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Dam Lies and Other Statistics: Taking the Measure of Irrigation in China, 1931–91

by James E. Nickum

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Environment Series
No. 18, January 1995

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CONTENTS

Appendices

Figures

Tables

China, one of the earliest cultures to control water for agricultural use, was a leader in its technological development and practical applications in most, except for the current, centuries. During the People's Republic period since 1949, the renovation and new development of water control facilities have been central features of China's successful strategy to increase agricultural production. Those concerned with statistical system reform in other countries may find of particular interest the frequency of reporting and the abundance of data categories that have evolved over time to address the problem of water control quality and the measurement of efficiency of water system performance. Yet these data should not be used uncritically. Systematic biases and major inconsistencies in data reliability underlie published series. The massive proliferation of published statistical information on China since 1980 has made available an almost bewildering array of alternative data for understanding spatial and intertemporal variations in water control throughout the country. Yet the basis and definition of these statistical categories are not always clear, hindering responsible use for analytic purposes. Provincial and national data on irrigated area and other water control indicators are among the most commonly used series in economic analyses of Chinese agriculture.

James Nickum began pulling this work together almost ten years ago. Dr. Nickum, a leading authority on Chinese water control systems, is recognized both within China and internationally. There is probably no other researcher who could have put together this paper. It is not only the product of a decade of direct efforts to collect, systematize, investigate, and evaluate a mass of Chinese data. It is also a by-product of two-and-a-half decades of research specialization on the task of understanding and analyzing Chinese water systems from a Western economist's viewpoint. The study benefits as well from Nickum's extensive contacts throughout China's research and administrative organizations related to water, and from his intimate first-hand knowledge of Chinese water control systems.

A working manuscript has been available since the mid-1980s, providing the basis for detailed insights about the problems, performance, and prognosis of Chinese agriculture under economic reform, as they relate to water control. The research activities of several staff at the International Food Policy Research Institute (IFPRI) and a small group of specialists on Chinese agriculture have benefited from the evolving manuscript. I am delighted that the East-West Center has decided to present the work to a broader audience.

Here, then, is a capital good for the China research community and, for those less familiar with China, a guide to understanding China's immense successes and significant problems in water control. It is a piece of research, a convenient compendium of specialized data linking readily available and relatively obscure sources, and an evaluative guide providing substantial material aimed at promoting informed and intelligent use of the numbers for analytic purposes. Although it does not refer to macroeconomic modeling efforts directly, the paper certainly goes a long way toward explaining anomalous results among many published works that include water control data in efforts to model Chinese agriculture of the 1980s. Nickum does not unequivocally favor a particular published or adjusted series. Appropriate selection of data depends upon the purposes to which they will be applied. Researchers are recommended to read the entire paper and make their own judgments. Ample material is provided to inform that choice.

Nevertheless, a few general points can be distilled from Nickum's work. The importance of water control maintenance and development to the past performance and future potential of Chinese agriculture is confirmed. It is also clear that conflict has developed between, on the one hand, the historic orientation of water control organizations and the types of statistics they gather, and on the other, analytic needs associated with China's evolving agricultural economy and the public sector's role within it. Although organizations are successfully evolving, current technological needs, combined with the implications of economic and public sector reforms, are generating even greater demands for change. No one statistical category provides a good, all-purpose water control indicator, but various statistical information is collected and published. Available series provide an imperfect reflection of the underlying reality. (Specific interprovincial or intertemporal comparisons can be quite misleading.) Yet Chinese water control data can be used to provide a strikingly detailed understanding of the complex and heterogeneous system defining the world's oldest and largest hydraulic agriculture.

Bruce Stone
Washington, D.C.

The present work began a long time ago as a simple water-skimming exercise. I had collected some irrigated area figures at provincial and occasionally national levels during research for my doctoral dissertation on the role of the people's commune in mobilizing rural labor to construct public works after the Great Leap Forward. At that time—I turned in the final draft to my committee just before enplaning for my first trip to China in fall 1974—the statistical system of China was in shreds and access to China was severely limited. Little new light was shed for the remainder of the decade. Hence, shortly after I met him during my second trip to China in 1980, Bruce Stone suggested that I assemble what I had on my 3" × 5" cards on China's irrigated area figures, since any numbers were better than none.

A number of problems presented themselves immediately. It turned out that not very many figures were available, especially for the 1960s, and the validity and meaning of those I had access to were unclear, to put it mildly. It was not even certain who was collecting and reporting the occasional gem that typically was dropped into the body of a largely unrelated public relations report broadcast by the Chinese media.

Opportunities also arose in the 1980s. The statistical system came back to life, first with a trickle and then with a torrent of data and specifics on definition and methods of collection. I had an opportunity to deepen my contacts in China through a longer-term stay at the Institute of Geography of the Chinese Academy of Sciences in 1984, and subsequently as country officer for Winrock International, based at the Chinese Academy of Agricultural Sciences in Beijing, in 1986–88. I did a lot of shopping then at the book outlets of the State Statistical Bureau, the Ministry of Water Resources, and the Ministry of Agriculture and Forestry.

It therefore became possible to assemble a more complete set of irrigated area figures, even on occasion for the Cultural Revolutionary hiatuses of the 1960s. The numerous tables in this volume, a bane to a long string of editors, probably provide in one place the most complete series anywhere of national and provincial-level figures on irrigated area in China, including both major reporting systems. This allows a detailed view of intertemporal trends, both nationally and by region and province. In the past, quantitative models of China's agricultural development have commonly omitted water, despite the position of irrigation as a primary focus, almost an obsession, of rural development policy. Now that we have numbers, it should be possible to calculate more sophisticated estimates of the impact of irrigation.

As an economist who is more inclined to institutional analysis than number crunching, however, I found the most interesting aspect of doing this work was what it shows about the bureaucratic construction of knowledge. Irrigated area figures are important implements of the policy debates and budget battles in Beijing and, presumably, within the provinces. Indeed they are even now used by many as a sphygmomanometer for the health of the agricultural sector. In this role, they are biased measures of questionable meaning. The problem is that there are no good alternatives.

The incentives of those reporting irrigated area figures for the two reporting systems are in opposition—villages inclined to report lower numbers to reduce their exposure to the tax authorities, water deliverers inclined to report higher numbers. The irony is that, because of the nature of irrigation and the way it is measured, each system can report different figures for a given state of reality without deliberately prevaricating.

An even more fundamental epistemological problem is that the categories used, especially "effectively irrigated area," are poor and sometimes misleading measures of what really counts, the most economically efficient (and/or equitable) application of water to crop root zones. Yet the same categories are clearly the most economically efficient ones to collect and use. In this sense, the present study illustrates in one sector of one country the much larger issue of the problematical role and value of much key information in policy making. This problem transcends irrigation and goes well beyond the great borders of China, however those are measured.

