-80% of those of the whole year; the degree of concentration is higher than those in Europe and America and is similar to India. The ratio of the maximum to minimum of the annual runoff volume ranges from 2 to 3 for the Yangtze, Pearl, and Songhua rivers, 4 for the Yellow, and 15-20 for the Huaihe and Haihe rivers.

All the main rivers in China have experienced consecutive dry and wet years. For example, in the past 60 years, the Yellow River had 11 consecutive years of low flow(1922-1932). During this period the main annual runoff was

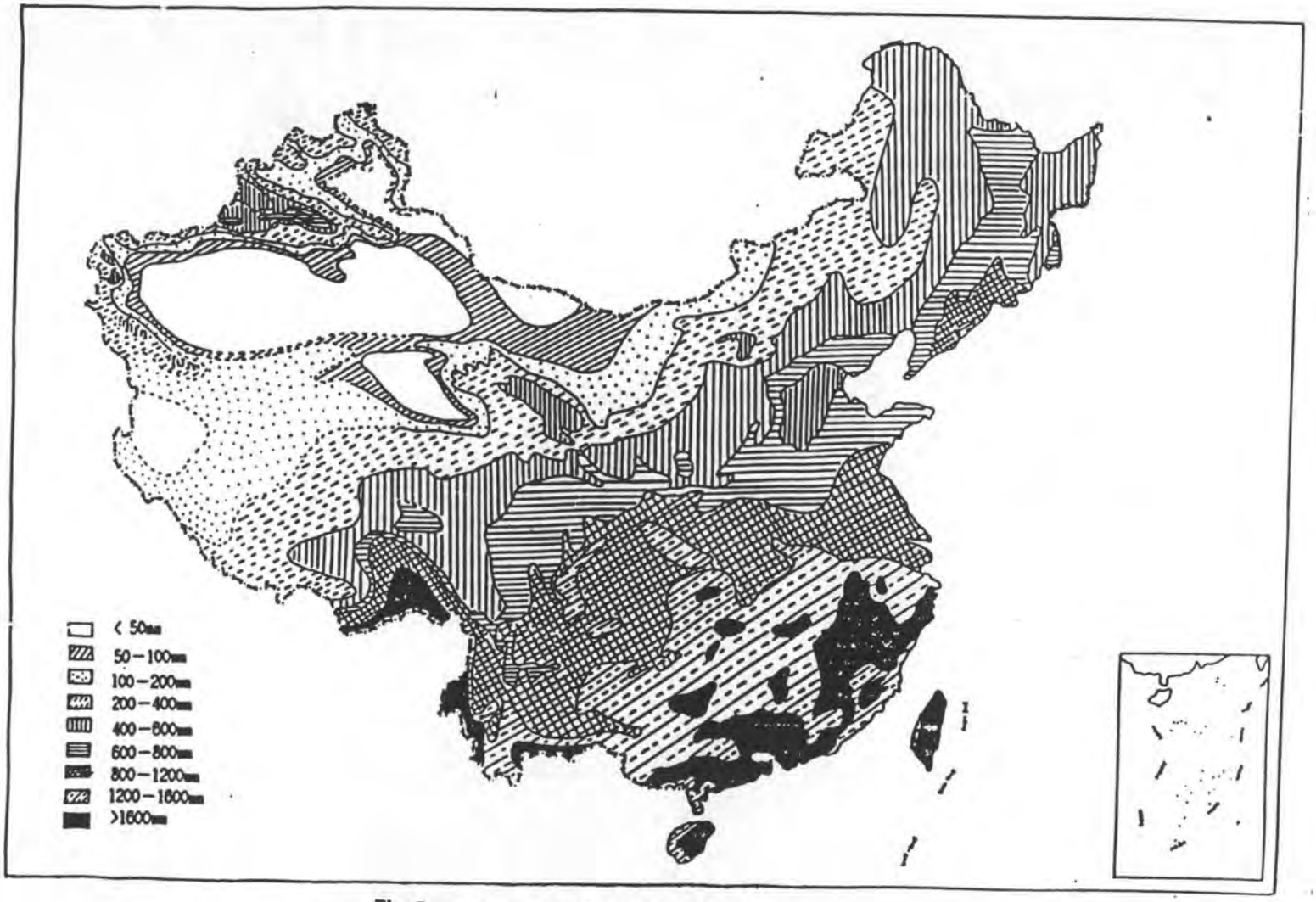


Fig. 2 Average annual precipitation

24% less than that of the normal years, and also had 9 consecutive years of high flow(1943-1951), when the mean annual runoff was 19% more than that of the normal years.

