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WATER RESOURCES DEVELOPMENT IN THE PEOPLE'S REPUBLIC OF CHINA

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WATER RESOURCES DEVELOPMENT IN THE PEOPLE'S REPUBLIC OF CHINA

Jan-Erik Gustafsson
Trita-kut 1035

Abstract

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This thesis compares the Chinese water resources development in relation to a conceptual framework of water resources planning and development concepts of the Third World. It identifies, with the help of a historical and contextual methodology, the important key factors of the physical, technological and socio-economic environment. These factors contribute to the water resources development in general and the Chinese water resources development in particular.

After having reviewed the water resources development of the United States the following definition of a desirable comprehensive resources planning is proposed; a societal integrated planning, which seeks to optimize a basin-wide and multi-purpose use and management of water and land resources within a framework of legal, socio-economic and ecological constraints.

The Chinese water resources base is characterized by an uneven spatial and time distribution of precipitation, runoff and high silt content of river water, which historically has caused numerous flood and drought problems. Furthermore, due to the large population, the per capita availability of water is low, in particular in semi-arid Northern China.

The empirical data collected during a research visit in 1982, show that a basin-wide and multi-purpose approach to water resources planning was applied in the years after 1949. Though faced with many shortcomings in the beginning, China has gradually implemented the idea of a comprehensive water resources planning. In the three decades after 1949 the efficiency in water use has been much improved. Since the middle of the 1970s water quality aspects and ecological considerations have been incorporated in the planning of the water resources development. Thus, nowadays the performance of a comprehensive water resources planning in China is of an advanced international level.

The Chinese water resources development has been performed under the guidance of a basic needs approach of national economic peformance and within a framework of state ownership of water resources and basically cooperative ownership of land resources. The adoption of a basic needs approach has implied priority to agricultural development and the overall development of rural areas, where 80 percent of the Chinese population live. The setting up of a workable planning and management rural organization has been the basic pre-supposition of the Chinese water resources development. In particular, China has been effective in engaging her abundant labour force in current agricultural production, soil and water conservation works and in an expanding small-scale industry. Under the conditions of scarcity of arable land the cooperative ownership approach has been consistent with a rather efficient control of land use and water resources development, if compared to most other Third World countries. Though the Chinese experience has been conditioned by many traditional and specific factors, it is likely that lessons of the Chinese experience will have increasing future relevance for Third World countries and industrialized countries as well.

Key words: Water resources development, water resources planning, water resources management, China, rural development, cooperative development, basic needs.

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PREFACE

This thesis is the second part of the overall project dealing with "Land and Water Resources Planning in the People's Republic of China"(see chapter 1). The thesis work has been carried through basically by myself, having an appointment as a research student and lecturer at the Department of Land Improvement and Drainage at the Royal Institute of Technology. I visited China for three weeks in 1979 and six weeks in 1982. The second time I took part in a research programme established between the the Royal Swedish Academy of Engineering Sciences and Academia Sinica of the People's Republic of China in my capacity as a post-graduate student. I wish to give special thanks to the concerned personnel at the Swedish Technical Attache Service in Beijing and the Royal Swedish Academy of Engineering Sciences in Stockholm. I also owe thanks to SAREC (Swedish Agency for Research Cooperation with Developing Countries), C.F. Lundströms Foundation Upplands Väsby and Styffes Foundation at the Royal Institute of Technology for their financial support of the costs not covered within the research programme.

The research visit was performed from August 26th to October 6th in 1982. My host organization was the Commission for Integrated Surveys of Natural Resources of Academia Sinica, especially its Water Resources Division. I owe deep gratitude to all the personnel involved with my visit at the Commission. In particular, I wish to thank Mr Yang Zhou-huai and Mr Guan Zhi-hua. Mr Yang was my excellent English interpreter during the whole stay in China. Mr Guan, a research scientist at the Commission, had done much of the careful preparations before my arrival and also accompanied me during most of the visit. By their deep knowledge, Mr Yang and Mr Guan gave me much insight into Chinese cultural and social life during my spare time, when for example visiting historical and cultural places. I also owe much gratitude to all the other people I met, for their willingness to give me information about the water resources development.

The work with the thesis would have been impossible without the material and moral support from colleagues and staff at the Department of Land Improvement and Drainage. I am very grateful to my supervisor professor Gert Knutsson for his patient reading and comments on the drafts of the thesis. Also associate professor Erik Danfors has given valuable comments on the drafts.

During the work a lot of people outside my department have in one way or another been involved, in some cases unawarely involved, in the preparation of the thesis. Without giving any names, they are all acknowledged for their helpful inspiration.

Gillian Karneus at the office of the International Federation of Institute for Advanced Study has checked the English language of all chapters. John Tonks at the Royal Institute of Technology has checked the English language of the abstract and this preface. I am much grateful for their valuable help.

All the photographs (Plates I - XV) are shot by the author. The cover picture is a Chinese paper-cut from the city of Yangzhou. When referring to money values in the text the Chinese currency has been used. In June 1983 the Chinese currency of 1 Yuan or 1 Renminbi was equivalent to 3.85 Swedish Crowns or about half a US dollar.

Finally, this thesis is the end-product of earlier drafts. Naturally, I have the sole responsibility of the resulting end-product, which hereby is submitted to the general public.

Stockholm in February 1984

Jan-Erik Gustafsson

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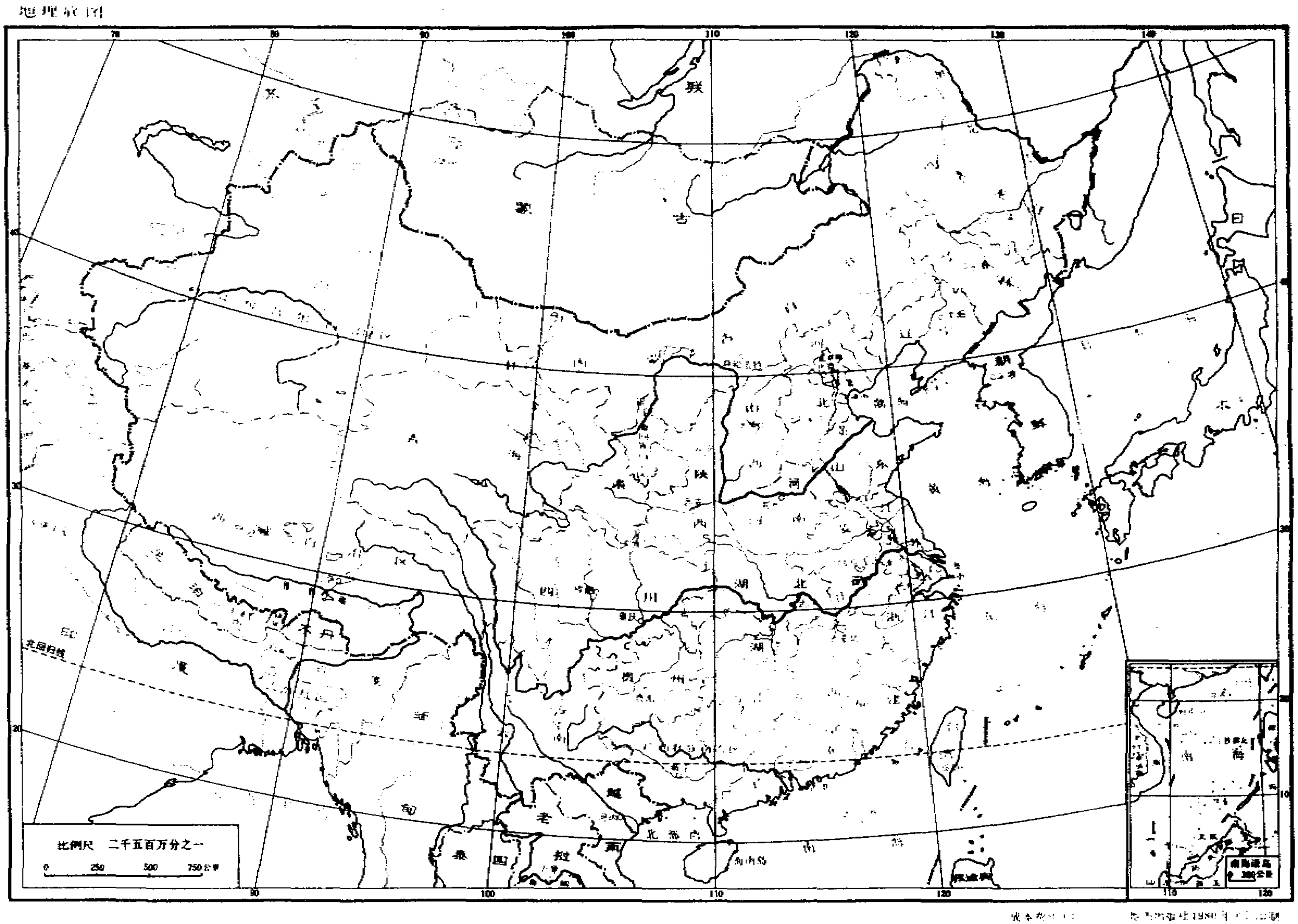


The official map of the People's Republic of China (China Map Publication Press, 1980)

"Contrary to the popular belief that nature always remains the same -a belief that has lead to static theories of environmentalism and to their equally static rejections- nature changes profoundly whenever man, in response to simple or complex historical causes, profoundly changes his technical equipment, his social organization, and his world outlook. Man never stops affecting his natural environment. He constantly transforms it; and he actualizes new forces whenever his efforts carry him to a new level of operation. Whether a new level can be attained at all, or once attained, where it will lead, depends first on the institutional order and second on the ultimate target of man's activity: the physical, chemical,and biological world accessible to him. Institutional conditions being the equal, it is the difference in the natural setting that suggests and permits -or precludes- the development of new forms of technology, subsistence, and social control"

Karl A. Wittfogel, Oriental Despotism 1957

CHAPTER 1

INTRODUCTION

This thesis consists of the second part of an interdisciplinary study dealing with "Mark- och vattenhushållning i Kina" (Land and Water Resources Planning in the People's Republic of China, Gustafsson 1977).

The first part of the project elaborated the subject of "Markutnyttjande och jordbruksutveckling i Kina sedan 1949" (Land Utilization and Agricultural Development in the People's Republic of China since 1949, Gustafsson 1981a, b). It was based upon two fundamental ideas. First, that every nation should chiefly adhere to the principle of self-reliance to generate a national economic surplus, which must be invested in order to raise the material and cultural living standards of its people. Second, the agricultural sector has to be given overall priority for the development planning of Third World countries. Summing up these ideas means that an agricultural labour productivity which exceeds the personal needs of the labourers is the foundation of all societies.

It is shown in the reports that China has created a substantial national economic surplus within the agricultural sector. Also, compared to other countries, China has made agricultural and rural development a priority. The reports also identified water as a cruical and determinating factor of agricultural development and the growth of the national economy (Gustafsson 1981a, pp 76-81; Gustafsson 1981b, pp 42-44). The utilization and planning of China's water resources has played a key role in her economic development since 1949.

Purpose and limitations of the thesis

The purpose of this thesis is to review and evaluate the Chinese water resources development since 1949. In the study, water resources development is considered as a general concept, which concerns the human activities and institutions that involve the use, planning and management of water resources.

The thesis is based upon the same fundamental ideas as was the paradigm in the first part of the project. Furthermore the thesis is based upon the idea that water resources development today should in general be considered a national and not a private concern. It has generally been recognized, that water resources development is an important societal activity, which concerns the social welfare of a society. Therefore the author accepts the premise that the public sector i.e. governmental, communal or cooperative institutions are best suited to carry out the framework planning, which is needed to obtain the greatest and most equitable welfare. In congruence with this premise a synoptic evaluation of the Chinese experience will be done in the light of a current framework of water resources development concepts or theory (chapter 2) and the development concepts or theory of the Third World (chapter 3).

There are several specific reasons for making a study of the Chinese water resources development from this starting point. First, China is an interesting case by reason of its size. The land area is similar in size to the United States and Canada. China constitutes about one fourth of the total world population and about one third of the population in the developing world (or the Third World) but it has roughly seven per cent of the cultivated area of the world.

Second, at the United Nations Conference in Argentina in 1977 the shortage of water was recognized as a limiting factor to social and economic development in many regions of the world. The fact that water is a restricting factor both for the agricultural development and the rest of the national economy in China has already been referred to.

Third, there is a substantial lack of knowledge about Chinese water resources development. There are no specific works of Chinese water resources development in a Nordic language except in the travel report by the Danish geographer Johannes Humlum (Humlum 1974). It was noted in the first part of the project that literature in the field of Chinese agricultural geography was scarce in the Nordic countries (Gustafsson 1981a). The main works are those by Erich Jacoby (Jacoby 1975), Jan Myrdal (Myrdal 1963, 1970, 1976, 1977, 1983) and various works and articles by the late Norwegian geographer Aadel Brun Tschudi (see Norsk Geografisk Tidskrift 1-1982, pp 5-7).

Geographical literature in English is, due to a larger circulation somewhat more abundant and comprehensive. In the sub-discipline of water resources geography there are some major works, which elucidate the Chinese water resources development from different aspects. Oksenberg (1970) discussed in particular the policy and institutional aspects of the mass irrigation campaign 1957-1958. Nishimura (1971) dealt with water utilization in relation to agricultural productivity for the 1949-1964 period. Nickum (1974) studied water resources development between 1962-1972 from the aspect of developing the cooperative economy. Vermeer (1977) treated in particular the labour organization aspect of water resources development and the state allocations of funds for water construction projects. The area studies are few. Greer (1979) dealt with modern water resources development of the Yellow River Basin from a historical and basin-wide perspective. Finally, Mosely (1982) studied the flood control works in the Yellow River Basin with special reference to soil and water conservation measures on the Chinese Loess Plateau.

None of these studies have extensively elaborated on Chinese water resources development in relation to a conceptual framework of water resources planning and development concepts of the Third World, which is the major theme of this thesis.

Fourth, China is a developing country in contrast to most other countries of the contemporary Third World. The Chinese experience of water resources development could therefore provide valuable knowledge, which could elucidate the failure of agricultural development in other countries of the Third World.

Fifth, China has applied a cooperative ownership approach to the control of land use and water resources development. As land and water scarcity is becoming a serious problem in many parts of the world the studying of the

Chinese case will provide answers to the general question to what degree has a cooperative ownership approach been consistent with an efficient control of land use and water resources development?

Methodology and organization of the thesis

The methodology applied in this thesis is both historical and contextual in nature. Water resources development is perceived in a historical perspective, which underlines its dynamic character. By using a historical approach the thesis tries to trace the important characteristics of the development of water resources at various societal stages.

The complexity of water resources development is too obvious to be stressed, which renders simplistic cause-effect methods inappropriate, Instead the thesis tries to identify, with the help of a contextual thinking, the important key factors of the physical, technological and socio-economic environment which contributes to water resources development in general (chapters 2-3) and the Chinese water resources development in particular (chapter 4-8). The perspective of comparison with other countries has been restricted in order to maintain the character of the thesis as a case study.

The detailed organization of the chapters is as follows: Chapter 2 attempts to give the conceptual foundations of water resources development in general. The water resources situation on a global level is briefly reviewed. Key factors inherent in modern water resources development are traced from the experience of the United States. A conceptual framework of water resources development is thereafter given. The framework provides the hypothetical key questions, which will be used when interpreting the Chinese experience. Chapter 3 reviews briefly the main orientations of development theory. The specific task of the chapter is to elucidate the relationship between water resources development and a basic needs approach as a social guideline towards national economic development.

Chapters 4 and 5 compose an empirical investigation of the Chinese water resources development as it was experienced during the author's research exchange visit to China in 1982. As there are few first hand accounts of Chinese water resources development available in a Western language (Humlum 1974; Nickum 1977a), these chapters have been made rather detailed. They are chiefly based upon the rearrangement of the author's travel notes. They have only been supplemented with some other written information obtained in China or collected in Sweden, when it has been necessary to increase the legibility of the text. Some mistakes will inevitably be made, when taking down notes from short visits to institutes, field sites etc. For example, it was rather confusing in the beginning of the trip before the author found out that a Chinese billion is equivalent to 10^8, while an American billion is equivalent to 10^9. By double-checking facts and figures, where it has been possible against other available information after returning to Sweden, it is hoped that the mistakes have been kept to a minimum. Thus, chapter 4 gives a description of the national Chinese water resources background, while chapter 5 attempts to depict the problems and the developments encountered in the large river basins.

Chapter 6 makes up a literature research analysis of efficiency in water use and irrigation management. This issue covers a field, where not only the literature of the Chinese experiences but also the experiences of other countries is scarce. For this reason the chapter has been concentrated upon the important issue of organization and efficiency in irrigation use. As in China, irrigation constitutes the most important water use in most other Third World countries.

Chapter 7 attempts a synthesising evaluation and interpretation of the Chinese water resources development, which draws upon preceding chapters 4 to 6 and complementary literature. The chapter aims at providing answers to the key hypothetical questions, which were discovered in chapter 2.

Finally, chapter 8 discusses in general terms the transferability of the Chinese water resources development experience in its broader context of rural development to other countries.

Some remarks on the gathering of water resources information

The general development information in Sweden of the Chinese development experience was briefly reviewed in the first part of this project (Gustafsson 1981a, pp 11-18). The availability of adequate statistical information in the West has varied with changes in the world political situation and with the internal Chinese political environment.

Before the People's Republic of China was elected a member in the UN in 1971, the Western interest in Chinese development was rather suspicious and chilly. Most of the research activities were directed from Hongkong and the information material in natural sciences in particular is scant for the 1949-1976 period. However, from the middle of the 1970s the outside interest in the Chinese development experience and a growing scientific and cultural exchange with China have resulted in an increasing amount of written information, though the modern geographical literature is still under-represented when compared to the availability of historical, political and economics literature.

Another reason for this recent positive development of information is that China has in the last 5-8 years begun to release a growing amount of written and statistical information, thereby also ending the relative lack of national released basic statistics during the 1958-1976 period. During the First Five Year Plan 1953-1957 China released basic national statistics, which have been widely cited in the West (The Great Years, State Statistical Bureau 1960). In the succeeding 1958-1976 period national statistical data gathering and the scientific data gathering endeavours were in particular downgraded and politically controlled. The Great Leap Forward 1958-1960 produced statistical data, which were highly exaggerated for political reasons. During the Cultural Revolution 1966-1976 scientific data gathering appears to have been seriously hampered. For instance the author was told that the Commission of Integrated Survey of Natural Resources was discontinued between 1969-1972, when the staff was sent to 7th May schools or requested to do fulltime rural work. Likewise the Water Conservancy and Hydro-electrical Power Scientific Research Institute in

Beijing was shut for political reasons between 1969-1978, when most of the staff was sent to work at dam sites.

On the other hand the problems of national statistical data gathering and scientific work appear not to have affected the local statistical work (Rawski 1979; Li 1984). In the aftermath of the Great Leap Forward there was a pressure on local production units to use comprehensive and reliable statistics for planning purposes. Also with the continuous improvements in th level of literacy and administrative skills the production units could more easily find competent peasants, who could keep accounting books and gather statistical data. For instance, the detailed information given to the author at Liu Lin and Xio Shi Guo brigades were recorded in books and were also illustrated on large plates kept at the accounting offices of the brigades.

Thus, today there is a widespread consensus amongst sinologists that there are no longer any serious doubts about the Chinese government's ability to collect reasonably accurate data on commodity output, production costs, employment, investments and other items (Kraus 1979; Rawski 1979; Wikland 1980). Having visited China in 1979 and 1982 the author agrees with the conclusion by Rawski; "Chinese statistical competence is visible at the microeconomic level, at which technical and managerial personnel impress well-informed foreign guests with detailed and precise accounts of their unit's affairs, as well as at the macroeconomic level, at which consistency checks regularly confirm the international coherence of Chinese statements about production, acreage, yields, consumption and trade" (Rawski 1979, p 151).

The author does not speak or read the Chinese language. Certainly, it is an advantage to read the Chinese language in any kind of research work on China. However, the occurrence of written information in a Western language has not been the most difficult problem encountered in this thesis, even if the water resources development and rural development literature has been rather scarce since before the middle of the 1970s. Instead it is the availability of the literature, which has constituted the main problem. Much time has been consumed with traditional library research, which has not always been successful due to inaccessibility, financial reasons etc. For instance, in 1982 there was no subscribers in any of the Nordic countries to the invaluable magazine China Report-Agriculture. The gathering of data from the research exchange visit to China has been of great value for the realization of this thesis, especially in respect to the empirical data that were collected. The inaccessibility of the literature, has also in some cases rendered consistency checks more difficult.

Another problem concerns the interpretation of individual statistical components. The definition of a statistical component used in the literature is not always indicated and could have been changed with time. Some problems with interpreting the grain statistics and the concept of irrigated areas were discussed in the first part of the project (Gustafsson 1981a, pp 77, 81-82). Neither has it been always unequivocal what kind of budgetary appropriations are included in the overall investment figures in soil and water conservation (for further information see Vermeer 1977 and Lardy 1978).

Finally, it seems that the national and local hydrological data gathering is accurate, reliable and of a high standard, however the national land resources statistics are not that accurate or reliable (Gustafsson 1983). The latter uncertainty is basically due to the fact that China has never carried out a comprehensive land use survey in the strict statistical sense, which causes some variations in official estimations of land-use types. However the shortcomings in the land resources statistics can be expected to be much improved in the near future, since a comprehensive land resources map project was started in 1978 (Wu 1981; Ruddle & Wu, 1983). The author was told at the Commission for Integrated Surveys of Natural Resources, that according to preliminary results the cultivated area was likely to have been underestimated, while the forest area had been exaggerated.

When confronting the interpretation of statistical figures in this thesis the principle has been to chose the "most" official and reliable value.

In summary, as a bureaucratic state China after 1949 inherited a longstanding tradition of compiling and gathering statistical records. By enforcing the traditional systematic approach to data gathering at the local level the standard of compiling and administrative skill has gradually within three decades reached a much improved level in most statistical fields. In particular, during the 1958-1976 period the compiling of national basic statistics and scientific data gathering was influenced by politics and in some cases was discontinued. This also negatively affected the availability of written and statistical information in the Western countries. Finally, considering the statistical capacity of contemporary China in its totality, it compares very favourably with the present state of statistical work in other Third World countries.

CHAPTER 2

CONCEPTS OF WATER RESOURCES PLANNING AND MANAGEMENT

AVAILABILITY AND CONSTRAINTS OF WATER RESOURCES AT THE WORLD LEVEL

Water resources should always be referred to in relation to a basin or catchment area and include all water for the time being contained in any source of supply in that area. It includes surface inland waters, ground water as well as storage water. This characteristic of water resources embraces the concept that there is not an unlimited supply and that human effort is necessary to make it available in a sufficient amount at the right time in the right place. Nowadays it has been at least on the intellectual level widely acknowledged, that water has become a scarce resource in many places or even regions of the world.

Several studies have been conducted, which try to relate water resources to the needs of society. In the middle of the 70s total withdrawal for consumption uses in the world was estimated to some 3 000 cubic kilometres of which the irrigation amount alone was accounting for about 80 percent. In 1973 Balcerski described the water need of society as a percentage of its longterm total annual runoff (see Lindh 1978).

In countries with less than a five percent water need, there are favourable conditions for water supply. When the water need is between 5-10 percent, the water supply conditions are still favourable, but densely populated areas will temporarily have supply problems and the provision for an overall water planning has increased. With 10-20 percent water need careful planning and high investments are necessary to solve the groving water problems. Finally, when the water needs exceed 20 percent, it is so scarce that it has become a major setback to the whole national economy. On a global basis the longterm total annual runoff is estimated to some 40 000 cubic kilometres. Thus the present global utilisation rate is some eight percent.

In another study de Marê (1976) has made a projection of the readily available water resources by the end of this century obtaining a global value of some 25 000 cubic kilometres. The concept is defined as the upper limit of water "that possibly could be utilized within today's technology and economy". The global figure was derived by summing up estimations carried out by 12 delimited regions of the world by applying a possible utilization factor of the longterm total runoff. With the economic crisis facing the world today most of the assumed factors look rather optimistic. In the Central Planned Asia region,which included the People's Republic of China, Mongolia, North Korea and Northern Vietnam, the readily available water resources were assessed to 1 930 cubic kilometres or eight percent of the world total. Based on this concept the present global utilization rate is 12.5 percent. I was projected to increase to 25 percent by 2000.

The most conservative estimation of the amount of water resources, which mankind could hope to use, is based on the view that only the stable runoff excluding the flood waters could reasonably be utilized (Ambroggi 1980). This amount has on a global basis been estimated to 14 000 cubic kilometres Lvovich 1977 (Lvovich 1977, 1979). However of this volume 5 000 cubic kilometres flow in more or less uninhabited regions of the world, which are climatically unsuited for human settlement. Hence, from this estimation the economically and technologically available world water resources, from which all water needs have to be met, is just 9 000 cubic kilometres. Thus global utilization rate has already exceeded 30 percent.

As in the distribution of water, arable land and population is very uneven geographically, it is a fact, that in certain regions like the Mediterranean, the Sahel, the North China Plain, the Western United States, Japan, etc water already is a major constraint for socio-economic development.

The future prospects are not encouraging. The worlds stable runoff evaluated on a per capita basis amounts only to 3 000 cubic metres. At present 40 percent of the worlds nations belong to the low category countries with an annual per capita total runoff between 1 000- 5 000 cubic metres and about ten countries belong to the very low category with less than 1 000 cubic metres. This situation will deteriorate by the year 2000 when 60 percent of countries will be in the low category and 20 countries in the very low category (Framji 1983).

On a global basis irrigation and agricultural development is the major concern. More than 50 percent of the worlds food supply comes from only 16 percent of the global cultivated land. At present the worlds irrigated area is 240 million ha, which is estimated to be increased to 400 million ha in 2000 by FAO. Thereby the agricultural output is anticipated to be 50 to 60 percent greater than that of 1980. Such an achievement will require an additional need of 2 000 cubic kilometres of water solely for irrigation, making up a total world demand of some 5 000 cubic kilometres by 2000. In spite of the anticipated expansion of the irrigated area according to another FAO estimate the under-nourished people in 90 developing countries will increase from 436 millions in 1974-76 to 588 millions by 2000, see table 1. Likewise the World Bank has declared to the world community that absolute poverty will not have been abolished by 2000. Instead at least 600 million people according to the bank will live in total poverty. Rene Dumont has commented on this World Bank statement with; "the most representative institution of world capitalism controlled by the rich countries confess itself as completely incapable to wipe out before the end of this century what the Indians more correctly call the humiliating poverty". (Dumont & Mottin 1982, p 27).

According to the author´s opinion, it has become an obvious fact today that _if_ the world community wants to eradicate the poverty problem, such a goal can not be realized without fundamental political, economical as well as institutional change both at the international level and within the nations. For instance the ongoing Water Decade illustrates some of the problems. The United Nation has declared the 1980s as the decade, when the world population should be provided with safe drinking water and satisfactory sanitation installations. The total expenditure of the decade programme was in 1980 estimated to $ 210 billion dollar or $ 21 billion per year. Certainly, there is little prospect in the short run of redistributing the world´s military expenditure, but compared to the annual expenses of armament of some $ 600-700 billion dollar the above mentioned Decade costs seem not be

TABLE 1. Average caloric supplies per capita and numbers of undernourished people estimated by FAO.

	Consumption (in kilocalories)		Undernourished people (in millions)	
	1974-76	2000	1974-76	2000
34 developed countries	3,316	3,476	-	-
developing countries	2,180	2,270	436	588
Africa	2,180	2,305	72	127
Far East	2,026	2,200	304	292
Latin America	2,525	2,846	41	46
Near East	2,560	2,846	19	23
Low-income developing countries	2,010	2,175	349	477

Source: Framji 1983, p 51.

insurmountable. However, even such an limited 10-year programme concentrated upon just one water activity would, according to the UN, mean capital investments far beyond the potential capability of most developing countries for many years to come. Neither the World Bank nor the UN system is capable of financing the necessary investments, as 80 percent of the cost of the Decade is planned to be generated by the developing countries themselves. Furthermore the UN Water Supply and Sanitation Decade makes no provision for any substantial redistribution of wealth from affluent countries to developing countries. *The very weakness with the Water and Sanitation Decade is that it has no overall strategy for rural and urban* development and no strategy for financing. The Water and Sanitation Decade do not touch upon the political, economical and institutional changes, which are needed in order to solve the poverty problem.

Another prominent feature of water utilization is the very wide differentiation between various communities at a different degree of standard of living, table 2. Residents in a community in southwest Malagasy Republic survive on two cubic metres of water per person and year, which is just above the biological minimum. The industrial demand in the developing countries is comparable to their domestic use or about 20-40 cubic metres per person per year. Contrasting to this figure, water requirement exceeds 2 000 cubic metres per person per year in high-industrial communities in United States. Such an extreme water demand will exhaust the water resources in a rather short period, if it is to be transplanted to most other places in the world and particularly to the Third World countries.

It is also obvious from table 2, that the scarcity of water is chiefly a problem of affluence in the rich countries, but a problem of basic needs in the Third World.

Table 2. The per capita requirement of different water services. In cubic metres per capita per year

Water service	Requirement	"Water environment"
Drinking water	1	Biological minimum
Rural minimum use	2	Rural residents in Malagasy
Agricultural use	300	To maintain the diet level at 2500 calories
Agricultural use	400	To maintain the diet level at 3000 calories
Direct domestic use	30	To sustain an acceptable quality of life
Municipal urban use	150-180	Developed countries
Industrial use	20-40	Developing countries
High-industrial use	2 300	Requirement in United States
Affluent society in excess of water resources	375	Withdrawal for all uses in Sweden with no irrigation demand
Developing society with limited water resources	475	Withdrawal for all uses in China with high irrigation demand

Source: Ambroggi 1980, pp 91-104, Gustafsson 1982, p 7, table 8 p 47.

STAGES OF WATER RESOURCES DEVELOPMENT

Several authors have referred the utilization of water resources to different stage of societal development (Szesztay 1977, Falkenmark 1981, Lindh 1981). Such descriptions have implicitly made the assumptions of abundant water resources and a low population pressure at the initial stage. Therefore they should not indiscriminately be applied to Third World countries in general, but will give a good idea of water resources development in Western capitalistic countries.

Firstly, this concept of stages stresses the dynamic role of water. Secondly, it visualizes the growing importance of water as a mean of production in the transition process from an agriculture-dominated society to a highly industrialized society.

Usually the stage of supply-orientation, resource-orientation and demand-orientation are discerned.

Water Resources Development in the United States

The concept of three stages in water resources development could be well illustrated by the United States example. There are several reasons for making this choice. United States is often concidered as the most advanced nation in water resources planning, it has a great influence on other Western countries research and planning and its "water ideology" could be expected to have been exported to a lot of Third World countries. The United States water resources development will therefore serve as a measure in judging the development of other countries. Besides this, there is a very thorough account of United States water development experience between 1776-1976, prepared before the bicentennial of the founding of the United States in 1976 (ASCE 1979). This account contains 13 articles, by different authors, which covers water resources development in its historical perspective from various aspects like research and methodology, systems planning, economic, social, environmental, public health etc. From the historical account it will be possible to propose a normative definition of water resources planning. The following review is basically drawn from the ASCE publication. Other studies of the United States water resources development have been made by Fox and Craine (Fox & Craine, 1962) and White (White, 1971).

The supply-orientated period in the United States covers the years between 1776-1925. This is the era of maximal individual freedom in water works constructions. However, most of the projects were limited in scope, because of the limited advance in science and technology. Before 1900 nearly all of the major projects were developed with private capital. National planning was virtually non-existence and Federal (governmental) involvement in water resources development was negligible. However, some farsighted individuals and communities heralded modern water planning concepts.

The first water projects involved canal transportation and navigation. When the Eire Canal between Buffalo and Albany was constructed in 1817, it was a remarkable engineering feat for that time, also providing training ground for many future civil engineers. The project has been considered as an early endeavour to apply a systematic treatise in water planning. When in 1807 private funds were insufficient to finance canals for interstate waterways connecting Chesapeak Bay with the Delaware River, canal construction provided the first attempt for introducing federal financing of water projects.

The majority of the early irrigation promoters in Western USA were speculators and plunderers of the land. Only during the 1870-1900 period some 80 million ha of virgin land was cultivated. Some people believed that any data gathering for irrigation planning in the West was unnecessary, because "the rain would follow the plough". Millions of tons soil were washed away from the land into the streams, rivers and lakes aggravating floods, fouling water supplies and disrupting navigation. No environmental concerns were considered about the reckless deforestation, the exhaustion of soil fertility and the depletion of fish and wildlife resources.

The speculation and reclamation of the Western virgin land was supported by several Federal laws of which perhaps the most important was the Desert Land Act of 1877. This act provided up to 640 acres to an individual at a low cost, if he could develop water to irrigate it. During the last three decades of the 19th century millions of private dollars were spent on building ineffective ditches, that would permit acquisition of land. The title for the land was thus provided by Federal laws, but a prior right to use water or in some states the ownership of water came from the individual state, an incompatibility which still causes administrative and legal disputes. The guiding principle for the State water laws was more or less taken from the mining laws, which reflected a belief of unlimited water resources. "First in time, first in right" became the leading slogan. What the water user had to do in order to obtain the water right was to show that his use would not reduce the availability to established users and that the use was productive. The prior appropriation of this doctrine, which still is in use, was incorporated in the Western state laws. One implication of the doctrine is that new developments can occur only if surplus and unallocated water exists, since no infringement in established water rights is allowed. The responses of water users and resources developers has been to increase the water supplies by impounding seasonly abundant water and to gain access to as much water rights as possible. Thus the guiding law system has retarded a basin-wide water planning, but given rise to many conflicts e.g. the upper and lower basin water rights controversies in the Colorado River Basin during the 1920s.

Inevitablely a growing reaction to this ruthless exploitation of natural resources arose. A notable exception of irrigation development was the irrigation scheme of the Mormon community in the State of Utah. When it was completed in 1847, it was the first one in U.S. history. The Mormons were able to organize a highly successful irrigation scheme, because of the collective strength of their community and their capable leaders. There experience should be debated today, because the Mormons recognized long before others, that water was a limited resource, which encouraged them to diversify their economic activities. The irrigation canals became the basis of industrial activities. They farmed small units intensively, because they recognized that they had to be self-reliant and self-sufficient as they had chosen to isolate themselves from external trade. Another example of collective behavior is that the farmers in the Midwest formed associations to drain land and to socially control the problems of constructing and maintaining the facilities.

John Wesly Powell was a prominent individual, who early recognized, that water resources were limited. In the 1870s he advocated, that because of scarce water in Western USA, it should be allocated to the best land. In his view private developments were inconsistent with maximum potential development. He put forward for the first time the principle of joint planning of land and water resources in the arid west and as suggested that before a project initiated, that political boundaries ought to be established to coincide with the drainage basins, so as to prevent conflicts over water rights. Powells latter prescription is probably the first suggestion of basin-wide planning in the Western World.

Powells criticism initiated the building up of Federal water planning institutions and the advance of science. On his recommendation the U.S. Geological Survey was created by the Congress in 1879 to collect and provide topographic, hydrologic and engineering information and cost estimates, when expediting irrigation planning. However, it was not before 1889 that the Survey's first water gauging station went into operation. In 1891 the U.S. Weather Bureau was established. When the Bureau of Reclamation was established in 1902, it was given the primary responsibility of the planning of the water resources in Colorado River Basin. The same year saw the first university textbook on hydrology by Mead (Mead 1904) from the University of Wisconsin.

Partly due to the deterioration of the natural resources the combating of floods gradually became a high priority in the early development of USA. In 1879 the Congress established the Mississippi River Commission to prepare plans for flood control and navigation, thereby for the first time giving recognition to the need for multi-purpose planning of a river basin. But still the planning and financing of this project was a local concern and did not involve any Federal involvement. It lasted to the 1910s before flood control became an important task for the Federal Government. Around 1910 several commissions, among them the National Conservation Commission, stressed the value of comprehensive planning of water resources development to the benefit of all of the people in the country. Thus the concept of "controlling every drop of water from headwater watershed to the sea" was further advanced as well as the goal of planning for the public for the first time was given any consideration. Further in 1917 as a result of the Mississippi and Sacramento River Control Act the Congress required that surveys of projects related to flood control should include a comprehensive study of the watershed. Reports on flood control projects were required to include data on the probable effects of the projects on above all navigable waterways and water power. The Federal planning was entrusted to the U.S. Army Corps of Engineers.

By far the most successful implementation of the new ideas occured in the Miami River Valley. The valley was naturally prone to flooding and the flood problems had been aggravated by changing land use such as extensive drainage for intensive agriculture and urbanization, resulting in several severe floods. After the 1913 flood, of which the river channel only managed to cope with 10 percent of the volume, an energetic citizen movement resulted in 1915 in the set up of the Miami Conservancy District. The very far-sighted engineer of this project, Arthur E. Morgan, realized that the entire basin had to be considered, if the flood problems should be solved. The integrated basin-wide planning, which was launched, made a systematic approach to the problem possible. Conventional design at that time favoured constructions of levees or dykes. However, it was shown that the combined effect of retarding basins and channel improvements was the only technically, economically and socially satisfactory solution. Also sensitivity studies twice that of the 1913 flood were carried out. The design has been so successful, that no further flood problems have occured up to the present time.

The environmental concern of water resources development was little and mostly indirect during the supply-orientated period. The principal theme concerned the environmental effects of deforestation. An early attempt to locally tackle this problem occured, when the State of Massachusetts in 1882 authorized the acquisition of municipal forests for the management of runoff from catchments providing municipal water. At the early 1900s an important conservationists movement was articulated. Its leading spokesman was the professional forester Gifford Pinchot. He advocated a more efficient use of natural resources in order to eliminate the excessive and abusive exploitation of land and water resources. It is interesting to note his utilitarian notion "that the first principle of conversation is development, the use of the natural resources on this continent for the benefit of the people who live here now". It has been pointed out that Pinchots view of conservation is consistent with" a political system guided by the ideal of efficiency and dominated by the technicians who could best determine how to achieve it", and observation which also is a good characterization of the coming resource-orientated period.

The resource-orientated period in the United States covers the years between 1925-1960. This is the era of growing Federal involvements in water construction projects on an economic efficiency basis. During this central period large reservoirs and dams, navigation channels, locks and aquaducts were constructed. There was a continuous specialization into the disciplines used in water projects planning, especially technical disciplines, because the belief in the perfectability of technique was boundless. There were hardly any doubts in man´s ability to conquer nature. The planning was one of pragmatism predominantly directed at single project planning and design-orientated. An elitism in planning was prevailing and the planning process was dominated by professionals with little concern for the general public.

The major water activity during the period became water power generation. In 1925 the Congress directed the U.S. Corps of Engineering and the Federal Power Commission to estimate the cost of making surveys of all the rivers having power potentialities. The resulting so called "308" report from the Corps of Engineering, accomplished in 1929, contained the first overall plans of water development in most of the rivers in the United States. The water activities of navigation, flood control and irrigation were also considered. During the Roosevelt administration additional planning studies directed attention to the broad problems of social and economic policy inherent in water resources development. The Mississippi Valley Committee was merged into the National Resource Board, which recommended 17 major drainage studies of the nation. But in 1943 the Board was refused funds, thereby ending the first major attempt at national water planning on a large scale.

An important point to make is that when technology had advanced to the stage of constructing large dams like the Hoover and Grand Coulee Dams planners had to consider the simultaneous utilization of the storage capacity for the main water activities. Typically enough, water-orientated recreation on the large reservoirs was made possible and advocated by the decision-makers. On the other hand the views of the fish and wildlife agencies mostly were disregarded by the water planners. Indeed even the analyses of Federal planning by political scientists tended to focus on how the professional planners and decisions-makers should be organized and on how they should cope with well-organized interest groups rather that with the process of planning itself. There was a general misconception of regarding planning more as an analytical exercise rather than a social process. The famous multi-purpose Hoover Dam in Colorado River was completed in 1936. At that time the objectives of the dam was far from clear. Its present location and size has been evaluated as more the choice of an influential Congressman than based upon a rational scientific analysis.

The large-scaled water projects also required some kind of an economic cost-benefit analysis, if planning should have any credibility. Economic analysis was first acquired of Federal projects by the Flood control Act of 1936. The Act divided the costs and benefits into two categories; tangibles (i.e. effects on national income) and intangibles. The latters were defined as "effects which are impracticable of being expressed in monetary terms such as scenic value or prevention of loss of life..." The estimation of tangibles, which could be expressed in monetary terms, have to some degree contributed to a better planning by preventing justification of bad projects, requiring answers to questions that lead to better understanding of project consequences and by identifying beneficiaries thereby helping building a broader repayment base. However, careful examinations of intangible environmental effects were never carried out. The technical-oriented philosophy of planning prevented ecological concepts from playing a significant role in water resources development.

Neither did economic arguments play a major role in securing public support for water quality projects. Rather, it was health aspects, which extorted some measures against water pollution. For example the water quality in Lake Michigan had deteriorated so badly by 1880, that the Chicago water supply was threatened. "Chicagoans of the nineteenth century were unblushing advocates of industrial development. Not even the increasing smoke and the pollution reduced the enthusiasm. Indeed, they glorified in it and viewed black smoke as a sign of progress, not contamination."

By 1900-1904 over 50 000 people died of typhoid of which 75 percent of the deaths were in the cities. Much of the water planning in the first decades of the 20th century in U.S. therefore dealt with water supply and sanitation. In the case Chicago the area-wide institution of Metropolitan Sanitary District of Greater Chicago was created in order to improve the water supply and sanitation conditions. By far the most effective methods to combat pollution occured, when various chlorine compounds and chlorine itself were introduced around 1910 as disinfection agents. By 1930, therefore, typhoid and other waterborne diseases were well under control. The introduction of chlorine has also enabled the authorities to use badly polluted water sources for drinking water purposes.

However, the introduction and effectiveness of the chlorination technology is one of two factors, which impeded the built out of waste water treatment technology before the 1960s. The other factor is the cherished notion of the natural purification capacity of receiving water. Both factors have delayed the comprehensive and effective water quality planning and management of water areas, even if the first one has improved public health.

Municipal, industrial, agricultural and mining interest all considered it their right to use the dilution and natural treatment capacity of the nearest available waterways. Only if the natural self-purification capacity was on the point of being used up could there be any water release from reservoirs to better the situation. Together those two notions have impeded and delayed adequate and effective water resources planning and management for over 60 years.

A notable exception of good planning was created with the set up Tennesse Valley Authority in 1933. Its objective was that "it should be charged with the broadest duty of planning for the proper use, conservation and development of the natural resources of Tennesse River drainage basin and its adjoining territory for the general social and economic welfare of the nation". The Tennesse River Valley was at that time one of the nations poorest regions with badly eroded land resources and continuous flooding problems. It has been said that the TVA project required use of system analysis methods at a time, when most of the tools needed to do the appropriate analysis had not been developed. The TVA project, the above mentioned Flood Control Act and the establishment of the Soil Conservation Service in 1933 became major stimulators to the advance of the specialized discipline of hydrology. The TVA project in this way exemplifies, that hydrologic techniques generally have been developed in response to perceived needs originating from practice. The Tennesse Valley Authority also became the first water institution to consider intangible effects in its planning, even if it was on a limited scale. The preservation of trees was conducted in construction areas and fair treatment was given to persons, who had to be replaced from reservoir areas. However, of the enormous amounts of books published yearly in the U.S. no basic textbook on social aspects of water resources planning had been published before 1976.

Part of an explanation of the weak water resources planning during the resource-orientated period was due to the conflicting interests of Federal and State authorities. In fact, very few states did well in water resources planning. One exception is the State of California, which developed its own water plan early in the 1930s involving the new concept of moving excess waters from the northern part of the State to the arid areas in the south. It was not before the Flood Control Act of 1944 that the Congress laid down the principle of Federal-State cooperation for navigation, flood control, irrigation and for Federal water development projects administered by the U.S. Corps of Engineers and the Bureau of Reclamation. However it lasted to the promulgation of the Water Resources Planning Act of 1965 before the administrative prospects of a nationwide water resources planning was proposed.

The demand-orientated period started in the United States around 1960. Since 1960 the Federal superiority in water resources planning has been acknowledged. The technical-oriented bias of earlier periods is questioned. The water demand has grown so high, that technological and social measures and policy options have to be taken to control and reduce the demand. Environmental and social aspects of water resources planning receives legal support. Water resources planning has become a researchable topic at the Universities. Modern system analysis begins to be applied as a tool in water resources planning. The planning process tends to broaden its scope and a conceptual framework could be discerned.

The suggestion of the Kerr Committee in the beginning of the 1960s could be taken as the initial point of the demand-orientated period. The Committee proposed that a comprehensive planning for water resources development should include all activities served by water resources and all measures available for meeting prospective demands, including preservation and improvement of water quality. This basic principle was later adopted by the Kennedy Administration leading to the enactment of the Water Resources Planning Act in 1965. The Act created a Federal Water Resources Council, it authorized the set up of Federal-State river commissions and it supplied a grant program to the States to assist them in carrying out water resources planning activities. Thereby the administrative prerequisites for a comprehensive planning was laid down.

It tooks some years to fully implement the needed legal structure of the basic principle. Still today engineers and planners feel, that the introduction of environmental and social considerations in planning is a retrogression and the elitist view of planning, that the planners should provide the public what was best for them, is difficult to change in a short period of time. However public environmental concern with associated court actions, critics from scholars at universities and elsewhere paved the way for the National Environmental Policy Act in 1969. This law claims the preparation of detailed statements describing the environmental impacts of the proposed project and alternatives to the proposed project. For water projects the act also requires the consideration of social impacts as a part of the environmental impact statement. With the Uniform Relocation Act of 1970 official recognition for the first time was given of the costs of relocation by providing economic compensation to over and above fair market value in order to assist people in finding a new home. Likewise the passing of the Clean Water Act 1972 marked a national commitment for the first time that all discharges of untreated wastes should be eliminated. Earlier the industry, for example, did very little to treat its wastes, if the recycled byproducts did not have a commercial value. This act was in 1973 followed by the call of the Congress to carry out the first nationwide planning of water quality control. The same year the Water Resources Council issued the "Principles and Standards for Planning Water and Related Land Resources". It required that both environmental quality and economic efficiency should be considered as criterias of Federal water resources planning. This statement could be said to be definite recognition of the need of a comprehensive water resources planning in the United States.

A Definition of Comprehensive Water Resources Planning: The United States water resources development is generalized in figure 1. The historical review has revealed several ideas, which today often are referred to as characteristics of water resources planning; a high degree governmental financing, collective behavior, joint planning of land and water resources, administrative boundaries congruent to drainage basins, basin-wide planning, multi-purpose planning of single water projects, economic and ecological efficiency, cost-benefit analysis, long-distance water transfer, social and environmental impact statements etc.

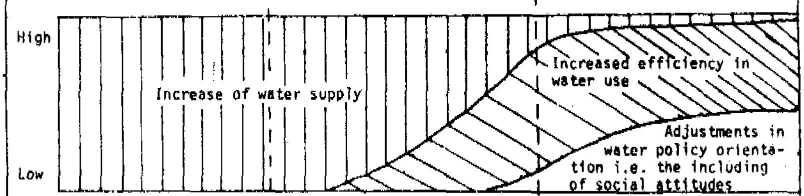
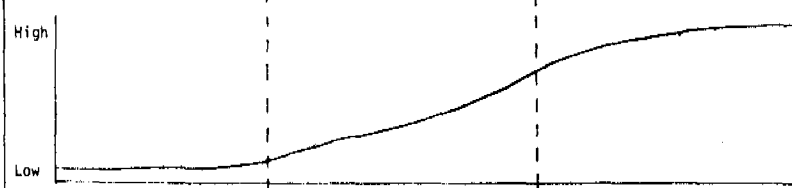
Water Planning Characteristics	Stage 1 1776 Supply orientation	Stage 2 1925 Resource orientation	Stage 3 1960 Demand orientation
Interrelation with the socio-economic system.	Limited in scope and technically oriented.	Limited in scope and technically-economically orientated.	High. Water is a limited factor of socio-economic development.
Complexity of water activities.	Low. Flood control, navigation and irrigation dominate.	Intermediate. Hydroelectric power dominates.	High. Environmental and recreative activities are added.
Level of water administration.	Low. Hydraulic engineering by project and sector. Private financing.	Intermediate. Integrated water resources management and multi-purpose utilization are promoted. Conflicts between Federal and State levels are common.	High. Water demand management is advocated. Federal financing. A legal framework of water planning is endorsed.
Efficiency of water use and water-related development resources.	Low.	Generally low.	High.
Orientation of water resources exploitation.			
Marginal cost of water supply and development			
Degree of river basin and interbasin development.	Major rivers virtually unregulated.	Increasing regulation (storage development, some water diversion projects, artificial recharge of ground water).	Maximum attainable and acceptable streamflow regulation in most major river systems. Intrabasin development.

Figure 1. Some characteristics of water resources development in the United States and its relation to different stages of development (After an idea from Szesztay 1977).

The most obvious result of the review is, that comprehensive water resources planning is a very recent undertaking or concept. It was developed in the 1960s and the research base is still very weak. It reflects a general perception of industrialized societies that the degree of socialization of property, in this case water construction assets, depends upon the increasing complexity of the production process. Hence, as the means of production becomes, more complex, interdependant and expensive societal institutions will by necessity increase their control of the water resources planning process.

Due to the complexity of modern society any comprehensive planning by character must be normative. Thus a definition of comprehensive planning may be; a societal integrated planning, which seeks to optimize a basin-wide and multi-purpose use and management of water and land resources within a national framework of legal, socio-economic and ecological constraints.

Some Comments to Water Resources Planning in Countries Other than United States

It is likely to be assumed that the water resources development has been similar to that of the United States in most other developed countries. The Meiji Restoration in 1868 started the modernization process of Japan. Some essential points of the Japanese water resources development have been summarized from different scattered sources (Economic Geographical Society of Japan 1964; Chattopadhyay 1977, Water Resources Development Public Corporation 1980; Kosuge 1981; Statistical Handbook of Japan 1982).

From the Meiji restoration up to the present the Japanese population has increased from 34 million to 118 millions. Japan has climatically relative ample water resources, but due to the population increase the per capita availability of the stable runoff has decreased from 9 800 cubic metres in 1868 to about the world average or 2 800 cubic metres at present. It should be noted, that Japan basically remained an agrarian rice-growing society up to the end of the Second World War. Already during the feudal Tokugawa period the rise planted area had increased from 1.30 million ha in 1688 to 2.58 million ha in 1878-1887 due to flood control, irrigation and land reclamation projects. The rise productivity was as high as 2.3 tons per ha during the latter years. This initial improvement in paddy cultivation was accompanied by a moderate 22 percent increase in the rice planted area and a likewise moderate 54 per increase in rice productivity from the 1880s up to the 1940s.

During the whole of this time span Japan was in a supply-orientated stage of water use. Irrigation water to the existing paddy fields and newly reclaimed fields was obtained by canal-diversion structures from the many rivers of Japan. With the exception of large river stabilization works most water and farmland constructions projects were undertaken on private initiative. One of the most important factors for the growth of agricultural productivity during this stage were the measures to improve the quality of the existing field-irrigation and drainage structures. The irregular shape of the paddy plots were reconstructed into rectangular fields and during the two first decades of this century extensive drainage works were undertaken inorder to improve the field water control. These achievements were supported by several laws and regulations. The Arable Land Readjustment Law from 1899 made it obligatory on the part of the landowners to adopt the recommended patterns of field consolidation. The land price was kept unchanged by this law for 30 years. Thus the peasants were assured that the consolidation would not lead to a rise in the land tax, which was the main instrument of resource mobilization. Already in 1909 after the land consolidation projects were basically completed the improvement of water management became the basic activity in agricultural production.

Furthermore, though Tokyo's urban area since the 1700 century up to the 1950s had mainly been dependant on diverted water from the Tama River for its domestic and industrial water supply, a large proportion of the Japanese rural and urban population was blessed with ample ground water of good quality withdrawn from household wells. Similar to the development in the United States the one-sided stress on the progress in techniques of public health and hygiene impeded a widespread understanding of future risks of pollution of surface and ground water in the course of the industrialization process.

Japan went into the resource-orientated stage of water use after the surrender of the Japanese military imperialism of the Second World War. The idea of multi-purpose exploitation of land and water resources was adopted from the TVA experience in the United States and introduced in the first years of the 1950s. This decade became the golden era of reservoirs building in Japan. Though plans were multi-purpose in their approach, as in the United States during this stage, a heavy emphasis was placed on the exploitation of power resources in combination with selection of suitable areas for industrial development, while the exploitation of water resources for the benefit of local peasants and fishermen were discouraged. Seldom did the peasant get a fair compensation for the property and land submerged by water and many resettled peasants came into great difficulties.

It should be noted that the Japanese development during this period were strongly influenced in a number of ways by the United States authorities. The heavy stress on power exploitation was promoted after a proposal by the US occupation troops, so that Japan in 1950 introduced a reform in the tax and rent system in a liberal free enterprise direction with the result that the property tax became a part of the revenue of the local autonomous governments. Consequently, the local municipal, prefecture and village governments, to improve their financial situation, all made great efforts to encourage the building of factories and the installation of power stations in their localities. Public and big companies investment in power exploitation projects was also promoted by the Korean War, when the United States used Japan as the chief supply source for manufacturing arms, transport equipment and daily necessities. As a result the Japanese industrial production reached a sharp increase during the Korean War.

Another important measure in the beginning of the 1950s was the radical land reform carried out by the Japanese liberal ruling elite under the auspice of the United States land reform export Wolf I Ladejinsky. In the US postwar strategy for Asia the Japanese land reform was essentially a response to the challenge of the Chinese revolution. The ideological aspect of the land reform was to wipe out the spread of the collective wind from the Chinese revolution by building a solid base of peasant proprietorship as a bastion of conservative thought. The land reform eliminated all large holdings and thereby also the influence of the militant landlord class as a political force. It converted the entire agrarian structure into one composed of small owners-farmers, cultivating around 1-2 ha mainly with family labour. The land reform made the peasant eager to invest and with the help of US capital and grants the government invested a lot in the industrial sector including the reservoir, cement and fertilizer industry.