James E. Nickum
Program on Environment
East-West Center

This treatise has had a long gestation period, more than a decade. Nourished by the ever greater richness of published information, it has grown substantially since its conception. Many have lent a helping hand along the way. The International Food Policy Research Institute (IFPRI), the Center for Chinese Studies at the University of California at Berkeley, Cornell University, the Committee on Scholarly Communication with the People's Republic of China, the Institute of Geography of the Chinese Academy of Sciences, the Winrock International Institute for Agricultural Development, the Chinese Academy of Agricultural Sciences, and the East-West Center provided me physical and spiritual sustenance while I did this work. Bruce Stone, formerly of IFPRI, suggested the topic and provided essential guidance and editing. I am grateful to him for his foreword. Many Chinese scholars, including Chen Jian, Liu Changming, Ren Hongzun, and especially Zhang Yue, helped me understand the intricacies of their country's irrigation statistics. Bill Easter, Maynard Hufschmidt, Mark Svendsen, and Regina Gregory helped me move the almost-complete manuscript through its final stages. Janet Pearce, Charles Mann, Jane He, and Yvonne Ying at IFPRI brought glimmerings of order out of the chaos. At the end, Senior Editor Helen Takeuchi, assisted by Mary Hayano, Loraine Ikeda, Joyce Kim, and Linda Shimabukuro at the East-West Center, and Brooks Bays made the many last preparations for publication, including drafting quality graphics and converting documents to the latest version of the word processor. My thanks to them all, with apologies to those I have forgotten.

This work is dedicated to the farmers of China, most of whom are irrigators.


China
National boundary
Provincial boundary
Disputed boundary
Major river
0 500 km
0 500 mi
RUSSIA
Lake Baikal
KAZAKHSTAN
MONGOLIA
KYRGYZSTAN
AFG.
PAK.
Xinjiang
Gansu
Qinghai
Xizang
Heilongjiang
Jilin
Neimenggu
Liaoning
N. KOREA
S. KOREA
Beijing
Tianjin
Hai He
Hebei
Shanxi
Shandong
Ningxia
Huang He
Yellow Sea
Jiangsu
Shaanxi
Henan
Shanghai
Anhui
Hubei
Chang Jiang
Sichuan
Zhejiang
East China Sea
NEPAL
BHUTAN
INDIA
BANGLADESH
Hunan
Jiangxi
Fujian
Guizhou
Yunnan
Guangxi
Guangdong
TAIWAN
Zhu Jiang
Hong Kong (U.K.)
MYANMAR
VIETNAM
LAOS
THAILAND
Bay of Bengal
Hainan
South China Sea
PHILIPPINES

INTRODUCTION

Irrigation and the numbers that measure it are considerably important to agriculture and food policy in the People's Republic of China. China has one of the world's largest irrigated areas—44 million hectares by one 1989 count, 48 million by another.[1] Although this is slightly less than one-half of China's arable land, it produces two-thirds of the country's grain and most of its cash crops, notably cotton (MWREP 1987, 25). Grains (including soybeans, broad beans, mung beans, peas, potatoes, and sweet potatoes) occupy three-quarters of China's sown area (ZGNCTJ87, 44).[2] Grain cultivation on irrigated land, with high yields per planting and high cropping intensities, provides annual yield levels at least double those on dry land.

Both the state and the nonstate ("mass") sectors have invested heavily in irrigation since 1949. Annual labor mobilization campaigns, sometimes involving more than 100 million rural laborers, have focused on irrigation and drainage works and the attendant land reshaping. State outlays on agriculture have been dominated by water control. Pumps provide China's rural areas with more than twice the horsepower of its tractors.

The net irrigated area increased fairly consistently during the first thirty years of the People's Republic of China, with major increases coming in the mid-1950s and during the 1965–73 period (see Appendix 3, Table A.1). The stagnation and, by some measures, slight decline in reported irrigated area in the early 1980s were of great concern to many Chinese policy makers. More recent years have seen a resumption of moderate growth in irrigated area figures.

This report discusses China's irrigated area statistics: who collects them and how; and what they say, seem to say, and do not say. Following an introduction to the reporting agencies and the categories they use, it examines a number of possible reporting biases and the relationship between different measures and the phenomena they assay. It then uses reported data, mostly from national and provincial yearbooks, to survey the course of irrigation development in China, concentrating on the provincial level. The latter part of the section on "Trends Shown by Published Data" focuses on trends after 1980, to examine the extent and nature of the reported decline in irrigated area.

The title of this monograph draws upon the adage that there are three kinds of lies: lies, damn lies, and statistics. Statistics may mislead because problems of measurement or reporting prevent them from accurately reflecting the phenomenon they purport to represent. These matters are of greatest concern here. Statistics may also be used selectively to support an argument or bolster a position rather than to illuminate actual conditions. Some examples are mentioned in the text, notably the distortions of the Great Leap Forward and the recent claims of a dramatic decline in irrigation area. In raising these problems from the title of this work to its conclusion, my main purpose is to caution those who would take irrigation statistics anywhere at face value. I do not mean to imply thereby that China's irrigation statistics are extraordinarily distorted. In fact, by world standards, they appear to be reasonably accurate.

In order to minimize the distortions of conversion and rounding errors, figures are reported in *mu*, the Chinese unit of land measurement and reporting for most of the period covered. The *mu* has been standardized at precisely one-fifteenth of a hectare; this is equal to 0.1647 acre (1 acre = 6.07 *mu*). For convenience, a conversion table between Chinese and international units is provided.

Area		Depth	
(*mu*)	(hectares)	(m^3/*mu*)	(millimeters)
10	2/3	100	150
20	1 1/3	200	300
30	2	300	450
40	2 2/3	400	600
50	3 1/3	500	750
60	4	600	900
70	4 2/3	700	1,050
80	5 1/3	800	1,200
90	6	900	1,350

The basic unit of study is generally the province or group of provinces with similar natural conditions. Following the Chinese convention, the three centrally administered municipalities (Shanghai, Beijing, and Tianjin) and the five autonomous regions (Neimenggu [Inner Mongolia], Guangxi, Xizang [Tibet], Ningxia, and Xinjiang) are treated as provinces. In most of the tables, the provinces are listed in the order given in Chinese statistical tables (i.e., more or less by geographical region rather than alphabetically). Hainan, the most recently established province (in April 1988), is included with Guangdong. For analytical purposes, provinces are sometimes grouped into (1) predominantly bunded fields (*shuitian*) vs. predominantly irrigated dryland; (2) irrigation zones; or (3) regional groupings. These divisions are detailed in Appendix 1. Appendix 2 explores the effect of the 1969 and 1979 boundary shifts between Neimenggu and its neighbors. Appendix 3 contains tables too large to include in the text, where they are referred to as "Table A.X."

The term "bunded field" is used here to translate the Chinese term *shuitian*, which is defined as "cultivated land surrounded by a raised embankment which can store water, most commonly to grow rice" (XHC 1987, 1068). The more commonly used English-language translations, "paddy" or "rice paddy," are ambiguous, as they may refer to the rice itself as well as to the field in which it grows. "Rice field" is too restrictive, as *shuitian* do not necessarily grow rice. "Wetfield" has also not been adopted, to avoid confusion with wetlands, and because the basic defining characteristic of *shuitian* is its raised embankment, or bund, not its consequent ability to hold water.