The great temporal variation of precipitation and runoff causes difficulties in the development of water resources. In order to fully develop water resources, the construction of reservoirs is indispensable for the regulation of natural flow, but it can also create environmental and ecological problems, such as inundation and resettlement of inhabitants, which will restrict the development and utilization of water resources.

All these characteristics of water resources in China are the main causes of the frequent drought and flood disasters, unstable agricultural production and serious unbalance between water demand and supply in some areas. It is evident that the harnessing of rivers and the development of water resources in China are long term arduous and complex tasks.

Table 2 Variation in water resources, population and land within China

Regions	% of the total of the country			Water volume per capita	Water volume per unit cultivated land
	Water resources	popula-tion	cultivated land	(m^3)	(m^3/ha)
Inland river (inclued Ertix River)	4.6	2.1	5.8	6287	21850
N part of China					
River of NE	6.9	9.8	19.8	1960	9560
Hailuan River	1.5	9.8	10.9	430	3760
Yellow River	2.6	8.2	12.7	874	5730
Huaihe and other	3.4	15.4	14.9	623	6310
Total	14.4	43.2	58.3	938	6810
S part of China					
Yangtze River	34.2	34.8	24.0	2763	39300
Pearl River	16.8	11.0	6.8	4307	67950
SE river	9.2	7.4	3.4	3528	73800
SW river	20.8	1.5	1.7	38431	327000
Total	81.0	54.7	35.9	4170	61950
Total regions	100	100	100	2730	28000

PRESENT STATUS OF WATER RESOURCES DEVELOPMENT AND UTILIZATION

Since the founding of the People's Republic of China, the undertaking of water resources development in China have been development rapidly. Lots of water projects for storage, diversion or pumping of water have been built with a total storage capacity of more than 450 km^3 and have provided large amount of water sources for irrigation, power generation, water supply, navigation etc. which has made great contributions to the development of economy as well as the promotion of living standards of Chinese people.

In 1980 the total amount of water supplied by hydra projects was 444 billion m^3, accounting for about 16% of the total volume of water resources. Of the supplied water, 86% or 382 billion m^3 was taken from rivers, and 14% or 62 billion m^3 from groundwater. The capacity of water supply ranked the second in the world only next to USA. Of the total supplied water, 88.2% was for agricultural uses, 10.3% for industrial uses and 1.5% for urban uses. The water uses per capita in China was 452 m^3 annually. At present the standard of water uses in China is still low in comparison with develop countries:the water uses per capita is only 1/5 of that of USA, 1/3 of USSR and 3/5 of the world average(see table 3). It can be predicted that the standard of water uses in China will be further promoted with the developments of industry and urban areas and the change of water use patterns.

Table 3 Water uses in China as compared with developed countries
(Sea water uses are not included)

Country	Year	Total water uses (km^3)	Water uses per capita (m^3)	In % of total water uses			
				Agriculture	Industry	Domestic	other
China	1980	443.7	452	88.2	10.3	1.5	
	1988	458.4	422	85.5	11.o	3.5	
USA	1975	467.6	2184	48.7	43.4	7.9	
USSR	1975	331.4	1304	48.9	32.0	4.8	14.4
Indian	1974	424.0	691	92.7	4.0	3.3	
Japan	1981	88.2	792	65.8	18.2	16.0	
World	1975	3000.0	744	70.0	21.0	5.0	4.0

WATER CRISIS

Though great achievements during the past 40 years have attracted world-wide attention, especially the fact that 22 percent of the world population were brought up on only 7 percent of the world farmland, but the sustainable economic and social development of China is and will be facing serious challenges more critical than those happened in any part of the world . Water is a particular problem. The shortage of water which is almost inevitable in China due to the following facts:

1. The Heavy Burden of Overpopulation

In 1989, the total population of our country has already topped 1.1 billion. It is estimated that by the year 2000 the total population of China will be around 1.3 billion. If the population growth can be controlled positively and efficiently, the total population of China by the year 2050 may reach the peak value of 1.5 billion; then the trend will begin to drop to decline in the birth rate. Although since 1980 family planning has been carried out by the State and has got obvious effects with annual natural growth rate of 1.33% from 1980 to 1989, the burden is still heavy and road is still long.

Overpopulation is the first challenge, which is always a key constraining factor for sustainable development of China. In addition, the nonconformity between population and resources(especially water, land and energy) is another constraining factor. The bulk of water resources in China should be developed for agriculture and industry to provide sufficient food, energy and other materials to meet the basic requirements for the livelihood of 1.5 billion people in the 21st century. Water resources, however, is limited.