Thanks to the land consolidation and water improvement project made during the supply-orientated stage the Japanese peasants could reap quick gains from massive application of chemical fertilizers and high-yielding varieties. Though the planted rice area was of the same magnitude as in the 1880s the rice yield had reached 4.8 tons per ha at the end of the 1970s. Thus it must be recognized that the US liberal growth model in its Japanese costume has provided high technological efficiency in obtaining a world record of agricultural productivity in rice growing.

However, one of the prices of the rapid Japanese industrial expansion has been a government highly subsidized rice growing agricultural economy with the supply of other grains basically being imported. Another price of the heavy industrialization approach has been the accompanying deterioration of the environment. It was not until the 1960s that there emerged a nationwide and public concern over the frequent pollution of river systems and ground water, not only from sewage disposal, but also from contamination with heavy metals and organic compounds discharged from industrial plants. Thus it was first in the 1960s that Japan began to consider water as a precious natural resource. When the Water Resources Public Corporation was established in 1962 as a coordinating water institution of national concern, this measure could be taken as the beginning of the demand-orientated stage. The Corporation has the overall responsibility for planning and implementing water projects in the six major river systems in Japan. Though Japan has reached the demand-orientated stage the implementing of comprehensive water resources planning is still in its initial phase. During this stage Japan has relinguished its economical dependancy on the United States and earned huge exports revenues, which has meant that Japan has been able to set aside considerable funds for environmental improvement. On the other hand the Japanese ruling elite has moved many of their polluting industries to countries in the Third World.

In England and Wales nine regional Water Authorities were created in 1974. The geographical areas of these authorities are not based on administrative units, but on groups of river basins with the purpose of minimizing the physical interdependencies within hydrological systems. At the national level the National Water Council has the duty to promote a national water policy. It should advice the concerned ministeries in their policy making and assist the regional Water Authorities. The Water Authorities have the responsibility of carrying out a comprehensive water planning of all water activities including water supply, pollution prevention, water and wildlife preservation, irrigation and drainage, flood control, fish-breeding, recreation etc. Probably England has the most advanced water planning system of the Western European countries (Porter 1978; Parker & Penning-Rowsell 1980; Hurst 1982).

In the centrally planned so-called socialist economies of the Soviet Union and Eastern Europe there only exists a rudimentary approach towards comprehensive water resource planning. In the European, the Caucasus and the Central Asian regions of the Soviet Union water shortage and water pollution are serious problems. These densely populated regions have only 12 percent of the total annual runoff, which has been estimated to some 4 000-4 500 cubic kilometres. The total water use is some 400 cubic kilometres in all the Soviet Union. Though a centrally planned state since the 1920s the Soviet Union has since the 1970s considered water as a free, priceless societal commodity. In theory there have been intentions to adopt a comprehensive use of water resources, but these intentions have seldom been realized in practice. However in the middle of the 1970s there existed no national policy rules or even a national coordinating body of water resources planning and management. Furthermore, over-centralization of decision-making in water use to the central ministery concerned has lead to isolated and uncoordinated planning and management as well as little responsibility and concern of water use at the regional and local levels. Wasteful use of water is a general problem in Soviet Union today. For instance the irrigation efficiency is only 20-30 percent.

The Soviet Union went through the resource-orientated stage of water use from 1930 up to the mid 1960s. As in the United States and Japan large reservoir constructions were the dominant project. Though said to be multi-purpose in plans, these reservoirs heavily favoured the power industry. They were financed by the power industry, so that gains and losses of other water activities and socio-economic and ecological constraints were seldom calculated in their plans. First with the Tenth Five Plan 1976-1980, it was declared, that the growth of the Soviet economy should be achieved by increased productivity and not chiefly by investments in new industrial plants, which had been the general method before. Today most of the rivers in the European Soviet Union are regulated with a cascade of reservoirs. Some negative effects of these extensive reservoirs buildings are the submerging of large areas of flat arable land, increased waterlogged areas and rapidly declining fish catches in the Black Sea and Caspian Sea due to the lowering of the water table caused by reduced inflow of river water. Most rivers are heavily polluted. It was first in the 1960s that measure were taken to recycle industrial water and treat industrial and domestic sewage water. In order to solve the acute water shortage problems of Western Soviet Union questionable plans are under way to transfer water over long distances. At present several tenth cubic kilometres of water, but in the future several hundred cubic kilometres of water will be transferred from the northflowing northeastern rivers of European Soviet Union and Siberia (Volgyes 1974; Gerner & Lundgren 1978; Tolmazin 1979).

Of the Nordic countries only Denmark could be said to have reached the demand-orientated stage of water use. Finland, Iceland, Norway and Sweden are still in the resource-orientated period. As the Danish rivers are rather small almost all the water demand is fullfilled by ground water abstraction. The Danish Water Act of 1978 requires, that water abstraction plans should be made in each of the 14 regional counties. These plans should be approved by the Regional Council and the Ministry of Environment. The purpose of the plan is to evaluate the total demand of water for all water activities in the region. The plan should be coordinated with the land use plan. The water abstraction plan will thereafter become the basis for the detailed water supply plan at the local level (Barford 1982).

Sweden has a resource-orientated type of sectorial or piecemeal planning. In Sweden the national and regional authorities are rather weak and much of the practical planning is carried out at the local level consisting of 279 municipals or communes. However nationwide guiding principles with the purpose of classifying and preserving valuable land and water resources of national, regional and local concern were presented in a Government Bill in 1972. The guidelines have not been brought together in any form of legislation, but in a circular in 1973 addressed to all planning authorities, the Government has recommended that they should be followed in all decisions concerning the planning and management of Sweden's aggregate water and land resources. It was not before the end of the 1960s, when the public became aware of the extensive use of detergents and washing agents, that Sweden launched a successful programme for the construction of municipal sewage treatment plants. From just a few percent in the 1960s biological-chemical treatment plants have been constructed in urban areas covering 71 percent of the urban population in 1979. With the promulgation of the new Water Act in 1984 provisions have been made in the law to incorporate in a water construction project not only the economic aspects but also socio-economic and ecological aspects. When a proposed new Nature Resource Law and a new Building Act comes into force in 1987, there will be much better possibilities for an integrated planning of water and land resources. For instance the Building Act will impose upon the local planning authorities, a joint plan for water and land resources.

It seems from the example of the United States and this brief review of some other industrialized countries, that a need of a comprehensive water resources planning will not arise before the water-supply conditions have reached the point of substantially threating or delaying the economic development.

The historical situation in the Third World is completely different. Many Third World countries have without being industrialized already reached a stage, where the scarcity of water is a limiting factor to economic development. The population pressure is often high. Due to many factors such as inadequate technical knowledge and financial resources, organizational and socio-economic constraints, a sound basis for a comprehensive water resources planning has not been achieved in most Third World countries. For instance India has a rather advanced level of technical knowledge, but socio-economic constraints and lack of an organizational structure make comprehensive water resources planning out of the question. Tanzania could be said to have an adequate organization structure, but lack of technical knowledge, financial resources and aggravating socio-economic problems inhibit comprehensive water resources planning. In some Third World countries regional water resources planning has been conducted, usually under the auspices of Western experts. However a national guiding approach to water resources planning is seldom undertaken. It is hoped that chapters 4 to 6 will show that the Chinese water resources planning is rather unique in this respect.

A Conceptual Framework of Water Resources Planning

The literature of the planning concept in itself is rather ambiguous (see for instance Friedmann 1959; Friedmann & Hudson 1974). Before the 1950s planning in Western countries was in general believed to be an outcome of socialist ideology. Planning was denounced, as it inevitably must lead to a suppression of individual rights and liberties. Such a standpoint has been one of the main factors behind the delaying of comprehensive water resources planning in the United States. In its present form planning has become a certain manner, procedure or method of arriving at decisions and actions, the intention of which is to promote the social welfare of a society undergoing rapid change.

Planning has been a necessary tool for the survival of a modern society regardless of its ruling ideology or political system.

The domination of pure technicians in water resources development and the late-coming interest of planning have meant that the formulation of a coherent theory or even terminiology waits to be done. The literature is generally restricted to treating a specific aspect of water resources development and the terminiology is rather diffuse. What is needed is a theoretical framework, which could give answers to how comprehensive water resources planning should be conducted in practice.

Such an approach towards a framework planning has been put forward by Parker & Penning-Rowsell (1980, pp 1-17). In their useful approach water resources planning is described as occuring at the interface between the social and resource environments, figure 2. The social environment or the social context consists of the social goals and guidelines of a society, which influence each other. Certainly, the most important of the social guidelines is the national economic performance and policy. It reflects the political power of the society, which in turn decides the allocation of money and manpower available for water resources planning. The institutional guidelines of legal framework and governmental structure are shaped against the background of the national economic performance. The legal framework could be said to be codified intentions of society aimed at facilitating the planning process. The governmental structure is the base of political power and the social attitudes influence the goals of society and hopefully guide the judgements of political representatives.

Political scientists agree, that there must be a high degree of consistency between the national economic performance and policy and the social goals, if a satisfactory national development should occur (Johnston & Clark 1982, p 28). Actually, the relation between the social goals and the means of national economic performance is the central issue in development theory. In next chapter it will be argued that only a basic need approach to development problems is consistent with a comprehensive water resources planning in the Third World countries.

It is essential to recognize that various kinds of planning systems have a similar social context, but a particular resource base. The water resources planning system is founded on the national resource endowment, which includes minerals, land, water and air. The planning of land and water resources must be closely related to each other. For instance a change in the vegetative cover will affect quantity, quality and rate of runoff water. In recent years the growing concern for acid precipitation has shown that changes in the air conditions by waste disposal will generate harmful quality changes in water bodies. The interaction between land, air and water resources necessitates that water resources planning has to be basin-wide.

Furthermore there are important physical interdependencies related to the utilization of water itself. First, at a particular site in the drainage basin water has a multi-purpose potential, that is it could be used for several activities. Second, water used at one site has physical and economical consequences upstream and downstream. Third, a specific water

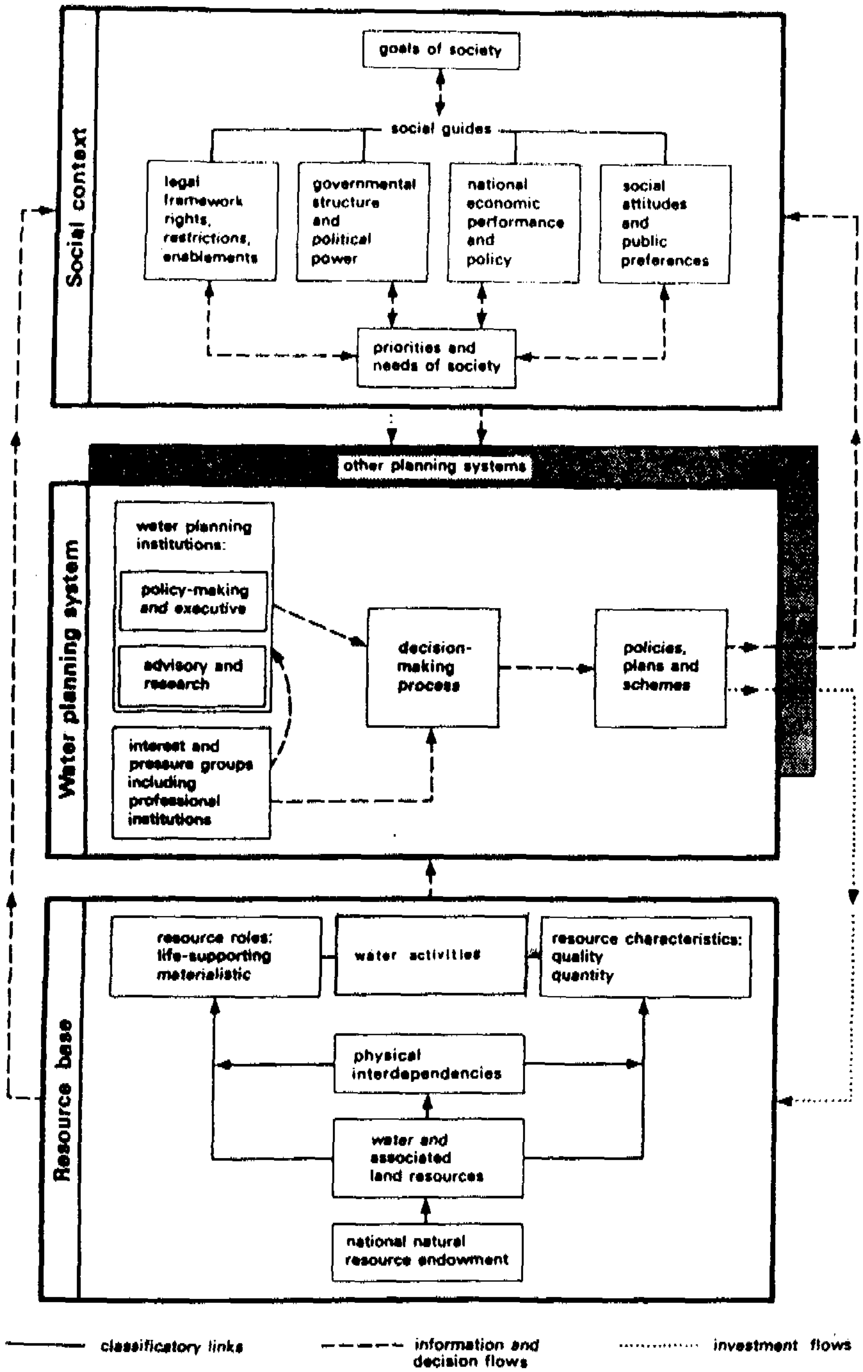


Figure 2. A conceptual framework of water resources planning (Adopted after some small changes from Parker & Penning-Rowsell 1980)

activity usually changes the balance between quantity and quality. The introduction of a new water activity by constructing a water project in the drainage basin can therefore produce positive and/or negative consequences to existing water activities.

At last it should be realized, that when water use has risen above the life-supporting essential need the modern industrialized society has hitherto produced an increasing amount of polluted waste water, which untreated or treated to some degree are released in the water bodies. Actually, this deterioration of water quality caused by waste water discharge diminish the amount of water, which can be used for life-supporting activities such as irrigation, fish-culture and drinking water in the future (Lvovich 1977).

The water planning system derives its information from the social context box and the resources base box as shown in figure 2. It is guided by the priorities and needs of society and to a high degree financed by society. Both society and water planners assess and evaluate the characteristics and functions of the resource base. The decision-making process is aimed at changing the conditions of the resource base in order to promote social welfare. The knowledge attained in the planning process may also provide feed-backs to change the priorities and needs of society. The decision-making process essentially tries to analyse and find solutions to conflicts between different water activities and land use practices, which will arise with the development of the water resources. Solutions are performed by water planning institutions, whose structure is usually determined by the government. Interest and pressure groups may also try to influence the water planning institutions. Solutions are formulated as policies, plans and schemes. "A policy is an overall statement of intent or a course of action which is usually related, either explicitly or implicitly, to a goal. Policies reflects preferences, priorities and principles and are usually of longer-term significance than plans and schemes which are based upon them. A plan is a means by which policies are put into operation and is concerned with reaching objectives or targets and integrating a set of smaller scale schemes in order to meet them. Plans are also concerned with timing, phasing and coordination of schemes to match financial budgets; they may be written documents but in some cases they may simply comprise a rolling financial programme. A scheme is an individual project, such as a sewage treatment works, designed to contribute to the achievement of the objectives or targets of a plan" (Parker & Penning-Rowsell 1980, p 13).

It is very obvious from a point of view of conceptual framework thinking, that water resources planning is a rather complex and integrated procedure conditioned by many interrelating factors of society and nature. Water resources planning is not just a technically-biased analysis of allocating water between conflicting water activities in a demand-orientated society. It must be conducted at various planning levels; national, regional and local. It is a predominantly social activity, which both influence the overall economic development at the national level, and also influence the standard of living of people at the village level. With the resource constraints given by the resource base a successful outcome of water policies, plans and schemes is highly dependant of relevant national social guidelines.

The conceptual framework of water planning will raise some general key questions, which could be considered as essential for the evaluation and assessment of the performance of a water resources planning system. Some important questions have been formulated by Parker & Penning-Rowsell (1980, pp 15-16). Their questions and some new questions will be used for the discussion and evaluation of the water resources planning system in China. The questions are referred to the social context box, the resource base box or the water planning system itself, but it should be remembered that there are no sharp boundaries between the three components of the water resources planning system.

Key social context question:

* To what extent has a basic need approach of national economic performance supported the water resource development in China?

* Has the Chinese society provided its water planners with an adequate framework of institutions, knowledge, legislation, financial and manpower provision?

* To what extent have social attitudes and preferences influenced the water resources development in China?

Key resource base questions:

* How to the characteristics and constraints of Chinese water resources influence the social guidelines and the water policies, plans and schemes?

* To what extent have resource management principles like water efficiency and water and soil conservation been incorporated in plans and schemes at the production level?

Key water planning system questions:

* Is the water resource technology used in the water projects adapted to the social context and the resources base?

* To what extent has the Chinese water resources development and the planning system improved the social welfare of its people?

* Is water resources planning comprehensive and systematic in China and are all relevant interests adequately involved?

All this question will be touched upon to a some extent in the following chapters. The importance of a basic need approach to water resources planning in Third World countries will be advocated in the next chapter. It would be useful for the reader to have the key questions in mind when reading the empirical presentation of water resources development in China in chapter 4 to 5. In chapter 6 water management principles, which promote efficiency and conservation of water and land resources will be treated more in detail. Deficiency in water management at the production level are often considered to be the main reason for failure of water projects in Third World countries. The other key questions will be discussed in chapter 7.

CHAPTER 3

WATER RESOURCES, SOCIAL GOALS AND THE BASIC NEEDS APPROACH TO DEVELOPMENT

Modernization goals

Development in Western thinking means modernization, which is characterized by the process of transition from an agriculture-dominated economy to a industrialized-dominated economy. Nations with a large rural population were in the 1950s labelled underdeveloped, in the 60s and 70s developing and from the middle of the 70s low-income or middle-income countries by Western official institutions. The gradual relabelling over time of the about 140 Third World countries reflects changed perceptions of development social goals and development theories. Three social goals have generally been acknowledged as self-evident in the development of Western countries since the 1950s; a high economic growth rate, equitable distribution of income and a high level of employment. From the middle of the 1970s a fourth social goal was added to the debate; a high degree of cultural and economical self-reliance.

In the 1950s Western economists only considered a high economic growth rate as a development goal relevant for the goalthinking of Third World countries. Third World countries were underdeveloped because of lack of economic growth rate or too low an economic growth rate. Development became equivalent to rapid economic growth and the problem of development was reduced to an economic question of providing capital to the Third World countries. With the words of the influential economist Arthur Lewis "...the central problem in the theory of economic development is to understand the process by which a community which was previously saving and investing 4 o 5 percent of its national income or less, converts itself into an economy, where voluntary savings is running at about 12 to 15 percent of national income or more. This is the central problem because the central fact of economic development is rapid capital accumulation" (Lewis 1954, p 155). Capital transfer from Western countries and increased savings out of higher profits from the industrial sector in Third World countries were established as the remedies of this neo-colonial solution to development. It was even believed that large and increasing income disparities were a necessity in order to promote investment and economic development in the early stage of economic development.

However during the 1960s, when investment ratios did not increase as was expected, it became obvious that an industrially-biased investment policy in itself did not generate economic growth. It was realized that many other factors were involved in the development issue and especially lack of education was identified as a crucial factor hampering economic growth. Besides this, in the 1950s Latin American economists had begun to question the Western liberal notion of comparative advantages of the world trade system, which in fact resulted in deteriorating terms of trade relative to the Western countries caused by an exchange of unequal values of commodities. The central developed nations benefitted from trade whereas the peripheral underdeveloped countries suffered from trade. This new school of developing thought therefore pursued an import substitution policy, planning and state interventionism in general in Third World countries and regional integration among them. To alleviate the growing critics of the liberal theory of development from economist in the Third World countries, it became opportune to relabel them as developing. However both the liberal theory and the Latin American import substitution policy were strongly growth-orientated and industrially-biased. The well-being of the rural population was seldom thought of.

It waited for the publishing of the Club of Rome report in 1970 "The Limits to Growth" and the World Bank and the Institute of Development Study in Sussex joint report in 1974 "Redistribution of Growth" where it was recognized in the West that economic growth automatically would not result in an acceptable income distribution or reduction in unemployment and underemployment. It was acknowledged that the poor and especially the rural poor had not benefitted much from development or from anything else. Thus it took more than 20 years for the Western countries to realize that the Third World countries were in need of the same three social goals that guided the Western nations. Consequently, as a reflection of the small results obtained and the thereby accompanying reorientation of social goals, Third World countries began to be relabelled low-income or middle-income countries by Western institutions (Lundahl 1978, Lundahl & Södersten 1979, Blomström & Hettne 1981, Hettne 1982).

However, the fourth social development goal was still lacking. With the oil crises in 1973 Western citizens became brutally reminded of that fact that Western wealth and affluence was to a high degree the result of the exploitation of the natural and manpower resources of the Third World. As a challenge to this fact Third World countries claimed for a New Economic International Order (NIEO), a policy which was adopted by the UN Assembly in 1974. With this momentous decision the lacking goal of economic and cultural self-reliance was added to the development package of social goals. The various forms of liberal development theories had been rejected by practise and "whether we/the Western countries/like it or no, the new paradigm has come to pass and the world we now try to care for is characterized by key words such as self-reliance, appropriate technology, south-south trade and basic needs" (Clarke 1978, p 12). The NIEO is a question of redistribution of wealth and social justice in the international arena and the fulfilment of basic needs is a question of redistribution of wealth and social justice in the national arena.

Certainly, the new development theory is likely to have relevance even for the rich countries (as noted by Galtung 1978, Hettne 1982 and others), where automatic economic growth no longer can be taken for granted and where the scientific and technological development no longer will provide full employment or permit an economic surplus which will enable a relative equitable distribution of income within the population. A New International Economic Order and the basic needs approach to national development are two manifestations of the same problem and they should not be polarized because as Galtung (1978) has pointed out "the real problem is how do we combine international social justice and internal social justice? For me the answer is self-reliance. It is a combination of three things, Third World self--reliance, national self-reliance inside the Third World and local self-reliance inside a nation. You can say the same thing about the First World. Self-reliance means that you make optimum use of your own resources, producing for your own consumption, before you start exchanging. So it is villages of the same level, nations of the same level, regions of the same, lifting each other up, by using their own resources, and by exchanging when that is not sufficient" (Galtung 1978, s 35).

The failure of rural development

The most serious failure of older development theories is the neglect of the rural and agriculture economic sector of the national economic performance. It is indeed true that the industry of the Third World countries has steadily expanded since World War II and some nations have even become middle-income countries. However, the promoting of rapid economic growth tied to industrialization has in most cases been attained at a tremendous cost to agriculture and rural population. As the industrialization progresses, industry competes with agriculture for land and water, funds and technology. On a world scale land and water resources have been polluted, have deteriorated and been exempted. The farmland area has been reduced and agricultural investment has been inadequate. At the same time the rush for industrialization leads to excessive urbanization. The annual urban population growth rate of the Third World nations has risen as high as 4.2 percent in the 1970s. According to FAO the annual per-capita grain growth rate of Third World countries only rose by 0.48 percent from 1955 to 1980, when it reached 238 kg per capita. Furthermore, the annual per capita grain growth rate for the 1970-80 period was only 0.08 percent and that for 1975-80 period had dropped to negative 2.3 percent. Consequently, the grain import by the Third World countries has increased from 20 million tons yearly in the early 1960 to 90 million tons annually in the early 1980s. At the same time the promoting of the capital transfer policy has in 1983 resulted in a staggering total $ 700 billion foreign debt of the Third World countries (Zhou 1982).

Moreover the poor people have received very little of the benefits from expanded production. Much of the surplus has been retransferred to the rich countries and the rich-and-poor polarization in the Third World countries has aggravated. While social wealth has been concentrated in the hands of an elite the labouring rural and urban people are living in dire poverty. For instance an 1980 updated WHO survey concluded that 60 percent of the population in Third World countries does not have easy access to safe drinking water. These 1 500 million people consist of 1 200-1 300 million in rural areas or more than 70 percent of the total rural population, and 200-300 million, or more than 30 percent of the urban population. The situation in regard to sanitation is even worse with 75 percent of the population having no sanitary facilities whatsoever. Out of 1 800-1 900 million people with no sanitary service over 85 percent live in rural areas. (Bourne 1981).

The failure of agricultural development in most Third World countries has received a lot of attention in recent years. Hyden (1980) and Dumont & Mottin (1982) have treated the precarious African situation. Dumont & Mottin show how the Western-centrated liberal development model among other things have created national and to a high degree corrupt bureaucracies in Tropical Africa, which are unable to pursue an agricultural development. With the exception of Egypt, Sudan, Tunizia and to some extent the Ivory Coast and Tanzania no African country before the 1980s had made any substantial allocations in the national budget for agricultural development. Instead investments in raw material industry, urban development and the development of the state bureaucracy with related privelegies to the elite and city-dwellers have been given priority.

Agricultural cash-crop production for the Western market has been favoured to the detriment of a striking neglect of grain production. Hyden explains that neither a capitalistic nor a socialistic bureaucracy have managed to modernize the pre-capitalistic peasant mode of production still prevailing in the African countryside. The African continent is unique in the respect that the majority of the continent's small-holders have not been subdued to a capitalistic nor socialistic mode of production in a manner that characterizes large parts of Asia and Latin America. Therefore the main reason for the many failures and shortcomings in the field of rural development are structural. The economic base of the peasant mode of production is a subsistence economy, which does not generate any economic surplus for development. The social attitude of the peasant toward development is ignorance of official policies. Planning is not a rational of the peasant economy. With the peasant mode of production planning simply make no sense, "because the peasant units of production are essentially independent of each other and there are few if any functional interdependencies that could promote any understanding of collective action beyond what the local economy may call in the case of emergency" (Hyden 1980, p 229). Hyden observes, that most African countries lack a hierarchical organisation, which can use power to change the peasant mode of production. Therefore, he concludes, "to expect planning to be an important economic development tool in the context of African economies is illusory" (Hyden 1980, p 230). At present, the social context of Africa heavily restricts an effective water resources planning.

Johnston & Clark (1982) have in their study Redesigning Rural Development reviewed much of the relevant literature on what is known about rural development. Their standpoint is that the rural poor up to the present in the majority of the development programs have failed to benefit from the development effort. They note, that in Third World countries 60 to 80 percent of the labour force is dependant on agriculture for a livelihood. But most challenging for the future is that it will take decades before the majority of the Third World countries reach the structural-transformation turning point, i.e. the time in the future when the agricultural labour force begins to decline. According to four hypothetical scenarios, the increase in the farm labour force over the next fifty years could range from a minimum of 75 percent, assuming a rapid decline in fertility and a very large increase in the rate of rural urban migration, to a maximum of 475 percent with fertility and migration unchanged (Johnston & Clark 1982, p 106). Such an heavy increase in the rural labour force will make great demands upon land and water resources, food supply, health, education and so on. Johnstone & Clark distinguish between a bimodal and unimodal strategy to rural development. A bimodal strategy could be identified with a liberal development approach and a unimodal strategy with a basic needs approach. The bimodal strategy is the most dominant in Third World countries. In the bimodal strategy funds for agricultural development including water projects are concentrated to a great extent to a subsector of a large farms, which adopts labour-saving and capital-using technologies, while the mass of the rural poor live at or below subsistence level. The bimodal strategy is generally associated with an industrialization first strategy, which results in terms of trade between agriculture and industry, which are unfavourable for, the agricultural sector. This impedes an increase in the agricultural productivity of the small-scaled agricultural sector and sustains the income possibilities of the peasant at a low margin. Contrary to the bimodal strategy the unimodal strategy pursues a labour-using and capital-saving technology, which will lead to increase in the agricultural productivity and income of the peasant within the framework of even intensively used small-scaled farm units. Johnston & Clark holds that Japan, Taiwan, South-Korea and China have followed such a strategy.

The very point with using the bimodal and unimodal strategy thinking is that it could be applied as an analysing instrument independent of political system. Johnston & Clark perceives that a redistribution of the rural wealth by a land reform is necessary in many Third World countries, but before the objective conditions for a land reform prevail the only solution to improve the humiliating situation of the rural poor is to apply a unimodal strategy. Therefore, they advocate three mutually supportive agricultural-orientated programs related to production, consumption and organization. The production-orientated program deals with rural employment opportunities and measures to increase the agricultural productivity. The consumer-orientated program deals with a widespread coverage of services related to health, nutrition and family planning. The organization-orientated program deals with measure to improve the institutional structure and managerial procedures through which rural people resolve local problems and are linked into the broader social system.

A basic needs approach

It can with much emphasis be concluded that the priorities and needs of Third World societies have to mutually rely on all the four social goals mentioned above. No one can be excluded. From this it is also obvious, that if a development theory or a development planning, for example water resources planning, wants to be societal or have credibility, it has to give priority to the rural and agricultural sector of the economy. However, an agricultural-orientated approach will not automatically lead to a new international economic order as for instance Arthur Lewis supposes (see Johnston & Clark 1982, 65). The modernization problem in Third World countries is so immense that for its solution both a NIEO is needed on the international area and an agricultural-oriented approach on the national arena. The implementation of NIEO is a highly political topic. The present reluctance of NIEO from the rich countries reflects the desire from the rich countries to continue to be rich at the expense of the poor countries. In this context, the very first advantage of the basic needs approach of national economic performance is that if it is properly implemented, it will give priority to rural and agricultural development. The second very important advantage of the basic needs approach is that it could be applied, and hopefully achieve substantial improvements of the well-being of the rural and urban poor, in support for and before the NIEO is envisaged in the international arena.

Certainly, the concept of basic needs is rather vague and a precise definition has not been given or maybe is not even desirable. One profound lesson from the failure of the liberal economic growth model should be that it was specific to advanced market economics and therefore not applicable to the various social and economical conditions in the Third World. It follows from the framework thinking applied in this study that the ultimate formulation of basic needs approach has to be country specific, because the resource base and cultural conditions differ from country to country. The first time it appeared as a formal development strategy was in the Declaration of Principles and Programme of Action by ILO adopted by the World Employment Conference in 1976 (ILO 1976; Hoadley 1981; Leipziger 1981). While considering the challenging employment situation in the Third World it is not astonishing that ILO became the initiator of the approach. After 1976 there has been much discussion on the matter, if the basic needs should have a minimum, material or human character (Galtung 1978; Mazingira 1978; Streeten & Burki 1978; Hettne 1982). The author agree with Green (1978) that the conception of basic needs "rejects the sacrifice of a minimum decent (socially determined) standard of life for workers and peasant, either to provide the 'incentive' for capitalist accumulation or the means to socialist reconstruction for the putative benefit of rather vaguely identified future generations. In rejecting the maximization of the rate of growth productive forces, it also denies the primacy of accumulation" (Green 1978, p 7). This means that the basic needs are not the end situation, they just provide the material and cultural needs for further development. The basic needs approach should also promote a balance between the individual right of personal freedom and the individual commitment to implement collective social goals and guidelines.

With these considerations and from what been said in this chapter about social goals, a unimodal strategy of agricultural development and national priority given to the agricultural sector, the most important targets of the basic needs approach may be summarized from various sources as follows; (ILO 1976, p 32, Green 1978, p 7; Leipziger 1981, p 122). The basic needs approach should seek to provide:

* basic consumer goods of household consumption, adequate food, shelter, clothing, household equipment and furniture

* universal access to basic services; primary and adult education, pure and safe water supply, preventive and curative health programme, sanitation, adequate public transports and communications, electricity

* productive longterm employment opportunities or self-employment yielding both high enough productivity and equitable enough renumeration to allow each household to meet its basic personal consumption out of its own income

* an institutional framework and an economical and physical infrastructure capable of producing and facilitating the delivery of the goods and services required and which promote the generating of a surplus to finance basic communal service and the providing of investments sufficient to sustain the increase in productive forces needed to raise the standard of living of the poor

* governmental commitment as well as mass participation of the people concerned in the planning and implementation of projects.

There are several implications of regarding a basic needs approach as a national social guideline to water resources planning in Third World countries. First, the Western historical water resources development, associated with industrialization as described by the US example in figure 1, is a special case and inappropriate for application by Third Worlds countries of today. Up to the present time the Western water resources development has been guided by a liberal water ideology, which has tended to look upon water resources development as an isolated engineering problem for promoting a high economic growth rate. Moreover the Western water resources development has been conducted under favourable climatic conditions in high latitudes. Western water resources development at its low-income stage was achieved with comparatively low population pressure and supply of ample water resources. Third World countries of today have generally unfavourable climatic conditions and a high population pressure on land and water. Thus, the chief characteristic of Third world countries of today is that they objectively are both low-income and in a demand-orientated stage of water resources development.

Firstly to a very high degree the liberal water ideology has been imposed upon Third World countries, which have social and economic conditions not suited for such a development strategy. From the point of view of Western ideology they have essentially been treated and in most cases still are treated with water policies belonging to the supply or resource-orientated stages of Western water resources development. Moreover, the Western water resources development was done parallell to the exploiting of cheap natural resources in Third World countries, which means that the Western water resources development has been subsidized by the nations and people of the Third World. Certainly, this is not an option given to the Third World countries of today. Needless to say, the imposing of an inappropriate Western water ideology on Third World countries explains much of the neglect or nonexistence of a national and government commitment for water resources planning in most Third World countries. With the acceptance of a basic needs approach as an appropriate social guideline the current water resources planning situation will gradually change, because the basic needs approach can not be effected without a societal planning for social welfare.

Secondly, water resources development in Third World countries has becoming more widely realized to be intimately related to a basic needs approach (Swaminathan 1979; van Damme 1980;Lindh 1981). It has already been noticed that irrigation is the main water consumption activity in the Third World. Massive irrigation and drainage works are needed in the future to cope with the food and clothing problems. Flood prevention is needed to protect agricultural land, life and property. There are immense requirements for safe water and sanitation. Waterways will provide transport possibilities and hydropower development will provide a base for electrification. Already Adam Smith observed that many water works constructions were well suited for public undertaking (James & Rogers 1979, p 54). Nurkse has strongly stressed labour-intensive public works as an important mean of reducing under-employment and as a measure of raising the productivity of the land (Nurkse 1953, Gustafsson 1981b).

Thirdly, the basic needs approach clearly, points out the complexity of water resources planning. It has to be contextual and integrative. The meaning of a single water project depends upon its relation to the whole context of which it is a part. When making a water resources plan targets of the basic needs approach and relevant water activities have to be integrated and priority has to be given to targets and water activities in accordance with the specific national, regional and local social, economical and resource conditions. Thus to give some examples, without an adequate food supply labour productivity will remain low. Without access to education, provision of clean water and sanitation is likely to be ineffective in improving the state of health of the people. Without allocating funds for annual maintenance and other recurrent costs after investment has been finished in a new water facility, the project will soon fall in disorder. Without an organizational structure, which is wanted or accepted by the people and based upon the peoples participation most water schemes are likely to fail after a period of time. Without reliance of ecological principles deforestation will reduce reservoir storage capacity, salinization will hamper crop production and waste disposal to water courses will render the provision of safe and pure water more difficult.

Thus we can conclude and summarize that operative water policies in Third World countries have to rely on certain important principles or hypothesis, including

* integration of development of water resources within a broader framework of a basic needs strategy with subsequent sub-strategies such as agricultural, rural, urban, educational, health and sanitation development,

* a democratic labour utilization policy based upon people's motivation and participation

* water resources development consistent with ecological principles, including conservation of available land and water resources and measures against environmental abuse.

It has been claimed by many authors that China seems to have followed a basic needs approach in her development (Agarwal 1978; Aziz 1978; Green 1978; Hettne 1982). It was shown in the first part of this project, that China compared with other Third World countries has favoured agricultural development and basically feeds and supplies the daily necessities to its people (Gustafsson 1981 a,b). It was also shown that China has used massive manpower mobilization for construction of public work and that educational facilities are widespread, but still not sufficient for the needs of the country. It is generally acknowledged that China has been most successful in health and sanitation improvements (Hu 1980, Garfield & Salmon 1981). Some studies have indicated that the income distribution is rather equitable (Lardy 1978, Griffin & Saith 1980).

There should be no doubt that the Chinese national economic performance has followed a basic needs approach. The general Program of the Constitution of the Communist Party adopted in 1956 defined the basic law of Chinese socialism as follows: "The basic object of all party work is to satisfy the material and cultural needs of the people to the maximum possible extent. Therefore it is necessary that the living conditions of the people should improve steadily on the basis of increased production. This is also a requisite for stimulating the people's enthusiasm for production". (Wu 1980, p 15).

Thus, according to the Chinese view, the increasing material and cultural requirements of the people are satisfied step by step, and in turn these requirements promote the development of production. The basic requirements include "(1) personal needs (daily needs of the individual and family), (2) social and public needs (culture, education, sanitation, medical care, recreation, collective welfare facilities owned by enterprises, social relief and service trade), (3) cost of state administration and (4) expenditure on national defense. It should be said that the aim of production is to satisfy the first two requirements, and that the last two serve the first two by creating and securing a tranquil, peaceful and orderly environment for working and living" (Wu 1980, p 16)

Thus it can be concluded that the Chinese national economic performance is basic needs orientated and thereby the task of socialist planning is to develop both production and the improvement of the people's livelihood simultaneousely. To what extent water resource development has supported or been influenced by a basic needs approach will be investigated in the next chapters.

CHAPTER 4

THE CHINESE WATER RESOURCES BASE

SOME DATA REGARDING THE LAND RESOURCES

About 2/3 of China is mountain and hilly areas. Only 12 percent is plain areas.The official cultivated area of 99 million ha is concentrated to three main plains - Northeast Plain, North China Plain & Lower Middle Yangtse Plain-, the Pearl River Delta, Sichuan Basin and some other inland plains. About 1/3 of the cultivated area gives high and stable yields even if the weather conditions are bad. One reason behind this developement is that since 1952 the irrigated area has increased from 21 million ha to 46 million ha of which 22 million ha is irrigated rice land. Another 1/3 of the cultivated area is low productivity land. The saline-alkaline and waterlogged area amounts to about 20 million ha, 6 million ha is under severe soil erosion and 10 million ha is low productivity red soil areas in South China.

Table 3. Land Use in China at the end of the 70's.

	Million ha	Percent
Cultivated land	99-139 1)	10-14
Grasslands	390	41
Forests	122-82 1)	13-9
Deserts and barren mountains	203	21
Marshes and wetlands	11	1
Communication, urban and rural village areas	102	11
Inland water areas	27	3
Total area	954	100

1) The official estimate gives the figure to the left, but a recent estimate gives the figures to the right indicating an underestimation of the cultivated area and an overestimation of the forest area, see also p 6.

Source: The Commission for Intergrated Surveys of Natural Resources; Wu 1978; Wu 1981.

The grasslands make up 390 million ha concentrated to the semi- arid northern part of China. About 70 million ha of grassland lack water. There is a future potential to convert 6-7 million ha of grasslands to arable land, 10 million ha to artificial grasslands and 8 million ha to economic tree plantations. In total 25 million ha of grasslands could be changed to more intensive land use.

With a limited cultivated area, as well as potentially arable land, resulting in only 0.10 ha of cultivated area per capita, the main task for the Chinese agriculture in the future is to raise the land productivity. The present national grain productivity is 3.3 ton/ha of cultivated land, which means that there is a potential to increase the productivity. With this background, rational land use together with soil and water conservation will play an important role.

AMOUNT AND CHARACTERISTICS OF WATER RESOURCES

The utilization of water resources is, with the exception of the interior basins of northwestern China, governed by the behavior of the monsoon. Of the total land area 56,7 percent belongs to the Pacific catchment area,6,5 percent to the Indian Ocean catchment area and 0,5 percent to the North Artic catchment area. As much as 36,3 percent is a land area with no drainage to the oceans, figure 1. The precipitation varies from 1600 - 2000 mm in south-east to much less than 200 mm in northwest. The mean annual precipitation over the whole land surface is 6 000 cubic kilometres equivalent to a mean annual depth of 628 mm.

There are more than 1 500 rivers which have catchment areas bigger than 1 000 square kilometres, which carry the rainwater, ground water outflow and meltwater from glaciers to the sea or centre of inland basins. The mean annual runoff of all the rivers is 2 600 cubic kilometres equivalent to a mean runoff depth of 271 mm. The runoff values of the main rivers is given in table 4.

The annual ground water potential has been estimated to 700 cubic kilometres, of which 480 cubic kilometres are within the Yangtse River basin and the rest of South China. Only 220 cubic kilometres are located in North China. In the western part of China melting of glaciers is the main water supply for agriculture in that predominantly inland basin region. The water reserves in all Chinas glaciers is estimated to be about 2 000 cubic kilometres. The Chinese total annual amount of water is quite big but the per capita availiability of 2 600 cubic metres is one of the lowest in the world.

The Chinese water resources are characterized by uneven regional distribution, uneven time distribution both within a year and between years and generally high silt content.

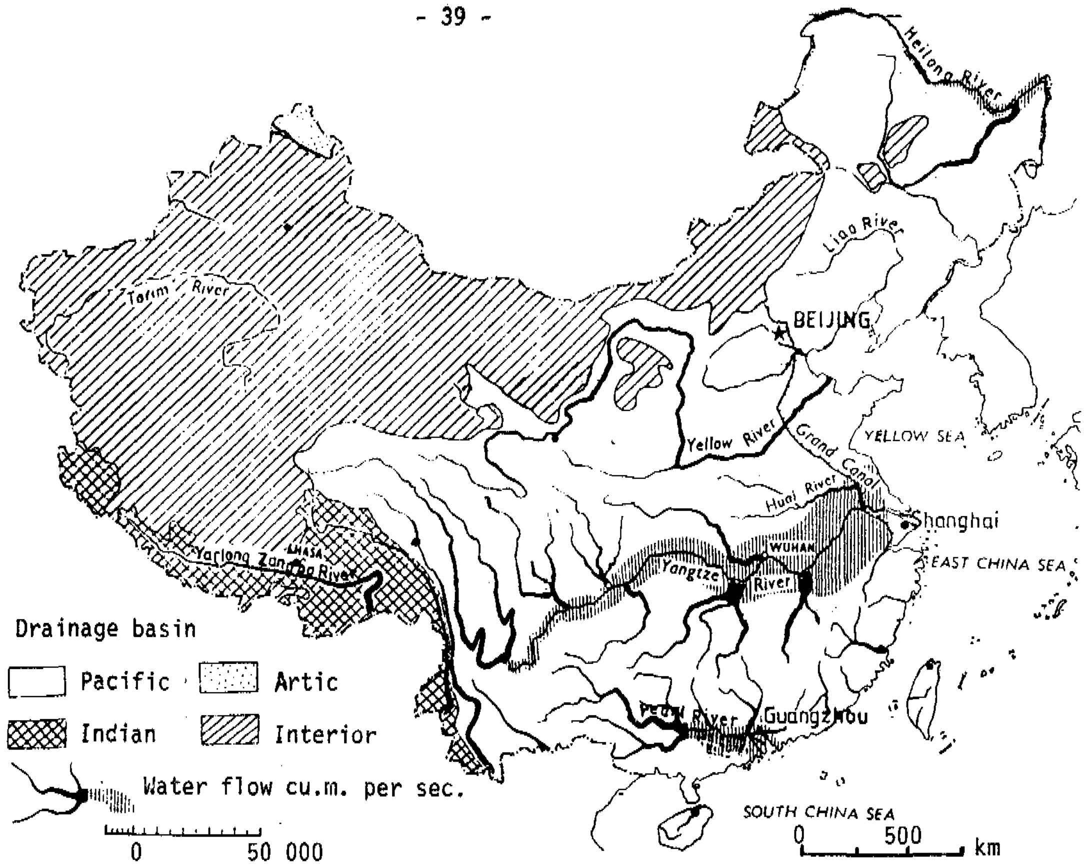


Figure 3. The main drainage basins in China (Geography of China, 1972).

Table 4. Hydrological characteristics of China's rivers.

River	Catchment area km^2	Length km	Total runoff km^3	%	Runoff depth mm
Yangtse River (Chang Jiang)	1 807 199	6 380	979,3	37,7	542
Pearl River (Zhu Jiang)	452 616	2 197	341,2	13,1	754
Heilong Jiang	890 000	3 420	270,9	10,4	167
Yarlong Zangbo (Brahamraputra)	246 000	1 940	116,7	4,5	474
Lancang Jiang (Mekong)	164 799	1 612	74,3	2,9	412

Nu Jiang (Salween)	142 681	1 540	70,1	2,7	469
Min Jiang (Fujian)	60 992	577	62,4	2,4	1 023
Yellow River (Huang He)	752 443	5 464	57,5	2,2	76
Qiantong Jiang (Zhejiang)	54 349	494	46,8	1,8	861
Huai He	185 700	1 000	35,1	1,4	189
Yalu Jiang (Liaoning Pr)	32 579	773	32,8	1,3	541
Han Jiang (Fujian Pr)	34 314	325	29,7	1,1	866
Hai He & Luan He	319 000	1 090	28,3	1,1	89
Qu Jiang (Zhejiang Pr)	17 543	338	19,4	0,8	1 106
Jiulong Jiang (Fujian Pr)	14 741	258	14,1	0,5	954
Yuan Jiang (Yunnan Pr)	34 917	772	12,9	0,5	370
Ili He (Xinjiang)	56 700	375	11,8	0,5	208
Ertrix He (Xinjiang Pr	50 860	442	10,8	0,4	212
Liao He	164 104	1 430	9,5	0,4	58
Jian Jiang (Guangdong Pr)	9 433	211	8,6	0,3	910
(Subtotal	5 490 970	-	2 232,2	86,0	-)
Inland rivers	3 480 000	-	126	4,9	36
All China	9 600 000		2 600	100,0	271

Source: "China's Physical Geography-Surface Water" 1981; Geography 1983.

Note: Jiang and He are equivalent to River.

Figure 4 gives a regional water resources classification. The distribution of surface runoff is basically similar to that of the precipitation, but with an even higher degree of variability. About 45 percent of the land area belongs to the arid and semi-arid or the regions in China with less than 50 mm annual runoff depth. When these climatic conditions are considered in relation to the cultivated area and the population there is an important imbalance between North and South China as table 5 shows.

Table 5. Water resources in relation to cultivated area and population.

	Percentage of total annual runoff	Percentage of total cultivated area	Percentage of total population
South China and Tibet	82	36	54
North China	18	64	46

In South China about 50-60 percent of the normal annual precipitation is concentrated to May-August. In North China about 70-80 percent of the annual precipitation is concentrated to July-September. The unfavourable yearly distribution of precipitation means that irrigation is needed to avoid drought problems during the spring season. Another feature of the Chinese precipitation is that the rains in the summer period often are very torrential and erosive to the soils. It is not unusual to record rainfall intensities of more than 300 mm/h within 10 minutes duration. Yearly variations in precipitation is also very remarkable in China, especially in the north. According to 258 years data from Beijing, the 1406 mm of rain in the wettest year 1959 is 5,8 times more than the 242 mm in the driest year 1869. Data regarding maximum and minimum recorded flow in the Yellow and Yangtse Rivers are given in table 7. The variation of the total annual runoff is also substantial. At Sanmenxia station in the Yellow River according to its 60 years records, the maximum annual runoff occured in 1964 and the minimum annual runoff in 1928, being 163 percent and 48 percent of the average runoff.

Floods and droughts therefore are closely related to the Chinese history. From studies of historical records the statistics shows that between 206 B.C. and 1949 A. D. there 1092 flood disasters and 1056 droughts have been recorded. Especially along the heavily populated middle and lower reaches of the Songhua River, Liao River, Hai River, Yellow River, Huai River, Yangtse River and Pearl River the surrounding land areas have to be protected by dykes. Still today there are at an average 23 million ha of cultivated land threatened by floods and droughts every year. The flood control of the main Chinese rivers is therefore a major concern for the whole country. The last very distinct feature of the Chinese rivers is the generally very high silt content. Some silt measurements data from Chinese rivers are given in table 6. The Yellow River is without competition the world's most siltloaded river. Within its middle section, it is flowing through the very erodible loess plateau area. In its central part the soil erosion rate exceeds 5 000 tons per square kilometres and year, figure 5. Also the rivers in the southwestern mountains of Yunnan Province are quite silt-

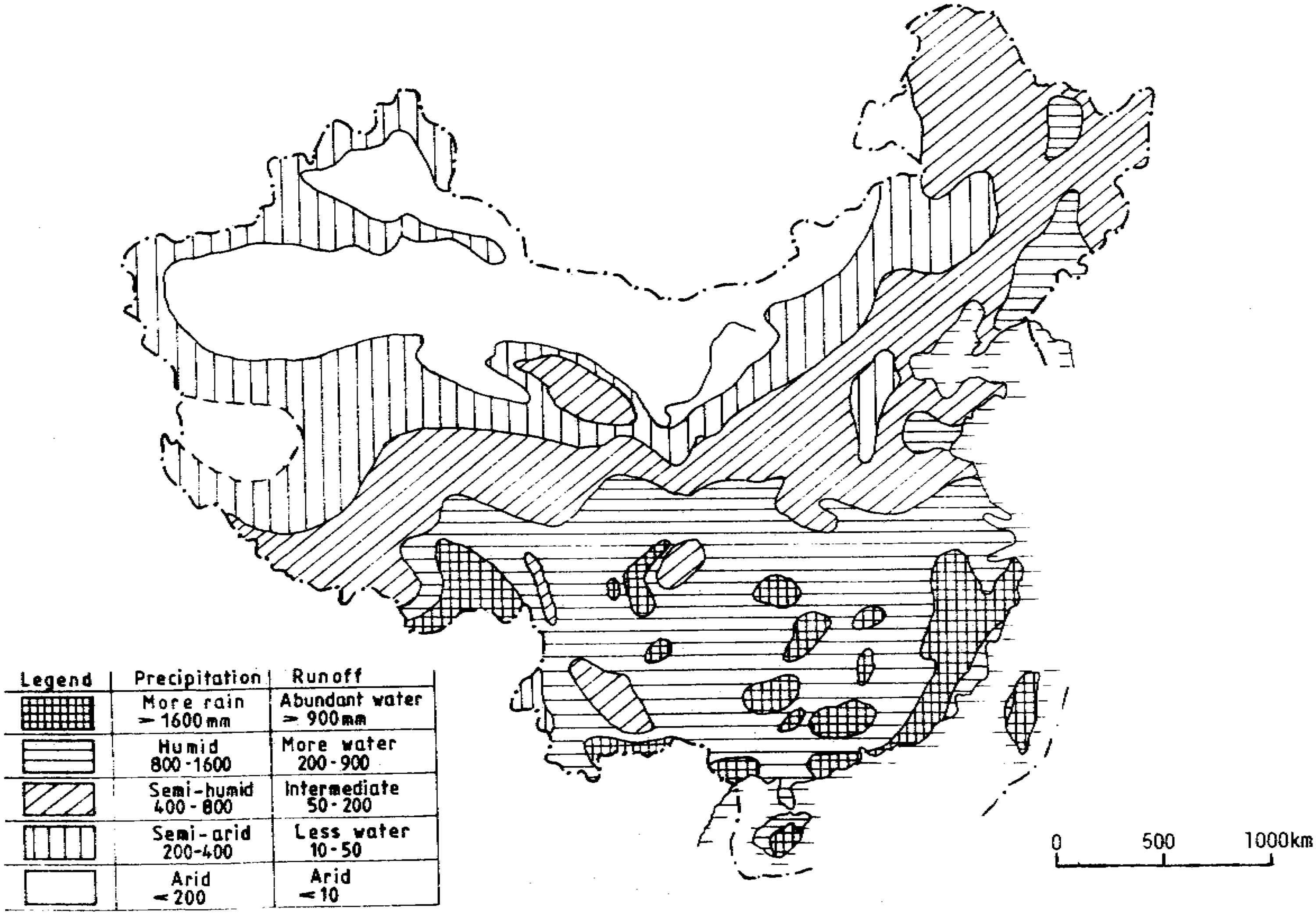


Figure 4. Regional water classification of China (Ministry of Water Conservancy and Power).