REPORTING AGENCIES

There are two national reporting systems for irrigated area—those of the State Statistical Bureau (SSB) and the Ministry of Water Resources (MWR).[3]

STATE STATISTICAL BUREAU SYSTEM

The SSB system, which has the highest official standing for its data, involves two line ministries as well as the bureau itself. SSB data rely on the self-reporting of basic production units collected by the bureau and by the Ministry of Agriculture (MOA).[4] The Agricultural Mechanization Management Bureau of the Ministry of Agricultural Machinery also appears to provide the SSB with data on pumps and pump irrigation. Since 1981, the SSB data have been published annually in the *Statistical Yearbook of China* and the *China Agricultural Yearbook*. Specific categories have varied from year to year. With few exceptions, provincial yearbooks published during the 1980s used SSB data. A detailed history of China's national statistical system (now SSB) also became available in the late 1980s (Wang 1986). According to Wang, the agricultural and forestry departments of the state statistical system compiled data for thirteen annual tables on agricultural production as early as 1952. Two of them were related to irrigation. The table entitled "Increases and reduction in cultivated area" included cultivated area at both the beginning and the end of the year, divided into bunded field, irrigated dryland, and dryland. The table entitled "Augmentation of irrigated area" had indices for initial status and additions during the year for the number of water control facilities and the irrigated area, divided into bunded field and irrigated dryland. The latter was subdivided by source: canals (improved existing, newly built), reservoirs, ponds, wells, waterwheels, and pumps. No provision was made for reporting declines in the irrigated area (Wang 1986, 365).

Although the statistical system subsequently grew and improved during the mid-1950s, agricultural reporting was simplified. The number of tables was reduced to seven by 1957. Cultivated area was divided into bunded field and dryland, but irrigated dryland was not reported, nor does irrigated area appear to have otherwise been reported through the state statistical system at this time (Wang 1986, 372).

The Great Leap Forward of 1958–60 witnessed a reversal of the paradox. The quality of reporting suffered greatly, but the number of tables increased (the text does not provide a specific number), as did, presumably, the number of categories. By 1960, irrigated dryland was again included as a subcategory of cultivated area and a category for "farm water and erosion control" was included, containing "indices for the degree of farm water control, and so forth" (Wang 1986, 377).

In July 1960, the SSB adopted the *zhufu* (primary-secondary) policy of emphasizing survey data over tabular reports (Wang 1986, 172). This was followed in August by the closing of the Statistics Press as part of a virtual blackout of open reporting of statistics, which lasted for nearly two decades (Wang 1986, 353).[5]

Despite the *zhufu* policy, the desire by higher government agencies to improve their planning during the recovery period of the early 1960s led to greater demands on the regularized reporting system, notably on the local (provincial and below) statistical departments, which were usually understaffed and "incomplete" (*bu jianquan*). Local statistical bureau heads complained that the SSB was not actually carrying out the *zhufu* policy (Wang 1986, 172). In reaction, the SSB consolidated the agricultural data requirements of different government statistical departments and professional ministries into unified report forms, beginning in 1962, with the stipulation that no additions could be made without permission. The results were spotty. Local statistical organizations still felt subject to redundant and unreasonable demands, and forms were added, even by the SSB (Wang 1986, 381).

In 1964, the political climate shifted toward populism with publication of the "Little Red Book," known more formally as *Quotations from the Works of Chairman Mao Zedong*. Critics of the SSB were emboldened (Wang 1986, 172). At the National Statistical Work Conference in August 1964, even establishmentarian leaders such as Liu Shaoqi and Zhou Enlai criticized agricultural reports as "too many, too chaotic" (*duo luan*) and directed that the reporting system be simplified (Wang 1986, 176).

In 1965, the number of annual reports in agriculture was cut nearly in half, to seven, often by consolidation. The table on "cultivated area" continued to cover bunded field, dryland, and irrigated dryland categories, but other irrigation-related reports were dropped from the list (Wang 1986, 381–82).

The issue of the form and role of statistical information-gathering did not go away, however. In June 1965, the SSB called a number of meetings to discuss statistical policy and finally drafted a compromise report. Nonetheless, continuing differences led the leaders to order a "rectification" of the SSB (Wang 1986, 176). Except for Beijing, all provincial statistical bureaus were merged into "professional groups" (*yewu dazu*) under the provincial "revolutionary committees"; most of these groups were placed under the provincial planning authorities.

With the outbreak of the Cultural Revolution in 1966, the SSB was "simplified" out of existence and replaced by a "statistical group" under the State Planning Commission. In spring 1967 the Farm Output Survey Team (*Nongchanliang Diaocha Zongdui*) and its branches at the province level were abolished as "independent kingdoms." The provincial authorities assumed responsibility for reassigning local personnel. Apparently the *zhufu* controversy was solved by doing away with both surveys and tables. The criticism leveled at the survey teams indicates that they were regarded as the greater of the two evils by local leaders concerned about losing part of their control over the flow of information.

For the next three years, national statistical work came to a standstill, except for three reporting systems: (1) banks, public finance, and tax systems; (2) rail, communications, and post; and (3) commerce, grain, and foreign trade. Many regions used their own forms to collect information on items such as agricultural and industrial output (Wang 1986, 184). These do not appear to have included irrigation-related data.

Problems for statisticians were far from over. Beginning about 1969, most of the 20,000 statistical professionals in the former SSB system were sent to "May 7 cadre schools" or directly to the villages for "labor reform" and "reeducation." The number of active statistical personnel fell drastically, reaching a nadir in 1969–70. There was some recovery after the 1971 National Statistical Conference, but the entire system's professional staff at the county level and above numbered only 7,800 as late as 1976, which was 37 percent of the 1965 level. Staffing at the provincial level was at only 26 percent of the 1965 figure (Wang 1986, 182).

Archives suffered as well. In response to "Order Number 1" of 1969, issued by the central authorities, some statistical materials were burned or otherwise destroyed. Particularly damaging was the loss of detailed local data and some documents on statistical history. The same year witnessed the closing of many financial schools and other educational institutions, during which many library materials, documents, and scientific reports were irretrievably lost (Wang 1986, 183).

Although the SSB did not recover its status as an independent entity until February 1978 (Wang 1986, 196), its replacement body under the State Planning Commission collected and arranged the 1967–69 data (from May 1970 to December 1971) and reinstituted standardized annual reports, beginning in 1971. For the first year there were twenty-two tables, eight of them related to agriculture. This total increased to sixty-seven in 1975 and 160 in 1982. In both years, fourteen tables dealt with agriculture. In addition, the SSB collected data for 1982 "agricultural production conditions" in each county, which apparently were not published.

Irrigation-related categories have been included in the tables on "Conditions of agricultural modernization" (effectively irrigated area, diesel irrigated area, and electrically irrigated area) and "Number of principal agricultural machines at year end" (types and numbers of irrigation and drainage machinery) (Wang 1986, 393, 403). These tables have been published every year since 1980 in the *Statistical Yearbook of China* and the *China Agricultural Yearbook.* Data are provided by province on *Conditions of Agricultural Modernization,* while those for irrigation and drainage machinery are national aggregates only.

According to Tuan and Crook (1983, 75, 78), of the 500 categories collected in a number of reports by the SSB and the Ministry of Agriculture in the early 1980s, about eleven were directly related to irrigation.

From the report entitled *Cultivated Area* (p. 75), the following categories appeared:

IV. Actual amount of cultivated land at year end
- A. Bunded fields
- B. Dry fields
  - of which: Irrigated fields

From the report entitled *Conditions of Agricultural Modernization* (p. 78), several more categories were requested:

V. On-farm irrigation
- A. Effectively irrigated area
  - of which: Mechanized [diesel] irrigation (including water lifted by turbines)
    - Area watered by electric pumps
    - Area watered by sprinklers
- B. High and stable-yield fields
- C. Electric pump wells
  - of which: Fully equipped[6]

Tuan and Crook (1983, VIII) also note:

> In 1980, the [agricultural statistical] system at the national level had only half the staff as in 1956. Many counties and most communes did not have full-time statistical workers by 1980.