2. The Compulsory Development of Irrigated Agriculture

Agriculture is the largest water consumer in China. In 1980 the water consumption for agricultural uses amounts to 391 billion m^3, namely 358 billion m^3 for cultivated land irrigation, equivalent to about 80.7% of the national total water supplied and 33.1 billion m^3 for uses of forestry, pasture, side occupation, livestock and households. From 1949 to 1980, the total irrigated area had developed from 16 million ha to 48.6 million ha, and the ratio of the irrigated area to the total cultivated land from 16% to 48%. Based on the data of 1980, 74% of the total grain output came from irrigated area which was 48% of the total cultivated land. So it is quite obvious that irrigation plays a very important role in maintaining and promoting the agricultural yield per unit area of land.

The big gap between food demand and cultivated land is the second challenge, which will be aggravated more and more in the next century. As new reclaimable cultivated land is not adequate to satisfy the increment of food demand due to overpopulation, the development of irrigated agriculture would

be compulsory. According to the estimation by MWR, based on water resources condition, the possible maximum potential of irrigated area may be 64 million ha, which increase one third of the irrigated area in 1988. The proportion of irrigated area to total cultivated land will increase to 60% . Grain yield from irrigated agriculture will make up over 75% of total grain yield. Even so, to satisfy the food demand of overpopulation will still be a difficult problem.

3. The Rapid Increase of Municipal and Industrial Water Uses

The rapid increase of water demand in industry is the third challenge. Although our industry is now still in its initial stage with the gross value of 1,822.4 billion Yuan in 1988, its water uses has topped 50,347 million tons. At present, water needed for industrial development is mainly seized of the agricultural water supply. Many reservoirs originally designed for agriculture are now shifted to serve industry and urban. This has further effected the development of grain production.

Urbanization is the fourth challenge. The growth of urban population, the improvement of their livelihood and the perfection of urban water supply facilities will increase the domestic water at a high speed. Under the condition of inadequate municipal water supply facilities and low domestic water use level, total domestic water use in 1988 was 1590 million tons. Even with such low standard, over half of our cities and towns were facing water shortage, one third of them were more serious, one tenth of them have faced crisis during the past decade.

4. The Degradation of Water Environment

At present, water pollution, massive destroy of natural vegetation, water and soil losses, shortage of water resources, ground water overdraft have been aggravated, with accompanied consequences of estuary siltation, salinazation, alkalization and desertification. All these water-related problems further deteriorated the water environment, impeded the national economic and social sustainable development and improvement of people's livelihood.

5. The Deficiency of Funds

China is still backward in economy, per capita national income is only about 1200 Yuan, equivalent to about 250 USD. To meet the water demand of agriculture, industry and domestic use, the ratio of water resources utilization must be increased from the present 18% to about 40% in the next century. It is well understood that to build water projects requires a large amount of investment. For example, newly increased irrigation area of 5.3 million ha up to the year 2000 will need total investment of 88 billion Yuan as estimated, not including the cost of water projects.

STRATEGIES FOR SUSTAINABLE DEVELOPMENT

With the rapid growth of population, the national economic development and the improvement of people's livelihood, water use in China certainly will further increase. It is estimated that by the end of this century the total water demand of agriculture, industry and domestic use will increase by 100 to 150 km^3 as compared to that in 1988. The construction of new water projects, however, needs a large amount of investment. Many difficulties of either funds or resources must be overcome indeed. The water resources in the Yellow River, Huai River, Hai River and Liao River are so deficient that by the year 2000 the contradiction between water demand and supply will be further intensified. In the 21st century, the water resources development in China will definitely face a very grim situation.

In order to narrow the gap of unbalance between water demand and supply in the arid and water deficient ares in the North and in the coastal cities, equal emphases must be paid to water conservation and water resources development in combination with protection and operation by means of comprehensive measures concerning all the aspects of development, utilization, protection and operation, i.e. on the basis of implementation of water conservation measures in all the water use fields, to develop new water sources, raise the efficiency of water use and accelerate the transition from water consuming to the water saving type economy. Only by those comprehensive measures can the ever pressing demand for water be gradually satisfied.