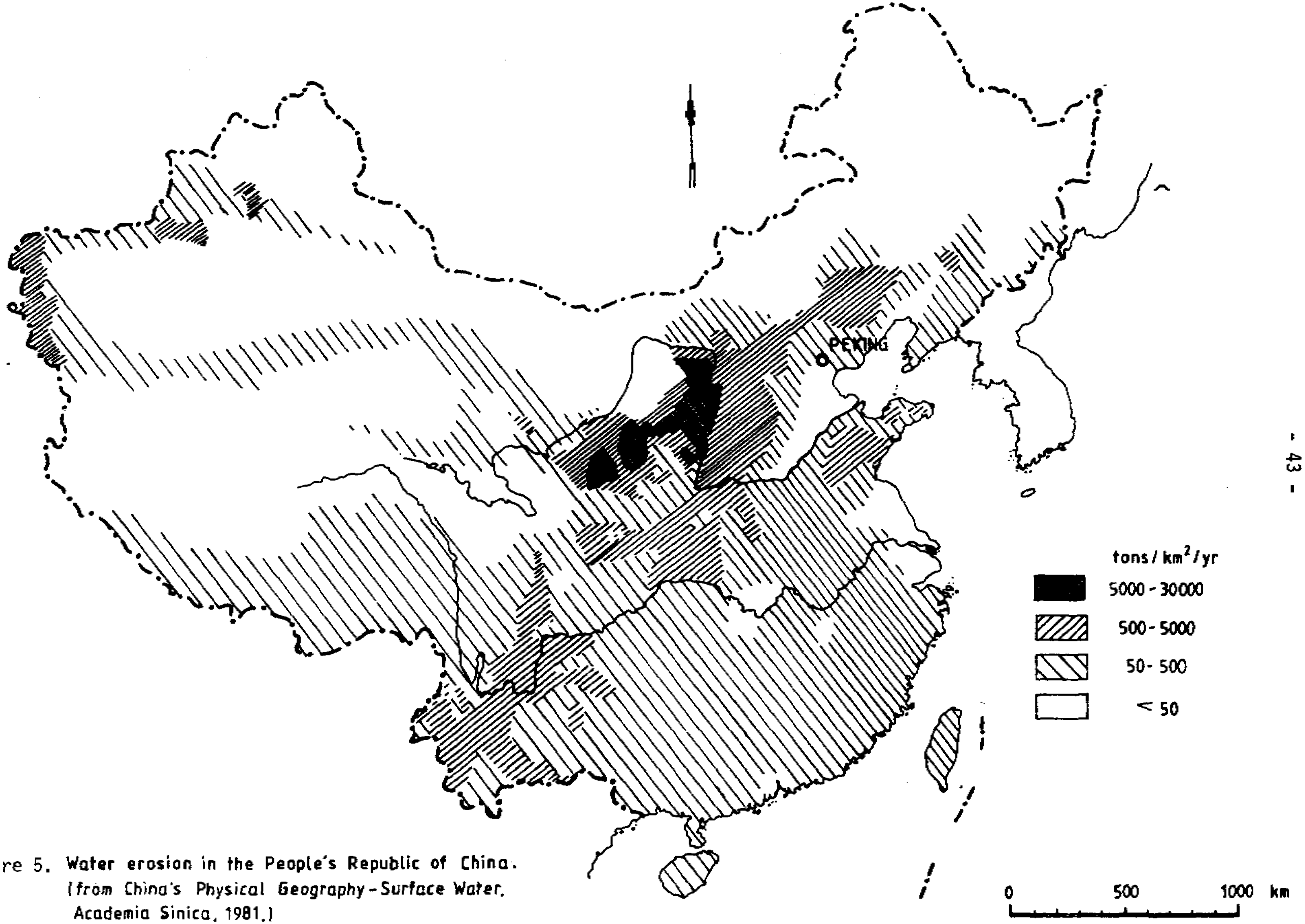


Figure 5. Water erosion in the People's Republic of China.
(from China's Physical Geography - Surface Water, Academia Sinica, 1981.)

Table 6. Silt conditions in some catchment areas.

River (Gauging period)	Area above gauging stn km^2	Average flow m^3/s	Average silt content kg/m^3	Total annual silt load million tons	Annual soil loss ton/km^2
Heilong Jiang (1957-1970)	527 795	2 394	0.157	10.69	20.7
Liao He (1959-1970)	120 764	107	3.60	20.98	173
Luan He (Hebei Pr)(1956-1970)	44 100	154	3.96	24.08	546
Hai He (1925-1952)	42 500	47.5	60.8	80.70	1 686
Yellow River (1919-1969)	687 869	1 350	37.7	1 600	2 330
Huai He (1956-1970)	121 330	899	0.397	13.08	107
Yangtse River (1956-1970)	1 705 383	28 500	0.575	499.6	293
Min Jiang (1951-1970)	54 500	1 550	0.135	7.51	138
Pearl River (1956-1970)	329 705	6 294	0.321	66.49	201
Yuan Jiang (1957-1969)	32 037	300	3.28	29.89	925
Yarlung Zangbo (1956-1970)	156 808	1 010	0.529	16.60	106
Tarim He (1954-1971)	48 100	203	4.56	29.10	604
Ganges River	955 000	11 760	3.92	1 451	1 519
Brahmaputra River	666 000	12 170	1.89	726	1 090
Nile River	2 978 000	2 830	1.25	111	37

Source: China's Physical Geography - Surface Water. 1981; Qian & Dai 1980.

Note; Jiang and He are equivalent to River.

Table 7. Some hydrological data of the Yellow and Yangtse Rivers.

	Maximum flow m^3/s	Minimum flow m^3/s	Max/min	Average flow m^3/s
Yellow River	36 300 (1843)	145 (1928)	250	1 820
Yangtse River	110 000 (1870)	2 680 (1979)	41	31 060

Source: Cheng 1979 and Ludlow 1980.

loaded. In general soil erosion rates above 100 tons per square kilometres and year is believed to affect the maintenance of water quality in rivers. Silt concentration in rivers is a major concern, when harnessing and exploiting the rivers.

UTILIZATION OF WATER RESOURCES

The Ministry of Water Conservancy and Power has the overall responsibility to collect hydrological and climatic data, needed to exploit the rivers. Since 1949 the Chinese have established hydrological and meteorological stations in all the rivers. In general, information is collected about water table, flow, air and water temperature, silt content, precipitation, wind velocity, ice conditions, changes in the river section, hydrochemistry etc at a hydrological station. One of the main purposes of the research expeditions set up by the Commission for *Integrated Surveys of Natural* Resources, was to establish a reliable hydrometeorological network system even in the remote areas. I was told that four main hydrological stations had been set up in the Yarlung Zangbo River in Tibet. Water table, flow and precipitation measurements were automatically recorded in every 24 h during the flood season at those stations. During other seasons measurements were taken 3 times a day. In Sichuan Province there were about 200 hydrological gauging stations in the rivers (see page 97). According to an American expert the density of the Chinese hydrological network system can be compared to the US network system (Matalas & Nordin 1980).

Recently the Ministry has established a central computer in Beijing to process all the data. At the provincial level the data is collected and transmitted to the central computer by a general hydrological unit under the provincial water planning and management bureau . In the very remote areas in western Tibet data has to be sent by horse and thereafter telegraphed. Processed hydrological data is published in a bulletin by the Ministry. Besides the hydrological network in rivers the meteorological network in catchments is run by the Meteorological Bureau of China and its provincial subdivisions. Ground water data is controlled by the Ministry of Geology. There is a cooperation between the two ministeries regarding ground water exploitation. At the moment there exist no unified national ground water network systems but to establish such a network has a high priority for the future. Hitherto an extensive ground water regime network including 14 000 observation wells has been established in 17 provinces in North China. The density of observation wells is one in very 30 - 150 square kilometres.

China has a long tradition in water resources utilization. The legendary Da Yu, who lived more than 4 000 years ago and finally became an emperor, is said to have been working day and night to conquer the Yellow River. He is considered as the father of Chinese water conservancy. At Mangshan pumping station along the Yellow River a huge statue will soon be erected to remind the Chinese of his achievements (see page 69). From 486 B.C. onward, the workers from generation to generation have dug the Grand Canal, which is 1794 km long from Hangzhou to Beijing. Another famous water conservationist was Ximen Bao, who lived during Warring State Periods (480-221 B.C.). He is famous in Chinese history for revealing for the peasants the superstitions spread by evil persons and local despots, that young females had to be thrown into the Zhang River in Henan to satisfy the river god. Evil persons used this kind of witchcraft to economically blackmail poor peasants families. He also promoted irrigation and canal developement in the Wei River valley and around the cities of Anyang, Louyang and Wuhan. During his lifetime a canal was finished, which connected the Yellow River with the Huai River system. The governor of Sichuan Province Li Bing understood hydraulic principles, when 250 B.C. he designed the still used and very impressive Dujiangyan irrigation system (see page 102). At that time ground water was exploited from deep shafts in the Sichuan basin and Wei River valley. Waterwheels were used to grind grain during Western Han (206 B.C. - 9 A.D.). The man-powered or animal-powered Chinese dragonbone pump became widely used for field irrigation during Eastern Han (25 - 220 A.D.) and is still used for pond-irrigating rice fields in many areas in China. At least during Tang (618 - 906) the noria pump became into common use, probably introduced from India. In a famous study, Chi Chao-Ting has concluded that during the dynasties the economical and political power has moved to that geographical area, which has best been able to control and utilize the water resources (Chi 1937).

After the fall of the increasingly corrupt Qing dynasty in the democratic revolution of of 1911, some efforts were made to introduce modern science and technology in water resources utilization. But due to internal problems, the Japanese occupation during the 30s and 40s and other foreign involvments no unified efforts were really achieved. It is historically , evident that, Chinese engineers were innovators in the devising of water conservancy works. But by the beginning of the 20th century this had radically changed and there was virtually no engineer trained in modern water control methods. In 1915 the father of modern hydraulic engineering in China Li Yizhi, after returning from training in Europe, set up Hehai Hydraulic Engineering College in Nanjing (Wang 1982). This was the first such modern education facility of its kind. Under the supervision of Li Yizhi and his assistants the Jinghui Canal and dam in central Shaanxi was completed in 1932 irrigating 33 000 ha. In the 40s some comprehensive river basin planning was done in the Huai River basin, the Yongding River basin outside Beijing and the Gan Jiang basin in Jiangxi. But on the whole these were scattered achievements. By 1949 there were less than 10 modern constructed reservoir dams in all China. It has been the ardous mission of the new government to introduce modern science and technology in water resources utilization since 1949.

At the end of the 70s the annual water utilization was 476 cubic kilometres of which 39,6 cubic kilometres are abstracted ground water. This is around 18 percent of the total annual runoff of the whole country. Usually such a national average utilization rate indicates severe water supply problems in the national economy, which need much planning and investments to be solved. The total water consumption in China maybe divided into various uses according to table 8.

Table 8. Water use in China in 1950, 1979 and in the year 2000.

		1950		1979	Annual increase 1950-79, %	2000	Projected annual increase,%
Rural areas:		99.6		419.5	4.9	530-595	1.2-1.8
Irrigation	-		400.5		-		
Households & small industry	-		19.5		-		
Urban areas:		3.5		57.2	9.7	115-145	3.7-4.8
Households	0.7		4.9		6.7		
Industry	2.4		26.3		8.3		
Cooling water	0.4		26.0		15.0		
Total use:		103.1		476.7	5.2	645-740	1.5-2.2

Source: The Commission for Intergrated Survey of Natural Resources; Ministry of Water Conservancy and Power; Zhongguo Shuili 1-1983 (Transl. in China Report: Agriculture No 254-1983); Li 1983 (Article translated in China Report: Agriculture No 272-1983).

About 90 percent of the consumption is used in rural areas, mainly for irrigation. This is the common pattern for basically irrigation-relying economies in the Third World. However the industrial water consumption excluding cooling water of 26 cubic kilometres in China is quite substantial, when compared to the 18 cubic kilometres industrial water consumption in Japan 1975.

The degree of utilization of the water resources varies with the north-south climatical conditions, table 9. In north China practically all water which could be used for irrigation, industry and households are used for these purposes.

The soil and water construction works in China since 1949 have been very impressive. The total state investment in water conservancy projects has been more than 100 billions Yuan or 50 billion US dollars. In addition there has been a huge financial and labour investment at the Commune level. For some years, 10 million of the rural labour force have been engaged in farmland and water capital construction works during the winter season. Between 1949 -1980 about 84 500 reservoirs have been constructed. Together their storage volume is 248 cubic kilometres, which is 54 percent of the total annual water use in China, table 10. The storage capacity of the flood

Table 9. Degree of utilization of some rivers in China

	Percentage	km^3
Liao He	68	6,5
Hai He & Luan He	67	18,4
Yellow River	39	22,4
Huai He	63	22,1
Yangtse River	16	156,7
Zhejiang and Fujian Rivers (Min Jiang, Qiantong Jiang, Han Jiang, Ou Jiang, Jiulong Jiang)	< 4	6,9
Pearl River & Jian Jiang	15	53,7
Southwestern China rivers (Yarlung Zangbo, Lancang Jiang, Nu Jiang, Yuan Jiang)	< 1	2,7
Inlands rivers (Ili, Ertrix, Tarim He)	32	9,3
The whole country	17,5	476

Source: The Commission for Integrated Surveys of Natural Resources and Ministry of Water Conservancy and Power.

Table 10. Development of water storage capacity in China 1949-1980.

Reservoir size, million m^3		Numbers	Total volume km^3		Responsible unit
Large	> 100	300	133	29 %	Ministry of Water Conservancy and Power
Middle	100 - 10	2 200			Provincial government
Small	10 - 0,1	82 000	115	25 %	County or commune government
Ponds	< 0,1	>6 000 000			Brigades
Flood retention basins			212	46 %	Ministry of Water Conservancy and Power
Total water storage capacity			460	100 %	

Source: Ministry of Water Conservancy and Power.

retention basins along the rivers is 212 cubic kilometres. Up to 1978 the reservoir surface water area, suitable for fish breeding, has reached 2 million ha of which 1.3 million ha has been used for fish production. Since the middle of the 1960s 2.1 million machine-operated ground water wells have been constructed in North China, watering an area of 11.3 million ha. About 8.7 million ha of land is irrigated exclusively by ground water.

Using the water from reservoirs and wells, the irrigated area has increased from 16 million ha in 1949 to 46 million ha, which is 46 percent of the cultivated area. By introducing pumps on large scale since 1949 the low-lying cultivated area under drainage control nowadays is 29.7 million ha. The total drainage power installed is 74 million horsepower table 11.

To prevent floods more than 160 000 km of dykes have been constructed along the rivers. Together with this the river channels have been dredged. New flood discharge outlets have been excavated for the Hai and Huai Rivers.

The regional distribution in 1980 of some important water utilization indicators are shown in table 11. The regional distribution of the total reservoir capacity, the dammed pond water storage capacity and the number of machine-operated wells have been mapped in figure 6. The water resources regions have been chosen by the author with reference to physiographic and socio-economic conditions. For statistical reasons the boundaries of the water resources regions coincide with provincial boundaries.

The total reservoir capacity in table 11 is 47 cubic kilometres less than the figure given in table 10. Probably, this is due to different estimations of the flood retention basin capacity. It is obvious, that much reservoir building capacity has been allocated to the water-deficient North China water resources regions. In the fringe mountain areas to the North China Plain many reservoirs have been constructed in order to prevent flooding of the plain. The hilly-mountain Central-south water resource region has been well suited for reservoir constructions and traditionally this region also has a lot of ponds. About 85 percent of the ground water exploitation has been concentrated to the North China Plain and the Loess Plateau water resources regions. Since 1965 most of the expansion of the irrigated area has taken place in these regions. In the West water resources region qanat (or karez) irrigation using meltwater from glaciers is important. Irrigation of cultivated land is less important in the temperate North-east water resources region. The permanent drainage and irrigation capacity is distributed well in accordance with the need of the country. The drainage capacity is concentrated to the humid water resources regions of the Lower Yangtse, Central-south and South-west.

Hydroelectric power generation in China before 1949 was negligible. According to the Ministry of Water Conservancy and Powers investigations, China has a potential of 680 million kW of which 380 million could be exploited. Up to today 17 million kW have been installed representing 4,5 percent of the exploitable resources.

Table 11. *The regional distribution in 1980 of some important water utilization indicators.*

Water Resources Regions	Total reservoir capacity km^3		Pond water storage capacity, km^3.		Wells equipped with machine-operated pumps Thousands.		Irrigated area Million ha		Permanent drainage and irrigation stations equipped with pumps, Million HP.		Powered drainage and irrigation machinery Million HP	
North-east	26.4	6.4	0.3	1.1	103	4.9	1.40	3.1	0.72	2.9	2.12	2.8
Loess Plateau	24.2	5.9	0.5	1.8	353	16.9	4.15	9.3	3.44	14.1	8.46	11.3
North China Plain	116.6	28.2	2.5	9.2	1 449	69.4	13.05	29.3	4.30	17.6	32.45	43.5
Lower Yangtse	66.5	16.1	5.2	19.0	143	6.8	7.72	17.3	5.70	23.3	12.96	17.4
Central-south	136.3	33.0	12.8	46.9	12	0.6	9.42	21.2	6.94	28.4	11.49	15.4
South-west	37.8	9.1	5.9	21.6	7	0.3	5.82	13.1	3.22	13.2	6.38	8.5
West	5.3	1.3	0.1	0.4	22	1.1	2.92	6.7	0.13	0.5	0.80	1.1
National total	413.1	100.0	27.3	100.0	2 089	100.0	44.48	100.0	24.45	100.0	74.66	100

Source: China Report:Agriculture No 255 -1983.

Note:

Water Resources Regions	Included provinces	Main rivers
North-east	Heilongjiang, Jilin	Heilong Jiang,Songhua Jiang
Loess Plateau	Nei Mongol,Ningxia,Gansu, Shaanxi Shanxi	Middle Yellow River
North China Plain	Liaoning,Hebei,Beijing,Tianjing, Henan, Shandong	Liao He, Hai & Luan He, Lower Yellow River, Upper Huai He
Lower Yangtse	Jiangsu,Shanghai,Anhui, Zhejiang	Lower Huai He, Lower Yangtse River
Central-south	Hubei,Hunan,Jiangxi,Fujian,Guangdong	Middle Yangtse River,Min Jiang,Lower Pearl River
South-west	Sichuan,Yunnan,Guizhou,Guangxi	Upper Yangtse River,Upper Pearl River, Lancang Jiang,Nu Jiang
West	Xinjiang, Qinghai,Xizang(Tibet)	Tarim He, Yarlung Zangbo River

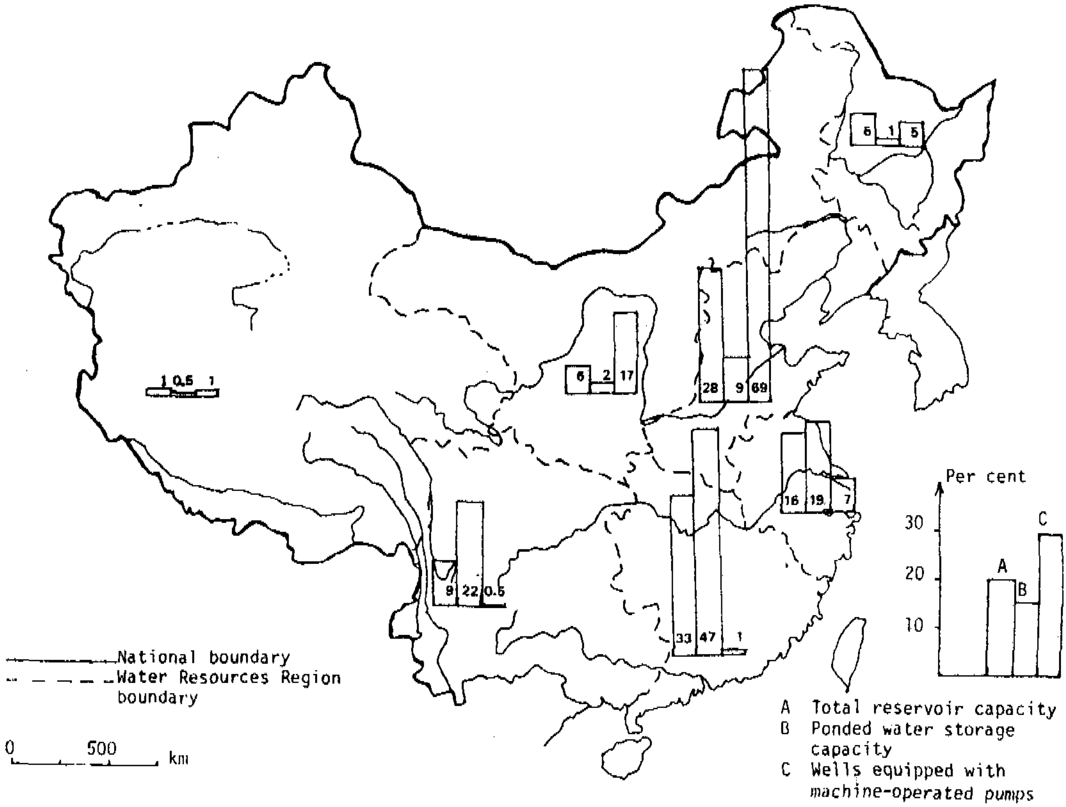
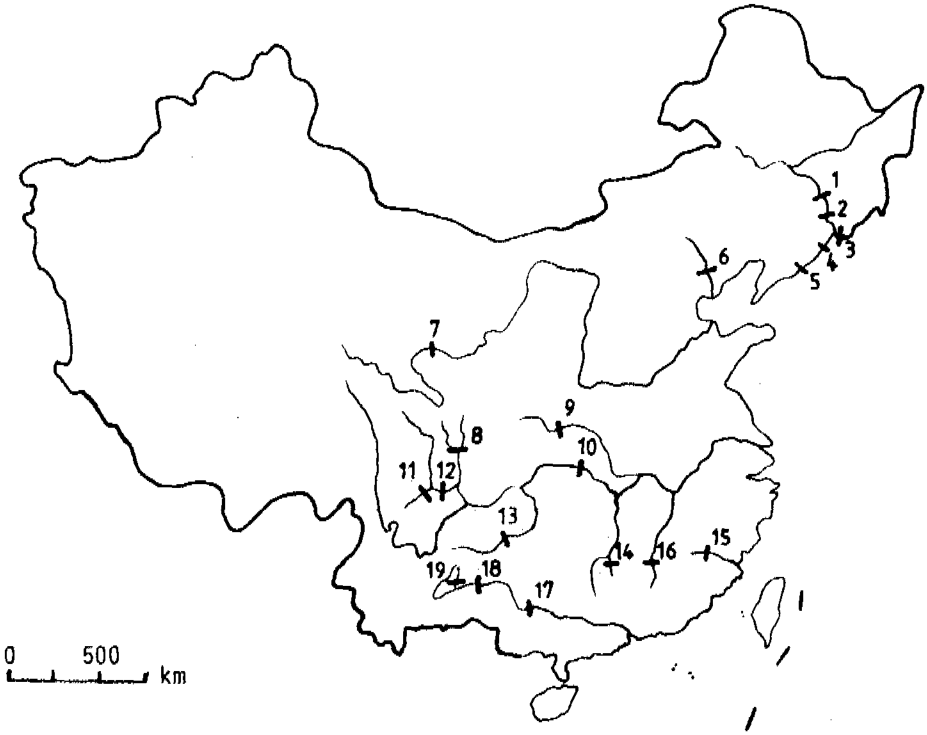


Figure 6. Regional distribution of total reservoir capacity, ponded water storage capacity and wells eguipped with machine-operated pumps (China Report:Agriculture No 255-1983).

The biggest hydroelectric power station in China is Liujia in the upper Yellow River with 1.25 million kW. When the Gezhouba project is finished in 1986, it will have a generating capacity of 2.75 million kW (see page 108). Much of the potential hydroelectric power generation capacity is located in remote mountainous areas, where the transport capacity is very weak. Qinghai-Tibet plateau has a potential of 200 million kW and Sichuan province 150 million kW, see figure 7.

For a vast country such as China the development of small hydroelectric power stations is of vital importance for the regional economy and to solve the problem of energy shortage in rural areas. There are 90 000 small hydroelectric power stations in China with a total capacity of 6,33 million kW 1980. They account for 1/3 of the total electricity generating from water power.



1. Hongshi	7. Longyang	13. Wujiang
2. Baishan	8. Yuzixi	14. Dongjiang
3. Laohushao	9. Ankang	15. Shaxikou
4. Shuifeng	10. Gezhouba	16. Wanan
5. Taipingwan	11. Nanyahe	17. Dahua
6. Panjiakou	12. Tongjiezi	18. Tianshengqiao
		19. Lubuge

Figure 7. Hydropower stations under construction with a generaring capacity of over 100 000 kW (Beijing Review 49-1982).

Thus, a lot of work has been done for the quantitative development of Chinese water resources. But due to the industrialization process many new pollution problems have been created especially around cities and industrial centres. The water pollution problems are the most serious in springtime, when the rivers have their lowest flow. Soil erosion is still very serious due to increasing population pressure. Especially during the Cultural Revolution the soil erosion problem was aggravated in many areas, caused by indiscriminate felling of forests (see page 101). Before the Stockholm Environmental Conference 1972 there was very little concern regarding water pollution in China. The water quality research done by the Institute of Geography Academia Sinica Beijing in the Guanting reservoir, one of Beijing's two main water supply reservoirs, which started in 1972, was one of the first industrial pollution research projects. According to an estimation by the Ministry of Water Conservancy and Power the total amount of sewage water today amounts to 26 cubic kilometres. Most of this quantity is discharged directly into the water areas without any treatment. But the researchers, politicians, planners and other decision-makers have been aware of the pollution threat during the 70s.

Table 12. Some water quality indicators of industrial and domestic water pollution in the large river systems. Average values; ppb = parts per billion.

River	Location	Degree of mineralization mg/l	phenol,	CN^-,	As,	Hg,	Cr
			ppb				
Yangtse	Wan County	200	3	-	-	-	-
	Jiujiang-Wuhu		2	-	-	-	-
	Shanghai		4	-	-	-	-
Huai He			5-9	-	2	-	-
Yellow	Lanzhou		4	3	-	-	-
	East of Wei He		-	-	336[x]	-	-
	Xiaoqing He, Jinan		30	-	10	-	17
Hai He	Yongding He	500	1-9	1-20	1-40	0.5-2	1-10
	Fu He, Baoding		33	-	-	-	-
	Tianjin		4	4-9	10	0.3	-
National surface water standard			10	50	40	1	50

x This value is due to high As content derived from eroded Loess soil.
Source: Wang & Liu 1983.

In China the environmental authorities focus on the five pollutants phenol, CN^-, As, Hg and Cr as indicators of river pollution. In general the water quality of the large rivers still is of good quality, but an increasing degree of pollution has been observed since the middle of the 1970s. Due to the large river flow and relative high content of suspended matter the Yangtse River has a high dilution capacity. The very high silt content in the Yellow River is favourable for rendering pollutants inactive. Thus river pollution is most serious at industrial reaches of the large rivers and in some smaller rivers with a low water flow. Table 12 provides some average values of quality indicators from the large rivers recorded along the industrial reaches. Though in most case these values are below the state surface water standards, for instance Xiaoqing He in Jinan area Shandong is highly polluted with phenol pollution predominant. The values are 3 to 20 times higher than the acceptable standards. An analysis of 2 700 samples recorded in the low water period from the industrially polluted reaches of the Yangtse River has shown that 22.5 percent of the samples have a phenol content reaching or exceeding the national standard for surface water.

A lot of water research projects have started by concentrating on heavy metals and pesticides. A national river standard has been published and channel, drinking, irrigation, fishing and recreation water standards have been prepared but not published. In 1979 China also promulgated its first Environmental Protection Law, which aims to "ensure, during construction of a modernised socialist state, rational use of the natural environment, prevention and elimination of environmental pollution and damage to eco-systems in order to create a clean and favourable living and working environment, protect the health of the people and promote economic development" (Article 2). In accordance with the general principles in the Environmental Protection Act a more specified Water Resources Protection Act was said to have been published. Recently in May 1982 the General Office of Environmental Protection under the State Council, established in 1973, was merged into the new Ministry of Urban & Rural Construction and Environmental Protection. Under this ministry there are protection bureaux in the provinces. At every section of the Yangtse River and along its tributaries, a total of 172 water quality monitoring stations have been built. Such stations have also been established in the Yellow River and Huai River. At the central level environmental protection questions are coordinated between the small protection offices at each ministry. Through this reorganisation the environmental issues have received ministerial status in China.

Compared to the conditions before 1949 a tremendous amount of work has been done to harness and utilize the water resources. The question of preventing the water resources from being deteriorated by pollution has been a national concern at the end of 70s. There are four main factors behind these achievements. Firstly, the Chinese central political leadership and authorities have been aware of the great importance to harness the rivers and to use them comprehensively. Secondly China has, compared to other Third World countries, given high priority to rural and agricultural development, an approach which has been very important when implementing the flood resisting, irrigation and drainage construction works in the rivers. Thirdly the land reform accompanied by the cooperative movements in the 50s created the necessary atmosphere and institutional conditions to carry out the farmland and water capital construction works. Fourthly, only within the framework of basically cooperative ownership of the land and state ownership of water areas, has it been possible to mobilize the huge amount of people for the construction works.

CHAPTER 5.

WATER RESOURCES DEVELOPEMENT IN THE MAIN RIVER BASINS

Every large river basin has its own characteristics and problems in water resources development according to the geographical and demographical conditions prevailing in the basin. This chapter intends to give a brief idea of the problems and work done in the Hai, Yellow, Huai, Yangtse and Pearl River basins, based mainly on information which I received from talks and field trips during the visit to China in 1982.

THE HAI RIVER BASIN

The main water resources problem in the Hai River basin system is flood prevention in combination with seasonal lack of water both in total terms and in relation to the population of the area.

The rivers in the Hai basin have their sources to the west in the Taihang Mountains and to the north in the Yanshan Mountains. At Tianjin some of these rivers (Yongding, Daqing, Ziya, Da Yun or South Canal or a part of the Grand Canal) converge into the Hai River, then flowing into the Bohai Sea. The Chaobai River and Northern Canal to the north of Beijing-Tianjin and Tuhai and Majia Rivers north of the Yellow River in Shandong also belong to the basin, but they have their own outlets in the Bohai Sea. The total area of the basin is 264 600 square kilometres of which roughly a half is mountain area and the other part plain area, see table 13 and figure 8.

Table 13. Catchment area and annual runoff from the Hai River and Luan River basins.

	Catchment area	Annual runoff	
	km^2	km^3	mm
Hai River	264 600	22.6	85
Luan River	54 400	5.7	129
Total	319 000	28,3	89

The plain is a two crop per season area with autumn wheat followed by maize as the most common crop combination. Sometimes the Luan River in the northeast with a catchment area of more than 54 400 square kilometres is incorporated in the Hai River system.

The Hai River basin plain or the North China Plain is a fault depression. Eroded sand and silt, transported from the mountain areas by the silt-laden rivers, have accumulated in the depression, making it a vast alluvial plain. The thickness of the Quarternary sediment ranges from 350 m to 600 m. The elevation of the piedmont plain of the Taihang Mountains does not exceed 100 m and the height above sea level at the Bohai Sea area is 2 - 6 m, which means a surface gradient of 0,1 - 0,3 percent.

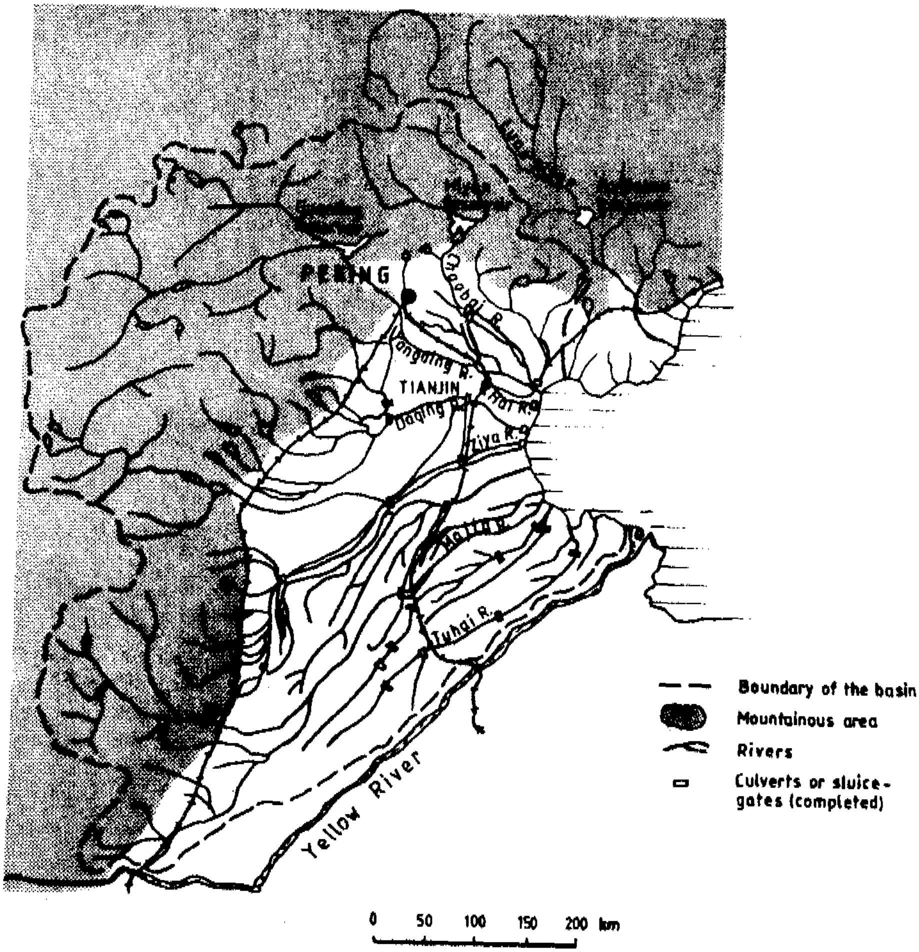


Figure 8. The Hai River Basin (Revised map from Beijing Review 39-1974)

Because of the gentle inclination from west to east the North China Plain is very vulnerable to waterlogging and salinization. It has near the surface a shallow fresh ground water aquifer with a high water table. There are a lot of low-lying lakes and marshlands. South of Beijing and Tianjin the alluvial plain contains four main ground water bearing zones. They have a base depth at 30-60 m respectively 150-200 m, 300-400 m and 420-540 m. The two upper zones are mainly saline aquifers, while the two lower zones contain fresh water. The first is replenished by atmospheric water, while the others are confined by a low rate of replenishment. The saline soils and the saline ground water has a genetic connection with the transgressions and regressions of the Bohai Sea and surface evaporation in the geological past.

The Hai River basin is a semi-arid and semi-humid area (see figure 4). The average annual precipitation is 500-600 mm. The maximum precipitation in a flood year reaches 900-1300 mm and the minimum precipitation in a dry year is 200-250 mm. Historical research has shown, that in the 580 years between 1368 and 1948 floods ravaged the basin 387 times and droughts 407 times. Recent research has shown that in the plain area, there is a meteorological cycle of 10 to 11 years with three humid years, four normal years and three dry years. Most of the annual precipitation or 60-80 percent is concentrated to the summer months of July, August and September.

The annual flow of the Hai and Luan Rivers only makes up 28.3 cubic kilometers or equivalent to 1 percent of China's total runoff (see table 4). But the population is more than 7 percent and the cultivated area 12 percent of China's total.

Before 1949 the North China Plain was one of the most poverty-stricken in the whole country. The maintenance of river courses and dykes in the Hai basin was neglected and in disorder. The waterdischarging capacity of the Hai River at the estuary was only 1 300 cubic metres per second. A flood in 1917 affected an arable area of 3.6 million ha and a population of 6.2 million. In nearly 20 000 villages many houses collapsed. The severe flood of 1939 caused the Yongding, Daqing and Ziya Rivers to break their dykes, submerging a farmland area of 3.3 million ha. Ten thousands of houses collapsed and some 20 000 people drowned or died of hunger. Most of Tianjin's streets were under two meters of water for two months, see figure 9. During the flooding prices of grain, fuel and other necessities were raised five to six fold in Tianjin. Neither could the authorities cope with droughts. In the 1920 drought rivers, shallow water wells, lakes and ponds dried up affecting farmland in 97 counties. In 600 villages in Xingtai County alone, over 11 000 starved to death.

In 1949 the new government immediately gave flood prevention a high priority. Dyke repairs were done first. Channels in the middle and lower reaches of the Chaobai and Yongding Rivers were dredged and a lot of flood diversion canals and drainage ditches were dug.

A vital part in any flood prevention programme is the building of reservoirs in the mountain areas.Besides protecting the lower reaches against flood, reservoirs provide water for irrigation, power generation, fishbreeding, industry and drinking. The Guanting Reservoir, one of Beijings two main reservoirs, was completed in 1951 after two and a half years work on the upper reaches of the Yongding River. It was the first large reservoir constructed in the Hai River basin. In total up to 1963 18 large, 41 medium-sized and about 1 000 small reservoirs had been completed.

Miyun Reservoir: The Miyun Reservoir is one of the biggest and most well-known reservoirs constructed during this period. It is located on the Chao and Bai Rivers about 75 km northeast of Beijing, where the Yanshan Mountain meets the plain. South of the reservoir the two rivers form the Chaobai River. The reservoir was constructed during the "Great Leap" Forward from September 1958 to September 1960. An average of 100 000 people worked at the construction site each day. They worked in three shifts and put in a

Figure 9. *Tianjin streets inundated in the 1939 flood* (After Ho 1975).

total of roughly 70 million eight-hour labour days. The total earth and stonework in the project amounted to 38 million cubic metres. The workers lived around the reservoir and 90 percent came from the area benefiting from the reservoir.

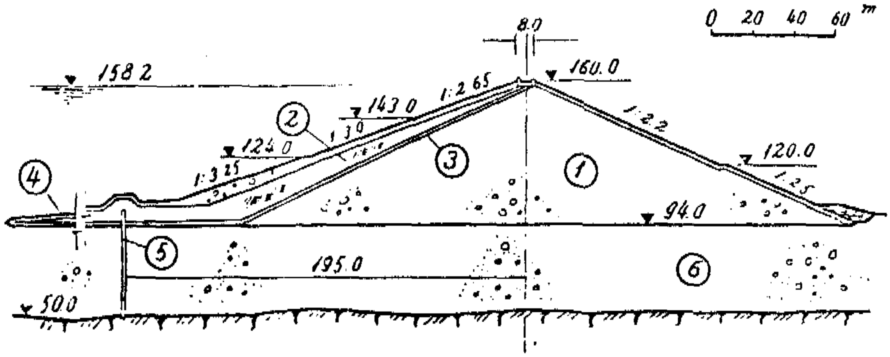
The Miyun Reservoir catchment area is 15 780 square kilometres, which is 88 percent of the whole Chaobai basin. The reservoir surface has an area of 188 square kilometres and the maximum designed storage is 4 400 million cubic metres.

The water was blocked by constructing two main and five minor dams. In total, those constructions have eight discharge channels and three flood spillways. The spillways have a maximum capacity of 9 000 cubic metres per second.

The 66 m high Bai River dam is the main dam. It is a sand and gravel earthdam with a sloping clay core, see figure 10. The dam is founded on a 44 m alluvium of sand and gravel. To resist earthquakes, holes have been drilled in rows 3 m apart at some locations in the alluvium and thereafter injected with reinforced concrete. The condition of the dam is supervised by various automatic control instruments. The ground water level downstream is 14 m below surface, which means that the seepage through the dam is very low.

Like most reservoirs in China Miyun Reservoir has been constructed for a multi-purpose use. Its main function is flood prevention, but it also serves for irrigation, urban water supply, electricity generation, fishery and recreation.

The 100 years peak flow is 9 700 cubic metres per second and the 1 000 years peak flow is 15 900 cubic metres per second. The reservoir cuts the 100 year peak flow by 80 percent. The flood control storage is 1 800 million cubic metres. Thus the total area protected from a 100 years flood is 410 000 ha downstreams in Beijing and Tianjin Municipialities and Hebei Province.



1. Sand and gravel
2. Clay
3. Filter layer
4. Clay blanket
5. Injected concrete diaphragm
6. Alluvium of sand and gravel

Height of dam:	66 m
Length of dam	960 m
Damfill:	11 million cubic metres

Figure 10. Crossection of the Bai River Dam, Miyun Reservoir (After Nickum 1977a)

At the maximum 1 900 million cubic metres could be used for irrigation and water supply. About 3/4 of the amount irrigates an area of 270 000 ha. The introduction of irrigation and the application of fertilizers has increased the crop yield from 1.5 ton/ha to more than 6 ton/ha. Two crops per year have been common. Another 1/4 is channeled to Beijing and Tianjin to be used in industry and households. Beijing is supplied by a 104 km long concrete and earth canal with a maximum capacity of 60 cubic metres per second. The water to Tianjin is first released into the Chaobai River and then led by an artificial canal to Tianjin. The maximum capacity for Tianjin water supply is 100 cubic metres per second.

The main power station is at the Bai River dam. There is also a small one at Chao River dam. The total generating capacity is 71 000 kW. Electricity is generated during the irrigation season in spring and autumn or when it is needed to satisfy a peak demand in Beijing.

The fishing in the reservoir is controlled by the Beijing Agricultural Bureau. Only the people, who before the impoundment lived in the reservoir area, are allowed to fish there. Every year 15 million smolts of carpfishes etc are raised in the ponds downstream of the Bai River dam by the Bureau. The annual catch is about 1.5 million kg. In 1972, the catch from the Miyun Reservoir constituted 60 percent of the freshwater fish supply to the Beijing market.

In later years a part of the reservoir near the Bai River dam is being developed as a recreational area. Leisure boating is allowed and the reservoir management committee has plans to build a restaurant and a hotel.

The reservoir is managed by the Miyun Reservoir Management Committee under Beijing Water Conservancy Bureau. However, the allocation of water is decided by the Ministry of Water Conservancy and Power, because the reservoir supplies water not only to Beijing but also to Tianjin and Hebei. The Committee has about 600 employed. Management committees all over China like the Miyun strive to have a high degree of self-reliance. That is, why only about 100 of the staff are maintenance and management workers (including 20 technicians). The Committee runs a hospital (!), has orchards and forests. Below the two main dams they grow apples and pears, producing 500 000 kg/year. The catchment above the reservoir is being developed for forestry and the Committee controls an area of 1 330 ha near to the reservoir. But most of the 15 780 square kilometre catchment area has not been planted for forest, because of its very thin soils and steep terrain.

Water samples are taken twice per month in the reservoir and the inlet rivers according to the national regulations for large and medium-sized reservoirs. The water was said to be and seemed to be of good quality with an average pH value around 7 and secchi transparence around 2 metres. There are no industries upstreams. After sedimentation and chlorination the water is used for drinking in Tianjin and Beijing. The water charge is 30 Yuan per ha and 0.15 Yuan per cubic metres for city use.

The total construction costs for the whole Miyun project was 2 500 million Yuan, a sum which included the daily expenses for the labour. Fifty-seven villages with 50 000 people had to be relocated from inundated land to villages benefiting from the reservoir. About 10 000 ha of arable land was flooded. On the other hand, the construction of the reservoir has meant a potential to reclaim 70 000 ha along the Chaobai River, a reclamation which still goes on.

Water Conservation Works during the 60s and 70s: Thus the water conservation projects undertaken during the 50s have had great impact on the economical development thereafter, as the Miyun case shows. However, concentrating on reservoir building was not enough. In 1963, the century's heaviest rains fell continuously in the Taihang Mountain eastern foothills causing peak flows in the southern Hai River tributaries. The total waterflow from the upper streams nearly doubled that of 1939. Ten large reservoirs managed to store 46 percent or 4.2 cubic kilometres of the total volume. But still a peak flow of 78 000 cubic metres per second had to be carried through the rivers in the plain area. Large areas of farmland were flooded in Hebei. Tianjin was saved only after massive labour work from the Army and several hundred thousands of civilians.

This unprecedented flood caused the politicians and authorities put forward the slogan "The Hai River must be brought under permanent control". The way to basically change the situation was to increase the discharging capacity in the plain area. In the winter season of 1963/64 already more than 1 million people worked in key projects. In addition, a lot of other people were engaged in supplementary projects in the localities. In the year between 1963-1973 thirtyfour trunk waterways with a total length of 3 700 km were dug or dredged in the middle and lower reaches. During the ten years 4 300 km of flood prevention dykes were built, more than 270 tributaries and 150 000 canals or ditches dredged or dug and 60 000 bridges, waterlocks and culverts constructed. In Hebei 5.3 million people out of a total population of 41 million took part in harnessing the Hai River on different occasions. All these combined measures have increased the flood discharging capacity in the Hai Delta from the original 4 600 cubic kilometres per second to 24 680 cubic kilometres per second and the capacity for the removal of excessive rainfall runoff from waterlogged areas increased from 400 cubic kilometres per second to 2 100 cubic metres per second. At present the Hai He valley is basically free from the menace of floods and waterlogging.

The decisive work was then to increase the discharging capacity, which does not mean that other water conservancy works were neglected. Since the middle of 60s droughts have been combated by drilling about 600 000 groundwater wells to the various zones already mentioned. In Hebei between 1963-1978 49 large or medium-sized reservoirs have been built or enlarged, 1100 small reservoirs built or enlarged and 170 large-sized irrigation projects completed. In the whole basin, nowadays, there are 80 large and medium-sized reservoirs and more than 1 500 small reservoirs with a total storage capacity of all reservoirs above 20 cubic kilometres. In the part of the basin situated in Hebei province, the irrigated area has been increased to 3.5 million ha, 1.3 million waterlogged area has been drained and 513 000 ha saline and alkaline land has been improved. Since the beginning of the 70s the North China Plain is self-sufficient in grain. The per capita grain availability for the Hebei-Beijing-Tianjin region has increased from 201 kg in the 1952-1954 period to 284 kg in the 1978-1980 period.

Along with the labour intensive investments of water conservancy projects new problems have come up closely related to the population increase of the area, see table 14. The population density has reached 321 inhabitants per square kilometre, but the water availability from the runoff is only 389 cubic metres per capita. Thus a situation has arisen, where there are enough storage facilities, but not enough water to fill up the reservoirs in dry years. This problem has been very much accentuated during the severe dry years of 1980 and 1981. The drought was first alleviated in July 1982, when the summer rain began to fall. In July 1980 the drought-stricken area in the Hai basin reported to 2.8 million ha and more than 1 000 reservoirs of all sizes were dried up. In 1981, 82 of Beijing's 84 reservoirs were dried out. Beijing and Tianjin were forced to ration water in 1980-1982. This is a completely new situation compared to the beginning of the 70s, when e.g. Beijings water supply was described as ample.

Table 14. Area, population and population density of the Beijing and Tianjin Municipalities and Hebei Province.

	Area Million ha	Population Millions		Population density Inhabitants/km^2	
		1953	1982	1953	1982
Hebei	19,0	33,56	53,01	175	279
Beijing	1,68	4,51	9,23	268	549
Tianjin	1,1	4,53	7,76	412	705
Total	21,78	42,40	70,00	195	321

Beijing Water Supply: The water supply to Beijing is quite illustrative. The natural surface water resources in the reservoirs (Guanting, Miyun etc) is 2 cubic kilometres equivalent to only 217 cubic metres per capita. The ground water resources are calculated to be 3 cubic kilometres. But in 1980 already 4.6 cubic kilometres were used, see table 15.

Table 15. Utilization of water resources in Beijing Municipality.

			Groundwater	Surface water
User	km^3	Percent	km^3	km^3
Agriculture	3.0	65	1.65	1.35
Industry	1.3	28	0.65	0.65
Domestic	0.3	7	0.3	-
Total	4.6	100	2.6	2.0

Source: Chen 1982 & Beijing Bureau of Geology 1982.

With limited surface water resources, ground water utilization has been very important during the 70s. Beijing abstracts most of its groundwater for industrial and domestic use from the Yongding and Chaobai alluvial fan areas. Of the seven water plants in central Beijing five are supplied with ground water. About 42 000 ground water wells have been drilled within the Beijing administrative area of which 40 000 are irrigation wells and the other 2 000 industrial and municipial wells. The irrigation wells irrigate an area of 200 000 ha. The intensive use of ground water has in the central part of Beijing lead to an over-exploitation. Before 1970 there was no change in the lowest groundwater table, but since that time the lowest ground water table has sunk to about 1-1.5 m/year, resulting in a depression cone of 100 000 ha. The occurrence of depression cones have also developed in some other parts of the Hai River basin, caused by over-utilization of the deeply confined freshwater aquifers.

To remedy the water shortage situation in Beijing I was told that a lot of measures have been taken or are at the planning stage. In the case of the Beijing water supply the joint utilization and management of ground water and surface water is the guiding principle. Some of the future plans for the Beijing Municipality are:

1. Surface water should mainly be used for irrigation and ground water for municipial and industrial use.

2. Guanting and Miyun Reservoirs should be used in dry years because of their large storage capacity.

3. Increase and protect ground water resources by developing artificial recharge. Since 1974 recharge experiments have been carried out in gravel pits and some large wells in the Yongding alluvial fan in western Beijing, *using surface water from the Miyun Reservoir. The recharging capacity has* been 2 cubic metres per second in the largest gravel pit and 0.5 cubic metres per second in the largest well.

4. Gradually develop new water resources in order to alleviate the water stress in central Beijing and its suburbs. Most of the water resources have already been exploited, but it is possible to use more groundwater from the Chaobai alluvial fan area both north and south of the Miyun Reservoir. The Jiuma River southwest of Beijing could also be used for water supply.

5. Increase the amount of water, which could be recycled within the industrial sector. About 70 percent of the water used in industry is for cooling. At the end of the 70s the industries in Beijing only recycled about 30 percent, whereas in many places in the world the recycling rate is 50 to 60 percent. In eastern Beijing low permeability aquifers could be used to store cooling water, which could be reused the following summer for air conditioning. About 60 to 80 percent of the original cooling water could be saved by using the storage water.

6. Construct more sewage water plants. At the end of end of the 70s Beijing had two sewage treatment plants, treating only 8 percent of the 1.8 million tons of sewage water and industrial waste water. Part of the processed water will be used to irrigate farmland.

7. Vigorously develop the geothermal resources in Beijing in order to relieve the pressure on urban water supply and to improve the environment.

8. Work out uniform rules for ground water exploitation and establish a ground water monitoring network. In this field Beijing is at the front line in China. No industry or other unit is nowadays allowed to drill a new well without having a licence from the Beijing Water Resources Committee.

Against this background of a growing demand on ground water also in other parts in China, the State Council set up a National Groundwater Research Institute in August 1982. One of its main tasks will be to establish a nationwide ground water network, which could supply data for the overall planning and protection of ground water.

Tianjin Water Supply: The water supply is even more serious in Tianjin than in Beijing. Tianjin is in normal years supplied with water from nearby reservoirs and with 600 million cubic metres from the Miyun and Guanting Reservoirs. There are no new aquifers to be exploited. The ground water has been over-used in recent years leading to serious land subsidence. Earlier in 1972, 1973 and 1975 water had to be diverted from the Yellow River through the People's Victory Canal (Renmin Shengli Canal) by the Wei River and the Grand Canal to Tianjin, figure 11. In mid-august 1981 the State Council had an emergency meeting and decided to use the Miyun and Guanting Reservoirs only for Beijing's water supply the coming spring of 1982 and once again divert Yellow River water to Tianjin.

This time a total of 650 million cubic metres was planned to be diverted, which meant that the People's Victory Canal had to be dredged and two other canals, the Weishan and Panzhuang Water Canals, had to be expanded. All the dredging, excavation and construction works had to be done within three months during the autumn harvest and sowing period.

Under the leadership of a group at the State Council, headquarters were set up by the central and local authorities. Eight thousand cadres and 640 000 civilian workers were mobilized to work with thousands of trucks, water pumps, tractors, handcarts, picks and shovels. Altogether 33 million cubic metres of earth were moved. From October 15 to January 5 the People's Victory Canal and from November 27 to January 15 the Weishan and the Panzhuang Canal, together transferred 701 million cubic metres. As much as 65 percent or 451 million cubic metres reached Tianjin, filling up the water need for the spring season. The state allocated 260 million Yuan for the project. About 20 percent of the sum was used as economic compensation to the brigades along the canals. The whole project was completed so rapidly and successfully, that the vice minister of Water Conservancy and Power Li Boning in Beijing Review 34-1982 commented; "This cannot but be regarded as a miracle in the history of China's water conservancy construction".

With the diversion project in 1981 the immediate water shortage in Tianjin was solved. To cope with the longterm water need the second largest water conservancy project under construction in China is progressing at Panjiakou in Luan River basin 190 km northeast of Beijing, see figure 8. It is only smaller in scale to the Gezhouba dam project, see page 108. It involves the construction of a large reservoir, two middle-sized reservoirs (Daheiting and Yuqiao), a power plant and two water transporting canals to Tianjin and Tangshan. The large Panjiakou Reservoir dam has a height of 107.5 m and a length of 1 040 m. The reservoir has a maximum storage capacity of 2 930 million cubic metres. The usable capacity is 1 950 million cubic metres. A power house of 450 MW is now being constructed. The dam controls 75 percent of the Luan River basin and about 50 percent of its total flow. (Deng 1982). The work with the Tianjin water transporting canal started in May 1982 and the whole diversion project was completed far ahead of the original schedule in June 1983. The total length of the canal is 234 km. It includes the Daheting and Yuqiao Reservoirs, a 12.39 km long diversion tunnel, the dredging of two river sections totalling 108 km, the digging of a 64 km surface canal and a 26 km underground canal, three large pumping stations and a 500 000 cubic metres water treatment plant. In all, the diversion has involved 215 separate projects, 28,7 million cubic metres

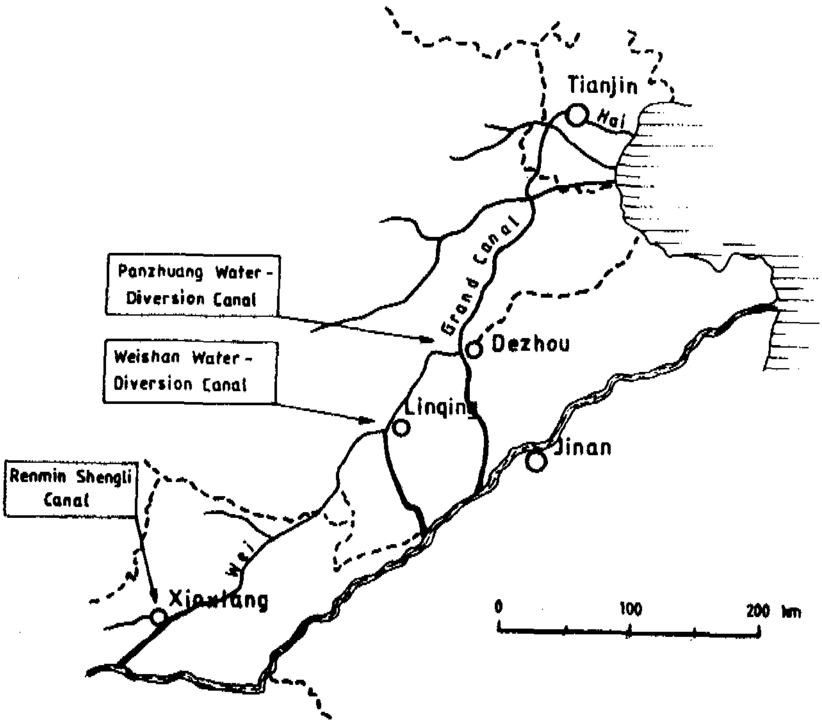


Figure 11. The Yellow River-Tianjin Diversion Scheme (After Beijing Review 34-1982).

of earth and stonework and 800 000 cubic metres of concrete work (Deng & Liu 1983; Hai 1983; World Water, August-1983).