> China relies on a census-type reporting system to collect agricultural data. Each of China's more than 5 million basic production units report each year on about 500 different categories of data in 13 quarterly and annual statistical reporting forms. One of the main deficiencies in China's statistical system is the lack of modern electronic data processing equipment to handle the huge volume of data.

According to Travers (1982, 480), the SSB had a nationwide staff of only 16,000 in the early 1980s. This low density of staffing, averaging less than 8 persons per county, raises the question of the adequacy of auditing and verification in the SSB reporting system.[7] The relatively short reporting interval of one year and the existence of alternative data series for irrigation, especially that of the Ministry of Water Resources (MWR), should operate to mitigate problems caused by low staffing ratios, however.[8]

MINISTRY OF WATER RESOURCES SYSTEM

The other national agency currently issuing irrigation-related data is the Planning Bureau of the MWR. MWR data are based on reports from project management bodies and, presumably, other basic-level line agencies within the water resources system. The state water resources bureaucracy usually extends down to the county (*xian*) water control bureau (*shuiliju*). Below this, "mass" organization commonly extends to the township level, which may have a "water management station."

We do not have a history of the MWR statistical system comparable to that of the SSB and its predecessors. The Ministry was not disbanded during the Cultural Revolution, a period of considerable activity in hydraulic construction. Although it is probable that the internal statistical reporting system of the MWR did not function very well in the late 1960s, province-level reporting appears to have been fully reestablished by 1972. A joint audit of the 1976 figures for irrigated area carried out by the State Planning Commission, the (then) Ministry of Agriculture and Forestry and the (then)

Ministry of Water Conservancy, yielded an adjusted national total of 681.95 million *mu*, almost 8 percent below the 740.07 million *mu* reported by the MWR system (Table A.2). The audited figure appears to have become the base for subsequent SSB reports (Table A.1). MWR reports were only slightly chastened: 1977 national totals from the SSB and MWR systems were 675.32 and 722.80 million *mu*, respectively, a difference of 6.4 percent. In most instances, therefore, the post-1976 MWR figures are consistent with those from 1972 to 1976 (Table A.2).[9]

Audit results of the 1976 figures were released, together with provincial figures for 1949, 1952, 1957, 1962, 1965, and 1972 through 1979, by the State Planning Commission of the MWR (Table A.2). Since this is the most complete and consistent series for selected years after 1949, it has been used here as the basis for drafting the trend graphs of individual provinces (see pp. 54–66). These figures, which are compared with those of SSB and contemporary sources, are discussed in the next section.

Reports for each year from 1983 to 1989 have appeared at irregular intervals in *China Water Conservancy* (ZGSL), the monthly journal of the MWR. The number of categories reported is quite extensive, including not only effectively irrigated area, actually irrigated area, and the area of stable, high-yield fields,[10] but also categories such as irrigated pastureland, area irrigated by pump, area affected by disasters, and the number of different types of irrigation installations (Table A.2). For 1987, the number of categories reported in the journal decreased to eight, but was broken down by province.[11] Most of the omitted categories were reported in the *Statistical Yearbook*, however (ZGTJNJ88, 235).

In 1991, the MWR began to publish an annual *China Water Resources Yearbook* (ZGSLNJ90) that provides far more comprehensive and detailed coverage of irrigation-related categories than before. These yearbooks also fill gaps in the historical record and provide revisions of other series.[12] Among the newly available data series are more detailed breakdowns of improvements in flood-prone land and of reduction in, as well as additions to, improved saline soil. From a hydrological management viewpoint, a particularly valuable section includes data series in several standard categories broken down by the eight major river basins (Huang He, Huai He, Hai He, Luan He, Chang Jiang, Zhu Jiang, Songhua Jiang, and Liao He).

COMPARISON OF SSB AND MWR SERIES

Tables A.3 through A.8 compare the national and provincial figures for irrigated area reported by the SSB and the MWR for 1983, 1985, 1987, 1988, 1989, and 1990. National MWR figures for all six years were about 8 percent higher than those of the SSB, comparable to the 8.5 percent disparity in 1976. With only minor exceptions (e.g., Shanghai in 1985; and Beijing, Tianjin, and Zhejiang in 1987), all the individual MWR figures are larger than or equal to those of the SSB.

It is a matter of argument which series better reflects the underlying reality, in part because that reality is itself a matter of argument. The imprecision of establishing just what constitutes an irrigated *mu*[13] opens the possibility of reporting bias. The MWR data base is provided by the irrigation bureaucracy, which might be expected to overestimate the command area of the projects under its aegis, as a matter of prestige and budgetary gamesmanship. On the other hand, SSB data are based on reports from producing units, which might be expected, where they can, to understate their production potential to hold down state procurement and tax quotas. Since the reporting biases are in opposite directions, we may roughly accept the MWR and SSB figures for effectively irrigated area (EIA)[14] as the upper and lower bounds for the category, respectively.

Although the national aggregates reported by the two systems are quite close considering these countervailing biases, there is considerable variation among provinces. The two systems reported the same number in Jilin, Jiangxi, Shandong, Sichuan, Yunnan, and Xizang in all five years during the 1980s. (The 1990 figures from the two systems were slightly different for Jilin and Xizang.) Others, especially Zhejiang and Shanghai, have been identical in most years.

Apparently during the 1980s, reports covering roughly one-third of China's EIA were either unified at the provincial level before being passed to the central agencies, or both systems relied on the same data sources (Table A.9). This unification provides another complication in using China's EIA, as there is no clear evidence that one series or the other predominates; hence, both are distorted by the process.

Table A.9 reconstitutes an approximation of preunification national totals for the SSB and MWR systems for the six years of comparison. The method employed used the figures reported by the MWR for actually irrigated area (AIA) (see p. 34) as a baseline for both the SSB and MWR EIA figures. Since AIA is reported only by the MWR, and frequently exceeds SSB EIA in ununified provinces, it may be assumed free of unification bias. The ratio of the AIA to EIA for the ununified provinces in each of the two series was then applied to aggregate AIA to generate estimates for the preunification EIA totals (this is shown mathematically in the notes to Table A.9).

The greater year-to-year variation, especially for the MWR, in reconstituted EIA compared to reported figures, is probably due to factors such as changes in the set of provinces unified and year-to-year differences in climate, which might affect AIA more than EIA. Nonetheless, this method indicates that during the 1980s, the MWR EIA was understated by an average of 13 million *mu* while the SSB EIA was overstated by about 16 million *mu*. Hence, unification distorted both series. In 1990, MWR figures dominated the newly unified reports, while the unrepresentativeness of the AIA/EIA ratios in the remaining ununified provinces led to the improbable result that the reported EIAs of both series were overstated.

As expected, the reconstituted MWR EIA total is consistently higher than reported, while that for the SSB is consistently less. This particular reconstruction gives no indication that one system dominated the other in unification during the 1980s. In 1985 and 1988, SSB figures were adjusted significantly more than those of MWR, but the opposite was the case in 1989; in 1983 and 1987 there was nearly proportional adjustment.