1. Enforcement of Water Saving Strategy

A society established with water-saving strategy should be set up in China in order to fill the gap between increasing demand and poor resources of water. In the period of 1980 to 1984, through propaganda and education, and various kinds of economic, administrative and legislative measure, such as to levy water charges and planned allocation, water conservation activities have been much more stressed, resulting in obvious benefits in all the water use fields. From 1978 to 1984, the total industrial output values of Beijing and Tianjin increased by 80% and 60% respectively, but the water consumption for industrial uses had been slightly declined due to the promotion of the rates of industrial water reuse, which had been raised from 46-50% to 72-73% respectively, and the reduction of the water consumption per unit industrial output value. In agricultural some effective measures can be used to save water, for example, adjustment of cropping pattern, planned water use, improvement of irrigation management, proper water prices policy, canal lining, as well as the development of pipe, sprinkler and drop irrigation. The water saving concepts have also been popularized gradually, which has yielded some good results.

The planned allocation, practicing strict water conservation, water draw-

ing permit system, measures for charging water charge and water resources fees shall be stipulated by the State Council.

Generally speaking, there are still great potentialities of water saving either in industry or in agriculture. Because of lack of funds and limited input, water conservation work in many areas remains insufficient, and therefore more input is needed to improve such situation.

2. Coordination of Economic Development with Water Resources Development

The North China region with total water resources of about 52 km^3, territorial area of 428,000 km^2 and population of over 126 million is the most seriously water deficient area in our country. Actually, in this region water demand has already gone beyond the bearing capacity of the local water resources. However this region is the political, economical and cultural center of China, with many cities, including Beijing and Tianjin. In 1987, under the condition of ten consecutive dry years, total water supply reached 44.5 km^3, equivalent to an average of 353 m^3 per capita, and the ratio of the water resources utilization was as high as 87.3%. Obviously, new industrial enterprises which are highly water consumptive and highly polluting should not be built in this region and agricultural structure should be adjusted to cut down water demand. In general, in areas deficient of water, urban growth and the development of highly water consumptive industries and agriculture shall be limited.

3. Development of New Water Sources to Reallocate Water Resources Rationally

During the period of 1980 to 1984, temporary water transfer project from the Yellow River to Tianjin was carried out twice in 1981 and 1982 to moderate the crisis of serious water shortage in Tianjin. In 1981, the State Council made a decision to accelerate the construction of the diversion projects from the Luan River to Tianjin and Tangshan, and from the Biliu River reservoir to Dalian. In 1984, the State Council also decided to construct the Yellow River-Qingdao diversion project. All the cases remind us that long term arrangement in advance is necessary for drought prevention, such as the east route, middle route and west route schemes of south-to-north water transfer from Yangtze River to north China, and other water transfer projects from the Yellow River to water deficient areas. For inter-basin water transfer projects, integrated planning and scientific justification must be undertaken. Water demands of both the export and import basins must be considered. Adverse impacts on the ecological environment must be studied and mitigated.

4. Reinforcement of Water Resources Protection

It is of vital importance to reinforce water and soil conservation activities, such as the protection of water sources and the control of pollution sources and to integrate the treatment of water and sewage with the control of pollution sources and to control the development of pollution by legal meas-

ures. On water use, waste water and sewage discharge, water quantity and quality, surface water and groundwater should be monitored comprehensively and regulated scientifically, and the advanced water conservation technologies should also be adopted for using water in more scientific and rational way and getting the comprehensive benefit of water resources to the highest degree, so that the limited water resources can be put into full and rational utilization.

MWR, as the department of water administration under the State Council, will devote its attention to three tasks in the near future: (1)basically control the pollution of drinking water sources and the eutrophication of lakes and reservoirs in the scenic spots; (2)control water qualities of main rivers, lakes, reservoirs and delivery channels to meet the national standard, especially those of the river reaches near large-and medium-sized cities; (3)control the groundwater quality in cities to meet the national drinking water quality standard.

5. Formation of Scientific Institution for Water Resources Administration

The Water Law of China stipulates that "the State shall exercise a system of unified administration on water resources in association with administration at various levels by various departments". The State Council has established the National Leading Group for Water Resources and Soil Conservation to reinforce the leadership on the integrated administration and protection of the national water resources , and the corresponding leading agencies have also been set up at provincial and municipal levels , which has provided the basis for the formation of scientific institution for water resources administration. Administration of water resources is a complex system engineering and requires a group of well qualified personnel, mastering in modern science and technology. Therefore, strict training to promote their capabilities both in administration and technology is of paramount importance.

6. The Control of Population Growth

Of all the strategies mentioned above, the control of overpopulation is of the utmost importance. The nonconformity between population and resources especially water and land is a key constraining factor for sustainable development of China. So, family planning is undoubtedly the basic policy of our country to control the population growth. Successful control of China's population growth will not only be conductive to the progress and development of China, but also to that of the world.

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