The most difficult part of the construction was the diversion tunnel through a spur of the Yanshan Mountain near to the Luan River. The tunnel had to be cut into a weathered, fragile, gneissian rock. It had to pass more than 20 fault zones, including some with a width of more than 30 metres, so that it had to be reinforced and lined with a technique never used in China before. To speed up the construction 15 inclined shafts were sunk through the mountain slopes to reach the base of the tunnel. Each of the 32 work teams excavated on average 3 m of rock per day. The construction of the tunnel would have taken 15 years, if the conventional method of tunnelling from two ends had been used. The tunnel with its capacity of 60 cubic metres per second was chiefly constructed by 12 000 members of the People's Liberation Army and the 11th Railway Engineering Corps. Another labour-intensive part of the project was the excavation of the surface canal, which was dug by about 100 000 workers from Tianjin, mainly with pick and shovel. This work was completed in 52 days instead of the planned four months.

Tianjin nowadays is supplied with 1 000 million cubic metres of water annually by the diversion project. With the completion of the project the costly temporary emergency diversion measures from the Yellow River are no longer needed.

To solve the shortage problems for the entire Hai Basin the Ministry of Water Conservancy and Power is considering the diversion of water from the Yangtse River to the North China Plain. There are plans to divert the tremendous amount of 1 000 cubic metres per second or about 30 000 million cubic metres per year (see page 114). But other solutions have been proposed. Professor Huang Wanli at the Qinghua University in 1979 suggested, that it would be better and much cheaper to store water in underground reservoirs. According to his estimation, there are 1.5 million ha of abandoned riverbeds with a storage capacity of 39 000 million cubic metres in the North China Plain, which could be used for the long-term solution of the North China Plains lack of water.

heaviest being 768 mm. During all these nine floods the dykes and embankments had stood firm. By reinforcing the dykes and dams, building flood retension basins in the lower reach, constructing reservoirs in the whole basin and dredging and widening the river course, dyke breaks have been avoided. The 155 large and medium-sized reservoirs built have a total storage capacity of 56 300 million cubic metres or similar to the average annual flow of the river.

Like the Hai River basin the Yellow River basin has the same uneven precipitation pattern, which means that dry periods are common. Before 1949 they were disastrous. In the 1920 drought 500 000 people starved to death in Shaanxi, Shanxi, Henan, Shandong and Hebei. The 1942 drought was even worse. In Hebei, Henan and Anhui 3 million people starved.

Droughts have been combated by the withdrawal of water from the reservoirs and diversion directly from the river to irrigate farmland. Since the middle of the 60s the drilling of ground water wells has been more and more common. Along the northern bend in Ningxia and Nei Monggol 12 000 million cubic metres is drawn for irrigation each year. The second largest irrigation area is situated around Zhengzhou, where around 10 000 million cubic metres is drawn each year. From the tributaries of the Wei River in Shaanxi and the Fen River in Shanxi a further 3 000 million cubic metres is drawn. Thus in the beginning of the 80s a total of about 25 000 million cubic metres is used annually for irrigation. Within the basin the irrigated area has expanded from 0.8 million ha in 1949 to 3.3 million ha in 1979. A further one million ha is irrigated outside the basin by the withdrawal of water in the lower reaches.

Mangshan Pumping Station: Northwest of the city of Zhengzhou the Mangshan Pumping station is situated at the southern bank of the Yellow River. This station was constructed between 1970 to 1972 by the Henan Provincial Government, Zhengzhou City and four People's Communes. The construction work included 4 million labour days. More than 3.5 million cubic metres of earth and stonework was dug. The total investment was 7.28 million Yuan.

The project involves the pumping of water in two stages up the Mangshan loess hill. In the first stage 16 pumps with a total design capacity of 10 cubic metres per second lift the water 33 m. The second stage is only used during the irrigation season, when two pumps with a total capacity of 1 cubic metre per second will lift the water further 53 m. The silt in the water from the first stage is settled in 10 basins and the water is then led 40 km through an open lined channel, 6 tunnels (3 400 m) and 3 aqueducts (788 m) to Zhengzhou. Seventy percent of the annual pumped water is for the drinking and industrial water supply of Zhengzhou. About 80 percent of the city's need comes from the Yellow River and 20 percent from ground water. Thirty percent of the annual pumped water from Mangshan is used for irrigation. The benefited area is 6 000 ha.

The high silt content in the water means big operational and economic problems. The average annual silt content is around 10 kg per cubic metres, however once a maximum value of 200 kg per cubic metre was recorded at Mangshan. The main particle size is 0.02 mm to 0.03 mm. Because of erosion-corrosion damage the pumps have to be repaired or changed after 2 500 hours, sometimes pump wheels are worn out after only 400 hours. Erosion-corrosion damage to different pump type designs has recently become a new important research topic at the Hydraulic Department, Qinghua University.

Like the Miyun reservoir and other similar projects, which I visited, Mangshan Pumping Station is being developed into a recreational and tourist scenic spot facing the Yellow River. More than 65 ha of the loess hill-slopes, which surrounds the pumping station, have been terraced and planted with ordinary trees, fruit trees and flowers. It was to the Mangshan hill Mao Zedong came on an inspection tour 30.10 1952, when he exclaimed the national call "Work on the Yellow River must be done well". In 1958 Zhou Enlai also visited the place, when he inspected the construction works of the 3 600 m long road and railway bridges, crossing the river near the pumping station. The hilltops have been decorated with pavilions and on one of them a huge statue of the Chinese water conservancy father Da Yü will soon be erected.

The Yellow River Commission: The management organisation etc of the Yellow River is rather complicated. The Yellow River Commission became the first river basin commission, when it was established in 1950. It is directly subordinated to the Ministry of Water Conservancy and Power and has its office in Zhengzhou, where also the Yellow River Exhibition Centre is situated. The Yellow River Commission is in charge of the planning of the entire basin. Besides planning work it runs research institutes like the Hydraulic Research Institute and Planning & Design Research Institute. It also runs a middle standard Water Conservancy College etc. and operates the main hydrological stations in the basin. In executing its duties the Yellow River Commission has to consult closely with other units, especially the provincial bureau of water conservancy, for instance the Shaanxi Provincial Soil and Water Conservation Bureau. The provincial bureaux are in charge of the water conservancy works in their provinces.

The first planning of the comprehensive utilization of the Yellow River was carried out from 1953 to 1955. The planning report was approved by the National People's Congress in 1955. The report was rather technical and optimistic in its visions. It has continuously been revised, due to economical and social reasons. The 1955 report proposed 46 dam sites in the main stream and a total installation of 26 million kW in the whole basin. The flood control flow was set at 36 000 cubic metres per second and the irrigated area was planned to 10 million ha. The planned area to be under soil conservation was set to 30 million ha.

In comparison the present plans up to 2 000 are; the total installation of hydroelectric power should be 17 million kW, the flood control flow is increased to 46 000 cubic metres per second, the irrigated area is planned to 6.7 million ha and the soil conservation area planned to be 11.4 million ha. At least the power installation goal up to 2 000 still looks rather optimistic, when compared to the present 2.4 million kW installed in the main stream, see table 16.

Table 16. Hydro Power Stations in the Main Yellow River Stream

	Drainage area	Total reservoir design volume	Height of dam	Installed capacity
	Million km^2	km^3	m	MW
Lungyanxia *	131	24.7	170	1 600
Liujiaxia	182	5.7	147	1 225
Yanguoxia	183	0.22	57	352
Bapanxia	216	0.049	33	180
Qingdongxia	275	0.62	43	272
Tienqiao	404	0.68	42	128
Sanmenxia	688	9.6	106	250

* Under construction

Source: Cheng 1979 and Yellow River Commission (Cf. Qian & Dai 1980, table 4).

Besides the Yellow River Commission and its subdivisions and the provincial bureaux, there are separate management units for allocation of water, flood prevention and dyke control. The Regulation Committee seated in Lanzhou is a coordinating unit of the nine provinces in the basin. Every province must present a water use plan to the Committee for the next drought season. Then the Committee decides the allocation of the available water, which could be used by the provinces. After the allocation, the provinces can chose the best suited crop combinations.

In the drought season all the main reservoirs are operated by the Yellow River Commission. However during the flood season the reservoirs are under direct control of a Flood Regulation unit at the Ministry of Water Conservancy and Power. There are also provincial Dyke Control Bureaux.

Sedimentation in reservoirs is a serious problem in the Yellow River basin. The large Sanmenxia Reservoir, built between 1957-1960, had to be reconstructed between 1966-1973. Before the impoundment very small amounts of silt were deposited in the alluvial valley above the dam site. But between 1960-1970 the enormous amount of 5 310 million cubic metres of silt or 55 percent of the design capacity was deposited in the reservoir, causing retrogressive backwater deposition and water logging problems for a distance as far west of Xian city in the Wei River valley. Downstream the dam, the clear water released from the reservoir caused erosion of the riverbed. The reconstruction of the reservoir was done in order to minimize the silt deposition. For this reason the flood discharging capacity was increased more than three times. The reservoir is nowadays operated at full discharge capacity, when the sediment load is high. During the dry season, when the sediment load is relatively small, the reservoir stores clear water for irrigation and power generation. Thus, after the reconstruction the amount of sediment deposition and erosion has been balanced in one year and the storage capacity has not decreased since then. The Yellow River Commission is trying to adopt this operation scheme at other reservoirs in the basin. Research done by the Commission has also shown, that the major part of the deposits in the lower Yellow River is composed mainly of coarse particles larger than 0.05 mm, coming from the central gullied hilly loess region in the middle part of the basin. Thus the main reason for the accumulation of silt in the Sanmenxia Reservoir and other reservoirs is the extensive areas of barren loess lands along the middle reaches of the Yellow River. This means, that soil conservation is the only long term solution to the various Yellow River problems. The Chinese seem to have identified the importance of soil conservation including afforestation much more during the 50s than the 60s. Today they state, that during the 60s to much attention was put solely on water conservation. But since the end of the 70s soil conservation again is considered as the basic measure for a successful water conservation.

Soil Conservation in Shaanxi Province

Various national authorities have given soil conservation measures a high priority in national planning the last five years. Under the State Council there is a coordinating soil erosion committee in which the Ministry of Water Conservancy and Power is represented by the chairman. In 1979, China got its first Environmental Protection Law, stating the principle to "use the land rationally according to local conditions, improve the soil and increase the vegetation to prevent soil erosion, hardening, alkalinization, desertification and water losses" (Article 10, chapter 2). The first National Forestry Law was also promulgated that year.

In 1982 these general laws were followed by the "Regulations governing the work of water and soil conservation" promulgated by the State Council. Article 7 stipulates, that "it is forbidden to open up and plant crops on slopes with a gradient of more than 25 degrees". In the summer of 1982 the 4th National Soil Conservation Conference was held in Beijing. It concluded, that soil conservation is a lifeline in the mountain and hilly areas and fundamental for flood control.

The Loess Plateau region has the most serious erosions problems in China, see figure 5. It is surrounded to the north by the Great Wall, to the east by the eastern fringe of the Taihang Mountains, to the south by the Qinling Mountain range and to the west by the border of Qinghai province. The Yellow River traverses its central part. The total area is 53 million ha of which the yellow earth covers 32 million ha. The average altitude of the plateau is about 1 000 m above sea level. In the western part the altitude could reach 2 000 m and in the southern part in Wei River valley the altitude is around 400 m.

The predominantly sandstone bedrock in the region is covered by thick deposits of loess. The average loess depth is 50 m with a normal range between 5 - 100 m. Around Lanzhou in Gansu maximum loess depths of 250 m have been recorded. It is believed that the weathering of blocks and stones in the deserts to the north and west of the Great Wall is the main source of loess. Since the late period of Early Pleistocene strong winds have moved the weathered dusty material and deposited it in the Loess Plateau area. This process is still going on, which also means that the upper layers are more sandy than the lower layers. The loess has a silt content above 50 percent and is mostly calcareous. Probably due to its clay content, it will develop a columnar structure after being water eroded.

The most typical loess soil in China is called a Heilutu soil, which could be described as a slightly argillic chernozemlike soil with a clay content around 20 percent and an organic matter content around 1 percent. In the drier western part of the plateau the soils change to sierozems (grey desert soils). In the Wei River valley the soil is named Loutu soil, which due to cultivation is a very well developed agric drab soil.

Because the loess is very friable and loose and has a high infiltration capacity (see table 17) it is very exposed to water erosion. The combination of newer and older yellow earth layers makes it also vulnerable to landslides. The plateau is mainly situated in the semi-arid zone, where drought condition occur every three years. But in the rainy season from July to September the rainfall intensity can be very high as figure 13 shows.

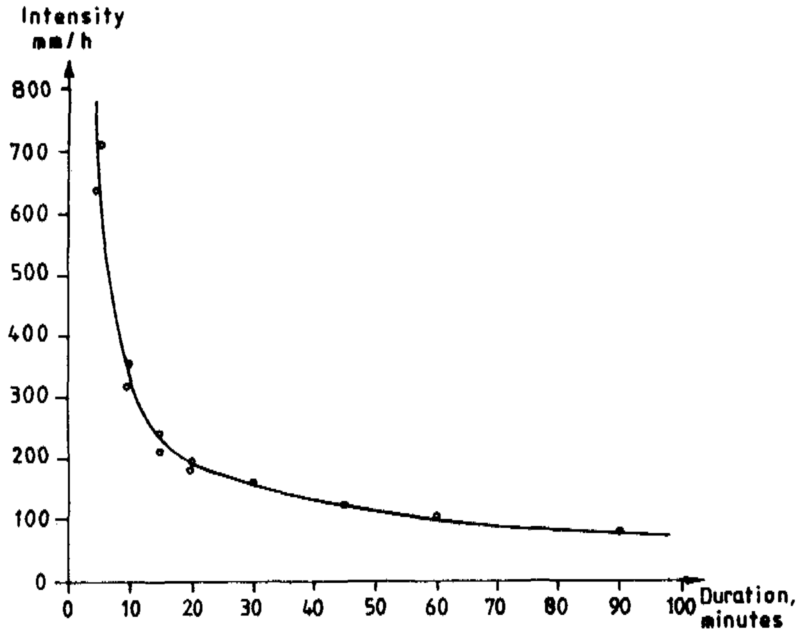


Figure 13. Maximum storm runoff intensity at various locations on the Loess Plateau 1969-1978 (Adopted from Bullentin of Soil and Water Conservation 1-1982 /in Chinese/).

It is the unfavourable combination of a very erodible soil and very erosive rainfalls, which makes the soil erosion so serious on the Loess Plateau. The forest cover is only 5 percent and the plateau has an uneven topography over an area of 43 million ha.

Studies in small basins have shown, that practically all the eroded soil is transported out of the basins and into the tributaries of the Yellow River. The average annual silt removal is more than 20 000 tons per square kilometre in the central area (see figure 5). At Sanmenxia the average annual silt transport in the Yellow River is 37.6 kg per cubic metre with a maximum recorded value of 666 kg per cubic metre. The highest maximum silt concentration recorded in the whole Loess Plateau area is 1 570 kg per cubic metre, a value reached in the Huangpu tributary.

Shaanxi province has the most serious soil loss. About 13.3 million ha in the province belongs to the Loess Plateau of which 10.1 million ha is counted as the soil erosion area. About half of the annual Yellow River silt load or 800 million tons is derived from the Shaanxi part of the Loess Plateau. There are two main loess landforms in Shaanxi. They are named the gully hilly area and the gully plateau area. Another important soil conservation area is the wind-sand area to the north of the gully hilly area. There are also some minor basin lands and stone mountain areas at the plateau. Some detailed information of the various landforms in Shaanxi is given in table 17.

The wind-sand area: This transitional zone to the Loess Plateau is situated along and south of the Great Wall in the Yulin Prefecture. The climate is semiarid with 350-450 mm of annual precipitation. The topography is high and rather flat. The principal soils is a windblown sand, which means a high infiltration capacity. Thus water erosion is less serious in this area. Because of the rather flat topography and an impervious basin floor underneath the sandy soil, the ground water is just 1-2 m below the surface in the depressions. There are about 120 small lakes, which are important for the local fish production. It is also possible to grow rice as an ordinary crop with average yields around 3 750 kg/ha.

Wind erosion is severe in the winter and spring season. The predominantly northwesternly winds create heavy sandstorms 19-20 days/year, when "you can not see a person a couple of metres in front of you". New sand dunes continually develop. The scarce original vegetation belongs to the steppe vegetation with sand-adopted shrubs as the most typical plants.

The main aim with the conservation measures in this wind-sand area is to combat the strong winds and to stabilize the sandy soils. In future this area is planned for a grazing and forestry base, where grain crops are grown only around Yulin. It is not unusual for the sand and water area to be used together. What is fundamentally called farmer's land is constructed by levelling sand dunes with the help of water. At many location a network pattern of planted grass is used to stabilize the sandy soil. In already stabilized areas the farmers use a rotational crop pratice system and plant protective trees around their fields. A wide protective forest shelter belt is planted along the Great Wall and protective forests are planted around the lake basins.

Table 17. Some information about the natural conditions in the Loess Region in Shaanxi Province.

Location	Straight distance, km	Geomorphology	Soils	Infiltration capacity, mm/min	Bioclimatic zone	Crops/Year	Main Crops
Xian	0	Low plateau land					Winterwheat, maize, cotton, vegetables, pepper
Wei River	15	Alluvial river basin	Lowtu	0.1 - 0.2		2	
Sanyuan	45	Low plateau land			Semihumid		
Tongchuan	95	Upper plateau land				3/2	
		Mountain forest steppland					Maize
Huangling Luochuan	125	Gully plateau area			Semihumid/ semiarid decidious		Maize, millet, winterwheat, sorghum,tobacco soybeans, buck-wheat
Yanan	265	Gully hilly area	Heavy Heilutu		Semiarid forest stepp	1	
Yulin	465	Wind-sand area	Light Heilutu	0.6 - 1	Semiarid stepp		Maize, rice, millet

I was told that altogether 227 000 ha of land had been terraced and/or laid under irrigation between 1950-1981, which was about 34 percent of the total cultivated area. Around 2 250 reservoirs had been constructed. Where the land is irrigated, it gives an average grain yield of 3 000 tons/ha. The total grain yield has increased 3.4 times between 1949 to 1977 or from 175 000 tons to 600 000 tons. Despite all the good work done in soil and water conservation, the per capita grain production is only 260 kg per capita or about 70 kg below the national average at the end of the 70s. It means, that this remote wind-sand area with its harsh environment still is very poor.

The gully hilly area: South of the wind-sand area and mostly in the Yanan Prefecture the 6.5 million ha big gully hilly area is situated. Its northernmost part belongs to the semi-arid zone (400 - 550 mm), but its southernmost part is semi-humid (600 - 700 mm). Around 60 percent of the annual precipitation occurs in July-September. The area is covered by a thick yellow earth. The bare round-shaped loess hills dominate the landscape and make it very beautiful. The hills are separated by deep gullies, which sometimes are widened to valleys. Because of the population pressure in the area, the hilltops and the steep slopes are usually cultivated. On the hilltop the farmer sows winter wheat, on the slope millet and some buckwheat and at the gully bottom or in the valley maize. In the north and central parts the length of the gullies are 5 - 7 km per square kilometres and the average soil loss 15 000 - 30 000 tons per square kilometre. Further to the south the length of the gullies has decreased to 3 - 4 km per square kilometre and the average annual soil loss to 10 000 - 15 000 tons per square kilometre. The average annual soil loss in some forest steppe areas is 100 - 1 000 tons per square kilometre.

The conservation policy of this area is to control the erosion both on the hillslopes and in the gullies. The area is planned to be a husbandry, forestry and fruit base. It will only strive for self-sufficiency of food grains. The Chinese's have adopted a lot of engineering and other measures to implement this policy.

1. Bench-terracing is practiced. The design is carried out to conserve for a hundred mm rain storm. The terraces do not need any drainage, because of the high infiltration capacity. The terraces are generally constructed from the gully bottom and upwards. Usually the construction team manages to terrace the whole slope in a season. They construct the terraces by taking the topsoil from the upstream slope and thereafter laying it on the downstream slope, see also the experience of the Liu Lin Brigade on page 78.
2. A series of siltation dams have been constructed in the gullies, see further the experience of Xio Shi Guo Brigade on page 80.
3. In the big gullies reservoirs are constructed with a special dam building technique using the local material. After the reservoir area has been silted up, it will be used for cultivation, see information about the Fan Tai Earth dam, on page 83.
4. Where it is possible trees are planted on the hilltops and grass species are sown on the slopes. Rather successful experiments with air seeding have been carried out since 1979, see further information on page 86.
5. Wherever it is possible, trees and shrubs are planted within the gullies. The vegetation cover will support the animal husbandry development and the firewood production. Sometimes gullies and hillslopes are "fenced off" to keep cattle and people away. This has proved to be a very effective way

to give the natural vegetation or replanted vegetation a chance to reestablish itself. Some common trees, shrubs and grass species used for soil conservation in Shaanxi are given in table 23 on page 85.
6. The farmers are recommended to practise ridging, contour bunding and to carry out tillage operations on the contour. Various inter-planting combinations are also recommended, for example maize and soybeans, in order to get a maximum vegetation cover during the storm period.

The gully plateau area: This geomorphological Loess Plateau unit is situated between the gully hilly area in the north and the Wei River plain in the south. The total area is 2.4 million ha. The climate is alternatively semi-arid and semi-humid (500-700 mm). The average annual temperature is 3-5^{o} lower than in Xian. Spring and summer droughts are some times very severe and the plateau is characterized by autumn frosts and dry winds. The topography increases from 800 m in the south to 1 200 m above the sea level in the north. The plateau land is rather gentle and has a slope of just 2-5 percent. This tableland is intersected by numerous gullies with depths from 50 m up to even 150 m. The most serious soil loss problem is the gravity gully erosion. If it is not controlled a gully will be come wider and wider and eventually erode the whole plateau into a gully hilly area. The original natural vegetation should be a decidious broadleaf forest. But most of the forests have been cut in order to gain agricultural land. The maximum soil loss is 3 000-5 000 tons per square kilometre and year. The principal crops are millet, winterwheat, maize, tobacco and soybeans. Where it is possible to exploit the deep ground water the crop yields can be very good. The area is famous for its use of oxen as draught animals.

The main conservation tasks are to stabilize the gullies and to construct fundamentally agricultural land upon the plateau. The relatively flat plateau is levelled and where needed terraced. The plateau edges are terraced and the terraced land is mostly used for orchards. At the gully crest a retaining wall is built to take care of the drainage water coming from the plateau area. Small reservoirs could sometimes be built at the gully crest. The reservoir bottom is sealed with red clay earth and the water is used for irrigation. The gully slopes are planted with trees or sown with grasses, if it is not possible to make the gully bottom into new grain fields. In some narrow gullies a comprehensive dame use system has been constructed. A series of siltation dams are constructed from the top of the gully downwards, but the lowest dam is utilized as a reservoir. The reservoir water is then used for gravity irrigation of the valley bottom. At some locations silty flood water is used to overflow into poor agricultural land. With these measures the soil fertility will improve and saline or stony land will be covered with new soil.

The Wei River valley: Most part of the Wei River valley are ancient fertile agricultural land. The land use is very intensive and almost all land is irrigated. For example, the area west of Xian up to Baoji is irrigated by three main irrigation channels, two of them built after 1949. The water is withdrawn from the Wei River. Each channel can irrigate more then 200 000 ha and the flow is 20-30 cubic metres per second. Surface irrigation is supplemented by ground water irrigation. Around Xian city there are problems of over use and pollution of ground water. The principal crops are winterwheat, maize and cotton. The average winter wheat yield is

3 000 kg per ha, but yields of 7 500 kg per ha could be obtained. The average maize yield is 5 000 kg per ha and the average cotton yield 750 kg per ha. The Wei River has a catchment area of 13 million ha and its length is about 800 km. Soil erosion is a minor problem in the valley area.

The <u>Liu Lin Brigade;</u> Liu Lin Brigade is situated in the gully hilly area in the southern outskirts of Yanan city. The brigade is well known among Western readers thanks to the writings of the Swedish author Jan Myrdal (Myrdal 1965). The brigade had a population of 1 045 inhabitants, living in 220 households. In 1962 the households were 122. The labour force is around 550 people. Some basic facts about the land use is given in table 18.

Table 18. Land use in the Liu Lin Brigade in 1962, 1972 and 1982. Figures for 1962 are given by Myrdal (1965) and figures for 1972 are given by Humlum (1974). Hectars, n.a = not available.

	1962	1972	1982
Arable area	158	205	173
- irrigated area	n.a	28	53
- plain and dam area	42	61	67
- area under conservation control on hilltops and slopes	n.a	115*	67
- terraced land	n.a	24	33
- private plot lands	n.a	n.a	42
Orchards	n.a	21	23
- irrigated and terraced area	n.a	n.a	16
Forest	n.a	35	133
Grazing area and other land	n.a	406	338
Total brigade area	667	667	667

* Not all of this area was under conservation control.

The land use conditions were very bad, when the conservation work started in the 50s. Since that time 33 ha of arable land and 16 ha of orchards have been terraced. In 1963 the construction of siltation dams began within their gullies, thereby creating new damland. The new damland is cultivated when possible or else planted with trees. Trees are also planted on the gully slopes and hillslopes. The planted trees are various species of poplars, willows and acacias.

Some hilly and gully slopes have been changed into terraces of one meter width. They are used as grazing land. The brigade raises 110 cattle and 1 300 goats and sheep.

The peasant families in the Liu Lin Brigade take their drinking water from four natural springs, each of which can produce 40 cubic metres per day. There are also three drilled irrigation wells, each with a capacity of 100 cubic metres per hour. Human and pig excrements are composted together and thereafter spread on the private plots or sold to the brigade as manure.

The future conservation policy is to enlarge the forest land by planting more trees on the hilltops, hillslopes and in the gullies. Some of the hilltops will be terraced and used for agriculture. But the long-term wish is that the brigade should manage to increase the productivity of the plain land so much, that the hilltops and upper hillslopes could be used only for forests and the lower hillslopes only for orchards. It can be seen from table 18, that this policy also has been rather successful during the 1970s.

Liu Lin Brigade is famous for its orchards with apple and pear trees and grapes, which climb up the lower terraced loess hill slopes. About 2/3 of the orchards are terraced and irrigated. Three pumps have been installed to lift the water step by step. Most of the water is withdrawn from the nearby Yan River, but some water is extracted from ground water wells. The irrigation season lasts one month in the spring. The fruit trees are drip-irrigated and they are inter-planted with soybeans. The average fruit yield is 7 500 kg per ha.

The orchards are managed by a specialized team or group. During the latest years the rural cooperative management system has been much debated and a lot of experiments have been conducted within the framework of the so called production responsibility system. Certainly the shaping of the management system will affect the possibilities of carrying out soil and water conservation work in the future (see further on page 139ff).

In Liu Lin Brigade they have, after much discussion, chosen a responsibility system based on specialization and labour. It means that a management team or group consists of individuals from different households. Each year the group contracts a fixed production amount after meetings and general discussions have taken place among the brigade members. The management group is responsible for all types of work including farmland and water conservation construction works within their area during the whole year.

For example, the orchard management group consists of 40 labourers. In 1981 they have contracted a production of 240 000 kg equivalent to a value 63 000 Yuan with the brigade. A member of the group gets his income, from the collective distribution according to the workpoint system but also from the newly established bonus system. If the orchard management group exceeds the fixed quota, they will get 20 percent of the excess production in money as a bonus from the brigade. In 1981 the total fruit production value reached 78 000 Yuan, which meant a bonus of 3 000 Yuan to share among the members. A member of the group is also allowed to use cut twigs from the fruit trees as firewood.

Moreover, the brigade has a forest management group and a fundamental construction group. The 11 members of the forest group look after the tree nurseries and the fuel forests, plant new trees and do terracing work. The duties of the 32 members of the fundamental construction group also include the performance of soil and water conservation constructions. This group has the freedom to make contracts with other brigades in the commune or even other contractors outside Liu Lin Commune.

The various soil and water conservation works have been a very important factor for the increases both in land productivity and living standards. The total grain yield has increased from 163 ton in 1961 to 473 ton in 1981. The income conditions in Liu Lin Brigade are given in table 19. The average distributed per capita collective income was 182 Yuan in 1981. To this figure the 50 Yuan average income from the private plots should be added, which makes up an average per capita total income of around 230 Yuan. Such an income was slightly above the national average in 1981.

The Xio Shi Guo Brigade; As the Liu Lin Brigade the Xio Shi Guo Brigade is situated within the gully hilly area about 40 km northeast of Yanan City. All the land is located along a big gully and within five smaller gullies which alleviates the conservation works.

Table 19. The income conditions in the Liu Lin Brigade 1961 and 1981. The 1961 figures are taken from Myrdals "Report from a Chinese Village". The values are in Yuan.

	1961		1981	
Total income		90 400		350 000[1]
agriculture	45 600		100 000	
animal husbandry	8 400		-[2]	
forestry and fruit	1 200		60 000	
vegetables	15 000		9 000	
sideline production (noddle and repair factory, tractor and other transport service to other brigades etc)	20 200		181 000	
Net income		68 600		210 000
Distributed collective income		65 900		190 050[3]
Distributed collective per capita income		127[4]		182

1. The total grain production and the total income was higher in 1979 and 1980.
2. Probably the animal husbandry value is included in the sideline production.
3. The total number of workdays in 1981 was 66 000.
4. The distributed collective per capita income is an estimation based on Myrdal´s household figures from Liu Lin production team.

Table 20. Land use in the Xio Shi Guo Brigade in 1982. Hectares.

Arable area		28
- irrigated area	4	
- new dam land	5	
- total terraced land	3	
- terraced land on hill and gully slopes	2	
Orchards		6
Forests		18
Grazing area and other land		58
Total brigade area		110

The brigade has 154 inhabitants, living in 34 households. The labour force numbers 59 people. There are 40 cattle and 142 goats and sheep. Some basic facts about the land use is given in table 20.

The brigade started to build the first siltation dams in 1956. At that time the number of households was only 1/3 of the present. The peasants were very poor and each person had a grain ration of only 100 kg. In 20 years they have put in 68 000 workdays in soil and water conservation works, moving 300 000 cubic metres of earth to a total investment of 42 000 Yuan. The government has supported this work with 10 000 Yuan.

In the beginning the first dams were destroyed by heavy rainstorms, because no spillways were built. But today all the five gullies are controlled thanks to the comprehensive planning and management applied. The brigade has used labour to build 33 dams and create 5 ha of new dam land. There a series of dams in each gully, which are needed, in order to control the storm floods.

The dam land is suited for maize or sorghum cultivation. Agriculture, animal husbandry and forestry have been planned and managed together. Trees have been sown, which reduce the risk for dam collapses during rainstorms. The grass gives fodder and could also be used for fertilizing purposes. The planting of fruit trees has diversified the economy. The combined result of all these measures has been, that all the flood water is conserved within the gully and if it is not used by the plants, it will become ground water. The peasants in the Xio Shi Guo Brigade have learnt the technique of building a siltation dam by sending a person to a soil conservation workshop. A soil conservation workshop is arranged every year by the Yanan County Soil and Water Conservation Bureau, see page 84.

Soil conservation measures will indirectly conserve the precious water. The brigade has constructed three small and shallow waterponds behind three earthdams. Throughout the year there is a continuous flow through the ponds. They are used for irrigation, and they are also stocked with grasseating fish species. The fish production is enough to supply the brigade with its own fish demand. The small fish seedlings are bought from the Yanan County Soil and Water Conservation Bureau, which has a 7 ha dam raising area just outside the city.

The brigade has also dug a groundwater well with a depth of 10 m and a diameter at the bottom of 3 m. This well could supply pumped irrigation water to 1/3 ha of dam land each time. It could be filled in one day. They plan to dig some more wells in order to control the irrigation and drainage needs of the dam land. The families get their drinking water from four natural springs.

The construction of high yielding new dam land has created a favourable situation for better land use. The average productivity on different kinds of cultivated land is given in table 21 for the Xio Shi Guo and Liu Lin Brigades.

Table 21. Average productivity of different types of cultivated land in the Xio Shi Guo and Liu Lin Brigades. Kg per ha.

Land type	Crop	Average productivity, kg per ha Xio Shi Guo	Liu Lin
Plainland and new dam land	Maize[1]	7 500	6 000 - 7 500
Hillslope land	Millet	1 500	2 250
Hilltop land	Winter wheat	1 500	1 500

1. New maize varieties have helped to increase the yield

The Xio Shi Gun Brigade previously had 60 ha arable land of which 33 ha was hillslope land. Today the arable area is only 28 ha. The rest has been converted into forests, orchards and grazing areas. The brigade's immediate future task is to level a hilltop of 3 ha with the purpose of conserving water for winter wheat cultivation.

The various soil and water conservation works have substantially increased the productivity of the land and the standard of living, see table 22. The total grain yield has increased from 46 tons in 1971 to 81 tons in 1981. The year 1980 was even better, when 103 tons were harvested. In 1981 each brigade member had a grain distribution of 409 kg as compared to 255 kg in 1971. The distributed collective income was 212 Yuan in 1981 as compared to 56 Yuan in 1971.

Table 22. Total grain production and the distribution of grain and collective income in the Xio Shi Guo Brigade

	1971	1975	1980	1981
Total grain yield, tons	46	78,5	103	81
Grain sold to the state, tons			16	13,5
Agricultural grain tax, tons				1,5
Distributed grain per capita, kg	255	286	497,5	409
Distributed collective income per capita, Yuan	56	102	183	212

It should also be noted, that up to 1982 the land was managed collectively by the brigade members. But from 1982 a change was made in the system of responsibility. The land is still owned by the brigade, but it is now managed on the base of production contracts to households. The land was divided among the members in March 1982. For each labourer a household received 1/3 ha of land and for each child or old person in addition 1/6 ha of land to manage within the household responsibility system. The conversion was made to the household responsibility system because it was supported by the central party leadership.

Fan Tai Earthdam; This dam is situated in a 4 km long, deep gully in the southern outskirts of Yanan. In 1957-1960 an earthdam was built in the lower part of the gully. The Fan Tai Dam was constructed between 1976-1979 in the upper part of the gully. The catchment area above the dam is five square kilometres and it has a vegetation cover of 50 percent. Trees have been planted and grasses sown within the catchment 1980-1981.

The Fai Tai Dam is an experimental large sized dam. The height is 51 m, the length 173 m, the base width 350 m and the crest width 7 m. The dam volume is 630 000 cubic metres. The water storing capacity is 5.8 million cubic metres. There are a total of five large sized dams with a height above 50 m in Yanan County. Together there are about 4 500 earthdams of all sizes in the county.

The purpose of the Fan Tai Dam is to control erosion upstream and to create new arable land. Before the dammed area becomes completely silted up, it will be used as a reservoir with the possibility of irrigating 100 ha of land near the dam. The silt accumulation rate is calculated to 40 000 tons per year, which means that it will take about 50 years before the dam is silted up. Up to the autumn of 1982 eight metres of soil and two metres of water had accumulated on the reservoir bottom. When the reservoir area is silted up 55 ha of new dam land will be gained.

The dam has been cheap to construct. The material used has been the loess, taken from the steep gully slopes on both sides of the dam ends. At one side the silt content was 80 percent, sand content 6 percent and clay content 14 percent. At the other side the silt content was 70 percent, sand content 11 percent and clay content 19 percent. The whole dam is encased by a "clay" cover (well-dried and pressed loess). The cover has a width of 8 m at the base and 1 m at the crest. The crest itself is sealed with a 2 m deep "clay" layer. During the construction, the dam was built in segments. Firstly, the "clay" cover was built up. Secondly, the volume between the two side covers was filled with muddy silt up to a height of 50 centimetres. The filling material was taken from the gully slopes, which had been prepared by using explosives. Then the loosened silt was washed away to fill up the dam volume between the covers with the help of pumped water accumulated above the dam. The pressure used to wash away the silt was 12 kg per square centimetre. A second 50 centimetres muddy silt layer could be applied, when the first layer had been consolidated so much, "that a man could walk upon it". There are emergency spillways under the dam, which were used during the construction period. After the construction the dam had to be dried out in three consecutive years, before the damed area could be allowed to accumulate water. The total cost was 470 000 Yuan, which means 0.75 Yuan per cubic metre. The cost of the 420 000 cubic metres of muddy silt fill was only 0.12 Yuan per cubic metre.

The Fan Tai Dam is a large sized dam. One conclusion, which has been drawn from this dam, is that it is better to have a series of smaller earth dams in a gully, because a big dam usually takes too long to silt up.

The Yanan County Soil and Water Conservation Bureau; The Liu Lin Brigade, the Xio Shi Guo Brigade and the Fan Tai Earthdam are all situated in Yanan County and the gully hilly area. The county has a Soil and Water Conservation Bureau with together 82 persons employed. There are 35 soil conservation technicians, and 35 water conservation technicians and 12 administrators. The Bureau designs the county projects and gives advice on the commune level. It also initiates research projects. One of the Bureau's main problems is that it is not very well equipped with maps. It has just a draft topographical map at the scale of 1:10 000 and some reprints of air photographs borrowed from some research institutes. When designing a dam site, they usually rely on air photos together with field surveys of soil and vegetation.

The population has increased rapidly in Yanan. In 1937 only 7 000 people lived in the city area and 80 percent of the land in the county was seriously eroded. There was neither terraced land nor dam land. Only in 1981, did the county became self-sufficient in grain. Today the city area has 75 000 inhabitants and in the countryside there are another 110 000 inhabitants. The county has today 1/10 ha per capita of terraced and dam land.

The plans for the future are to double that figure. Most of the hilltop and hillslope arable land could then be afforested. The immediate future plans are to conserve 670 ha of terraced and new dam land per year, to afforest 6 700 ha of land per year(incl. orchards) and to seed grass species on 3 300 ha of new land per year.

In order to implement this plan every peasant labourer in the county is obliged to offer 30-40 workdays per year. If the peasant has constructed additional new farmland, he will not get any workpoints for his work, which was the common practice in the 70s. Instead he will have the whole profit from the crop production the first three years. After three years the land is handed over to the collective unit and will then be managed under the responsibility system. During the first three years the peasant does not pay any tax and the government will support him with farm equipment to a value of 300 Yuan per ha developed arable land. The seeded grassland belongs to the family who seeds it. No other family is allowed to enter the area. The peasant can buy the seed from the brigade. Some brigades even supply the peasant with seed without payment. In 1982 each peasant family seeded 2/15 ha of grassland on an average. The forest land belongs to the state or commune. However the trees planted on the land are owned by the planter and will after his death be inherited by his wife or son.

Table 23. The most common trees, shrubs and herbs used at the Shaanxi Loess Plateau

	Family	English name
Salix matsudana Koidz.	Salicaceae	Peking Willow
Salix mongolica Siuz.	-"-	-
Populus Simonii Carr.	-"-	Chinese Poplar
Hippophae rhamnoides L.	Elaeagnaceae	Sea Buckthorn
Elaeagnus angustifolia L.	-"-	Narrow-leaved Elaegnus, Oleasker
Tamarix chinensis Lour.	Tamaricaceae	Chinese Tamarisk
Astragalus adsurgens Pall.	Fabaceae	Loco, Ascending Milk Vetch
Melilotus alba Med.	-"-	White Melilot
Caragana microphylla Lam.	-"-	-
Amorpha frutilosa L.	-"-	False Indigo, Bastard Indigo
Hedysarum scoparium Fisch et Mey	-"-	-
Artemisia sphaerocephala Krasch.	Asteraceae	-

Source: Shaanxi Soil Conservation Bureau 1982

Airseeding The most common trees, shrubs and grasses planted or sown in the Shaanxi Loess Plateau are given in table 23.

With the aim of investigating the possibilities of airseeding trees, shrubs and grasses several institutes at the Wugong Research Center started a joint project in 1975. Wuqi County in the semi-arid steppe zone (390 mm) and Yichuan County in the forest steppe zone (570 mm) were selected as test areas. In 1976 the research group began their airseeding experiments in these two areas with different kinds of seed, table 24. They varied the pretreatment of the seed, the applied quantity, the seeding time and the seeding technology. In 1979 the research group concluded:

- Loco is very suitable for airseeding.
- Airseeding of Chinese Pine and Caragana were also successful.
- Sea Buckthorn can be sown together with Loco.
- Loco, Peashrub and Sea Buckthorn can be seeded all over the Plateau.
- In Wuqi County airseeding was the most efficient way to get a vegetative cover.

The airseeding with the legume plant Loco has been very successful. It resists wind, cold and drought very well. The root system is very deep, table 25.

Table 24. Tree, shrub and herb species, which have been airseeded at the Shaanxi Loess Plateau

	Family	English name
Pinus tabulaeformis Carr.	Pinaceae	Chinese Pine
Thuja orientalis L.	Cupressaceae	Oriental Arbor-vitae
Ulmus pumila L.	Ulmaceae	Siberian Elm
Toxicodendron verniciflua (Stokes) Barkl.	Anacardiaceae	Varnish Tree, Japanese Laquertree
Pyrus betulifolia Bunge	Rosaceae	Birchleaf Pear
Hippophae rhamnoides L.	Elaeagnaceae	Sea Buckthorn
Astragalus adsurgens	Fubaceae	Loco, Ascending Milk Vetch
Melilotus alba Med.	-"-	White Meliot
Medicago sativa L.	-"-	Lucerne, Alfaalfa
Sophora davidii Kom.	-"-	Vetchleaf Sophora
Caragana korshinskii	-"-	-

Source: Wugong Institute of Soil and Water Conservation 1982

Table 25. Some characteristics of Loco after airseeding.

Year after seeding	Height m	Root depth m	Crop yield tons/ha
2nd	0.6 - 1.0	1 - 2	7 500
3rd	1.10	3 - 4	21 000
4th	1.20	6 - 7	22 500

Source: Wugong Institute of Soil and Water Conservation 1982

Loco germinates best after a rainfall of 30 - 50 mm followed by a clear sky, it should thus be seeded in the summer season at the Loess Plateau. It will develop sprouts 5 - 6 days after the rainfall and after another 45 days leaves will develop. About 25 - 28 percent of the total seed will germinate of which 85 percent will survive the first winter. Already in the second year the root system has become 1-2 m deep, table 25. After 3 years each 1/15 ha will carry 3 000-13 000 plants.

Loco is a multi-purpose plant. It decreases the soil erosion, improves soil fertility as well as provides fodder and fuel. Experiments have shown, that the drainage water flow from seeded areas is 96 percent less and it contains 55 percent less silt. After 5 years of Loco growth, conditions are favourable for planting trees. Loco can also be seeded together with Sea Buckthorn.

Because Loco is a legume and due to nitrogen fixation it has been shown to increase the nitrogen content in the soil by 32 percent. The deep root system increases the humus content and improves the soil structure. In fact, if after the 5th year Loco is cut and the land use changed to agriculture, the millet yield will almost double. Loco has the possibilities of being an important fodder plant. It will yield a harvest of more than 20 000 tons per ha each second year, but it has to be reseeded after 7 years. The nitrogen protein content is 4.8 percent. After being torn to pieces and processed to "mud" the Chinese use it as fodder for pigs, chicken and cows. The milk productivity will become much higher compared to the use of stalks and leaves from the maize plant. Each hectar of Loco could supply 15-30 sheep or goats compared to less than 1 in areas, where Loco is scarce. The Loco plant is also an important honey plant for bees. And finally the stalks are an excellent fuel.

In Wuqi County each 1/15 ha airseeded with Sea Buckthorn contains 200-400 plants, which are 1-1.5 m high. This shrub has a lifetime of several decades. It could be used as fodder, fuel and fertilizer. In Yichuan County 2 000 ha have been airseeded with Chinese Pine. After 4 years growth, the plant has developed a 1-2 m deep root system. The Chinese Pine will supply timber.

Airseeding is a quick and cheap measure for obtaining a vegetative cover. Around 1 000 ha could be sown per day at a cost of 30 Yuan per ha. The total area seeded of all plants up to 1982 was around 70 000 ha. It has been estimated that 6.5 million ha of land at the Loess Plateau is suitable for Loco growth, which means that airseeding has a great future potential.

Table 26. Area under soil conservation control in the Shaanxi Loess Plateau at the end of 1981.

	Hectars
Terraces on slope land	350 000
Terraces on plateau land	210 000
New dam land	43 000
Land overflooded with silty water	12 000
Soil conservation forests	1 000 000
Artificial grassland	300 000
"Fenced off" hilly forest land	180 000
New irrigated land	420 000
Total soil conservation area	2 515 000

Source: Shaanxi Soil Conservation Bureau 1982.

As shown in table 26, 2.5 million ha is under soil conservation control in Shaanxi Loess Plateau. Continuous soil conservation work will improve the living conditions in the harsh Loess Plateau environment as well as being the key factor to the ultimate solution of the flood and silt problems in the North China Plain.

THE HUAI RIVER BASIN

The Huai River basin was not visited by the author, but for comprehensive reasons some information of the water resources development should be given.

The Huai River rises in the Tongbai Shan mountains in Henan and flows through the provinces of Henan, Anhui and Jiangsu, figure 14. In its middle reach the Huai River flows into Lake Hongze. From Lake Hongze the main river outlet empties its water into the Yangtse River in the vicinity of Yangzhou. Another outlet also starts from Lake Hongze, passes through the North Jiangsu Main Canal before the water reaches the Yellow Sea. The catchment area is 185 700 square kilometres at the outflow into the Yangtse River, but will increase to 262 000 square kilometres if the area east of Lake Hongze is incorporated (Tang et al 1983).

The Water courses of the many tributaries of the Huai River in its upper part are situated in crystalline rock areas, which make the silt content of the Huai River rather low in its natural stage of development. However, the silt-laden Yellow River has encroached upon the Huai River basin many times. The water control situation was very chaotic in the 1927-1949 period, when several dikes broke along the Yellow River and caused its silt-laden water to enter into the Huai River basin. The Yellow River water and silt filled up irrigation and drainage channels, lakes and cultivated land causing widespread devastation. The deliberate dyke destruction in 1938 especially caused severe famine in large parts of the Huai basin (see page 67).

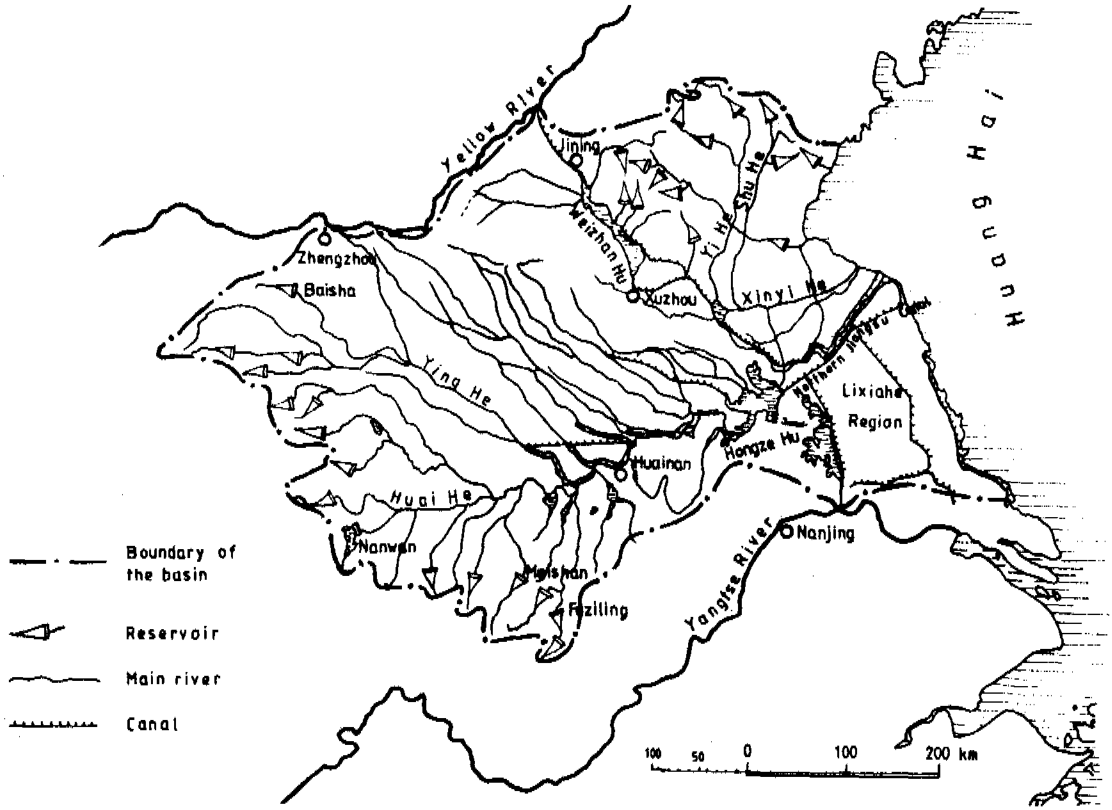


Figure 14 .The Huai River basin with its main reservoirs. (Revised after Humlum 1974).

Facing this destitution, the new government gave overall priority for state investment in water conservancy for the regulation of the Huai River basin in the 1950s. In 1950 Mao Zedong issued the appeal that "Huai River must be harnessed" according to the principles of "the full coordination of storage and channel dispatch" and "turning water from a menace into a resource" (Water conservancy in China 1956).

The harnessing of the Huai River has been carried out in two stages. The first stage eliminated the dangers of flood inundation and waterlogging by reinforcing dikes on the main course and tributaries and draining waterlogged areas. The second stage has basically eliminated flood of unusual magnitude and has also promoted the development of industrial and agricultural production by expanding irrigation, river navigation and power generation. As early as 1956 five reservoirs, 15 flood retention basins and 160 regulating gates and culverts had been constructed. In addition, 2 840 km of dikes had been repaired and strengthened, and 298 channels and drainage ditches totalling 6 303 km in length dredged and excavated. Altogether over 400 million cubic metres of earthwork was dug.

During this period the Foziling reservoir in the Pi He Tributary was among the separate construction projects, see figure 14. Foziling Reservoir has a reinforced. concrete 500 m long multiple-arch dam with a height over 70 m. Its total design capacity was 500 million cubic metres. It was constructed with the assistance of Soviet technicians in 1952-1954 and together with the Guanting Reservoir in Hai River basin, it became a construction symbol of the new China. The five reservoirs and the retention basins controlled over 13 cubic kilometres of flood water and thus played an important role in flattening out the flood peaks.The 170 km long Northern Jiangsu Main Canal was also constructed during this period. It was built in the winter season and the following year by mobilizing the labour of 800 000 peasants of Jiangsu province. In order to give the canal a capacity of 800 cubic metres per second 72 million cubic metres of earth were dug and moved. The Canal could also provide irrigation water to an area of 1.6 million ha.

Later in the 1960s the large Pishihang Irrigation System was constructed in the hilly areas of southeastern Anhui province. Today it covers an irrigated area over 400 000 ha. The Pishihang Irrigation System connects Foziling, Meishan, three other large reservoirs and more than 800 medium and small reservoirs. It also links together irrigated areas of both the Huai and Yangtse River basins. The accumulated length of the main canals is 1 500 km and the submains an laterals totals 40 000 km. The system has been developed into a inter-basin multi-purpose project, which benefits not only irrigation, but also navigation, power generation, aquatic production and municipial water supply. (Humlum 1974; Zhang 1980).

In summary, since the early 1950s 184 large and medium reservoirs have been built in the mountain and hilly areas with a total storage capacity of 38 cubic kilometres. In the plain areas lakes and ponds are also controlled to store flood water, so that the storage capacity has reached 28 cubic kilometres. In the lower reaches existing water courses have been dredged and enlarged and new canals have been constructed. All dikes have been reinforced on the main course and tributaries. The peak flow capacity at the outlet into the Yangtse River has been increased from 8 000 to 22 000 cubic metres per second. By taking the above measures together with the construction of farmland drainage systems, floods and waterlogging are basically controlled in the Huai River basin.

Plate I The Bai River Dam of the Miyun Reservoir with the apple and pear orchard at the foot of the dam, Beijing Municipality.

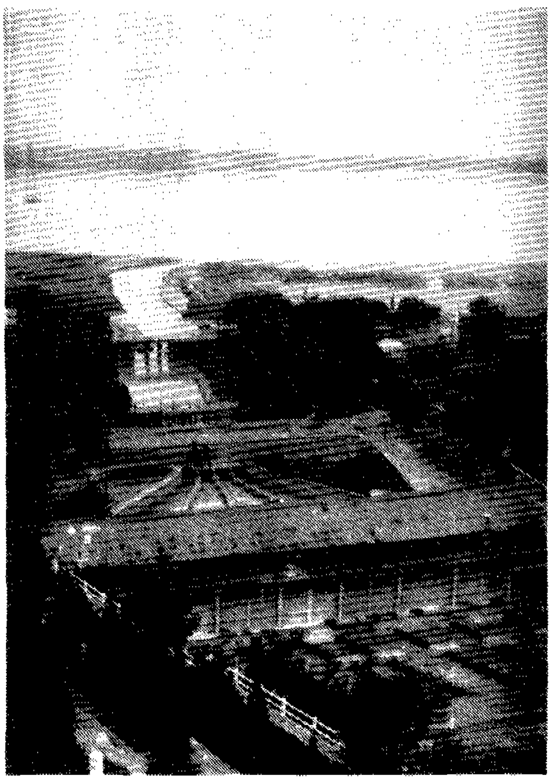


Plate II View over the Yellow River from Mangshan Pumping Station, Henan.