In the audit reports of 1976 (Table A.2), no adjustment was made to figures from Shanghai, Zhejiang, Jiangxi, Shandong, Guangdong, or Shaanxi. In Jilin, Yunnan, and Xizang, however, the adjustments were substantial (31 percent, 17 percent, and 21 percent, respectively), indicating that the consistency of reporting noted above in those areas in 1983, 1985, and 1987–90 is the outcome of a more recent reporting process. There seems to be no particular geographical relationship among the provinces for which MWR and SSB data are similar or are sharply divergent.

In Beijing, Tianjin, Hebei, and Xinjiang, the reported figures for 1976, 1983, 1985, 1987, 1988, 1989, and 1990 are very close, usually within a single percent (Xinjiang's data may actually have been unified in 1990). These are all provinces where dryland irrigation is very important. The nearness of the reports could indicate that the irrigated area is closely monitored, and that there is some coordination between the agricultural and irrigation departments there.

In some places, however, notably the northeast region (Heilongjiang, Liaoning, and Neimenggu) and Guangdong, the figures issued by the two systems in the four years were significantly different. The low percentage of arable land under irrigation may account for the variation in the northeast (see pp. 54–59). Guangdong's record is harder to explain.[15]

These outlier reports have not shown a clear tendency to converge, indicating consistency of the bases used within each system but no consensus between them. There was a small convergence between the two systems from 1983 to 1987 in the northeast, but a divergence in Guangdong. In other areas, EIA in Jiangsu increased between 1985 and 1987 according to MWR figures, but declined according to those of SSB, widening the disparity. The opposite is true of Henan from 1983 to 1987: MWR's statistics went down over the period, while those of SSB went up, slightly closing the gap.

There was a clear convergence in Guizhou Province, where a 24 percent gap in 1983 fell to 12 percent in 1985 and was closed completely by 1987, indicating a conscious effort at unifying the series. In the process, the MWR figure was adjusted downward by 830,000 *mu*, while that of the SSB increased by 1.28 million *mu*. In general, SSB data on EIA have a higher variability than those of the MWR, reflecting differences in the reporting systems.

In 1990 there was a further round of series unification at the province level. A comparison of Tables A.7 and A.8 indicates that the MWR figure was adopted in almost all cases. Liaoning, Jiangsu, and Anhui all exhibit major increases in the SSB figures while there is little change in the MWR figures. The 1990 report for Henan is closer to the 1989 SSB figure, but this could reflect an overall reassessment of that province's EIA. Its AIA/EIA ratio has been consistently at or near the bottom, even following readjustment in 1990. This indicates that a lot of actually unirrigated land is carried on the books in Henan. Corroboration for this is provided on pp. 67–75, "The 1980s Decline and Recovery of Irrigated Area." Of the nation's 19 million *mu* gross decline in (MWR) EIA in 1990, Henan accounted for 38 percent (7 million *mu*). One-half of this was attributed to damaged or abandoned projects, including pump wells.

In Hubei, which was both second only to Henan in reported decline in MWR irrigated area, both series adjusted toward the middle; the gap was not completely closed. In Guangdong/Hainan, with the third largest disparity in absolute terms, the gap between the two series narrowed slightly through an upward adjustment in the SSB series, while the MWR figure remained the same.

As a result of all these adjustments, China's reported irrigated area, according to the SSB, jumped by 3.7 million *mu*, over 5 percent, in the single year of 1990. Yet by MWR reckoning, irrigated area remained roughly constant. In this case, the MWR report is more credible.

A continuing divergence between the two systems appears in a number of provinces in reporting the number of pump wells (Table 1). Pump wells, sometimes translated as "tubewells" and termed *jidian jing* (mechanized and electrified wells) or simply *jijing* (mechanized wells) in Chinese, are defined as follows (Yan 1985, 78):

Table 1 Provinces ranked by tubewells, 1987

	Number of pump wells (thousand)		
Province	Total tubewells	Outfitted	Completed
Hebei	663	608	600
Henan	655	558	449
Shandong	549	549	532
Shaanxi	129	120	109
Anhui	107	34	28
Shanxi	73	75	64
Liaoning	72	80	70
Neimenggu	71	102	80
Heilongjiang	55	62	55
Beijing	43	42	41
Jilin	42	42	39
Jiangsu	36	37	33
Gansu	34	30	25
Tianjin	25	28	25
Xinjiang	19	22	20
Fujian	15	8	6
Sichuan	11	11	11
Ningxia	7	7	7
Guangdong	5	4	4
Hubei	4	5	5
Yunnan	3	2	2
Zhejiang	2	2	2
Qinghai	1	1	1
Jiangxi	1	1	1
Guangxi	1	1	1
Hunan	0	0	0
Xizang	0	0	0
Guizhou	0	0	0
Shanghai	0	0	0
Total	2,623	2,430	2,207

Sources: Tubewell data from ZGTJNJ88, 234. Outfitted and completed wells data from ZGNYNJ88, 369.
Note: Totals as given in source, subject to slight rounding error.

> Water wells which are outfitted with a diesel engine, electric motor or other motive equipment which drives a water pump to irrigate farmland. (The category) includes wells which have already been outfitted [*peitao*] and those which are awaiting equipment to be outfitted.
>
> Outfitted mechanized and electrified wells are those which have installed mechanical or electric water lifting equipment (including [power] lines) enabling them to carry out irrigation in the current year. In the case where one set of equipment serves several wells but is able to provide timely irrigation . . . (the wells) should be viewed as "outfitted mechanized and electrified wells."

The *Statistical Yearbook* reports figures for the total number of pump wells, whereas the *Agricultural Yearbook* provides data for the number of pump wells that have been "outfitted" and "completed."[16] The source for the *Statistical Yearbook* appears to be the SSB system. The *Agricultural Yearbook* cites MWR as its source.

The difference in sources leads to some incongruities between the series, especially at the provincial level. In particular, while the national total of outfitted pump wells was reported for 1987 as being 193,000 less than that of all pump wells, as one would expect, seven provinces reported more outfitted than the total. Most striking was Neimenggu, which reported a total of only 71,000 pump wells (ZGTJNJ88, 234), but 102,000 outfitted pump wells, of which 80,000 were complete (ZGNYNJ88, 369).

These anomalies have remained consistent between years, indicating differences in reporting systems rather than reporting or recording errors. In some cases, the differences have widened. For example, in Neimenggu, total pump wells were reported as having fallen by 3,000 between 1986 and 1988, while the number outfitted increased by 3,000.

CHINESE ACADEMY OF SCIENCES

Other series have existed, especially before 1980. Two organizational units of the Chinese Academy of Sciences (CAS) provided figures for 1978. The more comprehensive of these was published by the CAS Institute of Geography, which provided provincial figures for the 1978 cultivated area (as a percentage of the national total of 1.49 billion *mu*), bunded field/dryland shares, and the percentage of dryland irrigated (ZGNYDL 1980, 77–79). Using the Chinese convention of counting virtually all bunded land as irrigated,[17] these series allow the derivation of irrigated area figures for 1978 (Table A.10). The Committee for the Comprehensive Survey of Natural Resources provided 1978 irrigated area figures for Hebei, Henan, Beijing, and Tianjin that differed from those offered by the Institute of Geography (Zhang 1981, 14). The former claimed irrigated areas of 49.57, 46.00, 5.12, and 5.79 million *mu*, respectively; the latter, 54.8, 56.0, 5.1, and 5.4 million *mu*. The Institute of Geography figures are closer to the SSB numbers for 1980 and 1981 (Table A.11).