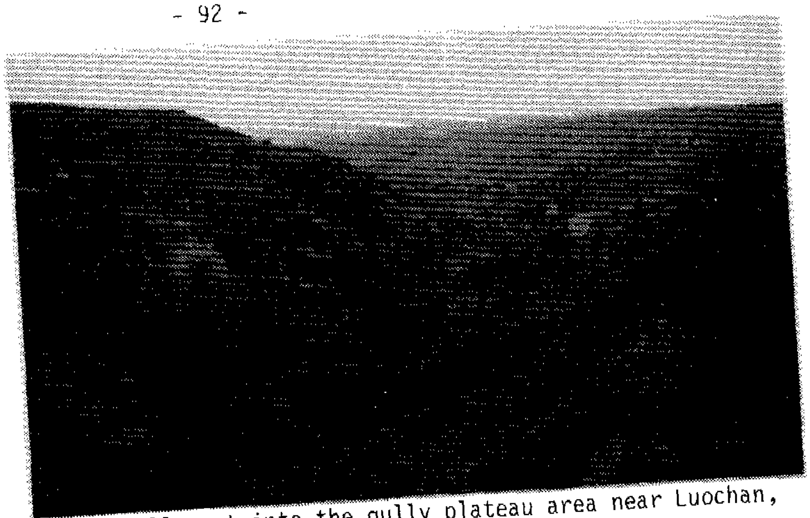


Plate III A huge gully cut into the gully plateau area near Luochan, Shaanxi.

Plate IV Maize growing on new dam land in the Xio Shi Guo Brigade in the gully hilly area Yanan County, Shaanxi.

Plate V A dug ground water well at the gully bottom in the Xio Shi Guo Brigade.

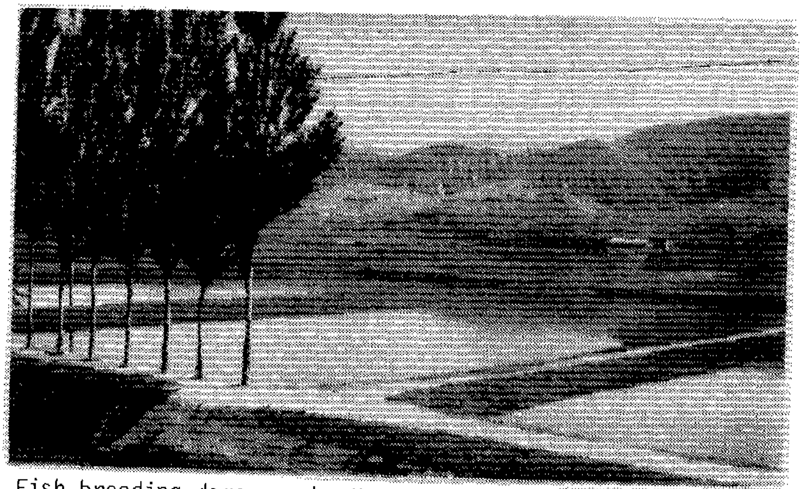


Plate VI Fish breeding dams run by Yanan Soil and Water Conservation Bureau, Shaanxi.

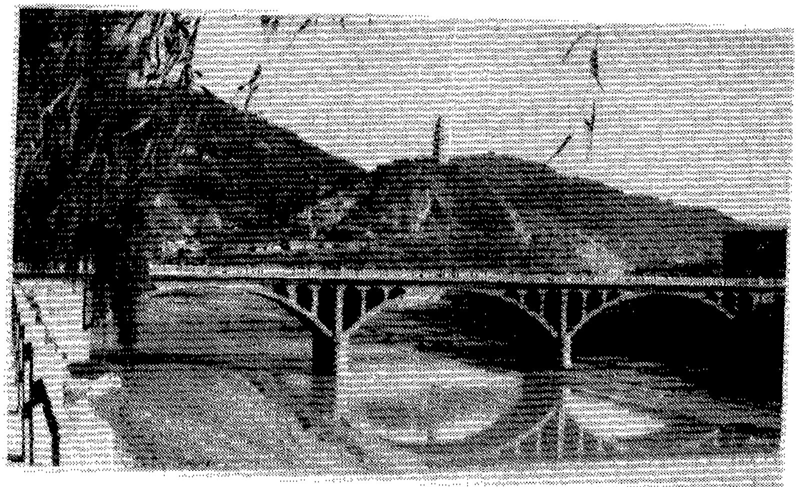


Plate VII The Yanan Bridge and the Yanan Pagoda - a symbol of the New China.

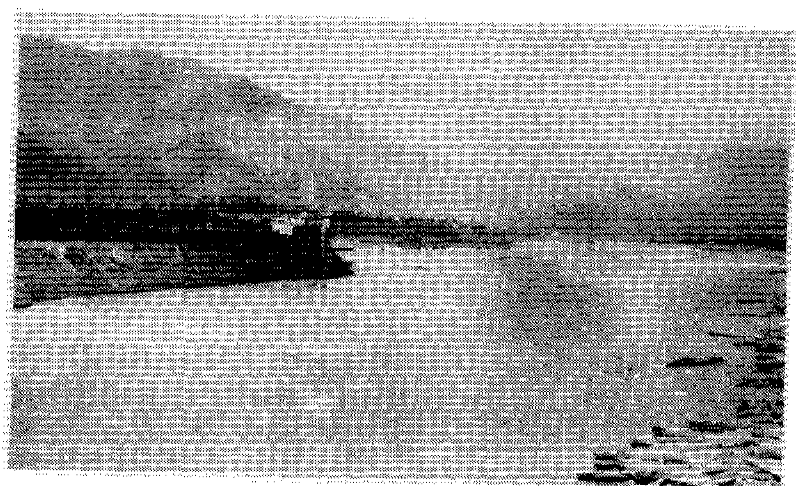


Plate VIII The Fish Snout or the diversion head with the inner channel in the front of the Dujiangyan Diversion Project, Sichuan.

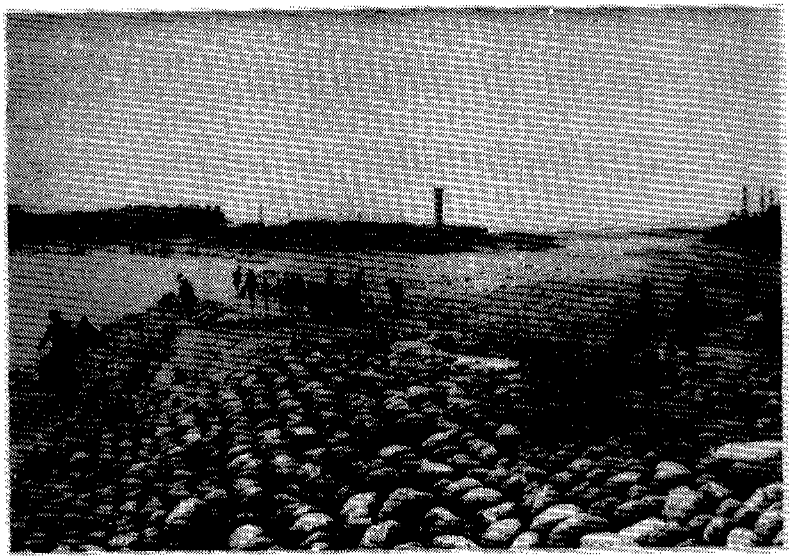


Plate IX The Flying Sand Spillway with the inner channel to the left of the Dujiangyan Diversion Project.

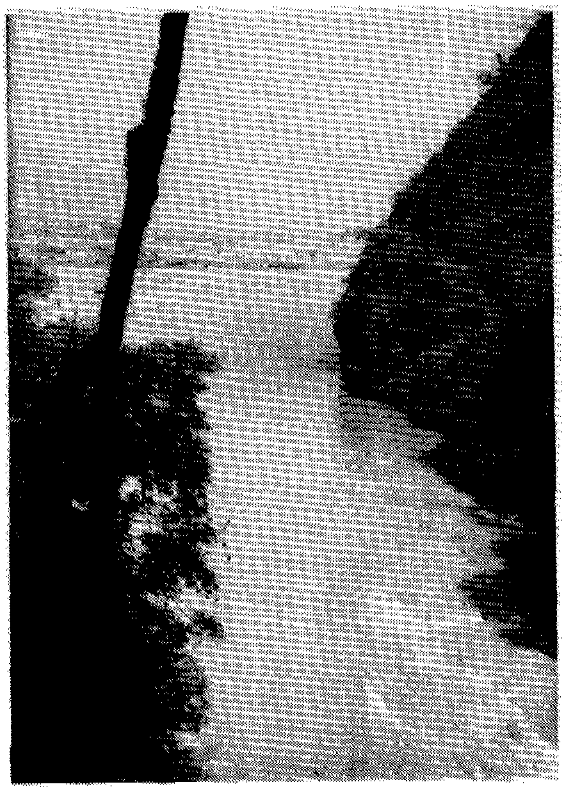


Plate X The Baopingkou Channel or the bedrock cut of the Dujiangyan Diversion Project viewed from the Li Bing Temple.

Plate XI The 27-bay spillway of the Gezhouba Dam Project Yichang, Hubei.

Plate XII A newly constructed section of the Grand Canal near the city of Yangzhou, Jiangsu.

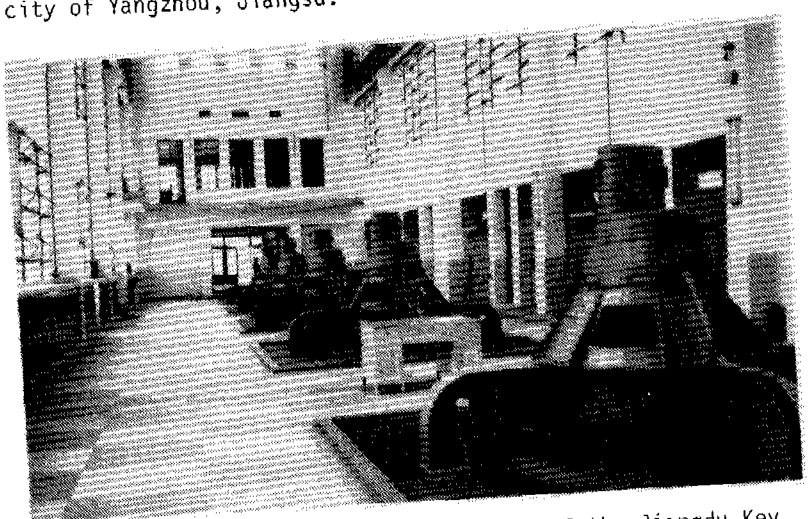


Plate XIII Interior from the No. 4 Pumping Station of the Jiangdu Key Water Conservation Project, Jiangsu.

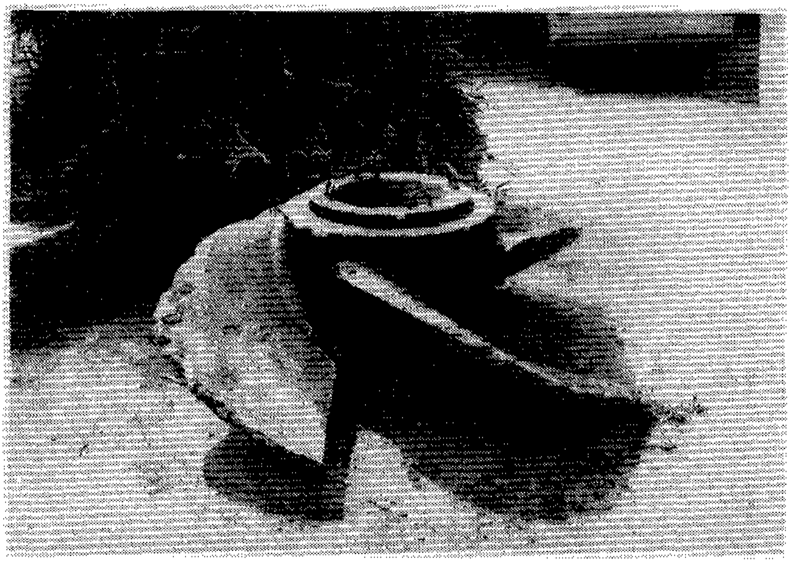


Plate XIV A locally manufactured and worn out concrete turbine wheel of the Conghua Artificial Lake Power Station, Guangdong.

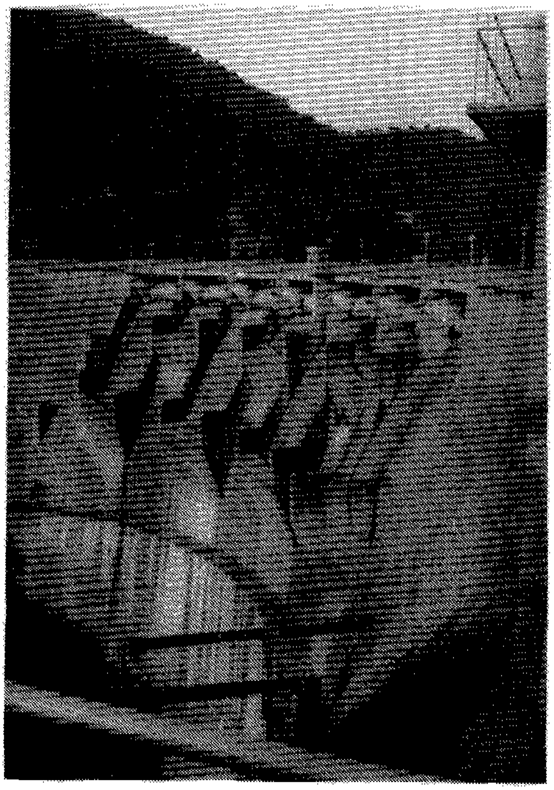


Plate XV The Liuxi River Arch Concrete Dam of the Liuxi Reservoir, Guangdong.

THE YANGTSE RIVER BASIN

The Yangtse River is one of the largest rivers with the most abundant water in the world. The catchment area is 1 808 000 square kilometres and the length is 6 300 km from the source high up in the Qinghai Tibet Plateau to the estuary in the Yellow Sea near Shanghai. The annual water flow of 1 000 cubic kilometres is about 20 times that of the Yellow River.

The Yangtse River basin has a long agricultural tradition (see further Dujiangyan Diversion Works on page 102). Today it is China's most important agricultural area. Its grain output of predominantly rice accounts for 70 percent of the national total, but the cultivated area is just 25 percent and the population is 33 percent of the national total. The various types of projects, which I visited (see further Dujiangyan Diversion Works p. 102, Long Quan Irrigation Scheme p. 106, Jiangdu Key Water Conservancy Project p. 115, Guazhou Water Conservancy Project p. 117), have all contributed greatly to the agricultural developement. The cotton output is 50 percent of the national total, also other cash crops like tea, tobacco, oil-bearing crops, hemp and fruits are important. The freshwater output is 66 percent of the national total.

In the valley there are big industrial centres like Shanghai, Wuhan and Chongqing, making the Yangtse River valley into one of China's most economically developed areas, see figure 15. The Yangtse River is an important transportation link. The main course has a navigable distance of 3 000 km. In 1981 the river handled 68 percent of the inland waterway freight in China. The Gezhouba Dam project is a key navigation work. Before 1949 no bridge spanned the river. With the completion of the famous Wuhan and Nanjing Bridges in 1957 and 1968 the railway and road communications between North and South China were much improved. Since the middle of the 70s tourism has developed vigorously in the basin. The cruises starting from Chongqing take the tourists through three famous Yangtse gorges; Quitang, Wu and Xiling. Towering sandstone and limestone mountains drop almost perpendicularly into the river, as the passengers boat navigates in the fast current. After leaving the Xiling Gorge the mighty Gezhouba Dam appears at Yichang. For many centuries this gorge passage has been the main communication link for the people living in the Sichuan inland basin with the rest of China.

Water Resources Utilization in Sichuan Province

Sichuan is China's most populous province with 99,7 million inhabitants according to the population census in 1982. There is an unfavourable relationship between the population pattern in Western and Eastern parts of Sichuan and the water resources and the cultivated area, see tables 27-28.

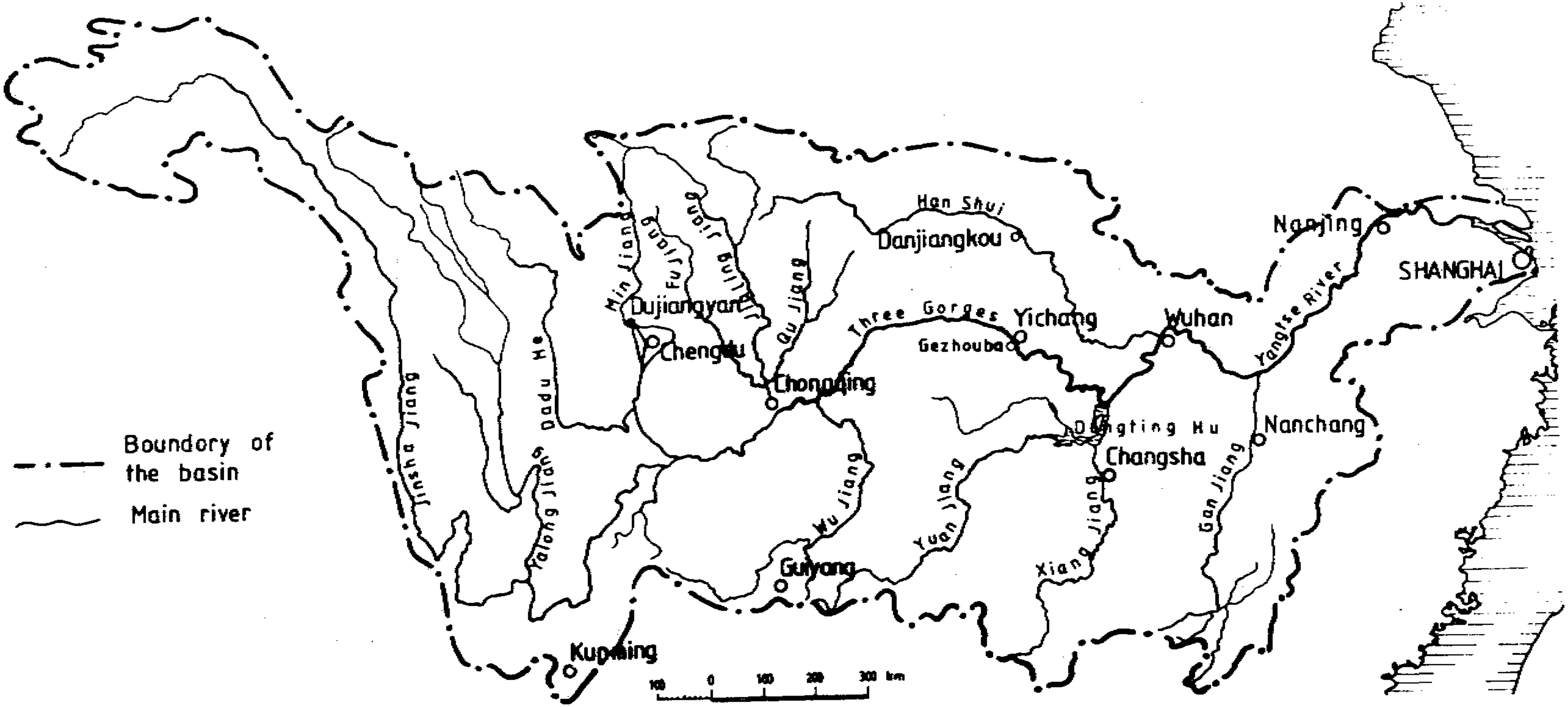


Figure 15. The Yangtse River basin and its main tributaries (Revised after Humlum 1974)

Table 27. Area, landforms, population and water resources in Western and Eastern Part of Sichuan Province.

	Area		Landforms	Population		Water Resources	
	km^2	%		Millions	%	km^3	%
East	269 800	49,3	Hilly low mountain and plain areas	93,7	94	89	25
West	287 800	50,7	High mountain and plateau areas	6	6	268	75
Total	567 600	100	-	99,7	100	357	100

Source: Sichuan Provincial Water Conservation Bureau 1982

The western part belongs to the remote high mountain and plateau areas of the Qinghai-Tibet Plateau, while the populous eastern part consists of hilly low mountains and plain areas. The Sichuan Basin in the eastern part is surrounded by high mountain ranges through which the Yangtse River has cut its course. The Sichuan Basin has an average altitude of about 500 m above sea level, while the mountains in the Qinghai-Tibet Plateau are higher than 4 000 above sea level.

The Sichuan land use pattern is close to the national land use pattern as table 28 shows. Of the cultivated area 71 percent or 4.8 million ha is situated in Eastern Sichuan.

Table 28. The land use pattern in Sichuan Province compared to the national land use pattern.

	Area Million ha		Percentage Sichuan	National
Cultivated land		6.7	12	10
Western Sichuan	1.9			
Eastern Sichuan	4.8			
Grasslands		15.3	27	41
Forest		7.4	13	13
Other land		27.4	48	36
Total		56.8	100	100

Source: Sichuan Provincial Water Conservation Bureau and table 3.

As much as 97 percent of the province area belongs to the Yangtse River basin. There are 19 rivers with a catchment area bigger than 10 000 square kilometres and 1 380 rivers bigger than 100 square kilometres. The rivers are mainly supplied by rainfall, but some of the rivers in the western part are supplied by melted water. The mean annual runoff of all rivers in Sichuan is 357 cubic kilometres, an amount equal to 36 percent of the total annual runoff of the entire Yangtse River basin. As elsewhere in China the rainfall distribution is quite uneven. Around 60-70 percent of the annual rainfall will come between June and September, mostly as rainstorms. The period from November to February is very dry. It should be noted, that about 3/4 of the water resources are situated in the mountainous western part, where the cultivated area is less than 30 percent, which means that theoretically only 90 cubic kilometres could be withdrawn for agricultural and industrial use.

In the province there are 380 rivers, which have a hydroelectric power potential bigger than 10 000 kW. The total theoretical hydropower potential has been estimated to 150 million kW of which 3/4 is situated in the western part. About 92 million kW could be exploited.

In 1949 the total water consumption was 2.6 cubic kilometres or below 1 percent of the available resources. But in 1979 the water use had increased to 21.0 cubic kilometres or 5.9 percent of the available resources, see table 29. Thus the per capita use was 215 cubic metres in 1979, which is a rather low figure compared to the situation in the capital region (see page 62).

Table 29. Water consumption in 1979 and the projection for the year 2000 in Sichuan Province.

	1979		2000		
	km^3	%	km^3	%	Increase %
Irrigation	17.6	83.8	23.9	73.5	36
Animal husbandry	0.3	1.6	0.5	1.9	67
Industry	1.9	8.9	4.0	12.3	110
Households	1.2	5.7	4.1	12.3	233
Total	21.0	100	32.5	100	59

Source: Sichuan Provincial Water Conservation Bureau 1982

About 84 percent of the water consumption is used for irrigation, which means that 46 percent of the cultivated area is irrigated. Of the irrigation water used, 55.9 percent is reservoir water, 36.2 percent diverted water from rivers and 7.9 percent pumped water from rivers. The ground water use is neglible today, but it has a big potential in the future. For example, there are unexploited deep gravel and sandy aquifers below the Chengdu Plain.

There was almost no hydroelectric power generation in Sichuan before 1949. The installed capacity was only 1920 kW. In 1979 the installed capacity had reached 1 900 000 kW, which is a 1 000 times increase since 1949. The province produced 10 500 millions kWh electricity from water power that year. According to the national standards a large hydroelectric power station is above 250 000 kW and a small-sized one is below 25 000 kW. In Sichuan, the large and middle-sized stations occupy 46 percent of the capacity producing 60 percent of the electricity.

These figures imply, that small hydroelectric power stations play an important role in the generation of hydroelectricity.

Sichuan Provincial Water Conservation Bureau has experienced some useful guidelines, when planning water utilization. They are:

1. Comprehensive planning and use of water.
2. Protection of the water resources.
3. Correct handling of the demand and supply of water.

A comprehensive planning is needed and implies that the actual water resources are matched with overall river utilization in order to reach an optimal and rational use of water. Because the natural and social conditions vary a lot, as it has been seen, the Bureau has different approaches in the western and eastern parts of Sichuan. In the mountainous Western Sichuan the comprehensive demand of water is quite small, which means that hydroelectric power generation is given priority in the Jinsha (Yangtse River upper section), Yalong and Dadu Rivers. In the basin area in Eastern Sichuan the Bureau gives priority to a multi-purpose utilization of the water resources. However, in the Sichuan Basin it is a difficult task to correctly judge which water need is the most important. The Tuo River was mentioned as such an example. In 1982 the Bureau had come to the conclusion, that too much emphasis had been put on hydropower generation and the reclamation of river shore land to the detriment of flood protection, navigation and the water need in the upper part of the basin. They considered, that these policy options had aggravated the very big flood, which affected Tuo River basin in July 1981.

The awareness of protecting the water resources was not very high before the end of the 70s. Water quality was neglected, which has meant that many rivers are polluted with industrial and sewage water. The promulgation of the Environmental Protection Law in 1979 meant a change to the better. Today all factories in a river basin have to present a plan, which shows how they aim to treat the waste water. It is compulsory for newly constructed and reconstructed factories to have pollution treatment equipment. The growing amount of residential sewage water from urban areas is more difficult to tackle, because the authorities consider it too costly at the present stage of economic developement to construct public sewage treatment plants.

Another protection problem is how to conserve the forest resources in the upstream catchment areas. The forests adjust the climate, decrease the surface runoff, soil erosion and the flood peaks. The main cause of the very big flood in July 1981 in the Min, Tuo, Fu and Jialing River basins, which killed 920 people and inundated 2 600 factories and 830 000 ha of farmland, was an unfavourable atmospheric situation. But another major cause of the devastation was deforestation in the upstream areas. The forest cover has increased from 10 percent in 1960 to 13.1 percent in 1979, but the annual amount of silt transported out from Sichuan Province by the Yangtse River is about the same as in the beginning of the 50s. Locally, deforestation was a serious problem during the Cultural Revolution and is probably still so in many areas. In Jinxing Commune, Guilin County, 200 springs dried out due to the cutting of forests during the Cultural Revolution. Every tourist could easily observe the frequency of denuded mountain and hillslopes and silty water from the passenger's boat, when travelling through the famous Yangtse River section from Chongqing to Yichang (including the three gorges). If the national and provincial authorities continue to stress the importance of forest conservation the situation is likely to improve in the future. There will be more communes like Lin Shan in Yanting County. Between 1960-1972 this commune afforested 800 ha or 10 percent of its total area, which has improved the local climate and also created 130 new springs.

Another problem has been to correctly handle the demand and supply of water. In water-abundant Western Sichuan, this is not a large problem. The water is supplied according to the demand. Earlier this allocation principle was applied also in water-scarce areas in Eastern Sichuan, which lead to problems. Nowadays the water is allocated according to the actual supply of water. For example in agriculture a better water efficiency has been achieved since 1977 in these water-scarce areas. Better crop varieties, change in the sowing period and other changes in crop management have saved water. In a drought year the change from rice to a dryland crop like maize will still give a good harvest.

The water projection for the year 2000 is shown in table 29. The total increase is estimated to 11.5 cubic kilometres. The projection assumes, that the water use per unit will decrease in agriculture and industry and that the ground water proportion of the total amount will increase. The ground water should mainly be used for the industrial and every day consumption.

The most difficult problem will be to supply the central Sichuan Basin with enough water. In a year when the precipitation is 75 percent of the normal value, the total available resources are 26 cubic kilometres in this area, but the demand in 2000 is expected to be 27 cubic kilometres. Thus, the general idea is to construct some large reservoirs in the Jinsha, Yalong and Dadu Rivers in Western Sichuan, which could supply energy and irrigation water to the Sichuan Basin. Today there are only three large reservoirs, mainly used for irrigation, and another one is under construction. As many as ten large reservoirs for multi-purpose use are in the planning stage. Small and middle-sized hydroelectric power stations should be built in Eastern Sichuan in order to provide electricity for irrigation schemes and the small and middle-sized industries.

Dujiangyan Diversion: Dujiangyan Diversion Work is probably unsurpassed as an ancient engineering work, that has continued to serve mankind up to the present time. Today it combines the traditional and modern art of engineering work. Joseph Needham has described the project in his Science and Civilisation of China (Needham 1971). Other descriptions have been made by Lowdermilk and Jones (Lowdermilk 1943, Jones 1954, Zhang 1980).

The project supplies domestic and industrial water to a huge population and makes irrigation possible of the vast Chengdu Plain and surrounding mountain hilly areas. It is believed to be the worlds oldest project still in operation. The ingenious idea of diverting the Min River water into a system of distributary channels similar to those on a delta was conceived about 250 BC by the governor of the region Li Bing and his son Er Lang. From that time up to 1949 the project has guaranteed irrigation water for the nearby 200 000 ha of intensively cultivated farmland on the Chengdu Plain. Since 1949 the projects command area has been increased, so that in 1982 almost 600 000 ha was irrigated. The diversion work has a potential of irrigation 1 100 000 ha in the future, see figure 16. Twenty-seven counties were supplied with irrigation water in 1982 compared to 14 counties at the end of the 40s.

The whole irrigation area has a population of 15 million, the provincial capital of Chengdu included. Because of its ample supply of water the Chengdu Plain has often been called "the garden of China". In general two grain crops are harvested annually. The most common crop combination is winter wheat followed by rice. The summer harvest of winter wheat yields on the average 3 750 kg per ha and the autumn harvest of rice 7 500 kg per ha.

The most important engineering work of the irrigation scheme is Dujiangyan, which is situated at Guanxian Town (700 m above sea level) and 50 km to the north of Chengdu (500 m above sea level). Here at the edge of the Qinghai-Tibet Plateau the Min River (a tributary to Yangtse River) has rushed down the foothills of the more than 4 000 m high precipitous mountains. From Dujiangyan up to the source area the distance is 340 km and the catchment area 23 000 square kilometres. In an average year 15 cubic kilometres of water will pass Dujiangyan of which 80 percent passes from May to October.

It was this water volume that Li Bing and Er Lang diverted by separating the river course in an outer and inner channel. The diversion project has three main structures; a division-head, an overflow spillway and a bedrock cut, see figure 17.

The division head or the Fish Snout in the midstream, which separates the water to the outer and inner channels, was originally constructed with piled stones and boulders, but it has nowadays been reinforced with concrete. The Fish Snout is immediately followed by two large lined dikes of piled stone blocks. The dike of the inner channel merges further downstream into the roughly 240 m long overflow spillway or Flying Sand Spillway. By designing a steeper bottom slope of the inner channel (today 0.7%) rather than the outer channel Li Bing could guarentee the inner channel 60 percent of the total flow during the dry season.

The water volume flowing through the rock 20 m wide cut or the Baopingkou Channel is during the high water season regulated by the Flying Sand Spillway. The surplus water overflows the Flying Sand Spillway so that each year 7 cubic kilometres of water flow through the rock cut. It took eight years to cut out the Baopingkou Channel from the bedrock. At the most, a rock depth of 40 m was cut to reach the bottom of the channel's cross-section. Upon the thereby separated rock hill the Fu Long Temple (Taming Dragon Temple) was built to commemorate Li Bing.

Probably the Flying Sand Spillway is the most important structure of the whole project. Besides regulating the water volume of the inner channel it also separates sand, silt and bed-load carried by the water. When the water overflows in the high water season 80 percent of the sand and silt content is separated from the inner channel water. Above that, in an average year 1.5 million tons of stone and boulders roll over the crest of the Flying

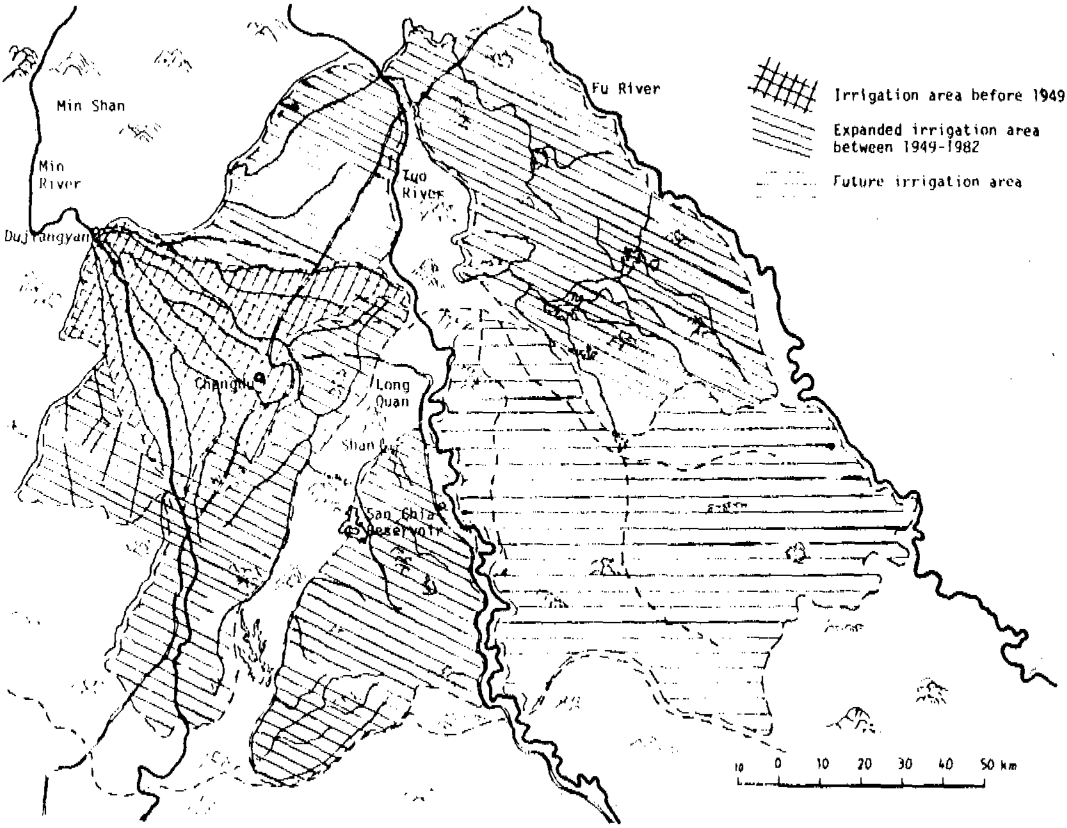


Figure 16. Irrigation command area of the Dujiangyan Diversion Works (Redrawn from an information pamphlet)

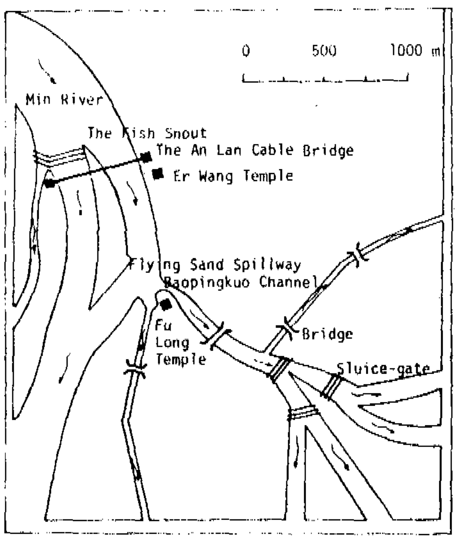


Figure 17. Illustration plan of the Dujiangyan Diversion Works (Redrawn from an information pamphlet)

Sand Spillway. There is a tale which says; When eight man put in a stone in Dujiangyan, it will become a stone of 10-20 centimetres diameter in Chengdu. The average annual sand and silt amount passing the crossection just before the Fish Snout is 8.4 million tons, but thanks to the Flying Sand Spillway only 0.84 million tons is transported through the Baopingkou Channel. Thus the inner channel is guaranteed irrigation water with a small amount of sand and silt.

When the water has passed Dujiangyan it is divided into many subchannels, laterals and sublaterals. At the beginning of the 50s the outer and the inner channel had a subchannel system with a total length of 583 km respectively 588 km on the Chengdu Plain. The effectiviness of the irrigation project has been so well preserved during the centuries, because the maintenance measures of Li Bing have been so carefully conducted. After the Min River has rushed down the vast mountain slopes the current is so swift, that the river dumps bed load material of rock and boulders. Li Bing recognized that these would quickly fill his diversion channel and throw the current out of the inner channel. He therefore prescribed yearly excavations of the accumulated debris. He had stone tablets carved with the injunction "Dredge Silt Deep, Keep Spillway Low". The stone tablets were set up together with statues of Li Bing and Er Lang in the Er Lang Temple, which was built on the eastern side of the inner channel. By making the maintenance into a kind of religious faith literally hundreds of millions of people during the centuries have enjoyed security against famine and flood.

Firstly, every year in November the entire flow in Min River was diverted into the inner channel by means of a temporary coffer dam made of bamboo sausages (also called gabions) filled with boulders laid against tripods. Then up to February the outer channel was dredged before the coffer dam was broken and secondly a new temporary coffer dam was built from the Fish Snout across the inner channel. The inner channel was then excavated and dredged until three huge iron bars became visible. It is believed that Li Bing had chained these three "iron dragons" to the bottom of the stream bed opposite the Flying Sand Spillway. The crest of the Flying Sand Spillway should be two metres above the stream bottom to maintain a constant flow of water every year. The inner channel coffer dam was broken at a great ceremony in April just before the irrigation season was beginning.

Li Bing also constructed a gauge to measure the water level in the Baopingkou Channel. During Eastern Han (25-220 AD) three stone statues were erected as gauges in the centre of the inner channel. They were probably destroyed by a storm flood in the 1000 century, but two of them were recovered in the middle of the 70s, when construction work was carried out in the inner channel. One of them, a stone statue of Li Bing, is displayed in the Fu Long Temple. It is 2.9 metres tall and weighs 4.5 tons. Characters encarved on the statues have proved, that Li Bing was the designer of the Duijiangyan Diversion Works.

Today the maintenance work is carried out without building the temporary coffer dams. A concrete sluice gate structure has been constructed across the mouth of the outer channel just below the Fish Snout. There are many sluice gates and other water-regulating structures further down in the irrigation system. The outer and the inner channels have almost been completely lined. I was told that the inner channel had only been dredged twice during the last 20 years. Since 1977 an advanced system, which has the goal of automatically controlling all the numerous sluice-gates, has been built out. In 1982 this system was able to allocate irrigation water to 200 000 ha from the operation centre at Guanxian.

Long Quan Irrigation Scheme: Long Quan Irrigation Scheme, situated in the mountain hilly area south of Chengdu, is an example of a labour-intensive project, which has expanded the irrigation area under the Dujiangyan Diversion, see figure 16. In 1980 more than 0.2 cubic kilometres of water was diverted to this irrigation area which was developed in the 1970s. South of Chengdu the water flows through a 6 274 m long tunnel under the Long Quan Mountains before it reaches San Chia Reservoir and two other minor reservoirs, see table 30. There is also another large-sized reservoir called Heilungtan in the southern part of the irrigation area, but this one is not supplied by water through the tunnel. These reservoirs are named counterregulating reservoirs by the Chinese, which means that they are built in order to use the Min River water more efficiently. Min River water will be stored during the rainy season in the reservoirs in order to meet the irrigation need in the dry season. When the Long Quan Irrigation Scheme is fully developed 0.4 cubic metres of water will be diverted from the Min River.

The San Chia Reservoir has a storage capacity of 225 million cubic metres. Its main dam is 990 m long and 35.5 m high, see table 31. The two most important purposes of the reservoir are irrigation and fish-culture.

In 1981 the Long Quan Irrigation Scheme supplied water to 40 000 ha and the future outlook is to double that area. About 1/6 of the total cultivated land in four counties with a population of 4 million benefits today from the water of the reservoirs. The scheme has increased the ability to resist natural calamities and as a consequence the grain yields have become high and stable. Most of the cultivated land has changed from one crop of rice to two crops, usually winter wheat and rice. The average productivity has been raised from 3 900 kg per ha before irrigation to 7 800 kg per ha with irrigation. The total grain increase due to the irrigation projects developed between 1973-1980 has been 438 500 tons, which means an average annual increase of about 140 kg per capita gained by the people living in the four counties.

Between 1976-1981 around 20.3 million fish-sprawns of ten various species have been set out in the San Chia Reservoir. During the same period 500 tons of fish have been caught. The goal is to reach an annual catch of 400 tons in 1990.

In 1978 two small hydroelectric power stations began to produce electricity. They have a total capacity of 2 500 kW. More small hydroelectric power stations will be built in the future.

The San Chia Reservoir is operated and maintained by the San Chia Reservoir Management Committee subordinate to Sichuan Provincial Water Conservation Bureau. It has 137 persons employed of which six are engineers. The commit-

Table 30. Some facts about the Long Quan Irrigation Area

Main diversion tunnel; length, m.		6 274
capacity, m^3/s		32
Reservoir storage capacity, million m^3		616.6
Heilungtan	352	
San Chia	225	
Shi Pan	69.6	
Zhang Chi Yi	15	
Irrigation area 1982, ha		40 000
Future Irrigation area, ha		80 000
Total length of irrigation structures, km		673.2
7 main canals	121.6	
46 aqueducts	5.1	
49 gates and locks	-	
76 tunnels	16.6	
87 highway drains	5.1	
16 submains	219.2	
70 subchannels (irrigates more than 600 ha)	305.6	
Moved volume of earth and stone, million m^3		23
Mobilized labour, million labour days		78
Number of resettled population		27 000
State investment, million Yuan		90.6
Construction period		1970-

Source: San Chia Reservoir Management Committee 1982

tee allocates the water and has the responsibility for the maintenance work down to the submain canal level, see table 30. The sub-channels below the submains are controlled by the People's Communes administration. A special water inspector within the administration has the overall responsibility for the allocation and distribution of the water within the commune. There are also maintenance stations, which are operated at the commune level. The irrigation fee was 25.5 Yuan/ha for paddy and 9 Yuan per ha for dryland crops in the Long Quan Irrigation Scheme. In order to reach a more efficient water use in the future the fee will be changed into Yuan per cubic metre of water.

The management committee has conserved part of the land around the reservoir. Up to now 85 ha have been planted with 478 000 saplings (Yuclums, pines, spruces, cedars, fruit-trees). Before 1985 they plan to afforest a further 107 ha.

Like most other water conservation projects in China the Long Quan Irrigation Scheme is a labour-intensive project. Since construction started in 1970 the project has involved 78 million labour days. More than 23 million cubic metres of earth and stone have been moved. The 27 000 persons, who earlier lived in the submerged reservoir area have been resettled in the People's Communes, which benefit from the project. The state investment has been 90.6 million Yuan.

Table 31. Some facts about the San Chia Dam and Reservoir.

Building material	Stonefilled dam with claycore
Catchment area, km^2	171
Average annual rainfall, mm	883
Average annual evapotranspiration	1 221
Storage capacity, million m^3	225
Surface area, km^2	27
Maximum depth, m	37
Length of main dam, m	990.4
Top height of dame above sea level, m	465
Seepage through dam, m^3/day	174
Design seepage through dam, m^3/day	270
Spillway capacity, m^3/s	148.5
Emergency spillway capacity, m^3/s (a tunnel below the dam)	89
Irrigation outlet capacity, m^3/s	24
Length of 4 main canals, km	59
Length of 10 submains, km	148.5

Source: San Chia Reservoir Management Committee, 1982

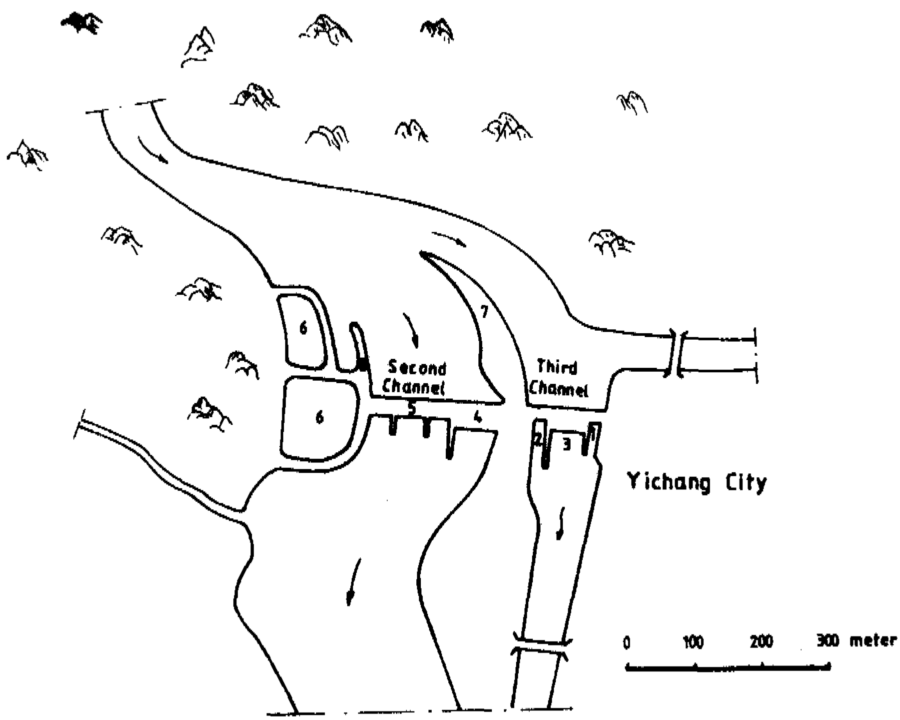
Labour has been mobilized from the communes which benefit from the project during the slack season for agriculture. The state pays the worker an allowance for his daily costs at the construction site. He is also remunerated with workpoints from the brigade he belongs to. Only modern equipment was used, when constructing the tunnels and the San Chia main dam. These works has been carried out by the Sichuan Energy Construction Company, which has gained long experience, since it was established in the 1950s. As seen in the figures above the labour productivity is very low from a Western point of view. However China has limited financial resources and has to rely on the policy of a high degree of self-reliance and self-sufficiency. The framework of the rural cooperative system enables the Chinese to use labour as a capital investment instead of money.

Water Resources Utilization in the Middle and Lower Reaches of Yangtse River

The Gezhouba Dam Project: If the Dujiangyan Irrigation Scheme is China's most remarkable ancient water conservancy project, the Gezhouba Dam Project is the most remarkable modern water conservancy project. The Gezhouba is the first dam to cross the Yangtse River. Some foreign writers have called it "a modern version of the Great Wall". The project has been very thoroughly prepared. The blueprints alone weigh 100 tons and require 25 trucks to transport them. Its power generating equipment is the biggest of its kind in the world and its shiplocks among the two or three biggest. Except for some heavy trucks and specialized equipment brought abroad, the planning, design, materials and equipments are made in China. The project has been described in detail by Ludlow (Ludlow 1980).The construction of the dam project started in 1970, but due to various technical problems it was suspended for revision of the preliminary design during 1973 and 1974. Since 1977 the construction rate has been very rapid.

The project is divided into two stages. The first stage was basically completed in 1982 and the second stage is scheduled to be completed in 1986. About 50 000 engineers, administrators and workers toil in three-shifts. Residental areas for the workers were built in 1973 and 1974 and the city of Yichang has increased its population from 80 000 to 370 000 during the 70s.

The dam is located 2 300 m south of Xiling Gorge, the last of the Three Gorges. After flowing out of the gorge the river water surface widens from 300 m at the gorge mouth to 2 200 m at the dam site, see figure 18. The project controls 55 percent of the entire Yangtse basin or about 1 million square kilometres. The mean annual flow is 453 cubic kilometres.



1. Shiplock No 3 (120x18 m, 3 000 tons)
2. Shiplock No 2 (280x34 m, 16 000 tons)
3. 6-bay silt-clearing sluice (108 m width, max. capacity 10 500 cubic metres per second)
4. Powerplant (965 000 kW)
5. 27-bay spillway (498 m width, max. capacity 83 900 cubic metres per second)
6. Cofferdam for the second stage under construction (First Channel)
7. Silt-guide embankment
8. Silt-guide embankment

Figure 18. The Gezhouba Dam Project in 1982.

Some characteristic water discharge data is shown in table 32. The completed scheme will include a 2 561 m long and 47 m high dam with its crest 70 m above sea level.

Table 32. Characteristic water discharges at the Gezhouba Dam.

	Cubic metres per second
Mean annual discharge	14 300
Maximum investigated flood discharge (1870)	110 000
Maximum recorded flood discharge (1981)	72 000
Second maximum recorded flood discharge (1896)	71 100
Minimum measured flow (1979)	2 680
Average dry season flow (Nov. - May)	6 860
Average wet season flow (June - Oct.)	24 800
Check flood discharge	110 000
Design flood discharge	86 000
Maximum discharge for power	17 935
Discharge for 98% assurance	3 410

The dam is a low head dam, which means that the flooded area is limited to the Xiling Gorge and the total reservoir storage is only 1.58 cubic kilometres. The dam has raised the average water level by 20 m. The first stage of structures across the second and the third channels includes a huge 27-bay spillway, two shiplocks, a 6-bay silt-clearing sluice and a seven unit power station. The second stage, now under construction, consists of one shiplock, one 5-bay and one 4-bay silt-clearing sluice an a 14 unit power station. The massiveness of this engineering project is shown by the amount of concrete work involved earth & stonework and metal work in table 33.

Table 33. Concrete work, earth & stonework and metal work at the Gezhouba Dam Project.

	First stage	Second stage
Concrete work, (million cubic metres).	6.22	5.25
Earth & stonework, (million cubic metres).	45	24
Metal work, (million tons).	0.037	0.0347

The two main purposes of the project are to produce electricity and to improve the navigation conditions. When completed, the project will have an installed capacity of 2 715 MW with a planned production of 14 100 million kWh distributed to the power grids in Hubei, Henan, Jiangxi, Hunan and Sichuan provinces. The design power head is 18.6 m with a maximum and minimum power head of 27 m (in the drought season) respectively 8.3 m (in the flood season). The two 170 MW lowhead units in the first stage power station are among the biggest in the world. The turbin runner is 11.3 m and the rotor of the generator 16.95 m in diameter. One important mission for the Gezhouba power station will be to supply electricity to the giant Sandouping Dam Project, now at the planning stage, 40 km upstreams in the Three Gorges from Gezhouba (see further on page 113).

Because of the raised water level due to the dam, the Yangtse Three Gorges section has been made safer for navigation on a stretch of 100 km. When all three shiplocks are completed, they will be able to operate 50 million tons of shipping annually. The huge No 2 shiplock has two 34 m high gates, weighing 600 tons each. They were welded together in ten separate sections. From the control room a moveable highway and railway bridge on the pier section of the upstream side of the lock allows the dam to be used for transportation. The No 2 and No 3 shiplocks went into operation in June 1981.

Two of the most difficult problems to solve have been related to the geological and siltation conditions. The rock strata at the dam site are composed of conglomerates, siltstones and sandstones with interbedded soft clay layers, which makes the geological conditions very unfavourable to the dam stability. Furthermore the sandstone rock will become very soft during rains. Another problem is the very large difference between summer (max. 39°C) and winter temperatures (min. -6°C). The final construction solution was similar to that used at the Bai River Dam (see page 59). Concrete foundation pillars have been driven 40 m through the weaker rock layers in some places.

The silt conditions have been most important for the project design. At Yichang, the Yangtse River carries 590 million tons of silt annually. It has been mentioned earlier, that due to local deforestation the silt content in the river has not decreased since the 50s. Afforestation in the upper ranges of Yangtse River therefore is very important for the efficient operation of the dam. At the damsite no siltation is permitted in the navigation channels. That is why the spillways have been located in the centre of the river bed. Using the same principle as at Dujiangyan two flow-separating and silt-guiding embankments have been designed at the left and right banks. They will eliminate sedimentation, which can possibly be caused by return water, and form independent navigation channels with still water. The huge right side embankment has basically been constructed upon a former island in the river course. The embankment separates the second and the third channels. There are also two submerged embankments in the second channel, which will prevent silt and bottom load entering the power stations. The silt-clearing sluices will be used to flush away accumulated sand and silt in the navigation channels. The Gezhouba silt design has been proved to be very good. In 1981 accumulated sand and silt in the Third Channels was flushed away only twice.

The most critical construction problem yet was the river closure in January 1981 during the construction of cofferdams to the First Channel. In a Gezhouba pamphlet the river closure was described as follows; "Materials and equipment prepared for the river closure mainly included rocks of 1.77 million cubic metres, 3 290 four-faced concrete blocks ranging from 10 to 25 tons per piece, 200 selfdumping cars of 20-45 tons, 7 loaders of 5-6.9 cubic metres and 24 bulldozers of 120-140 horsepower. The gap left for closure was 203 m wide with a maximum water depth of 10.7 m. The river closure was started at 7:30 on January 3, 1981, with a maximum flow velocity up to 7 m/s. At 19:53 on January 4, the river was successfully cut off by pouring materials of 106 200 cubic metres into it. The whole process lasted 36 hours and 23 minutes. The victory has created a new level in our country's river closure technique and accumulated new experience".

A national gold medal was awarded for high quality of engineering. Then later in May 1981 the reservoir started to be filled in steps until June 1981, when the water stage reached the initial storage level of 60 m.

Not long after being filled, the reservoir withstood the challenge of a very severe flood. From July 11 to 14, heavy rainfalls hit as mentioned earlier the basins of Min, Fu, Tuo and Jialing Rivers in Sichuan. On July 19 the flood peak arrived at Gezhouba with a maximum flow of 72 000 cubic metres per second, the highest in record on the main stem of the Yangtse. Data provided by instruments installed inside and outside the structures indicated that the performance of the structures met the design requirements.

The steep topography in the Xiling Gorge area has meant that the project has been carried through by resettling 10 000 households. The central and provincial governments have supplied them with new arable land in the vicinity of Yichang. The general guiding principle has been, that the standard of the peasants' daily life should not be impaired. A village with new buildings has been constructed. The peasants, formerly living on the Gezhouba island in the middle of the river course, were the main vegetable producers to Yichang city. At that time every peasant could earn 2 Yuan/day. But after the resettlement to a less productive red sandy soil area outside Yichang the daily earning was lowered to only 0.5 Yuan/day. Then the government decided to subsidize the peasants with the difference of 1.5 Yuan/day for three years. The rather favourable location of the dam has also reduced the environmental problems. The environmental effect on the landscape has been very little. I was given a figure, that the Gezhouba reservoir occupied a new land area, which was less than 10% of the over-flooded area of the large Danjiangkou reservoir in Han River Hubei, a tributary to the Yangtse River. There are no forest and few animals in the gorge area. According to a local source, the fish catches around Yichang have fallen considerably during the 70s due to industrial and domestic sewage water pollution. But the dam was said to have improved this situation. The various fish species grow much more rapidly nowadays.

However the Chinese sturgeon (Acipenser sinesis Gray), which migrates to the upper reaches of the Yangtse in Sichuan to spawn, is a problem. The sturgeon can reach a weight of 500 kg. It is the most economic fish in the Yangtse River. It lays its eggs in November-December. The eggs need a lot of oxygen during a period of 20 days in order to be developed. This rather extraordinary requirement could only be accomplished in the upper reaches, where the river flow is fast enough to enable the eggs to float upon the river water surface. In order to help the sturgeon to migrate above the dam it is caught in nets and transported to the upper side of the dam every September. A fish ladder has also been built, but it remains to be seen whether the fish will use the ladder. The sturgeon could also be artificially propagated. In order to ultimately solve this problem the Gezhouba authorities have set up a research center.

Finally it should be pointed out, that the Gezhouba project is both a huge educational asset as well as a highly profitable project. It is really a cooperative effort. More than 120 nationwide units have taken part in the preparations of the project and more than 100 national conferences have been conducted. The core of the technical force is made up by younger scientists and technicians trained in China after 1949. The Gezhouba Engineering Bureau has set up many part-time vocational schools like a secondary technical school and a technical college in order to train the workers' professional skills. Perhaps the most important training is practised at the construction site, when the senior and more experienced engineers and workers train their younger colleagues. According to Chinese tradition and the thoughts of Mao Zedong, true knowledge will come from or will be verified by action and practice. Nobody can claim to be able to understand the Chinese developement after 1949 or the Gezhouba project in particular, without taking the principle of learning by doing into consideration.

The overall cost of the project between 1970-1986 has been calculated to 3 500 million Yuan (1 750 million US dollars). With an electricity price of 0.05 Yuan/kWh the pay-off time will be less than five years, when the project is completed. However, since some generators have been installed 250 million Yuan had already been earned during the autumn of 1982.

The Three Gorges Project and the Transfer of Water to North China: If the Gezhouba is a remarkable project, then the Sandouping Dam Project or the Three Gorges Project is even more gigantic. At Sandouping about 40 km from Gezhouba in the gorge section, the Ministry of Water Conservancy and Power has designed a 2 600 m long concrete gravity dam with a maximum height of 210 m above sea level. The planned hydropower installation capacity is 25 000 MW or almost four times that of the Gezhouba. When the reservoir reaches 200 m the effective reservoir capacity will be 37.6 cubic kilometres affecting an upstream area all the way from Sandouping to Chongqing in Sichuan. The total investment has been calculated to a staggering 9 500 million Yuan and it will take 15 years to complete the construction works (for further detailed information, see Ludlow 1980).

However the Three Gorges Project is a much debated subject among scientists and cadres because of its scale and complexity. The environmental and social problems will be substantial. About 44 000 ha of farmland will be inundated. The project will involve the resettlement of 1.4 million inhabitants, living in towns and the countryside below the 200 m level.

Hydropower generation is not the basic purpose of the project. Instead the main purpose is flood control, and also the possibility of diverting water northwards along the middle route is considered. The risk that a big flood will break the dykes along the lower reaches of Yangtse River is a growing threat. The storage volume of Dongting Lake and other flood retension basins has decreased a lot, because the lake shore land has been reclaimed. Besides this, the silt transport into the shallow Dongting Lake has increased. Together the two factors augment the probability of flooding downstream, especially in the cities of Wuhan, Jiujiang and Nanjing. If a big flood occurs, the flood combating authorities must take the unpleasant decision of diverting water to Dongting Lake causing inundation in 10 counties, which will affect 3-4 million people. Otherwise Wuhan will be flooded. By building the Sandouping dam, the Chinese water conservancy authorities hope ultimately to abolish the risk of flooding in the lower reaches. Some people have the opinion, that instead of building the Sandouping dam, it would be better to build some flood storage dams in the tributaries of the Yangtse River.

Another major benefit of the dam will be the possibility of diverting water to the water-scarce North China Plain (for further deailed information , see Biswas et al. 1983). This diversion will be a part of the so called middle route. Water could be diverted from Sandouping northward to the Danjiangkou reservoir in the Han River valley, see figure 15. Danjiangkou is Chinas largest reservoir with a total storage capacity of 20.9 cubic kilometres and was built in 1958. From the Danjiangkou the water will be channeled to the vicinity of Zhengzhou, traverse the Yellow River by a 6 000 long aqueduct, then the water will flow in a canal between the foot of Taihang Mountain and the Beijing-Zhengzhou railway line all the way to Beijing. The total length of the canal will be 1 300 km. If this northward route is chosen, the Danjiangkou dam must be raised from 162 m to 175 m, a measure which will enable 23.7 cubic kilometres (about 725 cubic metres per second) annually to be diverted.

I was told the following advantages of this route at the Wuhan Institute of Hydraulic Engineering:
1. The water will flow by gravity all the way from Danjiangkou to North China Plain.
2. The topograhic conditions along the route are good with no high mountains or deep valleys.
3. The project will command a large irrigation area and the canal will avoid pollution from industries because of its location near to the Taihang Mountain range.
4. The quality of the ground water is very good along the canal which is a favourable condition to avoid salinization due to seepage from the canal.

The main disadvantages are;
1. The canal must traverse 168 large and middle-sized rivers, which have unstable flows and some of them several kilometres wide.
2. Because of high silt contents in the rivers and unstable river beds a lot of excavation and hydraulic structures are needed when traversing the rivers.
3. There are difficulties in finding suitable intermediate reservoirs along the route.

The middle route should be compared to the eastern route, which is planned to run from Jiangdu Pumping Station (see page 115) along and within the Grand Canal up to Beijing. To realize this diversion route, the water must be lifted 40 m. About 1 000 pumping stations must be built along the route and the water must pass the Yellow River in a tunnel 60 m below the river bottom. The waterlogging and salinization problems will be more extensive if compared to the middle route. There is also a risk that the bilharzia disease will be transmitted to North China. Both routes could cause ecological problems and salt water intrusion in the estuary area during drought periods. Recently the Ministry of Water Conservancy and Power set up a planning group, which should compare the two alternatives.

The Three Gorges Project and the proposed intrabasin diversion routes truly show some of the complexity of the strategic Chinese water planning, which will concern the whole nation. The investment will be huge both in knowledge, capital and labour. Feasability studies and scientific and general discussions will therefore probably continue for the rest of the decade and it is likely that none of the projects will start before 1990.

Jiangdu Key Water Conservancy Project: The Gezhouba Dam closure was awarded a national gold medal by the National Quality Evaluation Committee for its superior engineering work in 1981. In 1982 this price went to Jiangdu Key Water Conservancy Project. The key construction work is the Jiangdu pumping station, located 14 km to the east from the famous ancient city of Yangzhou, see figure 19.

The project area embraces 1.8 million ha including 1 million ha of cultivated land in the Lixiahe Region in central Jiangsu. The population in the region is more than 10 million.

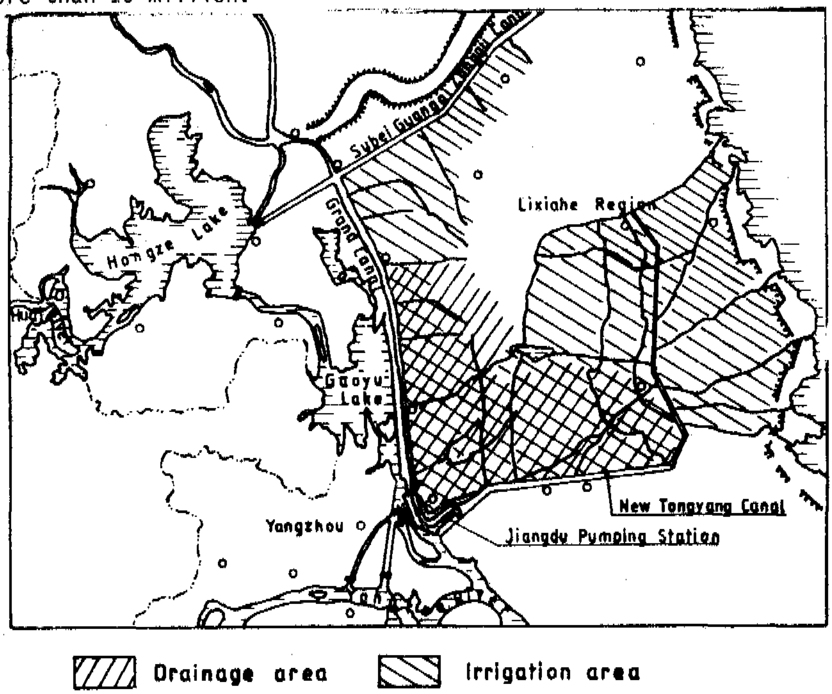


Figure 19. Jiangdu Pumping Station and the Lixiahe Region in Central Jiangsu Province.

Historically the Lixiahe Region has been a disaster-ridden area due to its rather adverse natural conditions. The land surface dips from the outer parts to the central part of the region causing waterlogging and salinization problems. In general, the water levels of the Huai River to the west, the Yangtse River to the south and the Yellow Sea to the east are respectively 6 m, 4 m and 2 m higher than the surrounding land. During the 1931 flood, the Huai River dykes were broken at 20 places and 7 700 people were killed. Salt water inundations from the Yellow Sea were common, aggravating the salinization problems. The last large salt water inundation occured in 1949. Quite often the area was hit by droughts. All these kinds of calamities contributed to the very low annual grain output of 1 500 kg/ha.

The Jiangdu Key Water Conservancy Project is a multi-purpose project for irrigation, drainage, navigation, power generation, fishing and soil improvement. The Northern Main Irrigation Channel from Hongze Lake to the Yellow Sea was dug during the 50s. Building began of the No 1 pumping station at Jiangdu in 1961 after natural calamities had hit the area during the Great Leap Forward.

Table 34. Equipment in Jiangdu Pumping Station

Name of station	Number of units	Motor		Pump			
		Type	Total capacity (kW)	Type	Diameter of impeller (m)	Lift height (m)	Total capacity (cms)
No 1	8	Vert. sync. 24 poles	6 400	Vertical axialflow	1.6	7	64
No 2	8		6 400		1.6	7	64
No 3	10		16 000	Vertical axialflow, full-regulation	2.0	8	135
No 4	7	Vert. sync. 40 poles	21 000		3.1	7	210
Total	33		49 800				473

The No 4 pumping station was completed in 1976. It has seven pump units each with a single capacity of 30 cubic metres per second. Today Jiangdu pumping station consists of four large electric pumping units equipped with 33 machine sets with a total installed capacity of 49 800 kW and a pumping capacity of 473 cubic metres per second, see table 34. So far 12 sluice gates, 5 boat locks, 2 trunk canals, 2 fish-ladders, numerous protection levees and gates in the river outlets to shelter against the sea water and many diverting and drainage channels have been built to constitute the Jiangdu Key Water Conservancy Project. Most of the construction work has been done by labour, mobilized during the agricultural slack winter and spring seasons.Some modern equipment has been used, when constructing the four pumping stations.

The Jiangdu irrigation and drainage scheme is the largest single one in China. When the Huai River water is unable to fill the irrigation needs in the Lixiahe Region, Yangtse water is led by gravity or pumped into the region to irrigate around 660 000 ha of farmland. Another benefit of this diversion is, that it makes it possible to divert the Huai water , which has been stored in the Hongtze Lake to the districts north of the Lixiahe region, which has further expanded the rice-growing area northward. In addition, the scheme can drain an area of 400 000 ha during the flood season. The pump turbines in No 3 station are reversible, which means that in case of excess water in the Huai River or Hongze Lake the water could be drained, as well as be used to generate electricity. Each pump unit has a capacity of 300 kW.

The water conservancy works that have been accomplished have meant that the Lixiahe Region generally takes two crops of rice and one crop of winter-wheat per year. The total grain productivity is more than 8 000 kg/ha, an increase of more than five times compared to the situation before the project works started.

The pumping station and its auxiliary works are managed by the Jiangsu Water Conservation Bureau. Each pump unit can be operated separately. There is a control center for the four pumping stations. In the future the bureau hopes to install an automatic flow control system, which will include all the sluice-gates etc. At present the irrigation and drainage water is not charged, but this should be changed in the future. The entire Jiangdu Key Water Conservancy Project has 400 employed of which 50 are technicians.

<u>The Guazhou Water Conservancy Project</u>: The Guazhou Water Conservancy Project in Hanjiang County Jiangsu is a typical self-sufficient project at the county level. It is located 15 km to the southwest of Yangzhou at the confluence of the old section of the Grand Canal and Yangtse River.

The project's main structures are a 23 m wide sluice-gate section, a 75 kW hydropower station, an additional small fish ladder, a pumping station of 14 pumpsets with a total capacity of 20 cubic metres per second and a boatlock (136 m long x 13.9 m wide) navigable for a 500 ton ship. The project was built between 1969-1975. The total investment was 3.2 million Yuan of which 3.1 million Yuan was paid by the Jiangsu Provincial Government and the rest by Hanjiang County. The Hanjiang County Water Conservancy Bureau has designed the project.

The main function of the project is the prevention of floods. In 1931 people in this area were poverty-stricken because of serious floods. Also in 1954 there was a serious flood and the National Government had to allocate food and money as relief. The flood resisting command area is 28 500 ha embracing parts of three counties and the city of Yangzhou. The discharging capacity is 340 cubic metres per second of flood water coming from the Huai River and local mountain streams. This capacity includes flood drainage from the pumping station. The project also affords protection from the high tides of the Yangtse. The downpours can be very heavy. In 1975 there was 580 mm of rain within two days. All the flood water was drained off the land to the Yangtse River and thanks to this measure the area was still able to produce a good grain crop of 7 500 kg per ha. In 1980 there was 190 mm of rain within seven hours. In 12 hours the flood water was basically drained off.

The project supplies irrigation water to 13 300 ha in the irrigation season. The water is lifted in steps by 30 pumping stations from the Yangtse River (average water level +4.5 m) to 43.5 m above sea level in the remote northwestern mountain hilly area. In the exceptionally dry year of 1978 140 million cubic metres of water was pumped by the Guazhou station from the Yangtse River to ensure the regular irrigation of the farmland. The project also controls the ground water level of 3 300 ha.

Before the construction people living in the area had to "rely on heaven". The average grain yield was just above 4 000 kg per ha. Nowadays they harvest two crops per year. The average grain yield has increased to more than 8 200 kg per ha. The rice yield has gone up from 3 000 to 6 000 kg per ha and the winter wheat yield from 750 to 5 250 kg per ha.

The project's main structures are managed by the Guazhou Water Conservancy Management Committee. It has 87 persons employed, but only one engineer. More than 70 percent of the 305 600 Yuan total income in 1981 came from sideline works such as a hotel, a department store, a plant shop, a radio repair shop etc. About 75 000 Yuan was boatlock fees and 8 000 Yuan flood resisting fees. They charge 0.08 Yuan per each ton loaded boat and 0.008 Yuan per each ton unloaded boat. The annual flood resistance fee is 1.5 Yuan per ha. During the flood season an additional fee of 0.10 Yuan per kWh is charged. The total cost in 1981 was 110 000 Yuan, which means that the Committee is self sufficient and has a considerable surplus. However, the costs do not include the irrigation pumping cost. At the moment the provincial government subsidizes the irrigation costs by paying 0.10 Yuan per kWh used in the irrigation season. The brigades or peasants were not charged for the irrigation water. I was told, that for the moment it was difficult to calculate a proper price because several counties were involved. Neither are the large-sized maintenence works such as lock and pump repairs included in the Management Committees budget. These costs are paid by the Jiangsu Provincial Water Conservation Bureau.

THE PEARL RIVER BASIN

Pearl River or Zhu Jiang is composed of the West River (Xi Jiang), the North River (Bei Jiang), the East River (Dong Jiang) and the Delta area. The basin covers parts of Yunnan, Guizhou, Guangdong, Hunan and Jiangxi Provinces, part of Guangxi Autonomous Region and a small part of Democratic Republic of Vietnam, see figure 20. The catchment area amounts to 452 500 square kilometres. The Pearl River Commission seated in Guangzhou is the coordinating planning and management unit for the entire basin. It has more than 1 000 people employed of which 200 are engineers and 400 technicians.

Table 35. Principle features of the Pearl River and its main streams.

	Drainage area (sq.km.)	Length (km)	Mean annual runoff (km^3)	%	Elevation drop (m)
West River	355 000	2 074	246.0	72	2134.2
North River	46 700	468	48.2	14	305
West and North River Delta	17 600	141	15.8	5	1.8
East River (incl delta)	33 200	523	31.2	9	840
Pearl River	452 500	2 215	341.2	100	2 136

Source: The Pearl River Commission 1982.

The Pearl River Basin can be divided in two equal large parts representing the two main geomorphological landforms, see table 36. The western half is a part of the mountainous Yunggui Plateau which has 1/3 of the population in the basin. About half of the western area consists of limestone bedrock. The beautiful karstic scenery has during hundreds of years inspired Chinese painters. Some 2 000 subterranean rivers have been found. Their total length has been estimated to twice the length of Yangtze River. Their water flow has been assessed to about 250 cubic kilometres (Beijing Review 1-1981). In Guangxi there are 600 underground rivers, which supply a flow of 190 cubic metres per second even in the dry season. The eastern half is also very mountainous, but it is intersected by broader alluvium plains and the delta region. The bedrock is predominantly of old granitic rock-series, which makes the leached soils poor in nutrients (see further Liuxi River Regulation on page 124).

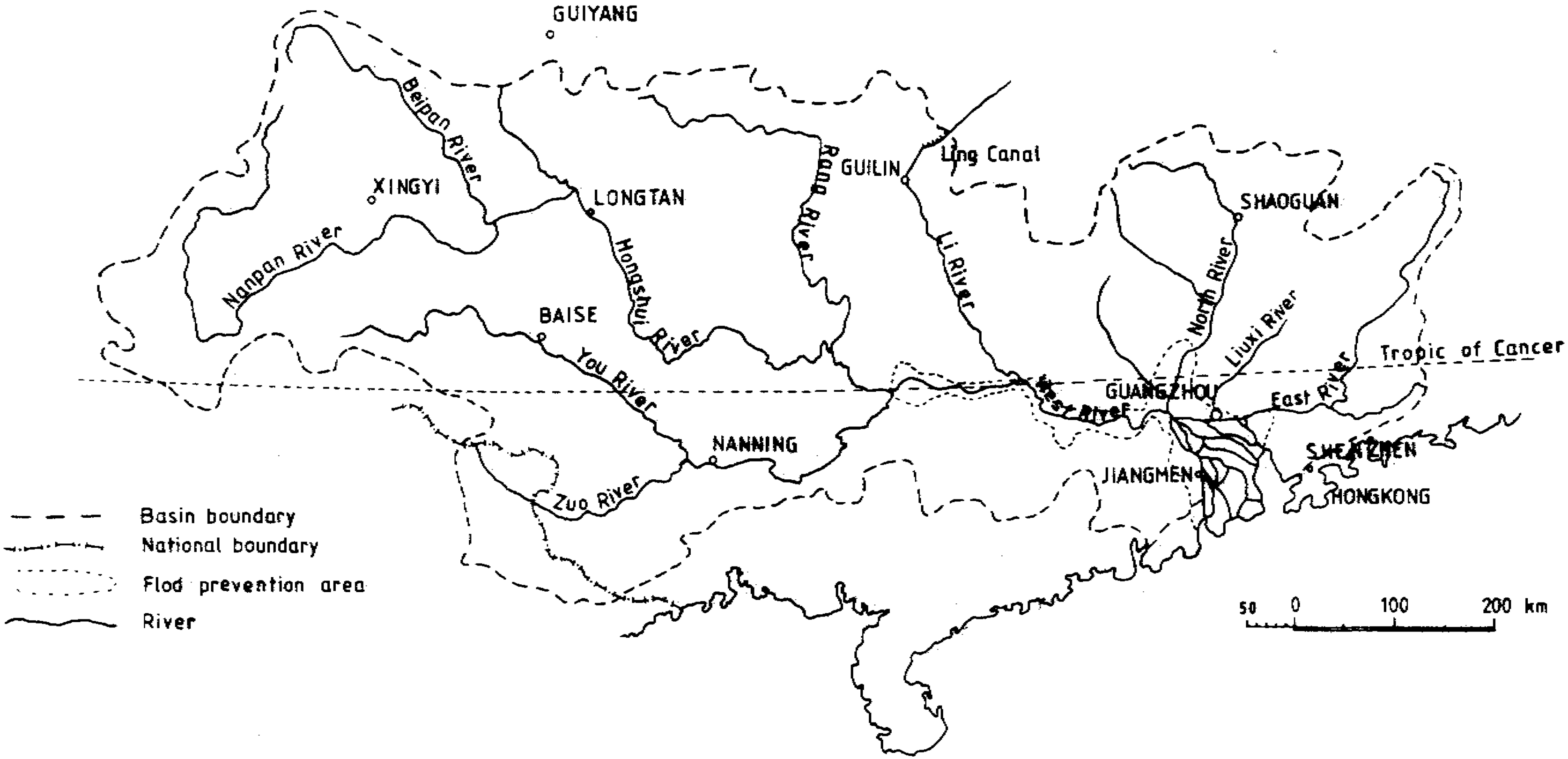


Figure 20. The Pearl River basin and its main tributaries (Redrawn and revised after a map from the Pearl River Commission)

Table 36. Area, landforms, population and water resources in Western and Eastern part of Pearl River Basin.

	Area		Landforms	Population		Water Resources	
	km^2	%		Millions	%	km^3	%
West	226 000	50	Mountain and plateau land (Yungui)	25	33	150	44
East	226 000	50	Mountains and hilly mountains, alluvium plains and the delta	51	67	190	56
Total	452 000	100	-	76	100	340	100

Source: The Pearl River Commission 1982

Since the Pearl River Basin is situated in the subtropical zone, it has a mild climate and abundant rainfall. The mean annual temperature is above 20°C. The mean annual precipitation in different regions in the basin varies between 1 000- 2 200 mm (see figure 4 on p. 42) and the mean annual evaporation varies between 1 000-1 800 mm. The average annual runoff is 341 cubic kilometres, which is 13.2 percent of the total runoff in the whole country and second to the Yangtse River discharge.

The Pearl River Basin is basically an agricultural region. The total population was 76 million inhabitants in 1982 of which 65 millions belong to the agricultural population. The cultivated land totals 5.2 million ha or 11.5 percent of the basin area. About 1/3 of the cultivated land is situated in the western half and the rest in the eastern half of the basin. The paddy-field area is 3.05 million ha. The land is very intensively used with only 0.068 ha of cultivated land available to each person. However the water availability of 4 500 cubic metres per capita is ranks first in China.

Before 1949, the Pearl River Valley was a disaster-stricken area. Drought often occurred in the mountainous regions along the upper and middle reaches, while the delta area and regions along the lower were frequently hit by floods, waterlogging damages, saline contamination and windstorms. In this century heavy floods occured in the years 1902, 1915, 1923, 1924, 1931, 1947 and 1949. In 1915 the Delta was hit by a flood of 200 years frequency. The peak discharge was measured at the Wuzhou hydrological station in the West River to 54 500 cubic metres per second and that in the Fei Lei Gorge in the North River was 18 600 cubic metres per second. The flood inundated 300 000 ha of farmland and brought havoc to some 2.76 million inhabitants. Guangzhou was flooded for a whole week. The 1915 years flood is described in the memoirs of the very remarkable Swedish engineer Wilhelm Olivekrona (Olivekrona 1960). He devoted his life to work as a water conservation engineer in China for almost 40 years. During the 1910, 1920 and 1930 decades he was engineer and later chief engineer of the Pearl

River Commission at that time. His memoirs give a valuable account of the political disorder and the economic backwardness during the period, which rendered very little success to water conservation works.

After 1949 the Pearl River Commission and other responsible units have striven for a unified planning and a comprehensive use of the basins water resources. Up to 1982, 362 large and medium-sized and numerous small water conservancy and hydroelectric power stations projects have been constructed.

Flood peaks causing inundations are prevented by the building of reservoirs, dykes and levees. The total storage capacity of the reservoirs is 38.8 cubic kilometres equivalent to 11 percent of the average annual runoff. The length of dykes and levees totals 10 328 km. With these measures of ordinary degree flood peaks and waterlogging could be combated. To further improve the situation more storage reservoirs will be built, the dykes and levees will be reinforced and the river regulation works in the Delta area will be expanded. In order to safeguard Guangzhou from a serious flood a multi-purpose reservoir is under design in the Fei Lei Gorge in the North River. The project will also provide 150 000 kW of generating capacity and a shiplock capable to handling a 500 ton ship.

The theoretical hydroelectric power potential in the Pearl River has been estimated to 33.5 million kW of which the developable power is 25 million kW. The Hongshui tributary in the West River is especially rich in water energy and its developable potential has been estimated to 10 million kW. Today the total installed capacity of all stations regardless of size has reached 4.5 million kW of which the installed capacity from large and middle sized stations account for 2.3 million kW. When the two large stations at Lubuge and Tianshengqiao, now under construction in the West River, are finished the installed capacity will increase with 1.4 million kW. Many areas in the Pearl River Basin are famous for their numerous small hydroelectric power stations.

The completed power stations have up to the present been concentrated to the eastern half of the basin, but in the future more stress will be laid on the water power development in the western half. For example in the Hongshui River there is a proposal to build a ten cascade project of large scale with the aim of bringing about comprehensive utilization benefits of flood control, irrigation and navigation. The Pearl River Commission also investigate how to increase economic efficiency and how to get a more comprehensive use of existing power stations.

Navigation is very important in the Pearl River Basin. There are 980 streams with a total navigable course of 11 300 km, which are used for transportation. The annual transportation capacity is 53 million tons, about equal to the capacity that will pass the Gezhouba Dam in the future (see page 108). In the near future the navigation channel between Nanning in the Guangxi Autonomous Region to Guangzhou and the Guangzhou City waterway outlets will be improved. Transportation and regulation plans will also be drawn for other parts of the basin including the Delta area. Furthermore feasibility studies will be made to investigate the economic rationality of the construction of canals, which will connect the Pearl River Basin with the Yangtse River Basin. Such a connection was first made during the Qin Dynasty (221-206 BC), when the famous Ling Canal was dug. The Ling Canal was built on a slightly falling contour between the Xiang River (Yangtse River Basin) to Li River (Pearl River Basin). According to Needham the canal was provided with navigation locks in the 12th century, several centuries before Leonardi da Vinci had ascribed to the idea of navigation locks in Europe (Needham 1971). The Ling Canal has been in continuous use since it was built.

The Delta area has its own specific problems. At the moment the West and the North Rivers have eight outlets through the Delta. The ground water table is very high, a fact which has contributed to the fact that parts of the Delta are dotted with numerous ponds for fish-culture. The high ground water table also causes salinity problems. Therefore much effort will be made in the future to raise the Delta's capacity of preventing flood and waterlogging by increasing the drainage and discharging capacity. Thereby the navigation conditions will also be improved. There are also about 45 000 ha of reclaimable beachland. After new regulation construction works have been finished in the Madaomen and Humen estuaries 27 000 ha will be reclaimed in the near future.

At present the area of farmland equipped with irrigation facilities has reached 60 percent of the total cultivated area, see table 37. However much

Table 37. Standard of cultivated land in the Pearl River Basin.

	Million ha	%
Farmland equipped with irrigation facilities	3.1	60
Dryland in need of irrigation	1.9	36
Other dryland	0.2	4
Total cultivated area	5.2	100

Source: The Pearl River Commission 1982.

of the irrigation installations are of low reliability and much water is wasted. Altogether 45.8 cubic kilometres of water is provided for irrigation during the dry season, which means an application of 1 480 mm. This very high figure indicates low irrigation efficiency even if most of the irrigation land is paddy fields. The main task for the future therefore is to improve the irrigation efficiency. Since the cultivated land plots in the basin are rather scattered and small in size, the balance of water and soil resources will be made separately in a unified planning and in line with local conditions. It means that medium and small-sized streams will be the chief irrigation water sources. But at the same time measures for retaining, diverting and pumping will be considered in order to solve the irrigation problems.

The daily water supply to the basin's principal towns and cities is taken directly from the main streams and reservoirs. Guangzhou has eight water plants, which take its water from the East River. Hongkong is also supplied with water from the East River. The industrial water consumption has been estimated to 4 cubic kilometres and other daily consumption water to 7.4 cubic kilometres, see table 38.

Table 38. The water consumption in the Pearl River Basin.

	km^3	%
Irrigation	45.8	80
Industry	4.0	7
Daily consumption (probably households and cooling water)	7.4	13
Total water use	57.2	100

Source: The Pearl River Commission 1982.

The water quality has deteriorated in many parts of the basin during the 70s. Some rivers, lakes, reservoirs and water sources in many cities are polluted to a different degree and the situation is especially troublesome during the low water period. If there are no septic tank systems or industrial purification equipment, sewage waters from households and industries are piped untreated into the rivers. The tourist city of Guilin put the basin's first sewage treatment plant into operation in 1981. Guangzhou has no treatment plant, but plants are planned.

The planners at the Pearl River Commission are aware of the pollution threat and it will be considered in the overall planning in the future. Much effort will be made to strictly implement the water sources protection laws and to control the pollution sources. Guilin sewage treatment plant will be followed by other ones. Energetic efforts will also be devoted to afforestation to check soil erosion. The guiding principle will be a unified planning over the entire basin in which mountain and plain regions, forestry and farmland regions, water quantity and water quality aspects will be integrated, so that a comprehensive use of the water resources will be obtained.

Liuxi River Regulation:The Liuxi River Basin is an intermediate small catchment of 2 300 square kilometres situated between the North and the East River Basins. The river empties its water in Zhu Jiang not far from Guangzhou. The Liuxi valley is a red sandy soil area with low fertility. It is possible to grow three crops per year (usually rice, rice and winter-wheat), but the peasants are unwilling to have more than two crops because of lack of chemical fertilizers. The average yield of two consecutive rice crops in Liuxi valley is 9 000 kg per ha. The winter wheat yield is quite moderate, 1 500 kg per ha or less. Alfalfa is sometimes sown in order to improve the soil fertility. Other crop combinations are two groundnut crops per year or a groundnut crop followed by a sugercane crop. The peasants have in 1980 adopted the responsibility system based upon households.

The Liuxi River is considered to be the best harnessed river in Guangdong. The climate conditions are very variable. For example rainstorms and thunderstorms are common and it is not unusual for 200 mm of rain to pour down within 24 hours. Rainfall intensities like this in combination with the cutting of trees and even collecting of grass for firewood has meant rather serious erosion problems in the Liuxi and Bei River valleys. During a heavy storm in May 1982, there was a large mudflow in the Bei River, which destroyed 10 000 ha of arable land. According to a local saying three days of rain meant flood and three days of sunshine meant drought before the regulation of the Liuxi River.

The Liuxi River has been harnessed for the multi-purpose utilization of flood control, hydroelectric power, irrigation, water supply and fish-culture. Some data from visited power stations and reservoirs are given in tables 39 and 40.

The Liuxi Reservoir was constructed between 1956-1959 with the help of Soviet technicians in the upper course of the river. The flood risk has thereby been much reduced. It is a large-sized reservoir with an effective storage capacity of 270 million cubic metres. The reservoir controls an area of 900 square kilometres of which 536 square kilometres are within the Liuxi River catchment. According to the American Water Resources Delegation (Nickum 1977a), which visited the 78 m high arch concrete dam in 1974, it has most unusual multi-level skijump spillways, one for each bay, which pitch water to different points in the canyon and thereby dissipate the water energy to protect the dam. The American delegation also mentions, that the use of skijump spillways at various levels is found only in certain sophisticated dam constructions in Italy and France and the provision of separate skijumps for each bay is still entirely unique to China. These spillways and a 273 m long tunnel spillway make up a maximum flood discharge of nearly 2 000 cubic metres per second. In addition, the dam was fitted with rather unique rubber crest gates.

The flow condition in the Liuxi River is very variable. In spite of the Liuxi Reservoir, a flow of 1 080 cubic metres per second was recorded through the spillways of the Conghua Artificial Lake Power Station in 1975. This maximum flow compared with the average flow at the station makes up the very high ratio of 270:1.

There is a total of 55 000 kW of installed hydroelectric power generating capacity in the Liuxi River. As much as 42 000 kW of this is installed in the underground Liuxi River Hydropower Station. The water is lead from the Liuxi Reservoir through an almost 2 000 m long rock tunnel to the four standing turbines in the underground station. New turbines manufactured in Harbin were installed in 1978. At the time the Liuxi River Hydropower

Table 39. Some data about hydroelectric power stations visited in the Liuxi River.

Name (Construction period)	Height above sea level, m	Installed generating capacity in kW and the number of turbines ( )	Power head m	Average flow m^3/s	Management unit
Conghua Artificial Lake Power Station (1958-1971)	100	1250 (5)	4	4	Conghua County Water Conservation Bureau
Tien Hu Power Stn (1959-1961)	255	320 (2)	38.2	0.8	———"———
Fei Tao Power Stn (1959-1961)	160	960 (3)	98.8	0.6	The Local People Commune
Liuxi Power Stn (1956-1959)	120	41 600 (4)	113	53	Guandong Provincial Water Conservation and HEP Bureau

Table 40. Some data about visited reservoirs in the Liuxi River.

Name (Construction period)	Height of dam above sea level m	Catchment area km^2	Surface area km^2	Max depth m	Storage capacity million m^3	Effective storage capacity m	Height of dam m	Length of dam m	Max. spillway capacity m^3/s
Liuxi Reservoir (1956-1959)	235	536	14.9	78	390	270	78	265	1 072
Tien Hu (Heavily Lake) Reservoir	295	10	0.37	40	10.3	8	38.2	130	-

Station was built, it was rather rare to build underground stations. The generated electricity is supplied to the Guangdong 110 kV network.

The Liuxi Reservoir supplies 3 700 ha of land with irrigation water. Fishing in the reservoir is managed by the forest farms, which surround the reservoir.

Besides the Liuxi River Hydroelectric Power Station there are a lot of small hydroelectric power stations in the river and its tributaries. I had the opportunity to visit Conghua County Artificial Lake Power Station and Tien Hu Power Station, see table 39. The construction of the Soviet designed Artificial Lake Power Station began in 1958. However, when the Soviet experts were withdrawn in 1960, they took away all the blueprints and design papers, which halted the construction for about 10 years. This power station is owned by the state, but it is managed by the Conghua County Water Conservation Bureau. The bureau pays 29 employers of which all were said to be workers. If there were any problems they could ask the technicians at the bureau. The power station was said to be an example of how to mobilize the masses for small-scaled hydroelectric power generation. Up to 1978 the station was operated with five concrete typed turbines with fixed blades. The staff had manufactured these turbines in their workshop. The cement-typed turbines have now been changed to steel-blade turbines, which had also been manufactured by the staff. However, the generators had been bought from a Guangdong factory at the price of 18 000 Yuan each. All the produced electricity of about 3 million kWh per year was supplied to the Guangdong network. The state remunerated the Conghua County Water Conservation Bureau with 200 000 Yuan for the delivered electricity.

The Tien Hu Reservoir and Power Station were built in one of the tributaries during the "Great Leap" period. It is managed by the Tien Hu Lake Management Area Committee subordinated to the Conghua County Water Conservation Bureau. Tien Hu is another example of a water conservation work, which after its completion has been developed into a tourist attraction. The Area Committee also runs a hotel, where most of its 120 employed work. As in the case of the Liuxi Reservoir there is a forest farm around the Tien Hu Reservoir. Various kinds of carp, grass and whitefishes are raised in the reservoir and it also supplies drinking water of first class quality. After passing the power station some of the water produces a cascade to attract the tourists, but most of the water will flow to the Fei Tao Power Station. This station is managed by the people's commune in the area.

CHAPTER 6

EFFICIENCY IN WATER USE AND IRRIGATION MANAGEMENT

In 1977 the United Nations Water conference stressed the worldwide importance of improving current water management practice of existing irrigation and drainage schemes. At present on a global basis some 3 000 cubic kilometers of water is withdrawn for the purpose of irrigation, but only 1 300 cubic kilometres is left for infiltration upon the irrigated soil. Thus, 57 percent of the total water withdrawn is lost during storage, conveyance or in application in the field. Moreover of the remaining 43 percent, which will infiltrate the soil, some part will contribute to the development of environmental problems such as increases in the waterlogged and salinized area due to over-irrigation. Over-irrigation is considered to be a wide-spread problem in many parts of the world. In 1975 FAO estimated the irrigated and drained area in the market economies of the Third World (excl. China) to 92 million ha respectively 134 million ha. The increase of the irrigated area up to 1990 was estimated to 22 million ha, but much more interesting for efficiency was, it was estimated that 45 million ha of the existing irrigated area would be improved by 1990. Moreover an additional 78 million ha of farmland of which 52 million ha on irrigated land and 26 million ha on non-irrigated land was targeted to be drained before 1990 (Jürriens & Bos 1980; Biswas 1983).

In chapter 3 it was argued, that before the middle of the 1970s the biased western development theory was never really challenged as the panacea for national development. Coherent with this biased industrial approach is the favouring of the construction aspect of water projects, with less attention paid to the management of water projects. Certainly, on a global basis this approach has favoured profit-seeking transnationals and other companies within the water construction and irrigation business, but seldom favoured the often illiterate peasants, who use the water. Over the last century there has been little incentive for any major innovation to efficiently improve the use of water as it has been considered as an abundant and free commodity. Or with the words of Skogerboe:

> "Aggravating this situation of so called "cheap water" is the fact that the development of irrigated agriculture in most places, even in the last few decades, has focused almost entirely upon the construction of water delivery sub-systems. The preoccupation with the installation of "hardware" results from a naive single-discipline approach to water management, and one discipline which cannot begin to solve the complex physical, economic and sociological problems involved. Probably the greatest deterrent to improved water management in most irrigation systems today is the inordinate focus on the water delivery sub-system and the almost complete neglect of other problems of the system such as the need for improved soil-plant-water management techniques, improvements in cultural practices, farm machinery, agrarian structural reforms, roads, marketing systems, advisory services and input supply systems, administration of institutions, water-laws, co-operative and water users associations and many other factors all of which must fit together in all their interdependencies and complementarities to form a most complex system" (Skogerboe 1983, pp 43-44).

Many other authors have also stressed the contextual framework of rural development, see chapter 3, the organizational and institutional aspects have especially been seriously neglected. Gradually more and more people have come to realize in the latter years that without a well-shaped rural or irrigation organizational structure, there will be no linkage between the state or government's intention of plans for rural development and the peasant's will or incentive to produce an agricultural economic surplus. Neither will the peasants have the incentive to rationally use the water under such circumstances. It is hoped that the UN Water Conference will represent a major break with current water-wasting ideologies.

The Chinese experience should be judged against this international background. It has already been claimed that China has rejected the biased Western liberal growth model by adopting a basic needs approach for her national development. Thus, it would be interesting in this chapter to reflect in more depth than in the preceding chapters the question of water efficiency and management in China. As elsewhere in the world and so also in China the available literature concerning water management at the consumption level is quite scarce.

Detailed field investigations of water management practice seem to be rare even in the Chinese language. In the English language a translation of the Meichuan Irrigation District experience (Nickum 1977b, Nickum 1981) and a report from ESCAP study tour to the Zing Ping Irrigation District and some other places (ESCAP 1979) seem to be the most detailed accounts of irrigation management. Thus, the presentation has to be restricted to a discussion of water efficiency in general in agriculture.

Water efficiency and production

The starting point of the discussion is to realize that the purpose of irrigation is not merely in the short run to increase crop production but more essential in the long run to achieve an agricultural production at a sustained high level. From history we know that the experience of hydraulic-dominated societies has primarily been one of applying too much water, which results in waterlogging and salinization and thereby reduced crop production. The construction and management aspect of irrigation projects cannot be dealt with separately. They are a dual entity.

Chinese sources often stress this entity.

> "The construction of farmland water conservancy projects provide the material conditions for resisting drought and natural disaster. In order to fully utilize water resources and project facilities so as to improve the soil and achieve the goal of increased agricultural output, our management work should be done properly on the basis of existing projects. Thus it has always been considered an important principle in the development of China's water conservancy since liberation that "construction and management are of equal importance", and it has been strongly advocated that after any single site is built, it should be managed and utilized well and continually consolidated to yield good results" (Irrigation Management 1965).

It is well-known that good water management will lead to a high degree of water efficiency. Then the question will be whether the Chinese policy statement above reflects the actual situation during various time periods since 1949.

The 1950s - decade of emphasis on construction

From various sources it can be concluded that the construction aspect was over-emphasized at the expense of the management aspect during the 1950s. Certainly during the Great Leap Forward 1958-1960 the inefficiency of a large number of construction projects was clearly exposed (Oksenberg 1970). The Chinese government claimed that 4 000 large irrigation districts diverting water directly from rivers had been constructed by the end of 1959, but it admitted some years later that in most of the systems 40 to 60 percent of the water was lost through leakage. Furthermore 30 percent of the designed capacities of the large- and medium-sized projects in the northern provinces and Liaoning were not utilized. Due to high seepage from canals and inadequate drainage the area of water-logged and saline land increased in many irrigation districts (Nishimura 1971). Even these figures seem rather high when considering the rather low irrigation efficiency of 35-50 percent in the water regions of the United States at that time (Oliver 1972). It should be noted that as late as the end of the 1950s the reservoir storage capacity was insufficient and improperly managed to cope with the severe drought of 1959. In Hebei 82 percent of the medium- and small-sized reservoirs and ponds had dried up by early August 1959 affecting 3.6 million ha of the 4.3 million ha of farmland in the province. In Jiangsu half of the claimed 500 reservoirs built in the hilly regions had dried up in mid-August 1959.

According to Nishimura (1971) the causes of inefficiency of water use in the 1950s should be primarily sought in three factors: technical defects, shortage of materials and poor management. The Chinese leaders had great ambitions and were hasty for a socialist modernization at that time. However, the technical foundation taken over from the old society was in general too weak for such a rapid development. There was a large shortage of skilled water technology personnel. Even if the number of water technicians in the organization of water conservancy increased from 5 460 in 1952 to 36 000 in 1958, it could not match the need of the large mass-campaigns during the end of the 1950s. There was a specially severe shortage of highly educated engineers and the reliance on Soviet technicians was in general great before their withdrawal in 1960.

At that time the systematic concentration on establishing a hydrological network, started in the 1950s, had not yet yielded any significant results. Also the geological conditions were basically unknown in most river basins. Thus the consideration of quality and scientific methods was often overlooked. Quantity alone received attention, which often resulted in poor technical designs.

On the other hand the Great Leap Forward in spite of its many shortcomings was the start of the self-reliance policy stressing decentralized decision-making and production responsibility at the lowest possible administrative level. This policy has been carried through from the beginning of the 1960s up to today. Partly, this shift in policy was due to the fact, that the state failed to supply enough funds and construction materials in spite of a rapid Soviet-styled industrialization carried out during the First Five Year Plan 1953-1957. The state could supply only two-fifths or a third of the quantity of cement and steel, demanded by large and middle-scaled water conservation and hydro-electric constructions in 1959, which forced engineers to use lower quality materials. The industrialized base was still too weak and had not increased enough to cope with the enormous modernization needs of the Chinese countryside. Within this context the Great Leap Forward may be said to symbolize the policy of substituting capital with labour for generating an economic surplus.

Thus many water construction projects lacked technical performance and were poorly managed, which resulted in low quality and poor utilization of water in the 1950s. One of the Soviet experts, Korniev, stated in 1958, that because the problem of management was underestimated many projects did not play their economic roles in irrigation and flood prevention (Dawson 1966, p 160). Nishimura (1971) gives a lot of concrete examples. For instance the majority of the 128 middle and small-sized reservoirs and some 200 000 ponds and dikes in Fu He Basin in Hebei could not be effective because of inferior quality. A flood in Guangdong in South China in June 1959 destroyed 28 000 large to small water conservation reservoirs and dikes due to improper design and construction materials.

Many of the large- and medium-sized reservoirs and dams in the Huai River Basin were built without sufficient hydrological and geological data. The author was given some information about the middle-scaled Ming Tomb Reservoir outside Beijing during his visit in China 1982. This reservoir was built during the peak mass-campaign of the Great Leap Forward with the participation of Mao Zedong and other national leaders. Due to insufficient geological investigations, it was built above a faulted and fractured zone, which has subsequently resulted in serious leakage, low efficiency and related management problems.

Thus low water efficiency and improper management of irrigation and other water construction projects were common. From the land reform up to the establishment of the People's Commune during the Great Leap Forward the rural organization was undergoing continuous change, which especially at lower levels rendered the water administration very weak. Therefore the 1950s could be said to be the trial and error period of water resources development. Due to the weak technical and material resource base inherited from the preliberation time, China probably had no other choice of policy. It is important that the experiences gained from the trial and error period result in more efficient water use in the future.

<u>The first half of 1960s-strengthening the rural organization</u>

Important policy steps towards a foundation for improved water efficiency were taken during the first half of the 1960s. In the aftermath of the Great Leap Forward, the authorities summed up the experiences of the 1950s. It became a general trend to advocate economic efficiency in water use by for instance filling in existing irrigation projects with ancillary works in order to better use the capacity, supplying irrigated areas with drainage facilities and improving water control and management. Especially the concept of high and stable yields and the regulations governing the People's Commune have had major influence on the water resources development.

The nation-wide launching of the high and stable yield concept in 1964 has upgraded the management aspect of water conservation. According to this concept farmland fields are to be developed with sufficient irrigation and drainage facilities, so that under ordinary conditions of drought or waterlogging agricultural production still may increase in a stable manner. At first the general output criteria related to the term ordinary conditions were those of the National Programme for Agricultural Development 1956-1967 put forward in 1956, i.e. a total grain yield of 3 tons/ha for the area north of Huang He, Qinling Mountains and Bailong He to the west, 3.75 tons/ha for the area between Huang He and Huai He and 6 tons/ha for the entire area south of Huai He (see Gustafsson 1981a). In China the irrigated area is equivalent to the area which has access to water from irrigation installations. But according to the Program an area with guaranteed irrigation should be able to sustain growth of crops in the case of 30-50 days without rain or 50-70 days in areas adaptable to the cultivation of two-season rice crops. However, when the high and stable yield concept was popularized in 1964, it was made very flexible by being dependant on the geographical area and the level of technology. Thus the overall standards of high and stable yields set at the provincial level were the guidelines for lower levels, which were promoted to arrange production for high and stable yields based on local resource conditions. Such a system gives room for decentralization, which promotes local initiative and participation in target setting. Vermeer quotes the standards for high and stable yields of the Guangdong Province set in 1965 as follows (Vermeer 1977, p 185);

1. Resist a drought that occurs once every 10 years.
2. Resist waterlogging that occurs once every 10 years.
3. Resist floods that occurs once every 20 years.
4. Resist the assault of typhoons of 9 degree force and tidal waves.
5. Provide an annual grain output of 6 tons/ha and where this target has already been attained 7.5 tons/ha or even higher.

Apparently the standards have become stricter with the mechanization of the irrigation and drainage systems. The nation-wide overall definition of high and stable yields used by the State Statistical Bureau today is a "field of assured harvest and consistently high yields despite drought and waterlogging" (China Report: Agriculture, No 255-1983, p 115).

The most important and basic policy document issued in the beginning of the 1960s was the Regulations on the Work of Rural People's Commune, also called the Sixty Articles (Sixty Articles 1962), which was adopted by the Tenth Plenary Session of the Eight Party Central Committee in 1962. This document laid down the fundamental rules and tasks concerning the People's Communes cooperative system. The stipulations of the Sixty Articles were written with the Model Regulations for an Advanced Agricultural Producers Cooperative (1956) as the prototype and with the purpose of preventing excessive egalitarianism in commune administration. There had been widespread problems of egalitarianism during the Great Leap Forward i.e.the tendancy to prematurely effect the transition to communism and especially the requisition of labour and assets from the collective units without compensation.

The Sixty Articles became the basic guideline for the cadres and decision makers at the commune level up to the Third Plenary Session of the Eleventh Party Committee in 1978, when the New Sixty Articles Document was adopted for trial implementation. When revising the original Sixty Articles, they were said to have played an important historical role in both promoting the consolidation of the People's Commune system and developing agriculture, but their implementation was sabotaged by Lin Biao and the Gang of Four during the Cultural Revolution. Therefore, the New Sixty Articles were said to be a reconfirmation of the important policies of the original ones, but written in the light of the new historical experience (New Sixty Articles 1978; Beijing Review 30-1983, p 22).

The Sixty Articles established the three-level ownership right of the means of production i.e. commune, brigade and production team. The team is the basic accounting unit and water consuming unit. Each level has a management committee (renamed revolutionary committee in 1968) for the daily work. The management committee of the production team is directly elected for a period of two years by voting of the residents. The management committees at the other two levels are appointed, also for a period of two years, by the representative peasants congresses at each level.

Among other duties the management committees of the People's Commune were given the responsibility of carrying out farmland and capital construction works including irrigation and drainage works inside the commune jurisdiction. If the command area of an irrigation project benefited all the brigades, the commune management committee had the responsibility for construction and management. Depending on the geographical conditions the commune management committee appoints an irrigation district committee or assigns a responsible person (water inspector, cf. p. 107) to be in charge of the distribution of water and the operation and maintenance of the command area. A plan for a new irrigation project to be run by the commune has to be approved by the county soil and water conservation bureau, before it can be implemented. In a case where the command area covers only a few of the brigades, the commune management committee is responsible for supervising the project and ensuring the election of an irrigation district committee and providing the rules for a joint management of the command area. Similarly small-scaled farmland capital construction projects within the brigade or production team jurisdiction are managed by the brigade or team. The assignment of tasks and the solving of disputes between several management units are carried out through negotiations, contracts and locally issued regulations by the commune management committee. By this system the Sixty Articles provided the basic organizational foundation for a good water management.

The Sixty Articles also provided important rules for the basic accounting unit (usually the production team). The team is responsible for the current production, delivering its products to the commune and the capital construction projects within its own boundaries. It has the obligation to organize production in accordance with the state plan. In doing so it should take local conditions into account in order to preserve land, water, forest resources and agricultural equipment. The Sixty Articles made an important distinction between the funding and the remuneration of labour for the construction of a project and the funding and remuneration of labour for the repair and maintenance of the same project. The investment expenses in farmland capital construction undertaken by the basic accounting unit come from the public accumulation fund, which is limited to 3-5 percent of the team's total distributable income. The labour used in capital construction and the labour used in agricultural production is calculated seperately. Thus, after approval through the production team's conference (all able-bodied persons in the households) a definite amount of obligatory labour work may be determined for each member who possesses the ability to carry out productive labour-intensive works e.g. small-scaled water conservation works. This kind of uncompensated labour is the Chinese method of labour accumulation for the collective economy. Labour for capital construction should in general be limited to at least 3 percent of the number of basic labour days in a year i.e. about a week of uncompensated corvee work per labour and year.

The labourers used in capital construction work above the determined quota have to be paid suitable wages from the public accumulation fund. Management tasks of small-scaled water conservancy work such as maintenance and repair of canals, ponds, dikes and soil improvements are calculated in workpoints in the same way as the labour used in agricultural production. According to this remuneration system each labour-day has a maximum value of 10 standard points. In general each labourer is given his number of standard points after an evaluation of his physical ability and the quantity and quality of the work done. The assigned standard workpoint of each labourer are then multiplied with his total amount of labour-days. The remuneration is given by the ratio of the individual's annual workpoints and the workpoints of the total labour force multiplied by the total distributable collective income. It is obvious that this kind of remuneration system promotes the construction of long-term farmland projects.

Chinese socialist planning has always had room for decentralization under the guidelines of the central plan and regulations. The high and stable yield concept favours local level participation and initiative. The Sixty Articles should be considered as one of the most important basic guidelines for the Chinese decentralized approach to development. They have provided an organizational and remuneration basis for a decentralized management of irrigation systems. From this it could be said that at least in theory construction and management were made equal in the beginning of the 1960s. However, an organizational and administrative basis is not the only prerequisite for improving water efficiency. Political disorder resulting in egalitarianism or extreme individualism, lack of unified leadership, lack of incentives both from the professionals and the water users, lack of science and technology, lack of educated and trained personnel are other factors, which could seriously affect the exchange of information between the professionals and the users of water.

The Cultural Revolution - a period of political turmoil

It is rather difficult to answer the question of how the political turmoil of the Cultural Revolution affected water resources management in China. It appears that many of the problems during this period could be related to factors such as the quality and independence of leadership, the promotion of science and technology and equality in management.

Firstly, at localities where the local leadership was strong, practically-orientated and relatively independent to the many shifts in the party struggle, it succeeded in implementing a unified leadership, which was able to carry out an overall planning and management of water conservation works. The introduction of motor pumps could be assumed to have improved the overall water efficiency. The electrically powered and diesel-powered irrigation and drainage capacity increased from 9 million HP in 1966 to 18.7 million HP in 1971, the most critical years of the Cultural Revolution. In 1981 the figure had risen to 74.6 million HP (see table 11 on page 50). Today 98 percent of irrigation pumping is mechanized (Kroutil 1979, p 75).