OTHER DATA SOURCES

The history of the reporting system is reflected in the availability of data from contemporary sources, presented in Table A.11. Figures for the early 1930s, probably 1931, are included to provide a rough baseline for considering both the status of irrigation in 1949 and whether subsequent developments in the early 1950s were entirely new or restorative, as in much of the rest of the economy. These earlier data are from Cressey (1934, 97), who cites Chang (1932). Without access to the latter, the exact source or basis of the 1931 numbers could not be determined.

The total for the provinces covered by Cressey and Chang is 272.5 million *mu*, higher than the 240 million *mu* given by the State Statistical Bureau for 1949 (Table A.1) even without compensating for the exclusion of Zhejiang, Guangxi, Qinghai, and Xinjiang from the 1931 figures. Using the 1949 figures for the latter four provincial-level units to fill the gaps in the 1931 data yields a national total of 316 million *mu*. This level was not reached until 1952 at the earliest, indicating that, as with other aspects of the economy, the 1949–52 period saw the restoration of irrigation to its prewar condition in the 1930s.

Nonetheless, a closer inspection of Table A.11 shows that the decline in irrigated area was concentrated in Sichuan, Yunnan, and Guizhou. Irrigated area in these three southwestern provinces fell by 73 percent, 46.5 million *mu*, or about 60 percent of the disparity between the 1932 and 1949 totals. The reported irrigated area did not recover its prewar levels until the Great Leap Forward years of 1957 and 1958, for which the official totals were probably exaggerated.

All the figures from 1949 to 1959 in Table A.11 are from contemporary reports, most of them in the provincial or national press, assembled in *Provincial Agricultural Statistics for Communist China* (PAS 1969). At that time, provincial statistics were published in the provincial presses but not nationally, so the coverage is not total. After 1960 the provincial press was not exported from China. Occasional reports on provincial conditions were released to the outside by the New China (*Xinhua*) News Agency. Many of these were collected by the United States Consulate in Hong Kong and published in *Survey of China Mainland Press* or kept in the files of the agricultural attache (USHKAA). After 1971 many provincial radio reports were transcribed and published in the *Daily Report* of the Foreign Broadcast Information Service (FBIS).

Table A.11 relies on these and a few other scattered sources for 1960–75. Only sixteen data points were found for the 1960s, all but two of them for 1963–66, far too few to indicate trends, except for the marked increase in irrigation in Beijing. Provincial data became far more abundant in the early 1970s, especially in 1973 and 1974. Beginning in 1981, complete SSB series have been published each year in the national statistical and agricultural yearbooks.

More recently, a number of provincial yearbooks have published historical series of varying degrees of coverage. These are presented in Table A.12 and compared with contemporary sources in Table A.13. Recently issued national figures for the period before 1976 indicate a reduction over previous MWR estimates (see Table A.1), with the SSB series now larger than that of the MWR for those years.

COMPARISON OF MWR AND OTHER SOURCES

The MWR series for selected years from 1949 to 1979 (Table A.2) differs with few and not always understandable exceptions from both the contemporary (Table A.11) and the provincial yearbook data (Table A.12). The MWR figures are identical with contemporary reports in only five instances—all in the earliest years, 1949 and 1952, in Shanxi, Shaanxi, and (for 1949 only) in Xinjiang. For the most part (77 out of 131 cases), MWR figures are higher than the contemporary reports, consistent with the upward tilt in reporting discussed earlier. Notable exceptions are (1) the Great Leap Forward year of 1957, when only five of twenty-three provisional MWR figures (Hebei, Jilin, Guangdong, Qinghai, and Xinjiang) are larger than the contemporary reports; and (2) the year 1978, when the series used for comparison is that reconstituted from CAS figures in Table A.10. In the latter case, fifteen MWR data points are higher, but fourteen are lower; none are identical. MWR figures for 1978 tend to be lower for the provinces of central-south and south China where bunded fields exceed 90 percent of cultivated area; they tend to be higher in the intermediate provinces, notably in the northeast, northwest, and east, where bunded fields comprise 10–90 percent of cultivated area.

The provincial yearbook figures of Table A.12 also tend to be lower than contemporary reports, and are more consistently so than the MWR data (87 out of 118 data points). This is so, even for the 1957 and 1976 data, reflecting the likely SSB origin of the underlying information. Nonetheless, the disparities between the series are not consistent. For example, MWR figures for Shanghai are higher in six of the eleven comparable years, but lower in two, and identical in the remaining three.

SUMMARY

Irrigation statistics are very important to Chinese food policy, so they are relatively complete, compared to those of most other countries. Shifts in the political climate have caused shifts in the number and quality of reports, however. For example, between 1960 and 1980 the Statistical Press was closed, some data were destroyed, and the ranks of statistical workers were decimated. Also, there were frequent changes in the categories covered in statistical reports.

Besides inconsistency over time, there are differences among reporting agencies. The two major sources of irrigated area statistics are the Ministry of Water Resources (MWR) and the State Statistical Bureau (SSB). Although not issued as regularly, MWR reports cover more categories and tend to be more complete and consistent. But their numbers are consistently higher than SSB data—perhaps because of different incentives affecting those reporting the data. Differences between the two reporting systems vary widely among provinces. Where they diverge, their countervailing biases provide many values that are likely to bracket the underlying reality.

In retrospect, it seems clear why China's leaders might complain that the numbers they receive are "too many, too chaotic." During the 1980s, some order appears to have been brought to reports of effectively irrigated area, although the two reporting systems do not always agree. Given the probable countervailing biases of the SSB and MWR, this may not be a bad thing, because it provides a probable range rather than a precise figure of uncertain validity. Where the systems agree, it may reflect a compromise that hardly improves the quality of the data.

A possibly more fundamental question than agency bias is that of just what is it that these figures purport to measure, and how successfully they do it. This issue is addressed in the next section.

WHAT IRRIGATED AREA MEASURES MEASURE

Measures of irrigated area rival those of employment or capacity utilization: the correspondence between the numbers and the underlying reality they claim to measure is problematic. Although the reporting system is to some degree responsible, the main reason for this nonconformity stems largely from the nature of irrigation itself.

The need for irrigation arises when there is a deficit in moisture available to the root zone of crops. The magnitude of this shortfall depends on a number of factors, including the amount and pattern of precipitation, runoff and evapotranspiration during critical growth periods, the types, varieties, numbers, and planting dates of crops grown, soil and slope conditions, methods of water application, and levels of management.

Figures 1 and 2 demonstrate some of these factors. Figure 1 is an actual histogram of precipitation in Shanxi. Figure 2 is more abstract and more general, including all forms of moisture. Moisture availability from nonirrigation sources is indicated by the line MM_1, which increases from an expected minimum level M_1 (at $P \rightarrow 1.0$).[18] If crop requirements are below M_1, supplemental waterings are always unnecessary. They may even be harmful.[19] If they are greater than M, irrigation will always increase yields, even in the wettest year. Many cases lie between M and M_1, where supplemental irrigation is necessary in some years but not in others. For example, at CR some irrigation would be required six years out of ten ($P = 0.4$).[20]

Irrigation facilities are rarely capable of providing adequate water to their entire command area in the driest years ($P \rightarrow 1.0$). It is almost always more productive to expand the command area beyond that which can be guaranteed a supply under all circumstances. More commonly, projects are designed to supply water up to a certain rate of guarantee.[21]

CROP IRRIGATION REQUIREMENTS

Crop irrigation requirements depend on the nature of the crop, soil structure and fertility, moisture otherwise available, climate and methods of irrigation (Linsley and Franzini 1979, 377, 379). Two of the most important determinants are the length of the growing period and the level of solar radiation (and the resulting potential evapotranspiration) during that time.

Table 2, from the People's Victory Canal in Henan (average annual precipitation P = 640 millimeters, potential evapotranspiration PET = 1400 millimeters), gives an indication of the differences in water requirements for different crops. These vary from place to place, depending not only on factors such as those just mentioned, but the general magnitudes for each crop.

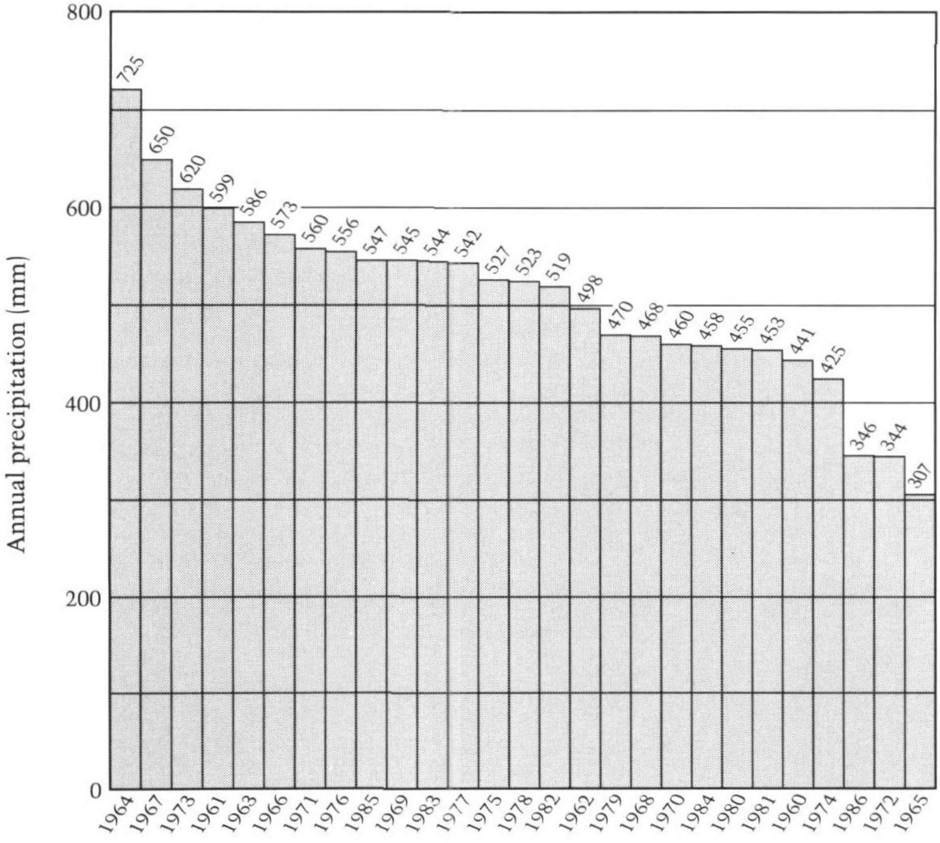

Figure 1 Annual precipitation in Shanxi Province, 1960–86 (Source: Chen 1987). Year ordering is not sequential. Bars are arranged from greatest to least annual precipitation with the relevant year indicated.

Table 2 also shows how the number of irrigation turns, and therefore the total volume of irrigation water applied to a given crop, depends critically on the amount of rainfall. Annual precipitation also varies considerably from year to year, especially as one goes from southeast to northwest in China.

Crop water "requirement" figures normally do not count operational or conveyance losses. Field requirements are almost always larger, even without conveyance. Conveyance losses, as measured, for example, by the "canal system effectiveness coefficient" *(quxi shui liyong xishu)*, can be quite significant, especially in large surface systems, where seepage losses usually exceed the amount of water actually delivered to the crop root zone. Often, however, seepage is a loss to a project but not to the entire irrigation sector, as it recharges the groundwater.

Crop requirements also depend on the intensity of use of production factors other than water, including management. Water can also substitute for other factors, such as labor for weeding of rice (Levine 1980, 53–57). Heavy applications of water may reduce soil salinization and prepare the ground for later crops (Carruthers and Clark 1981, 39).

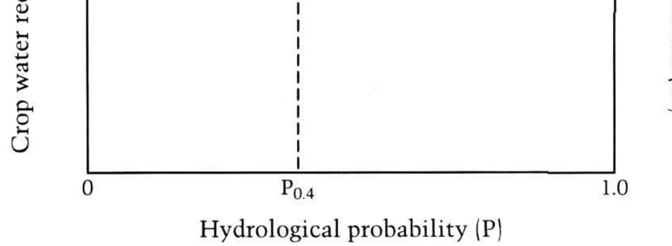

Figure 2 Available moisture (M) and crop water requirements (CR)

METHODS AND TIMING OF APPLICATION

The amount of water used also depends critically on the method of application. The three most common methods, in descending order of water use, are flood, basin or check, and furrow. More recently, drip and sprinkler irrigation have been used in China on high-value crops, but are not very widespread (150,000 *mu* and 10 million *mu*, respectively, in 1983; and a total of 9.18 million *mu* in 1990) (Zhang 1984; ZGSLNJ91, 655).

On-field application methods also vary in timing. There are at least four different methods of irrigating rice in China. These are listed below in descending order in terms of water requirements but ascending order in terms of reliability.

Table 2 Crops and irrigation norms, People's Victory Canal, Henan

Crop	Wheat	Maize	Cotton	Rice
Growing season (month/day)	9/26 to 5/30	6/03 to 8/25	3/25 to 8/25	4/25 to 9/27
No. of days	246	83	153	154
Crop water requirement (m^3/*mu*)	310	210	270	850
Precipitation (P - 50%)				
(mm)	157	396	570	570
(m^3/*mu*)	105	264	380	380
No. of irrigation turns required per crop	4	2	1	8
Irrigation norm (m^3/*mu*)	220	120	70	655
Precipitation (P - 75%)				
(mm)	122	273	510	510
(m^3/*mu*)	81	182	340	340
No. of irrigation turns required per crop	5	2	2	8
Irrigation norm (m^3/*mu*)	270	120	120	685
Precipitation (P - 90%)				
(mm)	99	185	320	320
(m^3/*mu*)	66	123	213	213
No. of irrigation turns required per crop	6	3	3	8
Irrigation norm (m^3/*mu*)	310	170	170	710

Source: MWRFWC (1984, 43–44).
Note: The source does not give precipitation for the rice season. Data for cotton have been substituted, as they are approximately the same time period.

Continuous Ponding

Water is maintained in the bunded rice field throughout the growing season. Currently, a depth of 4 to 7 centimeters is used; with traditional varieties, this is deeper. Continuous ponding is common in hilly regions with uncertain water supplies.

Flooding with Midseason Drainage

Bunded fields with a reliable water supply are drained in the latter part of the tillering stage and sometimes in the booting and heading stages as well.