Secondly, vocational education and research especially diminished considerably during the Cultural Revolution. It seems to have been impossible to be an expert without being a true Red. Consequently many research institutes and vocational training centres were shut down for long periods and the staff was forced to do labour work, completely giving up their teaching and research works. The neglect of the vocational training of grassroot technicians seems to have been a serious bottleneck, which hampered the goal of achieving a good water management and also the goal of widely expanding research experimental stations at the commune level. An article in Renmin Ribao in July 1982 noted, that China's grassroots water conservation personnel were too few in number to satisfy the demand of water conservation management work. The article stated that management at the prefectual and county level in general was good, but at the commune level it was too weak. In 1982 there were 100 000 water technicians working in the commune organization, i.e. less than two technicians per commune or 1 water technician per 7 500 inhabitants of the average-sized Chinese commune. Half of the communes did not have any water conservation office at all (Renmin Ribao 3.7.1982). Some months later the same paper stated, that low efficiency in the use of water and the great wastage of water resources in most of the localities throughout the country was a well-known problem (Renmin Ribao 4.12.1982).

Thirdly, Chinese papers in recent years have often denounced the common habit of cadres during the Cultural Revolution to command and coerce people to do soil and water conservation work in excess of the obligatory work without a fair compensation or, worse, no compensation at all. Thereby people were forced "to drink out of the common kettle", an egalitarianism violating the rules and spirit of the Sixty Articles. Related to this egalitarianism has been the absence of laws, e.g.a water law. Instead, one of the peculiarities with the Chinese water resources development is that Communist Party documents together with the consensus principle of conflict solution have served as the judicial system. Such a system may work well, when the party and people are united, but will easily lead to commandism and lawlessness during periods of party struggle and disorder.

Some reflections concerning the agricultural and water development 1967-1978

Due to lack of representative detailed data covering the whole of China it is not possible to make a comprehensive evaluation of water efficiency in China from the 1960s onwards. However, some reflections could be drawn. Between 1953 to 1978 the total grain yield increased from 164 million tons to 305 million tons, i.e. 141 million tons. The increase for the 1953-1965 period was 30 million tons and for the 1966-1978 period 111 million tons.

In the first part of this project it was estimated, that some 95 percent of the grain increase for the 1953-1965 period was due to (1) expansion of irrigated area (2) expansion of cropped area (3) increased use of chemical fertilizers and (4) increased application of organic manure, but only 5 percent was due to (5) the combination of other productivity-raising factors like high-yielding seeds, soil improvement, land-levelling, afforestation, terracing, drainage, deep-ploughing, biocids etc. The enlargement of the irrigated and cropped area amounted alone to some 60 percent of the increase. The grain increase during the first half of the 1953-1978 period was only 27 percent of that obtained during the second half of the period. Thus it could be concluded, that the rather low grain increase during the 1953-1965 period was basically gained from a large amount of construction works with low efficiency.

During the 1965-1978 period the situation was changed noticeably. The factors (1)-(4) decreased form 95 percent to 70 percent, with the increase of irrigated and cropped areas accounting alone for 35 percent, but the number (5) factors increased from some 5 percent to some 30 percent of the grain increase (Gustafsson 1981b). As several of the number (5) factors are closely related to water control, it indicates that in general the water efficiency has improved from 1965 onwards. Furthermore the average rice yield did not increase at all during the 1950s remaining at some 2,4 ton per ha. In 1980 it had reached 4.10 ton per ha, which is a figure well above the average of the Asian countries and only lower than that of Japan, North and South Korea. From international experience in rice cultivation it is well-known that an average productivity above 3.5 ton per ha cannot be achieved without high skills in water control.

Both China and India have similar water resources bases. They had in the beginning of the 1980s an irrigated area of around 30 percent of the sown area. However China produces some 325 million tons of grain from 100 million ha of cultivated land. India produces only 135 million tons of grain from 140 million ha, a grain yield which is only 25 million tons higher than the total grain yield of China in 1949 (Gustafsson 1981a, Vohra 1982).

Such facts support the thesis that water efficiency has substantially improved under the commune cooperative structure from the 1960s onwards. Thus gradually the management aspect of water projects was given more and more attention, even if the construction aspects still were dominant.

The recent development from 1978 onwards - priority to management

The Cultural Revolution retarded in some aspects the general direction towards a better water management. These short-comings have been remedied after the important Third Plenary Session of the Eleventh Party Congress in December 1978. Several national conferences on water conservation and management have been conducted thereafter. From these conferences it has been ultimately realized, that water should be considered to be a scarce resource all over China. This also applies to South China, where much water is needed for the second crop of rice.

Thus the National Water Conservancy Management Conference in May 1981 decided to shift the emphasis of water conservation from construction to management. The strengthening and improving of the management of existing projects were given primary priority. Every water management unit within a management system should adopt economic efficiency and self-accounting in their work. It was stressed, that only unified leadership and unified management would assure an optimal use of water for all purposes and would solve the problems of water use upstream and downstream of a river. After the Conference a program of "three checks and three sets" was launched and popularized to improve the management of existing projects. They are;

- o check safety and setting standards,
- o check effectiveness and setting measures,
- o check overall operations and setting development plans.

In line with this policy change the limited state capital funds have been concentrated to major state projects. When discussing China's water development, it should be remembered, that the balance of the Chinese national budget (some 120 million Yuan in 1982) is just 50 percent higher than that of the Swedish national budget (some 295 million SEK in 1983), but the Chinese population is 125 times that of Sweden. Thus, for many years to come China will allocate state funds to a limited number of water construction works of great national concern, but will give the overall priority to the development of small water conservation systems by relying on the strength and capacity of the commune cooperative system. The limited state funds will be concentrated on improving the flood prevention works in the major river basins, to solve the water shortage situation in North China and to pollution prevention of water resources (Li 1983).

The floods and flood threats in latter years have revealed an overly low standard of flood prevention in rivers. Related to the flood prevention work is the need of an improved land use planning (Ruddle & Wu 1983). During the Cultural Revolution many parts of China were deforested. Industrial and residential areas have been located without proper planning in flood-prone areas along the major rivers. Cities in North China like Tianjin, Beijing, Dalian, Qingdao and Taiyuan have already today serious water shortage problems (see pages 62-66). The irrigation water supply in the spring season is a growing problem in the North China Plain. The option now considered to alleviate these problems is the plan for a long-distance transfer of water from the Yangtse River and a better and more efficient use of ground water resources in North China. The State will also pay much attention to prevention of water pollution (see page 54). One new problem is the risk of soil and ground water pollution which has increased with the rapid industrialization of many of China's cities. For instance, due to irrigation with polluted water 17 000 ha of soils have been severely polluted in the eastern and northern suburbs of Xian.

The shift in emphasis in the national economic performance after 1979 towards "readjustment, reconstruction and consolidation" with the aim of restoring a balanced growth of the national economy has not lead to the abandonment of the self-reliant policy, as sometimes is believed outside China. The following quotation by a Deputy Minister of Water Conservancy shows the opposite.

"...the winter and spring slack season in farming should be used for capital construction of farmlands and for water and soil conservation work. This not only helps increase the certainty of being able to irrigate the existing area, but the irrigated area may be increased. In doing this work, it is necessary to summarize past experiences, adapt general methods to local situations, seek concrete results, and not practice formalism. Policies should be heeded, and a spirit of self-reliance fostered. In his report on the Sixth 5-year plan Premier Zhao noted, "It is necessary to vigorously improve the conditions of agricultural production, advocate peasant reliance on their own strength, accumulate funds and labour, and adapt general methods to specific situations to do needed capital construction works in agriculture". All jurisdictions can set fixed amounts of compulsory labour to be performed annually be each worker (20 - 40 workdays, for example) as accumulated labour for the purpose of doing farmland water conservancy and water and soil conservation work. This is a production activity like other farming activities in any given year, and it is not to be regarded as egalitarianism and indiscriminate transfer of resources. For projects under centralized planning that cut across jurisdictional lines, methods such as exchange of labour, exchange of equal value, working around a circuit or taking turns in receiving benefits may be used. This is, in effect, shared operations of water conservancy. Individual provinces should assure payments of expenses for farmland water conservancy and water and soil conservation, use them in a concentrated way, and make planned disbursement so as to increase their effectiveness. In order to strengthen organizational leadership for this work, it is recommended that once each year assignments and inspections of results should be summarized, and work continued. Experience has shown that when a production brigade or a team, a commune, or even a county perseveres for 5 or 6 years, 7 or 8 years, or 10 years and more, the agricultural situation can be vastly changed (Deputy Minister of Water Conservancy in Zhongguo Shuili No 1-1983)."

This statement confirms the typical Chinese policy of self-reliance and the way it is used in farmland and capital construction works. Coherent with the self-reliance policy the government has made overall efforts to increase its efficiency. The main instrument of this readjustment has been the allocation of increased state investments and expenditures to the agricultural and light industry sectors of the economy on behalf of th heavy industry sector. Thereby the government has ultimately abandoned the remains of the Soviet-styled character of accumulation from the 1950s (Gustafsson 1982b).

The educational aspect of water management has been improved since 1978. The task of augmenting the number of well-trained water technicians has started and a water conservation office will be set up in every Chinese commune (Renmin Ribao 3.7.1982). The promotion of scientific and technological attitudes in agriculture centered around the well-known Eight Point Charter (i.e. soil improvement, water conservancy, fertilization, seed selection, dense planting , plant protection, field management and improved equipments) has regained the importance it was given in the 1961-1965 period. Every commune and irrigation administration is recommended to set up one or several scientific experimental stations to support the rational use of land and water at the locality.

The egalitarian bias of the Cultural Revolution has been tackled by constructing a law and regulation system and by promoting a contracted responsibility system of management. The construction of a new law system is a major break with the decreed party judicial system of obtaining social consensus, which did not work well during the Cultural Revolution. For instance an Environmental Law and a Forestry Law were enacted in 1979. In 1982 these laws were complemented by the "Regulations governing the work of water and soil conservation". The writing of a Water Law and a Land Use Law are under preparation.

The basic tasks of the soil and water conservation units are defined in the Regulations as follows;

> "...The tasks of soil and water conservation organizations are to carry out the principles, policies and decrees of the state on water and soil conservation; conduct water and soil conservation surveys; make plans for water and soil conservation and organize the implementation of such plans; supervise and check up on water and soil conservation work by the departments concerned; organize and engage in scientific research on water and soil conservation, the training of qualified personnel and propaganda work in this regard and do a good job in managing and using funds and materials for water and soil conservation".

The other main organizational aspect of improving the efficiency of water and land use has been the instituting of the contracted responsibility system to be followed by producing and managing units. This system has been introduced parallel to the reconstruction of the commune cooperative organization, which aims to make a clear distinction between administrative, political and economical units of the cooperative. The local government of the commune has ceased to be a semi-administrative body of joint state and commune power dominated by communist party cadres. The administrative function has been transmitted to self-managing committees of the villages, which are guided by State Laws and Regulations for the various sectors of administration. Production ownership is thus kept in tact on the three levels. However, the commune, brigade and production team have been transformed to solely economic and statistical units, which are responsible for their own accounts. They have emerged into cooperative enterprises. In the future the party organisation will be held separate from the administrative and economic units. No party cadre will be assigned tasks in the village committee or the cooperative enterprise unless he has been elected or is competent and professional.

One of the basic aims with instituting the contracted responsibility system is to change the incentive structure of utilizing and managing natural resources and technical equipment. There will be fewer moral incentives and more economic incentives. Under the new system production and management of the cooperative economy have been delegated to households or specialized units. It means, that the production and management of public land and water for (1) agriculture, forestry, animal husbandry, fish-culture (2) specialized occupations like raising chicken, pigs, ducks, weaving, transportation, agricultural processing and (3) other productive items like management of reservoirs, irrigation districts, pump stations, repair and service work etc is contracted to (1) households, (2) special groups with labour taken from several households or (3) professional units according to mutually agreed conditions between the counterparts (Du 1983). At the present stage of experimentation innumerable types of contracts could be signed depending on the work to be done. The main outcome of the experimentation seems to be that the workpoint system stipulated by the Sixty Articles and the New Sixty Articles will be abandoned and gradually replaced by linking payment directly to the contracted production output or management work to be done. In the case of agricultural production the peasant will have an additional income from the surplus output above the contracted quota, of which he can freely dispose. With this new system of remuneration the contract also has to include specifications of administrative fees, accumulation fees and social service fees, which should be paid to the contracting collective unit. Also the participation of labour in compulsory farmland and capital construction projects wanted by the collective has to be specified. Furthermore water fees should be the main source of cash income for water conservancy management units.

In the case of water resources management comprehensive contracts, part-time contracts and contracting for specialized tasks have been proposed (Renmin Ribao 3.7.1982). At the cooperative level comprehensive contracting is recommended for the management of small-scaled reservoirs, larger irrigation districts within the commune area, large pumping stations and complex projects with quite a number of management items. Part-time contracts are used for small-scaled water conservation projects, which have no need for a full-time management body. Contracting for specialized tasks, signed between households and brigades, are for instance used in the Loess Plateau area for erosion and runoff control of small river basins (see page 85). These contracts stipulate the rights and duties between the contractors and the remuneration system to be chosen. Usually many brigades stipulate, that the production from a controlled gullied slope of for instance fruit, fodder-grass or fuel-wood will belong to the households for a period of 10 years or more and that sons and daughters may inherit the right to use the land.

It is fundamental, that under the new management system the basic water consumption unit has changed from the production team to the household. At first this caused a lot of confusion. The variation of the performance of contracts became large even for similar labour tasks and between the geographical areas, as the government policy was vague and no fixed or uniform rules existed. The experience of Baoding Prefecture in Hebei on the North China Plain gives an idea of what kind of new problems emerged, and how these problems were solved within the contracted responsibility system.

Baoding Prefecture mainly uses ground water for irrigation and in the summer of 1982 some 87 percent of the production teams had instituted the responsibility system. Due to faulty contracts many households in some teams purchased their own pumps for raising water, the pump equipment owned by the teams lay idle as a result of this. In other teams pumping equipment was damaged due to the frequent moving of the pumps between the contracted land areas. Irrigation was carried out without a unified plan. The problem of how to compensate the pump-operators was not solved and many households refused to pay the irrigation fee. In this counter-productive situation some production brigades set up irrigation district committees to which they transferred all collectively-owned water conservancy facilities, pump wells and water lifting equipment. The irrigation district was made responsible for safeguarding them. By relying on the principle of voluntary participation for mutual benefit all privately owned pumping equipment could be transferred to the district. An operator was employed. The district was to practice independent accounting, i.e. it should be responsible for its own profits or losses and practice enterprise-styled administration. The irrigation district was made responsible for all irrigation and drainage facilities and for the overall planning of all farmland. Each operator was assigned fields to be watered. After cooperation with the production team leaders the irrigation district came to an agreement with the individual households about the time of watering after an investigation of field water requirements had been conducted. All ground water wells were registered and the fees were collected on the basis of kwh used or per ha area watered (Hebei Ribao 24.9.1982; China Report: Agriculture No 240).

The problems of instituting the contracted responsibility system has probably been most difficult in small-scaled irrigation districts and especially in ground water areas like Baoding because a ground water well in general only waters some 5-10 ha. Formerly in most cases the production teams independantly owned and managed their wells. Consequently a unified planned overall water utilization at the commune level was seldom found. In comparison, because of the nature of the surface water, there existed some unified irrigation management bodies at least for large-scaled and medium-scaled irrigation districts relying on surface water, which easy could adopt to the new situation. Hunan has solved many of the new problems by popularizing a policy of "setting rights and issuing certificates". These certificates make clear the nature of ownership to water conservation facilities and clarify the authority of each indivudual water conservation unit. The certificate gives legal protection to the water conservation unit, when it has been approved by the notarial office of the County Judicial Bureau. This registration has strengthened the project management and the system is now recommended to be used everywhere in China (Li 1983).

The dilemma of small-scaled irrigation districts

The presentation has hitherto mainly dealt with efficiency and management problems inside the commune. It could be assumed, that most of the problems of water efficiency and management of irrigation districts concern the many small-scaled projects within the commune area.

At present China has 150 large irrigation districts with a command area above 20 000 ha, more than 5 000 medium-sized ones each covering an area somewhere between 667 - 20 000 ha and numerous small ones with an area below 667 ha (Zhang 1980; Xu 1982). Table 41 provides a list of large- and medium-scaled irrigation districts for which some information has been found in Western publications or languages. The most detailed descriptions are found of the Meichuan Reservoir Irrigation District in Hubei Province and Zing Ping Irrigation District in Guangxi Province.

The large and medium-sized irrigation districts have a professional management body set up by the government. Whereas the small-scaled irrigation districts usually fall within the cooperative and collective sector and thus no professional management organization is set up by the government. From the size of the figures given above it can be concluded that probably

Table 41 List of large- and medium-sized irrigation systems that have been described to some extent in a Western language.

NAME	PROVINCE	IRRIGATED AREA IN HECTARS	SOURCE
Irrigation system in plain areas, usually canal-fed			
Dujiangyan Irr. System	Sichuan	600 000	Zhang 1980 This report p.102
Ningxia Irr. System	Ningxia	170 000	Zhang 1980
San Shenggong Diversion and Irr. System	Nei Monggol	500 000	Zhang 1980
People's Victory Irr. System	Henan	40 000	Zhang 1980 Humlum 1974
Jiangdu Key Water Conservation System	Jiangsu	660 000	Humlum 1974; This report p.115
People's Yinjing Irr. System	Shaanxi	85 000	Humlum 1974;Nickum 1981
Guazhou Water Conservancy Project	Jiangsu	13 300	This report p.117
Jiangfengkou Flood Prevention and Irr. Project	Shandong Jiangsu	6 600	Nickum 1981
Pinggu Xian Mechanized Well Irr. System	Beijing	9 000	Nickum 1981
Mangshan Pumping Station and Irr. System	Henan	6 000	Humlum 1974; Nickum 1977a; This report p.69
Dongfanghong Irr. System	Shaanxi	79 000	Humlum 1974
Irrigation systems in hilly regions, usually reservoir-fed.			
Miyun Reservoir Project	Beijing	270 000	Humlum 1974; Nickum 1977a; This report p.57
Shaoshan Irr. System	Hunan	73 400	Humlum 1974; Zhang 1980; Nickum 1981.
Pishihang Irr. System	Anhui	400 000	Humlum 1974; Zhang 1980

NAME	PROVINCE	IRRIGATED AREA IN HECTARS	SOURCE
Meichuan Irr. System	Hubei	8 000	Nickum 1977b; Nickum 1981.
Qianli Canal Irr. System	Sichuan	9 300	Nickum 1981
Zing Ping Irr. System	Guangxi	11 300	ESCAP 1979
Red Flag Canal Irr. System	Henan	40 000	Humlum 1974; Lin 1974; Nickum 1977a
Hengdong Irr. System	Hunan	8 700	Humlum 1974
		3 000 000	

less than 10 million ha of the total irrigated area of 46 million ha is covered by large and medium-sized irrigation districts.

There are two main shortcomings with the small-scaled irrigation districts. First, there is no organizational linkage between the government management units and the cooperative management units. Second, they lack in general personnel with enough professional knowledge, which is needed for at rational use and scientific management.

As early as 1965 the Chinese authorities had summed up the experiences of the 1950s and laid down a comprehensive policy for irrigation management. Its main points could be recapitulated as follows;

Organizational management

1. Establishing a strong management structure at every level for the purpose of issuing management rules and regulations and formulating plans for production and finance.

2. Rational management of all irrigation facilities.

3. Enterprise-style type of management i.e. self-reliant and self-financing in operation, maintenance and repair, and promotion of side-line occupations to support the management unit.

Engineering project management

1. Rational operation of projects by the use of an annual control and operation plan.

2. Regular observation of the conditions of hydraulic structures.

3. Upholding project maintenance by means of inspections, repair at fixed intervals and removal of accumulated silt.

4. Overall responsibility for the improvement and reconstructing of the project.

On farm water use management

1. Implementing a planned water utilization by use of a water application plan, which is prepared in accordance with irrigation water sources, overall project conditions, water crop requirements and rational timing of watering and other arrangements for agricultural production and use of technology.

2. Canal system water measurements with the aim of guaranteeing an accurate implementation of the water application plan and to provide reliable data for their formulation.

3. Reduction of water losses in canals by means of rotational irrigation, improvement of irrigation techniques (land levelling, conjunctive use of irrigation and drainage systems, sprinklers etc), strict control of water quantity and measures to prevent canal seepage (lining etc).

4. Setting up experimental irrigation research stations with the aim of learning the individual characteristics of the irrigation district like climate, types of soils, crop water requirements, cultural aspects and so on. (Irrigation Management 1965).

It should be assumed that the implementation of a comprehensive irrigation management like this necessitates a strong and unified irrigation organization. As indicated earlier in this chapter, skilled irrigation manpower has been a limited resource. Therefore it is likely that large and medium-sized irrigation districts have been most successful in implementing a comprehensive irrigation management from 1965 onwards.

A rather detailed description of Meichuan Irrigation District in Hubei Province is found in a Chinese pamphlet, which has been translated by Nickum (Nickum 1977b, 1981). It is a model district (Xu 1982), which has succeeded in high water efficiency and good water management under conditions of scarcity of water and skilled manpower. Figure 21 shows the organizational chart of the Meichuan Irrigation District.

Today the Meichuan Irrigation District in Quangji County is supplied with water from one medium-sized reservoir, 30 small ones and 6010 ponds, which altogether cover an irrigated area of 8 000 ha in a hilly region of China. The medium-sized reservoir was constructed between 1957-1959. It has an earth-fill type main dam with a central clay core. It is 22 m high, 910 m long at the crest and has a dam volume of 1.03 million cubic metres. By continuously improving the system after the main reservoir was finished, the irrigated area has expanded from the designed 4 700 ha to some 8 000 ha in the 1970s, figure 22. In 1979 the total storage capacity of the system was 62.7 million cubic metres of which 35.9 million cubic metres was stored in the reservoirs to be used for late rice irrigation (July - October), when the need for irrigation is at its height. The remaining storage capacity was provided by the numerous ponds, making up 42.7 percent of the total storage and used to supply water for an early crop of rice (April - July).

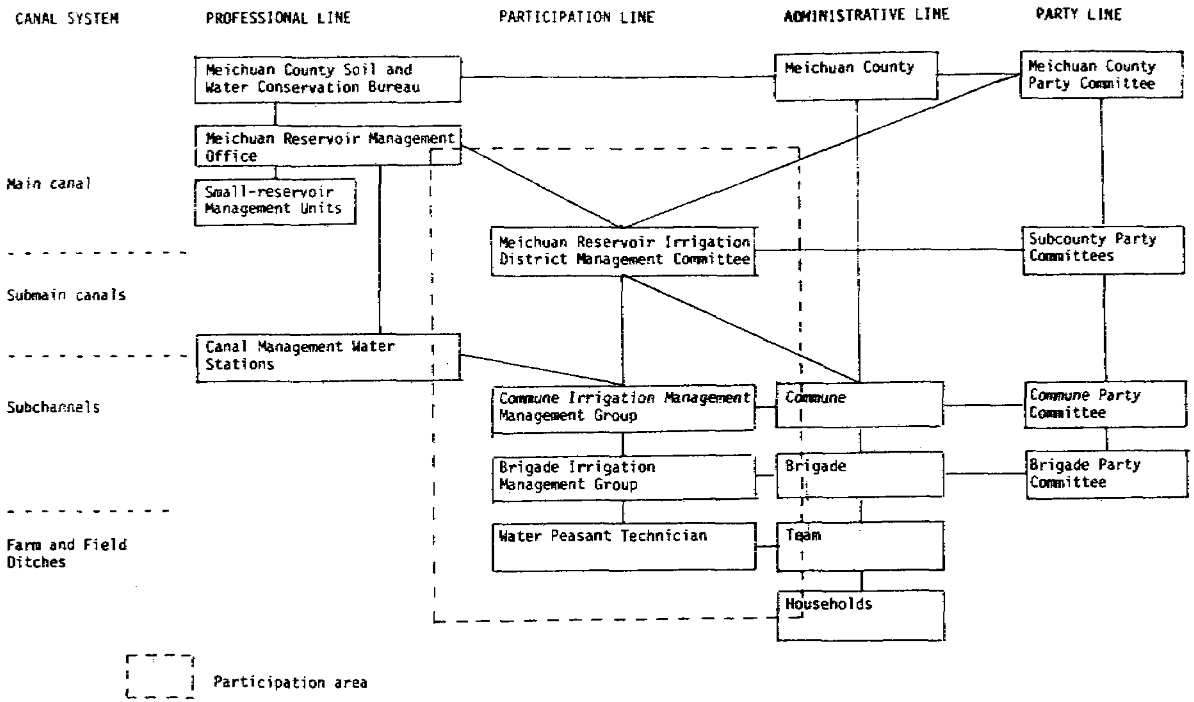


Figure 21. Organizational chart of the Meichuan Irrigation District, Hubei Province (Based on ESCAP 1979 and Nickum 1981)

Table 42 Average rainfall data (1958-1972) and field water consumption for the growing of double crop rice in Meichuan Irrigation District. Unit mm.

	Early rice April-June	Second rice July-October	Total
Rainfall	530	335	865
Field water consumption	471	573	1 044
Average annual rainfall	-	-	1 290

The Meichuan Irrigation District illustrates very well "the two legs" strategy philosophy, which is commonly practiced in many sectors of the Chinese society. The Meichuan project has preserved and expanded the traditional irrigation facilities like ponds (one leg) and connected them with a medium reservoir and some small reservoirs (the other leg) by canals and thus forming a complete water conservancy network with multi-functions of storage, diversion, irrigation and drainage of water. Owing to the canal system connecting reservoirs and ponds, the layout plan resembles water melons growing on vines. Therefore the popular name of this kind of irrigation system in China is "the long vines with melons".

An integrated management irrigation system such as Meichuan has many advantages. By using the ponded water for complementary irrigation of early rice the reservoir water can be allocated for heavy droughts. During the non-irrigation season the main reservoir water can be used to fill up the small reservoirs and ponds thereby reducing the peak discharge in the canals during the dry season. Earlier, before the high-water season water was released from the main reservoir and was wasted by flowing into the river. After connecting reservoirs and ponds this water has been redirected to fill up the ponds, thereby preventing losses. In South China small ponds may be filled with water several times in a year thus collecting the local runoff in an efficient way. The numerous ponds are managed at the brigade level, so that they can hold a minimum storage even in dry periods, which promotes the local fishpond-raising.

An important feature of the management of Meichuan Irrigation District is the link between professional skill and people's participation, figure 21. In the Meichuan Reservoir Irrigation District Management Committee this link is composed of professionals from the Meichuan Reservoir Management Office and Meichuan Soil and Water Conservation Bureau and the leaders or special appointed persons from the various communes. The Commune Irrigation Management Group and the Brigade Irrigation Management Group consists of leaders from the commune and the brigade and representatives of the masses. These three linkage management units supervise and give support to the professional management organization and discuss the important problems of management work i.e. the plan for distribution of water, the rules and regulations of management, the division of labour for repair and maintenance work of canals etc. These linkage units of the irrigation area usually meet twice a year before the irrigation season and once in winter-time. In the case of the Meichuan project party cadres seem to have an important function in initiating construction and management task and mobilising the peasant.

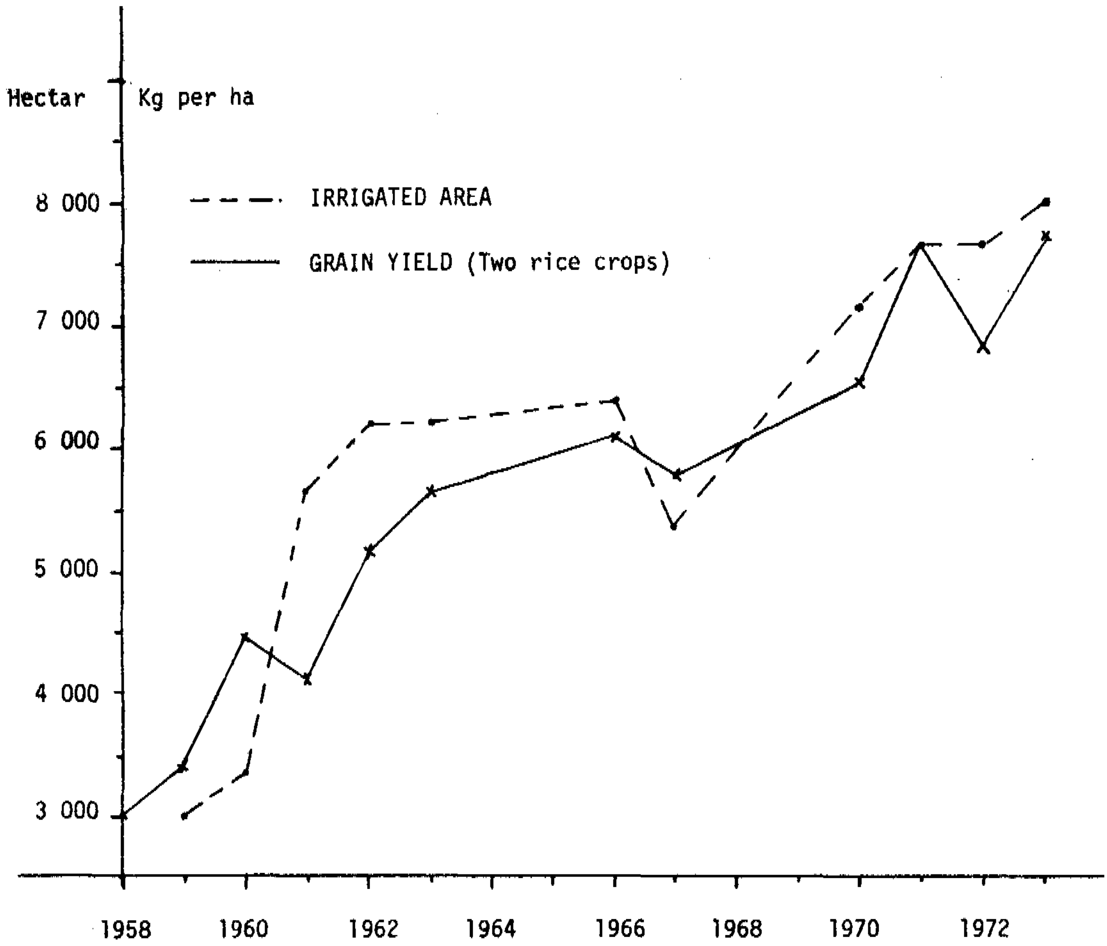


Figure 22 The development of irrigated area and grain yield in Meichuan Irrigation District, Hubei Province. (Source Nickum 1981, table 1 p.82).

Meichuan Irrigation District is a model unit in China. It has been constructed through hard and persevering work for more than 10 years. Further details of this remoulding of natural conditions are given in the translated article. The following passage, which is quoted from the translated article, illustrates very well the technique and flexibility used to solve the contradictory need of water between upper and lower reaches of a river.

> "After continually summing up their experience and uniting it with the actual conditions in the Meichuan Irrigation District, they adopted the water allocation principle of "Urgent first, then not urgent, and control the near to send to the distant; high land first, then low land and look out for the borders; and look first then release, grasp the entire situation."
>
> Based on the water conditions in each locality in the irrigation district, the porosity of its soil, the urgency with which its crops need water, and the course of the drought there, when water is released it is first allocated to areas urgently requiring irrigation. At the same time, water must be properly supplied to areas in the lower reaches.
>
> Contradictions break out easily between upper and lower reaches within the irrigation district, and these come even more to the fore under severe drought conditions. Because of this, the key is to do ideological work well with the communes in the upper and middle reaches and to adopt effective measures to control the near to send to the distant in order to guarantee water for the use of areas in the lower reaches. The Meichuan Reservoir Management Office analyzed conditions in the upper, middle and lower reaches and handled their principal contradictions separately. The upper reaches are close to the reservoir and can obtain water easily. They waste a lot of water. We should urgently and seriously demand that they emphasize "using water sparingly." The communes in the middle reaches are favourably situated, and it is convenient for them to block off the water. We should take aim at this thinking of "the water flows through my place, so I should be allowed to use it first," and advocate that these communes take the entire situation into account and sent "unity water," "Dragon River water" to the lower reaches. The lower reaches and border areas are faced with a canal line which is too long, a small amount of water transported, and difficulties in sending water. It is important that they grasp the "rational use of water". Communes are organized to think of every means to open up water sources of many types and grasp favourable opportunities to irrigate and store water in ponds.
>
> In carrying out the principle of "urgent first, then not urgent; control the near to send to the distant," they have adopted the tactic of "irrigating the upper and middle reaches in the day-time, gathering the waters together at night to send to the lower reaches." During the day, the water flows are scattered about to allow the upper and middle reaches to obtain some and promote their irrigation. At night, the areas in the upper and middle reaches are all forbidden to open their gates for irrigation in order to facilitate the gathering of water for transport to the lower reaches. In this way water use in the broader area is heeded in an

all-round way, and the guarantee of irrigation in the areas in the lower reaches is highlighted. Thus, the contradiction between upper and lower reaches is resolved comparatively well, and the water utilization sequence is improved considerably." (Translated by Nickum 1981).

The Zing Ping Irrigation District in Pinqiang County Guangxi Province has a similar organizational structure to the Meichuan Irrigation District. This irrigation system consists of one medium-sized reservoir with a 76 million cubic metres total storage capacity and 57 small-sized reservoirs of 12 million cubic metres total storage capacity. Originally the designed irrigated area was 8 000 ha, but by utilizing the return flow, improving the engineering facilities, carrying out extensive land levelling and other improvements in irrigation techniques, the irrigated area has been enlarged to 11 300 ha. Detailed information on the organization of the engineering project and on the management of water use on farms are provided in the ESCAP report.

It can easily be assumed from the experience of the Meichuan and Zing Ping Irrigation Districts, that only medium- and large-sized irrigation districts will provide the necessary organizational connection between the government's intentions for a rational use of water and the peasant's striving and will for higher and stable yields. It is hardly possible for a small-scaled irrigation project in the first phase of economic development to have the professional capacity needed to integrate all the three aspects of rational and scientific management demanded by the 1965 article. The problem is the small size of the project. Both the Meichuan and Zing Ping Irrigation District illustrate the application of scientific management in irrigation. Extensive land-levelling and reconstructing of irrigation fields and irrigation and drainage canals, meticulous application of water in keeping with varying water requirements of plants at different stages of growth, continuously connecting various types of water supplies into an integrated system and the setting up of irrigation research stations are some of the measures, which have saved water and raised the overall efficiency of the two projects.

The experience of Meichuan and Zing Ping Irrigation Districts is a solution to the small-scale dilemma of irrigation projects in hilly regions. The integrated use of reservoirs and ponds, in some places combined with complementary ground-water use, is the general solution for expanded agricultural production and more efficient use in hilly areas, see figure 22. In the plain areas the solution to the small-sized problem lies in the connection of several irrigation supply canals and complementary ground water wells to form an integrated system.

The instituting of the contracted responsibility system in water management, the judicial registration of irrigation facilities by ownership and the judicial regulation of the authority of water management units will make an end to the turmoil situation, which took part in many regions of China during the Cultural Revolution. These measures will improve the incentive structure between the professionals of the irrigation systems and the users of waters.

CHAPTER 7

EVALUATION AND DISCUSSION OF THE DEVELOPMENT OF CHINESE WATER RESOURCES

This chapter attempts to give a synthetic elucidation of the Chinese water resources development based upon the information given in chapters 4-6 and some complementary material. The evaluation will be carried out by answering the key questions of the water resources planning system, which were identified in chapter 2, see page 27.

TO WHAT EXTENT HAS THE WATER RESOURCES DEVELOPMENT IN CHINA BEEN SUPPORTED BY A BASIC NEEDS APPROACH?

The most essential task of a basic needs approach is to solve the food supply problem. Due to the characteristics of the Chinese water resource base this task can only be achieved by vigorously solving the water problems affecting the rural areas, where the majority of the population lives. The Chinese liaison between a basic needs approach and the development of water resources can be said to be articulated by three policy slogans, which are often quoted by officials and publications. These are;

- o Water is the lifeline of agriculture
- o Agriculture is the foundation and industry the leading factor of the national economy.
- o Construction is the base, management is the key of water projects.

One of the greatest merits of the new Chinese government, which came to power in 1949, was that its leaders before 1949 had already drawn a practical conclusion from Chinese history and from practical experience in the liberated areas. The conclusion was that the regulation and control of the Chinese rivers was the most crucial resource factor to cope with in order to increase the agricultural production. In a situation of limited capital funds the key invention of Chinese agricultural modernization has been to organize on a massive scale, not exceeded elsewhere in the world, its seasonal labour surplus in capital construction projects of which water and soil conservancy projects have been the most important. Basically these kinds of public work have been conducted within the framework of the Chinese cooperative system. Thus it has been shown in chapters 4 to 6, that large efforts have been made and priority given to water conservancy projects since the 1950s and onwards.

This development of water resources has been supported by the fact, that China compared to other Third World countries has practised the policy of simultaneously developing agriculture and industry. The rationale behind this policy is the understanding that only by modernizing the agricultural sector would it be possible to increase the purchasing power of the peasants and sustain a long-term industrial growth. The new government inherited a very weak base in 1949. There was virtually no machine-building industry and only a limited amount of repair work-shops. The steel-making capacity was less than 1 million tons per year and in 1949 the steel production was only 158 000 tons, which was less than 1/1000 of the world total output. The Chinese agriculture was in a backward stage consisting of scattered small-peasant and small-tenant farming. (Dong 1982).

As the Chinese leaders were devoted to a self-reliant and independent strategy for modernization, there was no other choice for capital accumulation than to simultaneously develop agriculture and industry. In general the highest priority has been given to develop heavy industry during the period from 1952 to 1979, but considerable efforts have also been made to develop agriculture and light industry with the aim of achieving a balanced growth of the national economy. The accumulated state investments for the 1952-1979 period was 630 billion Yuan (some $ 315 billion US dollar). The agricultural sector accounted for 12 percent, light industry 5 percent, heavy industry some 50 percent. The rest were investments in the non-productive service sector. The agricultural share of investment is high compared to most other Third World countries, which today depend on food import, international aid and relief work. The agricultural share of investment in China verifies the basic needs character of Chinese development. From 1979 the Chinese authorities have further stressed the importance of the agricultural sector of the national economy. It is planned that the agricultural share of the state investment should reach 18 percent by 1985. (Liang 1982).

Besides promoting numerous investments in farmland and capital construction works, the basic needs approach also points out the importance of management. A basic needs approach means that the investment funds basically should be generated by internal accumulation and not by capital transfer from abroad. Thus there will be bias against increasing the accumulated funds by practicing strict economy and avoiding waste. From chapter 6 it appears that the overall water efficiency has improved substantially in China the last 20 years. On the other hand it seems that the promotion of rational management has not kept pace with the numerous built out of water construction works, thus indicating wastage with funds and low efficiency in many projects. Especially during the Great Leap Forward and for most of the Cultural Revolution period, it may be said that construction was identified with proletarian labour work by leading cadres, but management was identified with non-proletarian white collar work and thereby impeded for political reasons. The Great Leap Forward and the Cultural Revolution also represent the periods with the highest priority given to state investments in the heavy industry sector relative to agricultural investments. In order to compensate the reduction in agricultural investment during these periods much labour was mobilized by moral incentives to carry out poorly designed construction work without paying much attention to management of the projects. From 1979 onwards improved management of existing water projects and combining small water projects with larger management units has been given a higher priority than the construction of new projects.

HAS THE CHINESE SOCIETY PROVIDED ITS WATER PLANNERS WITH AN ADEQUATE FRAMEWORK OF INSTITUTIONS, KNOWLEDGE, LEGISLATION, FINANCIAL AND MANPOWER PROVISION?

The development of Chinese water resources is intimately related to a workable administrative framework, which has promoted centralized planning of large-scaled projects and decentralized planning of small-scaled projects. The Ministry of Water Conservancy and Power has the overall national responsibility for water resources utilization. It has served as the central water resource institution since 1949. In the provinces and counties there are soil and water conservation bureaux which are subordinated to the Ministry. Other important units are the River Commissions of the large river basins. They should apply a basin-wide strategy approach in their planning and make overall plans for the entire basin. For this purpose they also run specialized river basin research institutes. The River Commissions have primarily advisory and consultative responsibilities to the Ministry of Water Conservancy and Power and its provincial and county units. An important task is to coordinate the provincial soil and water conservation works of the provincial bureaux within the basin. The Chinese River Commissions are rather unique. The Yellow River Commission was already established in 1950 and the first plan for a comprehensive utilization of the Yellow River was presented to the National People's Congress in 1955. Besides the soil and water conservation units already mentioned, there are a multitude of specialized permanent or temporary management units at various state levels for reservoirs and other construction works, allocation of water, flood and drought prevention, dyke control and repair etc.

At the local or commune level the principle of self-reliance encourages the cooperative units to undertake and design any projects of which they are capable. Half of the Chinese communes have a soil and water conservation office and the rest at least a responsible cadre for soil and water conservation. Self-taught peasant water technicians at the various cooperative management units plan, construct, operate and organize maintenance and repair of numerous projects of all types, e.g. small and medium-sized diversions and reservoirs, pump-wells, afforestation projects, reclamation projects, electrification based on small-sized hydropower generation stations. Large-scaled irrigation districts covering several communes in various counties have a management committee, which joins the professional skills of county soil and water conservation units and the practical skills of cooperative units. Thus the Chinese society has provided its water planners with rural and water institutions, which can hardly be found elsewhere in the Third World.

The Chinese society had basically failed to promote modern science and technology before 1949. China was faced with chronical rural poverty. Though the skill of traditional Chinese agriculture had reached a high level, the traditional Chinese agriculture was no longer able to increase food production without the supply of modern inputs. The agricultural productivity stagnated to an inevitably low level due to this lack of modern input. At the same time the population increased rapidly. In this situation the new government acknowledged the modernization of water resources utilization and technology as the most important factor for a rapid increase in agricultural productivity. However, China had to start form av very weak base. For instance there were fewer than 10 modern constructed reservoirs and few educated engineers and technicians. China had to start a scientific campaign to raise the standard of water resources technology and knowledge. A modern hydrological data network of more than 3 300 stations has been established almost from scratch within a period of 30 years in the Chinese rivers, which today covers even the remote areas of Western China. The Soviet technical assistance in water construction projects during the 1950s transferred modern knowledge, which enabled the Chinese to lay the foundations for their self-reliant water resources development from the 1960 onwards (Dutt & Costa 1980). As a lot of new problems were encountered in practical experience a wide coverage of soil and water conservation research institutes have been set up.

For instance the Department of Irrigation and Drainage at the Wuhan Institute of Hydraulic and Electrical Engineering has between 1955-1981 had some 3 900 graduate students, who today constitute a major technical corps at various construction projects all over China. At the worksite for water construction projects widespread use is usually made of an engineer-apprentice system to disseminate technical knowledge to workers from the benefited area (see pages 112-113). After the construction is finished, these apprentice-workers often have the adequate technical skills to organize small-scaled water conservancy works in their own commune. Though there is still widespread shortage of water technicians, which at the commune level has specially resulted in rather low water efficiency in many projects, the systematic research and educational approach applied by the Chinese must be judged to have played an important role in the development of water resources.

The Chinese water resources development has not been achieved on a legal basis in the Western meaning of parliamentary tradition. In general a formal legal structure has never been very important in rather homogenous agrarian communities like the Chinese society before 1949 and even in many Third World countries of today. Therefore, traditionally in China, disputes and conflicts were commonly handled on a non-legal basis by local leaders. Conflicts were considered to be a disturbance to the overall social harmony. By use of their moral leadership the local leaders were assigned by the Confusian bureaucracy to restore the social harmony. The new government adhered to this old tradition and has not until recently tried to establish an extensive legal system. The Communist party and its leaders at all levels may be said to have exercised the Confusian notion of moral leadership. The local party and management committees have dealt with the great majority of disputes and conflicts including water conflicts on a rather informal basis. However, there was an important difference compared to the pre-1949 situation. As the new leadership had a scientific attitude to problem-solving, it aimed at solving disputes and conflicts in the context of social and economic development rather than in restoring the social harmony.

The Constitution provides the basic rule, that water areas and water flows are owned by the state and land is owned either by the state or by the collective. In addition, party documents have more or less functioned as an informal judicial basis. For instance the stipulations in the Sixty Articles have provided the minimum rules needed for a uniform and rather comprehensive planning of land and water resources and unimodal rural development. It seems as if this informal system for conflict solution has on the whole been satisfactory as long as the Chinese leaders and people are united. However, it is inherent in any modernization process that the complexities of society will increase. Due to this complexity new types of disputes and conflicts will arise, which no local leader can solve on an informal basis. The weaknesses in the informal judicial system were clearly shown during the Cultural Revolution, when conflict solution degenerated into widespread commandism and political turmoil. The present leadership seems to have learnt the lesson from these years and has started an extensive work to construct a legal system of laws and regulations, among them an Environmental Protection Law and a Forestry Law.

The general directives for managing the natural resources are given in the amended Constitution adopted in 1982 (see Beijing Review 52-1982). For instance it stipulates that;

> ... The state ensures the rational use of natural resources and protects rare animals and plants. The appropriation or damage of natural resources by any organization or individual by whatever means is prohibited. (Article 9).
>
> ... No organization or individual may appropriate, buy, sell or lease land, or unlawfully transfer land in other ways. All organizations and individuals who use land must make rational use of land. (Article 10).
>
> ... The state practices strict economy and combats waste ... (Article 14).
>
> ... The state protects and improves the living environment and the ecological environment, and prevent the remedies of pollution and other public hazards. The state organize and encourage afforestation in the protection of forests. (Article 26).

Thus, Chinese water planners will probably have a solid legal basis for a rational use of land and water resources in the future.

The Chinese provision of financial funds and manpower for water conservancy projects is unique in the Third World. According to the Ministry of Water Concervancy and Power the State (i.e. central, provincial and county authorities) has invested 78 billion Yuan (some $ 40 billion U S dollars) or on the average 2.5 billion Yuan each year in water conservancy projects between 1950-1980. This sum is equivalent to some 10 percent of the total accumulated capital investments in China during that period. Most of the funds have been allocated to large and medium-scaled projects like reservoirs, hydro-power stations, dikes, navigation canals etc. Investments in water conservancy projects are not the only investments, but have been the most important ones, which have benefited agricultural development. Data from the First Five Years Plan 1953-1957 shows that water conservancy investments accounted for 60 percent of the capital investments from the Ministeries of Agriculture, Forestry, Water Conservancy and Power and Meteorology (Vermeer 1977, p 246).

Furthermore, even larger investments have been made by the collective sector in small-scaled farmland and water conservation capital construction projects (FWC-projects). For instance the construction of irrigation districts has basically been funded by the cooperative sector. From 1960 the collective sector has taken about 70-80 percent of the financial burden of large-scaled irrigation districts. Funds for FWC-projects are basically financed from the production surplus of the cooperative. The Sixty Articles stipulated, that the basic accounting unit should set aside five percent of total income before distribution to an accumulation fund. There are no exact figures of the total capital investments made by the collective sector. However, other figures indicate that the collective capital investments have averaged some 20 percent of the total state capital investments (Gustafsson 1981a, p 138). It is reasonable to assume that 30-50 percent of the total collective capital investments have been allocated for FWC-projects.

Given the 630 billion Yuan of accumulated state investments between 1952-1979, some 38-63 billion Yuan or 1.5-2 billion Yuan on an average each year could be roughly anticipated to have been invested. This sum has basically been used for equipment, materials, wages for full-time personnel and wages for labour.

During the slack winter season 10 million peasants have been mobilized for part-time FWC work. The justification for using uncompensated labour accumulation lies in the expected increase in agricultural productivity, which will in turn give higher future incomes to the collective. The advantages of applying labour accumulation within a cooperative framework were laid down in detail in chapter 6 in the first part of this project (Gustafsson 1981b).

A rough estimation of the value of the labour investments in FWC-projects could be based on figures showing the amount of earth and stones moved each year (Gustafsson 1981a, p 131). During the period 1950-1978 an average of some 7 billion cubic metres of earth and stone were moved per year. If we assume an average productivity of 1.5 cubic metres per workday, this shows that some 4.5 billion workdays have been spent on FWC-works each year (Vermeer 1977, p 280). With an average value of 0.8 Yuan per workday the value of the labour investment cost would be estimated to 3.5-4 billion Yuan each year.

Table 43. An estimation of the average annual national capital investments in water conservancy projects and the average annual capital investments in the agricultural sector in the Jiangsu Province 1950-1980. Billion Yuan per year.

National investments in water conservancy projects		Type of investment	Jiangsu investments in agricultural sector	
Billion Yuan per year	%		Billion Yuan per year	%
2.5	30	State	0.14	30
4.5-6	70	Collective	0.36	70
1-2	25	Equipments	0.13	25
3.5-4	45	Labour	0.23	45
7-8.5	100	Total	0.50	100

The average annual value of capital investments in water conservation projects is summarized in table 43 together with the average annual value of capital investments in the agricultural sector of Jiangsu province for the period 1950-1980. Jiangsu is one of the most prosperous provinces situated in the Lower Yangtse River Basin. For 30 years this province has built water conservation projects (e.g. channels and canals, reservoirs, culverts, dams, dykes, pumping stations etc). which have involved the moving of 23 billion cubic metres of earth and stone. During these years the total capital investments in the agricultural sector including FWC-works were about 15 billion Yuan or on average 0.5 billion Yuan per year (Zhao 1980). Table 43 indicates that the state sector in general has funded about 30 percent of the investments and the collective sector some 70 percent. About 2/3 of the investments made by the collective sector have been labour investments. Even if the figures given here are rough, they nevertheless prove the very important role the small-scaled capital investment projects have played in agricultural development and also clearly depict the two-legged policy of simultaneously promoting large-scaled and small-scaled capital projects.

TO WHAT EXTENT HAVE SOCIAL ATTITUDES AND PREFERENCES INFLUENCED THE WATER RESOURCES DEVELOPMENT IN CHINA?

In general social attitudes and preferences are conditioned by previous experience, cultural traditions, social values and the level of knowledge and education. It is well-known, that China is counted as one of the ancient hydraulic societies (Wittfogel 1981). The great achievements in constructing ancient hydraulic works and their impact on traditional China, among them the outstanding Dujiangyan Diversion Work, have thoroughly been described in Science and Civilization in China (Needham 1971). In a classical study Chi (1937) has argued that the economical and political power in old China was constantly moved to the geographical area or Key Economic Area, which for the time being could best control and utilize the water. Through the extensive building of transport canals and flood-control works the water was used for the purpose of transporting the grain tax from the subordinated area to the Key Economic Area as well as for transporting military troops. As a secondary purpose canal water was used for irrigation. Chinese history is full of floods and droughts, so that prominent Chinese statesmen like Da Yü and Li Bing have since ancient times given bureaucratic attention to water control and management (Li 1982). Furthermore Yang (1964) has evaluated the outstanding skill of traditional China to organize large amounts of labour for public capital construction works.

Besides these examples of previous experiences, water has always been treated with respect for its obvious life-supporting character. For instance, the Chinese have been aware of the health risk of polluted water for a very long time. Therefore, by tradition all drinking water is boiled before being consumed. This habit has considerably contributed to the relatively good health of the Chinese people (Braudel 1982). The traditional dignity of nature is expressed in the Chinese character for landscape, which is shan-shui, 山水 (hills and streams). According to the daoist belief of yin and yang hills and streams are two coexisting forces, which wax or wane, but never extinguish one another. Thus the daoist philosophy of popular thinking contains one of the modern ideas of water resources planning i.e. integrated management of land and water resources. From these examples it is seen that water has always had a comparatively high social value in China.

By giving high priority to water resources development, the new government has since 1949 strengthened the traditional state preference upon water use, which in its turn gradually has improved the people's attitude towards the proper planning and management of water resources. In this process the achievements in education have been of paramount importance. Almost all children attend primary school for at least five years. The soil and water resources management is a popular topic, which is integrated in many teaching subjects at all school levels. By providing widespread educational facilities the new government has been able to unmask the many traditional myths and beliefs in water perception including the mighty River Dragon King, thereby paving the way for a modern use and care of water.

The decisive force in remoulding the thoughts of a conservative agrarian society has been played by the Communist Party and its cadres. In an explorative and most interesting study Wakemann (1975) has analyzed the roots of Chinese communist thoughts as a synthesis of traditional Chinese beliefs and modern scientific concepts. The historical mission of the Communist Party has been the conviction that thoughts have to be expressed in action for the purpose of creating a social change and improvement for the mass of the people. This conviction has been combined with the notion that only an integration of state and society would enable the individual to be free, because no single man could be free until all men were free. Certainly this apppealing unity of state, society and man has facilitated the participation and mobilization of Chinese peasants with their labour and skill in massive water construction works. In the development debate today it is often argued, that a radical change in the people's livelihood could only be achieved, if the developmental change is generated from below. The Chinese experience contradicts this belief. The Chinese development has since the restoration of national sovereignty in 1949 been effected by inducing radical thoughts from above, which has been a prerequisite for the peasant's will to participate in the developing process.

It is first with the increasing water pollution problems, that public attitudes and preferences towards environmental problems have been aroused and expressed next to the Communist Party apparatus. The water quality aspect in water resources planning was first recognized in the beginning of the 1970s. According to the Ministry of Water Conservancy and Power most of the industrial and residental sewage water is discharged directly into the water areas without any treatment. The pollution problem is most serious around the larger cities and industrial centres. In the Chinese cities one side-effect of the housing construction boom, which started in 1979, has become the increasing risk of surface and ground water contamination. The traditional Chinese residental areas both in the cities and the countryside use a septic tank system. The sewage in the city areas is regularly collected by farmers from the neighbouring communes. After compostation the peasants use the sewage as fertilizer. But for high-story buildings the septic tank system is not applicable, so the sewage water is therefore piped away to the nearest water course. At best the sewage is treated mechanically and chlorinated. It is only in recent years that some municipal sewage water treatment plants has been constructed.

The Chinese authorities, scientists and planners, with whom the author talked, are much concerned with the pollution problem. Newspapers often carry pollution correspondent articles. China wants to avoid the environmental deterioration, which has accompanied the industrialization process in the Western and East European countries. The bias against the quantitative development of the Chinese water resources up to the middle of the 1970s was really a struggle against nature, but from that time a new ecological consciousness could be discerned. There are reasons for anticipating that the modernization drive and industrialization process will be accomplished together with the conservation of nature. Nature is no longer perceived as an enemy. Once more the water resources planners fetched inspiration for ecological consciousness from the traditional daoistic respect of nature.

HOW DO THE CHARACTERISTICS AND CONSTRAINTS OF CHINESE WATER RESOURCES INFLUENCE THE WATER POLICIES, PLANS AND SCHEMES?

Chapter 4 to 5 has provided some detailed information on the Chinese resource base, water utilization and organization as well as the water resources development within the context of the largest river basins. The great variation of rainfall in seasons and years is the principal physical cause of the historical and present droughts, waterlogging problems and floods. From the 1950s up to the present time the Chinese population has more than doubled, a fact which has decreased the water availability per capita from around 5 500 cubic metres by 1950 to the present rather low figure of 2 600 cubic metres. The regional distribution and availability of water resources for the larger river basins are summarized in table 44. The marked difference in water availability between north and south appears in the table. The basins of Hai & Luan, the Yellow and Huai Rivers have all extremely low water availability. Even South China, which has an abundant volume of runoff, has a per capita availability below 5 000 cubic metres due to its high population pressure.

Since 1949 the national water requirement has more than quadrupled reaching an annual water utilization of 470 cubic kilometres by the end of the 1970s. From 1949 up to 1979 the water utilization ratio of the total annual runoff has increased from 4 percent to 18 percent, implying that water resources planning and management ha become of vital importance for the national economic performance (see page 47). The North China Plain region especially has severe water shortage problems (see pages 55-66).

With this water resources background in mind the Chinese water resources development evaluated in numbers of soil and water conservation works is impressive by any international comparison. Water resources development in contemporary China has involved the regulation of entire river systems for comprehensive purposes with specific emphasis on flood prevention and guaranteed supplies of water for agricultural production. Compared to the situation before the liberation the massive investments in water storage facilities, coordination between surface and ground water resources and the coordination between the catchment area and the point of use of water are new developments in Chinese water resources utilization. Traditionally the Chinese water conservancy did not reach above the level of pond irrigation. (Shien 1951). Up to today around 86 000 reservoirs have been built with a total storage capacity of some 460 cubic kilometres. Before 1949 modern well-drilling techniques were not applied on a large scale and thus the wells were shallow and with a low capacity. Since 1960 machine-operated ground water wells have increasingly supplemented available water resources in North China. In recent years many of these wells have begun to be overutilized or even exhausted. The water authorities therefore plan the construction of large-scaled water diversion projects from the Yangtse River Basin as the long term solution to the North China water storage problem.

In traditional China, forest on hillslopes were considered as a fuel resource, which meant that the hillslopes became heavily deforested, causing severe erosion problems, especially in the Loess Plateau Area. Neither were the Chinese peasants able to control the erosion by massive terracing, afforestation schemes etc, as they lacked governmental economic and moral support (Todd and Eliassen 1940, p 407 ff). Still today erosion is a serious problem, but since 1949 erosion control measures have been adopted on a massive scale and the close relationship between land and water resources management has been gradually recognized (see further Gustafsson 1981b, pp 101-140). Since the middle of the 1970s water quality aspects have finally been integrated in the water resources planning and management process.

There have certainly been difficulties to overcome in carrying out the changes in Chinese water resources development in the last 30 years. Based on the information given to the author from various Chinese water authorities and some printed sources, the following phases could be roughly discerned (Nichimura 1971; Nickum 1974; Vermeer 1977; Gustafsson 1981a; Vaidyanathan 1983):

1949-1952: Elimination of major flood danger through the repairing and building of dikes and enlargement of flow capacities; restoration and repair of preliberation irrigation projects; redistribution of land by a radical land reform.

1953-1956; Promotion of water storage by reservoir building; enlarging the irrigated area mainly by building medium and small-sized canal and reservoir irrigation projects; carrying out a basin-wide regulation of the Huai River and working out a plan for the Yellow River regulation; a high degree of state financing of major projects and support from Soviet technicians; land consolidation by agricultural cooperativization.

1957-1960; Massive labour mobilization for carrying out larger medium and small-sized canal and reservoir projects during the "Great Leap" Forward; a shift to high degree financing at the provincial, county and commune level; withdrawal of Soviet technicians in 1960.

1961-1964; Radical reduction of new construction projects due to over-utilization of funds and labour 1957-1960; emphasis on improving the effectiveness of reservoirs and irrigation works already existing by filling in with ancillary works, supplementing the irrigation area with drainage facilities and by improving management and control; encouraging the principle of self-reliance on all administrative levels and stating the policy of "taking agriculture as the foundation and industry as the leading factor" of the national economic performance.

1965-1973; Concentrated efforts of state investments on a limited number of major projects; promoting the ground water development on a large scale in North China; coordinated management of various water supplies, irrigation and drainage works of different sizes; selective modernization with modern equipment like motor pumps, lining of canals with concrete etc; high reliance of collective egalitarian efforts at county and commune levels; downgrading of scientific research due to the Cultural Revolution.

Table: 44 Land and water resources and their availability in the large river basins.

River basin	Area km^2	%	Population 1981 millions	%	Cultivated land 1981 million ha	%	Mean annual runoff km^3	%	Average annual amount of water in cubic metres; per cultivated area	per capita
Hai & Luan He	319 000	3.3	92	9.2	11.3	11.4	28.3	1.1	2 520	310
Yellow River	752 000	7.8	82	8.2	13.1	13.2	56	2.1	4 270	680
Huai He	262 000	2.7	125	12.5	12.6	12.7	53	2.0	4 210	425
Yangtse River	1 807 000	18.8	346	34.6	24.7	24.9	980	37.7	39 700	2 830
Pearl River	452 000	4.7	74	7.4	5.2	5.3	342	13.0	65 800	4 620
All China	9 600 000	100	1 001	100	99	100	2 614	100	26 400	2 610

Source: Yao & Chen 1983, Table 1 and information given to the author presented in chapters 4-5.

1974-1978; Widespread governmental support for the Dazhai-type spirit of farmland and capital construction works, especially land leveling and terracing, accompanied by a new extensive upsurge of labour mobilization; increased amount of state funds to major construction projects; promotion of science and technology in agricultural and water resources development.

1979 - ; Scaling down the total number of state-funded major water construction projects; strong emphasis on increased water efficiency and improved water management in existing projects; major emphasis on soil conservation and afforestation; adopting of ecological considerations and water quality criteria in project planning; a shift in state allocation of funds from heavy industry sector to agriculture and light industry sector; promotion of the contract and responsibility system in agriculture and water management.

TO WHAT EXTENT HAVE WATER RESOURCES MANAGEMENT PRINCIPLES LIKE WATER EFFICIENCY AND SOIL CONSERVATION BEEN INCORPORATED IN PLANS AND SCHEMES AT THE PRODUCTION LEVEL?

The question of water efficiency, especially irrigation efficiency, was discussed in general terms in chapter 6. Policy documents and laws have since the 1950s stressed the rational use of natural resources and the equal importance of construction and management of water projects. However, in practice the quantitative expansion of water resources has dominated the plans and schemes, especially during the 1950s when China lacked sufficient technical knowledge, a material base and skilled manpower for an efficient water management. Since the 1960s the water efficiency has steadily been improved and in the 1980s management of existing water conservation projets has been given primary priority. Thus the water efficiency in irrigation projects is well above the average standard in Asia today. Large-scale irrigation districts like Meichuan and Zing Ping have advanced irrigation practice and in 1982 the Dujiangyan Diversion irrigation district installed an automatic control system of sluicegates, which can allocate irrigation water to 200 000 ha. By merging the numerous small-scaled irrigation projects of the collectives into larger systems and using all possible water resources in a rational way, the water efficiency will further increase. Thus the prospects for enlarging the irrigated area of high and stable yielding fields are good. China has good future prospects for efficient water use thanks to an organizational structure suitable for unified planning and management, which is lacking in most other Third World countries.

The need for an effective soil conservation policy has been advocated with renewed strength at all planning levels during the last five years. For instance, by time-consuming laborious work Shaanxi province has basically controlled 25 percent of its soil erosion area at the Loess Plateau in the last 30 years (see page 88). The experiences of Liu Lin and Xio Shi Guo Brigades are typical examples of the patient soil conservation work, carried out during several decades. When the comprehensive utilization of the Yellow River was planned in the 1950s due attention was given to the conservation of soil as a measure of reducing the quantity and improving the quality of the surface water flow.

After the summer floods of 1954 the large-scaled Guanting and Foziling reservoirs, constructed in the 1950-1954 period, had been designed without consideration being given to China's silt-laden rivers. (Oksenberg 1970). Since then, China has trained over one thousand college and technical school-graduates working in the field of river sedimentation and set up several research laboratories of high quality (Qian & Dai 1980). The impressive research works over the years have recently been presented in two large International River Sedimentation Basin Symposium in Beijing 1980 and 1982. In retrospect, too much emphasis was placed upon solving the silt problems within rivers and reservoirs and too little on preventing the silt from reaching rivers and reservoirs during the 1958-1976 period. The policy guideline of "taking grain as the key link to agricultural production" was too literally adhered to and lack of attention to local ecological conditions resulted in widespread deforestation and unwise land use in hilly areas. Also the cutting of firewood for household requirements has resulted in increased erosion in many areas. Unfortunately the land-use, water and energy policies were not satisfactorily coordinated by the state planning authorities, which to some extent was an effect of the political turmoil in the Cultural Revolution period. Thus the successful results in soil conservation have had an uneven spatial distribution and have above all been achieved in localities, where the local leadership has been thrifty and competent. However there are good reasons for hoping, that the forest cover increases and that the erosion rate decreases, as the government has been given top priority for investments in soil conservation projects in recent years.

IS THE WATER RESOURCES TECHNOLOGY USED IN WATER PROJECTS ADAPTED TO THE SOCIAL CONTEXT AND THE RESOURCE BASE?

The Chinese way to development has neither been bimodal or populistic. The water resources sector is just one of many sectors in which the two-legged strategy towards technological change has been applied. Unlike supporters of a Western liberal growth model, prejudiced against favouring "hardware technology" and "tractor cultivation", China has perceived a policy of simultaneously promoting the utilization of large- and small-scaled technology. This has been a rational adaption to the social context and resource base of China. The purpose has been to harness and restrict the variability of the Chinese water resources to the benefit of its population. China has consequently allocated the limited state economic surplus or financial funds to large-scale projects of national importance and likewise consequently mobilized and organized its rural surplus labour in numerous small scaled projects and undertakings, basically by using local technology. If viewed from an ethnocentric Western standpoint, in which machine-labour has always been considered in advance of human labour regardless of socio-economic conditions, the Chinese way of development seen on a project basis in most cases will lack economic efficiency. But in the Chinese efforts towards modernization even a small amount of physical labour work of low productivity will in the long run contribute to the increased material welfare of the society.

In the 1950s China had already obtained the ability to use modern large-scale water conservation techniques, which the regulation of Huai River, Miyun Reservoir and Liuxi Hydropower Station bear witness to. Today's large-scale showcase is the remarkable Gezhouba Dam Project in the Yangtse River, which has been completely designed and planned by Chinese scientists and technicians. The construction works are carried out by using equipment only made in China. The large-scale undertakings to solve the water supply situation in Tianjin have been accompanied by extensive labour mobilization. Large-scaled projects can also be accomplished by using local natural resources, which the Fan Tai Siltation Dam and Long Quan Irrigation Scheme illustrate. Traditional Chinese water resources techniques have been combined with modern techniques in the outstanding Dujiangyan Diversion and Irrigation Scheme. The author found during his visits to several institutes and laboratories that the Chinese water resources research has reached a high international standard in a period of 30 years.

The large-scale projects are very important, but it is the numerous small-scale soil and water conservation projects, that have remoulded the nature of the Chinese countryside. There is a reciprocal relationship between large- and small-scale projects. Without the small-scale projects the large-scale projects could not be fully utilized and without the large-scale projects many small-scale projects would not have been constructed. Without the patient soil and water conservation works at the village level like in Liu Lin and Xio Shi Guo Brigades on the Loess Plateau large dams like Sanmenxia would soon be silted up. Furthermore, without the large-scale Jiangdu Pumping Station, which supplies water to or drains water from the Lixiahe Region, the numerous small-scale irrigation and drainage works within the region would not have been accomplished. Large and small reservoirs in the Liuxi River system are combined into a comprehensive flood control and water power utilization. It is this kind of reciprocity in the water resource development and other sectors, which makes the Chinese development experience rather unique in the Third World.

TO WHAT EXTENT HAS THE CHINESE WATER RESOURCES DEVELOPMENT AND THE PLANNING SYSTEM IMPROVED THE WELFARE OF ITS PEOPLE?

It was postulated in chapters 2 and 3 that the planning and management of water resources ultimately aims at increasing the social welfare of a nation. In the Third World countries, which have accepted a basic needs approach as an overall planning guideline, the source for an widespread and equitable social welfare will basically originate from an increased agricultural production value. By accepting this premise the purpose of a rational use of water ad land resources will be to allocate them for different human activities, which will give an overall priority to agricultural production. If the agricultural production is put at the centre the water and land activities could be illustrated together with four groups of production factors as in figure 23.

An optimal agricultural production necessitates a timely water supply as well as adequate soil conditions. Soil and water conservation measures like flood prevention, irrigation, drainage, terracing, afforestation etc therefore all aim to provide a suitable resource environment for agricultural growth. Due to the complexity of agricultural production output figures show the aggregate result of numerous production factors including the ecological, soil and water conservation, input and socio-economic factors.

A result of the analysis in the first part of this project was, that the building out of basic soil and water conservation works i.e. flood prevention, irrigation and drainage projects were the main factors behind the increase of agricultural productivity in China during the 1952-1965 period (Gustafsson 1981b). It was not until the 1965-1978 period, that modern inputs, for instance, improved seeds and chemical fertilizers, became the dominating factors behind the growth of agricultural productivity, (see page 135). Thus the grain yield per cultivated area had a slight increase from 1.52 tons per ha to 1.80 tons per ha between 1952 and 1965, but a more rapid increase from 1.80 tons per ha to 3.08 tons per ha between 1965 and 1978. The parallelism with the Japanese experience seems to be obvious. The Chinese 1953-1965 period is comparable to the 1878-1940 period of Japanese agricultural and water resources development (see page 19). The Chinese and Japanese experiences give strong evidence to the thesis, that in an initial phase of modernization the expansion of the agricultural soil and water conservation infrastructure should be given overall priority at the expense of modern inputs.

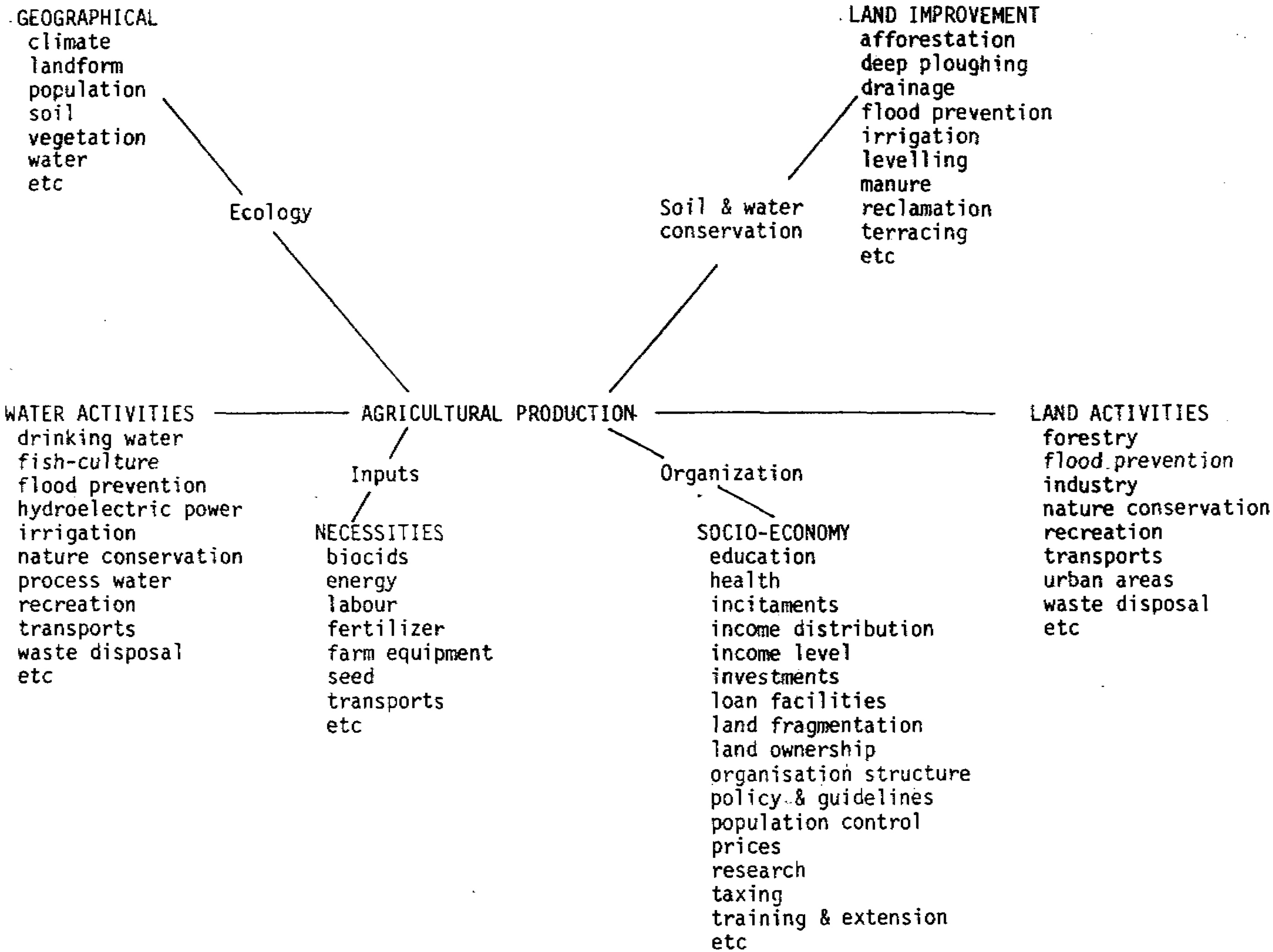
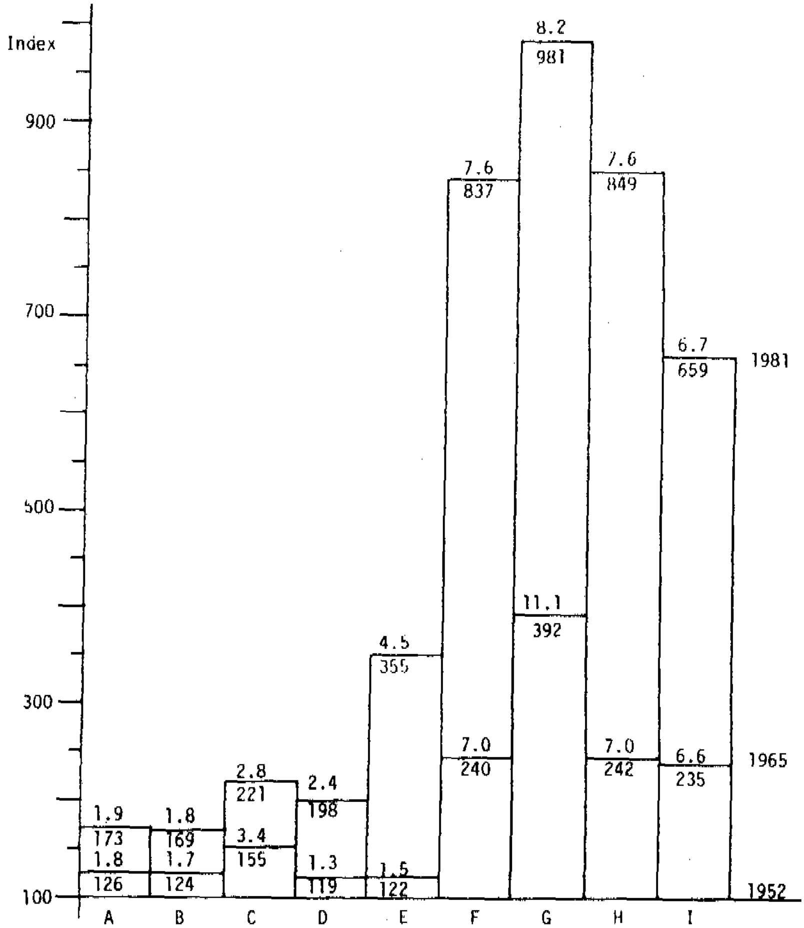


Figure 23. Human activities and production factors showing the complexity of agricultural production. (cf. Gustafsson 1982b)



A Population
100 = 574.82 millions

B Rural labour force
100 = 191.26 millions

C Irrigated area
100 = 21.3 million ha

D Total grain yield
100 = 163.9 million tons

E Gross agricultural output value
100= 48 400 million Yuan

F Gross industrial and agricultural output value
100 = 82 700 million Yuan

G State capital construction investments
100 = 4 360 million Yuan

H Total volyme of retail sales
100 = 27 680 million Yuan

I National income
100 = 58 900 million Yuan

Figure 24. The development of major economic and welfare indicators for the 1953-1965 and 1953-1981 period. Index and annual growth rate in percent. Source: State Statistical Bureau, see Beijing Review 48-1982.

In figure 24 the development of some important national welfare indicators are shown together with the growth of the irrigated area and the population. First the figure illustrates the initial difficulties of expanding agricultural production relative to population growth during the 1953-1965 period. The increase in the total grain yield was 0.5 per cent below the population growth and the per capita grain availability dropped from 285 kg in 1952 to 268 kg in 1965. The years between 1953 and 1965 were a period of trial and error in construction works, which for instance resulted in low water efficiency in water projects (see pages 130-134). Nevertheless this period provided the peasants with the experience and knowledge needed for the assimilation of modern inputs. Second welfare growth took off from 1965 onwards. Either the generated agricultural surplus is evaluated as the total grain yield or in value terms, the average annual growth rate has exceeded the population growth rate for the whole period of 1953-1981. The total grain yield expanded with 2.4 percent, which is 0.5 per cent above the population growth rate. In 1981 the per capita grain availability reached 325 kg. This is a figure well above the average for the Third World countries given by FAO (see page 30). Where the Third Worlds is in general facing a decrease in grain per capita availability, the Chinese per capita grain availability is increasing at a rate never previously recorded. Thus the average annual per capita grain growth rate was 1.2 percent for the 1966-1981 period and 2.2 percent for the 1979-1982 period.

The annual growth rate of the gross agricultural value in 1953-1981 has been 4.5 percent, which is a growth rate much higher than in most other Third World countries (Gustafsson 1981b, p33). Naturally this relatively rapid growth of the agricultural value has benefited from the massive state and collective investments in soil and water conservation works (see pages 154-156). Another decisive factor has been the gradual improvement of the terms of trade, i.e. the ratio between purchase prices of farm and sideline products sold in rural areas. If the amount of industrial products that could be exchanged for a fixed amount of certain agricultural products was set at 100 in 1950, it rose to 198 in 1978 and 269 in 1981. For instance raised purchase prices of grain and other agricultural products increased the peasant's income with some 25 000 million Yuan in 1979 and 1980. The selling price of such important input factors like farm machinery, chemical fertilizers and insecticides have been reduced 10, 7 and 6 times respectively since 1952. Therefore a given amount of agricultural products in 1981 could buy more than 2.5 times as many industrial goods as in 1950 (Gustafsson 1982b, Hsu 1982, Beijing Review 35-1983).

An essential point to make in this connection is that industry-biased liberal economic growth models in general have failed to improve the terms of trade in favour of agriculture (see page 28). Many well-meaning Western-sponsored agricultural infrastructure construction investments in the Third World have been wasted and the facilities ineffectively used or have even deteriorated due to the fact that the peasants have been seldom given any price incitements. The Chinese agricultural experience shows, that investments in soil and water conservation works must be accompanied by a government price policy in favour of agriculture, if broad segments of the population are to have welfare growth.

The other welfare indicators in figure 24 indicate, that the growth of the agricultural economic surplus has been accompanied by an overall growth of the national economy. For instance the national income has increased by an average annual rate of 6.7 percent. Since the period of the first Five Year Plan (1953-1957) 20-35 percent of the national income has been invested and the rest used for consumption (Dong 1982). Thus the Chinese capital formation has far exceeded the 12 to 15 percent, which Arthur Lewis considered necessary for a rapid capital accumulation (see page 28).

Table 45. The regional distribution of population, gross agricultural output value and total grain yield in the beginning of the 1950s and at the end of the 1970s.

Water Resources Regions	Population Millions 1953 [1]		1979 [1]		Gross agricultural output value, Million Yuan 1952 [2]		1980 [3]		Total grain yield Million tons 1953 [4]		1979 [4]	
North-east	23.19	4.0	53.53	5.5	3.37	7.5	10.24	6.3	13.35	8.2	23.37	7.3
Loess Plateau	50.46	8.7	93.64	9.6	4.14	9.2	12.91	7.9	15.27	9.4	25.86	8.1
North China Plain	157.02	26.9	245.81	25.3	12.20	27.0	41.96	25.8	36.60	22.5	75.72	23.7
Lower Yangtse	100.66	17.3	156.19	16.1	6.37	14.1	32.30	19.9	26.48	16.3	55.15	17.3
Central-south	125.70	21.6	212.54	21.9	10.64	23.6	35.97	22.1	37.14	22.8	75.16	23.5
South-west	117.76	20.2	191.90	19.7	7.63	16.9	25.90	15.9	31.67	19.5	58.96	18.5
West	7.82	1.3	18.11	1.9	0.77	1.7	3.43	2.1	2.10	1.3	5.16	1.6
Total	582.61	100.0	970.92	100.0	45.12	100.0	162.71	100.0	162.61	100.0	319.18	100.0

Sources:

1. Mid-1953 population is given by Jowett 1980 (table 2), see also Gustafsson 1982. End-1979 population is given in The Administrative Divsion...1980. End-1981 population is given by Beijing Review 33-1983, see also mid-1982 population census figures in Beijing Review 45-1982. The 1980 population used for calculation in figure 26 is the average of the 1979 and 1981 figures.
2. Lardy 1978, pp 197-198; Paine 1981, p 146; Beijing Review 48-1982, p 18. Value in 1952 constant prices.
3. China Agricultural Yearbook 1981. Translated in China Report:Agriculture No 255 1983. Value in 1970 constant prices.
4. Walker 1977 (table 1); Walker 1981 (appendix III); Gustafsson 1982. The grain yield of 1953 is the average of 1952-54,1979 is the average of 1978-80.
5. Provinces included in the water resources regions are given in table11 on page 50.

Hitherto the welfare indicators have concidered national statistical figures. Table 45 provides the regional distribution of population, gross agricultural output value and the total grain yield in the beginning of the 1950s and at the end of the 1970s for the different water resources regions defined in chapter 4, see table 11. A basic characteristic of the Chinese self-reliant method for development has been, that a free exchange of labour between localities has not been allowed. Instead the principle has been to assign employment opportunities to people in the agricultural and rural small-industry sector in the native locality (Rawski 1979). By promoting such a policy China has basically avoided the problem of urban migration and related unemployment problems. The prohibition of a free exchange of labour also means, that agricultural production has been promoted even in areas with a poor resource base. However, the general policy has been to subsidize the backward regions by appropriations in state, provincial and local budgets, transferring educated people and by other redistributive means (Lardy 1978). If this policy has been successful a relatively equitable regional distribution of welfare indicators could be anticipated.

Figure 25 shows the regional distribution of the annual average growth rate of the population, gross agricultural output value and total grain yield from the beginning of the 1950s up to the end of the 1970s. In table 45 the regional percentage distribution for the same indicators and time period was given. Finally the regional per capita distribution of the gross agricultural output value and the total grain yield are given in figure 26. The first thing to note from these facts is that there exists no conspicuous deviation from a pattern of relative equitable regional distribution.

The annual population growth rate is above the national average in the outer water resources regions (North-east, Loess Plateau and West), which means that these regions have increased their percental part of the total population. This is mainly due to a deliberate migration policy towards these regions. The annual growth rate of the gross agricultural output has been fairly uniform, ranging from a 4.0 percent increase in the North-east to 6.0 percent increase in the industrious Lower Yangtse water resources region. The percental figures also show that Lower Yangtse has benefited from its proximity to the Shanghai urban region. The annual growth rate of the total grain yield also shows a fairly uniform distribution around the national value of 2.6 percent. The outer regions have had a lower grain increase rate than the population growth rate, which was to be expected due to the migration policy towards these regions and their relative harsh environmental conditions.

The per capita gross agricultural output value has increased for all regions. The lowest values are recorded in the North-east and the Loess Plateau regions. Lower Yangtse has had the highest increase. The range between the regions has narrowed with 11 Yuan during the period. In China an area with a per capita grain yield below 275 kg could be considered to be grain deficient (Walker 1981). Only the North-east exceeded this value with a wide margin in 1952. However at the end of the 1970s this region had the highest grain availability, though it has had a high immigration rate since 1952. The grain availability is the lowest in the Loess Plateau and Western regions. The semi-arid conditions of these regions make the population pressure the severest in China. The grain availability increase in

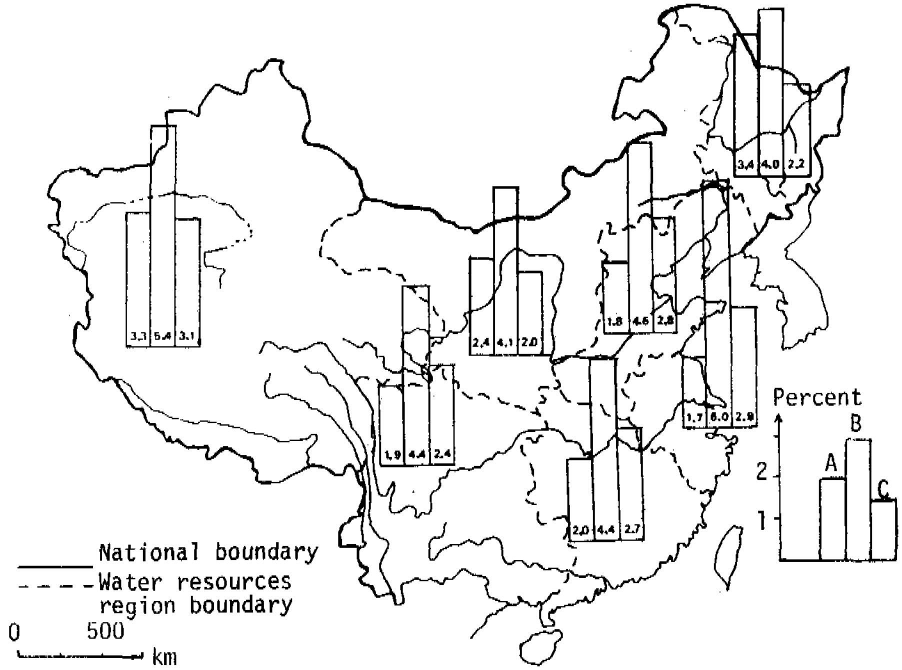


Figure 25. Regional annual growth rate of population 1953-1979 (A), gross agricultural output value 1953-1980 (B) and total grain yield 1953-1979 (C), (Data, see table 45).

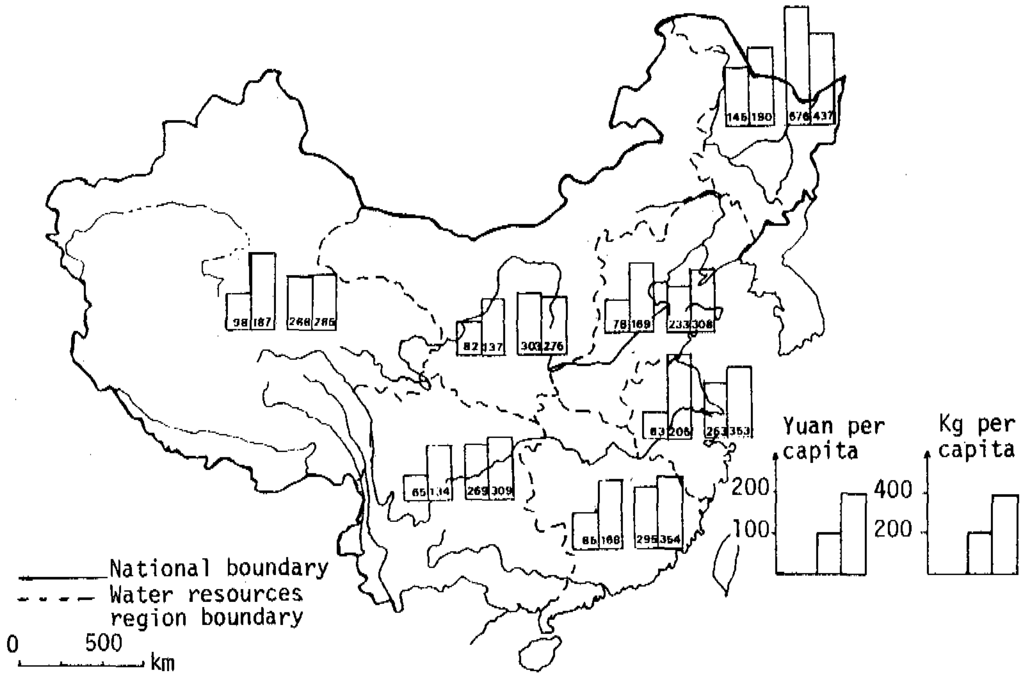


Figure 26. Regional distribution of per capita gross agricultural output value in 1952 (A) and in 1980 (B), and per capita total grain yield in 1953 (C) and in 1979 (D), (Data, see table 45).

the North China Plain and Lower Yangtse regions verifies, that the soil and water conservation works in the Hai, Lower Yellow and Huai River basins have had great impact upon the grain yields. It should finally be noted that the range in the per capita grain availability between the regions has decreased from 313 kg to 161 kg from 1952 to 1978-80.

In summary it could be concluded that the water resources development in different regions indicated by table 11 on page 50 has been well adopted to the achievement of a relative uniform regional distribution of population, gross agricultural output and total grain yield. Thus the Chinese water resources planning system, guided by a basic needs approach as a social guideline for national economic performance, has considerably contributed to an increase of the material and social welfare of the nation.

IS WATER RESOURCES PLANNING COMPREHENSIVE AND SYSTEMATIC IN CHINA AND ARE ALL RELEVANT INTERESTS INVOLVED?

Agrarian China before 1949 exhibited with some important exceptions the same typical water planning characteristics of a supply-orientated stage, which were illustrated as the first stage of the water resources development of the United States (figure 1, page 18). No national water policy of any substance existed in China. The limited number of water construction projects undertaken were isolated hydraulic achievements, which lacked coordination and were restricted in scope (Bazin 1946). The major rivers were unregulated, there were less than 10 modern reservoirs (see page 46) and it took eight years before the disastrous break in the Yellow River dyke caused by Chiang Kai-shek's troops was ultimately closed (see page 67)

Thus the characteristics of a supply-orientated stage give a good but nevertheless still inadequate description of the actual conditions. From the standpoint that all human beings have the right to a decent standard of living <u>the objective water needs in China were high already before 1949,</u> which <u>required a high interrelation of water resources planning with the</u> socio-economic system. Furthermore physical constraints in the resource base, an already high population pressure and the dependancy of the international economy created <u>marginal costs of water resources development,</u> which in comparison with <u>industrialized countries at this stage of early</u> development <u>was high and not low</u>. Thus a situation for an objective need for a planned <u>utilization of water</u> in combination with high marginal costs of development existed, but no planning of any substance was carried out. This brief description of China before 1949 still describes the situation in most Third World countries today.

Since 1949 the Chinese water resources situation has changed completely as has been shown by numerous examples in the preceding chapters 4-6. Almost from scratch various Chinese authorities have built up an extensive network system for gathering systematic water resources information. The land resources network monitoring system appears to be weaker, but it has been substantially improved from 1979 onwards. By promoting and implanting a collective behaviour inside the whole society as the Mormon community once effected on a limited scale in the United States in the middle of the 1800 century (see page 12), the new government adopted a strategy towards water resources development based upon a basic needs approach (see pages 32-36). After less than 25 years of water construction experience China has shown from the middle of the 1970s all the main characteristics of a demand orientated stage of development. The Soviet Union provided technical assistance and low interest loans to a value of 3 000 million US dollars during the First Five Years Plan 1952-1957 (Dutt & Costa 1980). With the exception of the Soviet technical and monetary assistance in the 1950s, it should be noted that China has achieved this progress basically by using her own financial funds and technological skill. The corresponding period for this development in other countries, has been more than 100 years in the United States, about 80 years in Japan and about 60 years in the Soviet Union (see pages 11-22).

With reference to figure 1 Chinese water resources development exhibits the main characteristics of a resource orientated stage with some deviations from the begining of the First Five Years Plan in 1953 up to the middle of the 1970s. The Chinese rivers underwent an increasing degree of regulation. Through the River Basin Commissions and cooperative regulations like the Sixty Articles, the State has provided adequate planning instruments for a large-scale as well as small-scale multi-purpose water utilization and an integrated water resources management, which has included water conflict solution on a consensus basis. The efficiency in water use has gradually improved during this stage.

By its extensive use of labour, which is unprecedented in the world, China has in practice managed to lower the marginal cost of water constructions relative to other Third World countries. The Chinese population has reaped the benefits from labour mobilization in the form of a multitude of soil and water construction assets, a gradually improved and widespread technical knowledge, the virtual abolishment of disguised unemployment and increased agricultural production. As in Western countries a large amount of reservoirs were built during this stage. Due to the conditions of the Chinese resource base and the government's adoption of the basic needs approach, large-scaled reservoir constructions for the one-sided purpose of hydropower generation and industrial development have not been given the same key priority as in Western industrialized countries. Reservoirs have been built in most cases for multi-purpose use. Flood control has been given overall attention. However irrigation, hydropower generation, fish-culture, water supply and transports have also been duly considered during the resource-orientated stage. Though the Chinese water resources development as in Western countries displayed a technical-economical and quantitative orientation, the Chinese planning of water resources at this stage already contrasted with the Western countries' experience i.e. it was highly interrelated and integrated with other societal planning activities. Being a socialist state the government has been able to allocate and control investment funds for water resources development.

From the middle of the 1970s a demand-orientated stage has been recognized by the Chinese authorities. It is realized that in many areas water shortage will hamper the growth of the national economy. The Hai, Yellow and Huai River basins show a high degree of stream-flow regulation. Long distance transfers of water from the Yangtse River basin to North China and from Western Sichuan to Eastern Sichuan have been carried out or are planned to remedy the water shortage situations in the North China Plain Region and Eastern Sichuan respectively. Since 1978 the government has given overall priority to an improved water efficiency of the existing water projects instead of quantitative expansion as the main method to increase the water supply.

Funds for new state construction projects have been concentrated to the most profitable ones. By promoting the conjunctive use of water, i.e. the use of water from several types of sources, small irrigation projects are joined into larger systems, which are better suited for a rational management. Furthermore the authorities advocate, that water should be priced as a scarce commodity and people are urged to save water. Water management units should be self-financing and deliver water on a contract basis.

With the rise in the standard of living the complexity of water activities has also increased. The limited ecological perseverance towards misuse of land and water resources in the course of the industrialization process has been recognized by the authorities and gradually by the general public. Human activities such as the disposal of waste and sewage, the use of chemical fertilizers and pesticides are all related to the modernization process, which in China and elsewhere have caused growing river and ground water pollution and been a public nuisance. Water pollution was not recognized as a resource problem before the middle of the 1970s and is probably the weakest aspect of comprehensive water resources planning in China at the present time.

However pollution problems have ministerial status by the setting up of the Ministry of Urban and Rural Construction and Environmental Protection in 1982. Pollution problems are also a rapidly growing research area. As was apparent to the author, it can be expected that the rather weak coordination today between soil and water conservation units on the one hand and environmental protection units on the other will be much improved in the near future. For instance article 6 of the Environmental Protection Law, adopted in 1979, addresses the necessity of environmental impact reports. It states that;

> "all enterprises and institutions shall pay adequate attention to the prevention of pollution and damage to the environment when selecting their sites, designing, constructing and planning production. In planning new construction, reconstruction and extension projects, a report on the potential environmental effects shall be submitted to the environmental protection department and other relevant departments for examination and approval before designing can be started. The installations for the prevention and other hazards to the public should be designed, built and put into operation at the same time as the main project. Discharge of all kind of harmful substances shall be in compliance with the criteria set down by the State".

In 1983 Worldletter reported, that some 40 environmental impact studies on industrial and other projects had been completed (Worldletter 1-1983). Environmental impact studies have also been carried out in the reconnaissance studies for long distance transfer of water from the Yangtse River Basin to the North China Plain Region (Biswas et al 1983).

The notion that a basin-wide planning incorporates a joint planning of land and water resources was realized by planners and policymakers in the 1950s, for instance in the planning of the Yellow River regulation, but during the 1960s and much of the 1970s the emphasis on this idea weakened substantially. This was basically due to inappropriate policies such as exaggerating the policy of "taking grain as the key link" to agricultural production regardless of local ecological conditions. Even if the national situation in this respect is difficult to interpret the Chinese authorities extensively admit that in many hilly areas this exaggeration has lead to deforestation and thereby an increased rate of soil erosion. This has in turn caused management problems concerning reservoirs due to rapid siltation. In the 1980s the concept of a joint planning of land and water resources has regained widespread emphasis in planning. A coordinating Soil Erosion Committee has been set up among the ministeries under the State Council. Afforestation probably has the highest national priority of all land improvement measures (see figure 23).

By tradition all kinds of conflicts in Chinese society (including water conflicts) have been solved on an informal basis, founded on the striving for consensus. This applied before 1949 and thereafter. From 1949 the communist party and its cadre has provided the specific principles for conflict solution, for instance given in the Sixty Articles, and acted as mediator. In this respect the cooperative character of Chinese society appears to have alleviated administrative boundary conflicts taking advantage of the relatively few vested interests involved. In the course of the resource-orientated stage changes of boundaries between for example commune units aiming to adopt administrative and basin boundaries congruent to each other seem to have been conducted with relative ease by using the method of negotiations. Negotiations have also been the method of solving conflicts in water use between upstream and downstream areas (see pages 148-149).

However, abuse of the consensus system during the Cultural Revolution by many party cadres and the increasing complexity of water activities have necessitated a formal basis for planning. With the rise of material standards the search for recreative areas and the care for nature conservation have been augmented. In the densely populated parts of China areas of water construction assets like reservoirs, sluice-gates and pumping stations have become places for popular excursions. Therefore in order to ensure that all concerned water activities are involved in the planning process a comprehensive water and land resources planning is endorsed. An Environmental Protection Law was enforced in 1979. Several new laws and planning standards are under preparation, among them a Water Law and water quality standards for different water uses.

In summary Chinese water resources planning since 1949 has always had a comprehensive and systematic ambition. Though the objective material needs at the end of the 1940s requested a demand-oriented approach, China has from the First Five Year Plan up to the middle of the 1970s gone through a resource-orientated stage of development, but due to an extensive labour utilization this stage has been shortened substantially compared to the respective stage of Western industrialized countries. Though still a low-income country China reached the demand-orientated stage of water resources planning in the middle of the 1970s. In less than 30 years the Chinese water resources technology and planning has reached advanced world level.

CHAPTER 8

SOME CONCLUDING REMARKS

A major theme in this study has been to show that water resources development is an integrated activity, which can not be isolated from its societal context. The Chinese water resources development has been performed within a framework of a basic needs approach of national development. In the 1970s there has been a growing consensus among China analysts, that China has achieved a successful material welfare growth based upon the four broad objectives of rapid economic growth rate, great economic equity, high rate of employment and a high degree of economic and cultural self-reliance (Lardy 1978, Rawski 1979, Ullerich 1979, Dernberger & Le Gall 1980, Griffin & Saith 1980, Weisskopf 1980, Paine 1981). This study has highlighted the important role the Chinese water resources development has played in obtaining the welfare growth.

The average annual rate of growth of various economic output indicators are considerably higher than the average of the Third World as a whole. China has simultaneously succeeded in providing virtually everyone with the security of a modest but adequate access to basic consumer goods and basic necessities. There remain considerable but not exceptional income differentials between regions, localities and individuals in contemporary China. Hitherto the Chinese have avoided the pattern of sharply increasing income disparities that have accompanied the process of early modernization in almost every other Third World country. China has been extremely effective in engaging its abundant labour force in current agricultural production, soil and water conservation works and in an expanding small-scale rural industry. Finally the Chinese modernization process, including the water resources development, has been produced under full national control of the economic activity, based upon the principle of a high degree of self-sufficiency in raw materials, funds and knowledge. The Chinese experience proves decisively that the achievement of rapid economic growth need not necessarily preclude the attainment of other development goals as believed by advocates of a liberal economic growth model.

If water construction projects are viewed solely from the technical aspect, one could always find success stories and failures. In this respect the Chinese water resources development experience is no exception. Especially during the 1950s and 1960s China had to pay the price of its self-reliant policy in the form of low quality of many construction projects, low labour productivity and not seldom construction failures. But nevertheless these technical shortcomings are not unique for the Chinese development experience. They existed also at similar stages of water resources development in the industrialized countries.

Actually, one have to recognize in order to understand the Chinese experience, that development is a process of spreading knowledge and skill to broad groups of the population. Thus, under circumstances of abundant labour resources and insignificant financial resources it has been a good option to engage the manpower in low productivity construction projects of low quality in its initial phase, than not mobilizing the manpower at all. Through their labour the mobilized workers and peasants have gradually gained higher technical knowledge and skill, which have enabled them to improve older low quality projects and raise the standards of new constructions projects. This is the experience of the Meichuan Irrigation District, Xio Shi Guo brigade and many other irrigation districts and brigades all over China. Thus when making a balance of the Chinese water resources development, it turns out to be positive. As it was shown in chapter 6 the water efficiency has been gradually improved. It could be said that the ratio between the successful projects and the unsuccessful projects has been much enlarged, while this ratio has become stagnant in most other Third World countries.

As it became more and more obvious in the 1970s that the liberal economic growth model was unsuccessful in the majority of Third World countries the interest in the Chinese experience grew rapidly. There is an agreement among most China analysts that the Chinese development strategy contains so many contextual components, that it is not easily transferable to other Third World countries. In a conceptual way the Chinese development experience implies a complete, integrated and consistent package of economic institutions and policies. For instance Dernberger & Le Gall (1980) have identified China as a mass- and rural-orientated case, which includes the collectivization of agriculture, the rural small-scale industry and the administrative system for allocation and distribution of labour and income as unique key elements. Adopting the terminology used by Johnston & Clark (1982) China could be described as a unimodal case, containing integrated programs for production, consumption and organization (see page 31).

The growth of the means of production since the second World War has been exceptional in the industrialized countries. Technical factors or lack of technical solutions are not the critical constraints towards modernization in Third World countries. Instead it is non-technical factors, i.e. socio-economical and organizational factors comprising the relations of production, which compose the crucial constraints of development. In the literature on water resources development so-called linkage problems between governmental authorities and organizations at the village level and the problem of grass-root participation are widely stressed as main obstacles.

The Chinese rural development illustrates this point. It was initiated by a profound socialist revolution, which was accompanied by a radical land reform that eradicated the large inequalities in land ownership. By the land reform land was reallocated to the peasants, who were relieved from the burden of land rent. It amounted to some 35 million tons of grain or some 30 percent of the total grain yield in 1949. The landlords had formerly spent this income on luxury consumption and had not expanded production. After the land reform this vast amount of wealth belonged to the peasants, who used some of it to increase their level of consumption and some for investments in land and water improvements (Dong 1982). However the Chinese leaders considered the land redistribution as merely a necessary precondition to attain a cooperative village-level framework. Land reform in countries with intensive methods of farming does not constitute a development programme by itself, unless it immediately leads to an integrative process of pooling the peasant's tools and land. In contemporary China 95 percent of the cultivated land is under cooperative ownership. The Chinese leaders have always regarded the advantages of a cooperative planning of rural development positively, but the management of cooperative property and assets has been the subject of much discussion and many controversies. At the moment the land is generally managed by the households, after they have signed annual production and management contracts with the cooperative unit. In the 1958-1978 period the land was jointly planned and managed by the production team, consisting of 20-30 households.

Some of the important advantages of a rural cooperative organization may be summed up as follows:

1. The cooperative village framework has provided the needed link between governmental centralized planning and economic guidance and the local level decentralized planning and management of rural development. The links between the state and the cooperative units are carried out by formalized negotiated compromises.

2. The cooperative organization has furnished the village level with a functional democracy, which has promoted the peasant's grass-roots participation in planning, implementation and management.

3. The cooperative property has given a solution for the scale of economy problems of small peasant private ownership under condition of land scarcity. By the introduction of scale economies in agriculture through cooperative property a scientific and rational attitude for the best use of land-, water- and labour resources have been promoted. Specifically the cooperative soil and water resources development has raised the demand for labour during the slack winter season and indirectly through the intensification of the cropping cycle, for instance by expansion of multiple cropping and diversification of the agricultural activities.

4. The cooperative system of investment allocation and income distribution has transferred the element of risk of failure in agricultural production from the individual peasant to the cooperative unit. Any production decrease due to unforeseen climatic disturbance or inefficiencies in soil and water construction works and agricultural production are subsidized by the cooperative unit through the spreading of any failure among its total economic activities. Thereby the low-income peasant's aversion to the introduction of new technology and modern agricultural inputs has been greatly reduced. The shift over to management by households could be interpreted from the risk aspect. At the end of the 1970s the income level of the peasants had reached such an level, that the individual peasant could take the risk of failure in agricultural production himself.

5. The cooperative units have provided the framework for a unimodal rural development. It has stimulated a gradual industrialization by setting up rural small-scale industries, provided marketing, supply and credit institutions as well as being responsible for consumer-oriented welfare programs for health and education. These are activities which are indispensable for a harmonious agricultural development.

The setting up of a workable cooperative planning and management rural organization has been the basic pre-supposition of the Chinese water resources development, which was also the major theme in chapter 6. This conclusion is further illustrated by the findings of the ESCAP workshop on efficient use and maintenance of irrigation systems at the farm level (ESCAP 1979). After visiting several irrigation areas specialists from eight Asian countries carried out an evaluation of the transferability of 17 main factors, which they considered had contributed to the effective use and maintenance of irrigation systems in China. The main factors were grouped into three headings: organization, engineering project and farm level management (cf. pages 143-144). A classification of four grades was adopted, see table 46. Class 1 indicated a factor, which was already carried out by one or more countries. In the other range class 4 indicated a factor, which had little prospect of adoption.

The factor of motivation and mobilization of the organizational management heading was not classified at the first stage of classification. As none of all the other 16 factors under the three headings was classified as 4 and most of them were given class 1 or 2, they are not reproduced here. However, the factor or motivation and mobilization of the people was considered as the principal factor of all factors, which had contributed to the relative success of the effective use and maintenance of irrigation systems in China. It was identified with 12 sub-factors, which had all contributed to the successful motivation and mobilization of the people. Therefore each sub-factor could be classified by itself according to degree of transferability. This classification is reproduced in table 46 due to the elucidation it gives to the Chinese water resources development and its integration with the cooperative system.

It is clear from table 46 that the class 3 and 4 sub-factors are closely related to the political- economic system of China. In a situation where few if any Third World countries outside China have adopted the underlying four broad objectives of a basic needs approach, it is rather unrealistic to think that these sub-factors of motivation and mobilization will be adopted by Third World countries in the short run. However, this conclusion does not mean that the Chinese development experience will lose its interest in the future.

On the contrary there are at least three reasons why the interest in the Chinese development experience will grow. First, Third World countries' claim for a New International Economic Order is a righteous struggle to weaken and abolish the industrialized countries (including the East European countries) ideological, political and economical penetration in the Third World. In the course of this struggle the interests in the four broad objectives of a basic needs approach will increase. Second, a rapidly growing labour force and decreasing per capita availability of cultivated land will increase the interest in cooperative solutions to development problems. It should be noted that the successful unimodal agricultural developments of Japan, South Korea and Taiwan have been conditioned by specific factors, which are not likely to be repeated elsewhere in the Third World. Based entirely on the liberal economic growth model they have been dependant on a rapid expansion of exports of manufactured goods, American-sponsered land reforms (see page 20) and massive transfer of American capital. For instance, between 1950-1963 US aid accounted for more than a third of the gross capital formation in Taiwan (Huntington 1968 cited from Chattopadhyay 1977, p 188). Third, with increasing equality and employment problems in industrialized countries it is likely that cooperative solutions will become relevant even for these countries.

Table 46 Important sub-factors for the motivation and mobilization of people in irrigation development identified by the ESCAP workshop participants in China 1978 and their degree of transferability.

Subfactor	Class
o Collective ownership of land	4
o Profit-sharing by workpoint system	4
o Production target setting through negotiations	4
o Generation of local capital development funds	3-4
o Decentralization of planning and decision-making	3
o Free and frequent flow of public information up and down the organization	
o Stable prices of agricultural products	3
o Use of slogans for dissemination of state policy	2
o Decentralized demonstration farms and extensive service	2
o Provision of agricultural credit, inputs, storage and marketing facilities	1-2
o Education of the public concerning achievements in agricultural production	1-2
o Fairly frequent public selection of leaders, direct at the lowest level, indirect at the higher levels through a system of negotiations and consensus	1-2

Key to classification:

1. Factor already being carried out by one or more countries

2. Factor, which could be carried out without any obstacle

3. Factor, which could be carried out but would require some time for preparations or adjustments

4. Factor with little prospect of adoption.

Source: ESCAP 1979, pp 14-15

The water resources development has been a vital part in the overall Chinese development experience. In many ways China has recorded a welfare growth over three decades, which is the result of a conspicuous skill in human organization and consciousness, based upon the peasant's simple needs and way of life. This is a most remarkable phenomenon in the second half of this century.

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