Variable Water Supply

Rice seedlings are transplanted into shallow water (about 3 centimeters). During tillering, the rice fields are kept alternatively wet and dry. During booting and heading, water is maintained at 3–4.5 centimeters. The soil is kept damp without standing water during the milk-ripe stage, and, as is typical with other on-field application methods, the fields are drained and dried about five–seven days before harvesting.

Dry Sown (Upland Bunded) Rice

Bunded field rice is sown directly after overwintering or spring crops such as wheat; it grows in wet soil and is irrigated as an upland crop according to the soil moisture status. This is a new method but is used extensively in northern areas, such as Beijing, which grow bunded field rice but are facing a water shortage. Experimental results show that the water requirement of dry sown bunded field rice is 4,500 to 6,000 cubic meters per hectare (300–400 cubic meters per *mu*) compared to 6,750 to 7,500 cubic meters per hectare (450–500 cubic meters per *mu*) for flood irrigation (Jiang ca. 1987, 6–7. The source does not give comparative yields or costs, but one may expect tradeoffs between water saved and the levels and costs of other inputs.)

Proper timing of irrigation can reduce the total water requirement, as crop sensitivity to water shortage varies between stages of growth. Because drought stress is more likely to harm plant growth than excess water and is harder to overcome (excess water can be drained in most cases), overwatering is a common tactic adopted by farmers who face an unreliable supply of water (Carruthers and Clark 1981, 42). This is especially true where they do not pay for the extra water used.

IRRIGATION SOURCES

The expense and reliability of irrigation water greatly depend on the source. Table 3 provides national data on water supplied to agriculture, by source, and the farmland each source irrigated in 1985. Figures for wells do not include the small portion of areas where groundwater is used conjunctively with surface supplies (Zhang 1984). Wells and surface pumps supplied significantly less water per *mu* than gravity diversions, due largely to their higher costs of operation and lower conveyance losses.

SUMMARY

The intrinsic nature of irrigation makes it difficult to measure the area under irrigation. Not all fields within a command area require supplemental watering in any given sea-

Table 3 Water supplied and area irrigated nationally, by water source, 1985

Water source	Water supplied in 1985: Total (km³)	Water supplied in 1985: Percent of total agricultural water	Area irrigated in 1985: Total (million *mu*)	Area irrigated in 1985: Percent of total effectively irrigated area
Storage projects	108.3	29.7	219	30.4
Diversion from flowing water	149.9	41.2	202	28.1
Surface pumps	41.2	11.3	136	18.9
Wells	57.6	15.8	132	18.4
Other sources	7.3	2.0	30	4.2
Total	364.3	100.0	719	100.0

Source: MWREP (1987, 30).

Note: Storage projects include reservoirs, tanks, ponds, and so forth.

son. In the driest years, not all fields counted as irrigated can be provided with adequate water. Crop irrigation requirements vary widely, depending on the length of the growing period, the level of solar radiation, conveyance losses, and the availability of other production factors such as management and the methods and timing of watering. The expense and reliability of irrigation water also depend on the source.

MEASURES USED IN CHINA

Irrigated area measures may be divided into two broad categories: those describing a command area and those representing the area actually receiving irrigation in a given year or, less frequently, a cropping season. Command area measures such as "effectively irrigated area" or "stable, high-yield fields," two of the most commonly used categories in Chinese reports, describe the area that could be irrigated with a given level of probability by existing facilities and sources. They are therefore subject to much guesswork and error but require little monitoring and recalculation. Measures such as China's "actually irrigated area" are more likely to designate actual applications of water to fields, but they may fluctuate considerably from year to year or season to season depending on natural conditions. Like command area measures, they say nothing about the intensity (or necessity) of application and are also likely to be based upon a degree of guesswork, considering the costs and dubious value of taking precise measurements.

COMMAND AREA MEASURES

Command area measures are economic concepts. Water can usually be provided to a larger area by adding mobile pumps and/or human labor to lift the water farther above the canal line or reservoir; yet this method is very expensive in terms of inputs of other resources.

Command area measures can also be administrative concepts. In some cases outside China, the area actually irrigated by a project includes fields that are not in the officially registered command area. Some of these plots use seepage water from canals; others rely on unauthorized appropriations. In either case, since they do not lie within the formal bounds of the scheme, project personnel do not include them in their reports. It is unclear to what degree similar administrative distortions obtain in China.

Effectively Irrigated Area *(youxiao guan'gai mianji)*

Effectively irrigated area (EIA) is the most common category used in reporting by both the MWR and SSB systems. It is comparable to the actual (as opposed to designed) command area of existing projects. The *Statistical Yearbook of China 1981* defines the effectively irrigated area as

> level land which has water sources and complete sets of irrigation facilities to lift and move adequate water for irrigation purposes under normal conditions. (ZGTJNJ81, 512–13)

Any land with operable irrigation facilities should be counted, even if not used in a given year because rainfall or cropping patterns make irrigation unnecessary. Areas with only partial facilities (e.g., wells without pumps or reservoirs without canals) should not be included, nor should "drought-fighting land," where crops outside the command area are watered on an emergency basis, using delivery systems such as shoulder poles and mule-drawn carts. *Au naturel* bunded fields that rely exclusively on precipitation are excluded as well. These have colorful names such as *dong shuitian* (winter bunded fields), *tun shuitian* (garrison bunded fields), *wangtian tian* (skygazing fields) and *leixiang tian* (thunder fields) (*Xibei Nongxueyuan* 1981, 129–30).

Effectively irrigated area is divided into two major subcategories: bunded fields (*shuitian*) and irrigated dryland (*shuijiaodi*):

> A *bunded field* is cultivated land which has a field ridge (or bund) and which can regularly store water for the cultivation of rice or aquatic crops such as lotus root or mat straw.
>
> *Dryland* is all cultivated land except bunded fields, no matter whether it has irrigation facilities. It includes (but is not

> restricted to] irrigated dryland, that is, dryland which has a water source and irrigation facilities and which can be irrigated normally under the conditions prevailing in an ordinary year. (*Xibei Nongxueyuan* 1981, 13)

The same source notes that these classifications are based on long-term use and relatively fixed conditions of irrigation. Upland crops may be grown in bunded fields in drought years or as part of a normal rotation such as rice–wheat–broad beans; and irrigated dryland may not receive irrigation in extremely dry or fortuitously wet years. Thus the effectively irrigated area tends to be greater than the actually irrigated area (see p. 34).

In most Chinese reports, "irrigated area" refers to effectively irrigated area. The *Agricultural Dictionary* makes a further distinction between "net irrigated area" *(jing guan'gai mianji)* and "gross irrigated area" (*mao guan'gai mianji*). The definition given for the former is the same as that provided by the *Statistical Yearbook* for effectively irrigated area, except that it does not include the provision about level land. "Gross irrigated area" includes land occupied by the canal system and its structures and by field paths (NYC 1979, 346). Neither of the definitions is used in reporting, however.

Effectively irrigated area applies only to agricultural land and excludes irrigated forest and pasture. Recently, figures for the latter have been published, and in 1984 and 1985 were added to effectively irrigated area to form a larger category, simply called "irrigated area" (see Table A.14). Over 97 percent of this national irrigated area figure was agricultural. China has very little irrigated forest or pasture.

One of the criteria for determining what is "effectively" irrigated and what is not appears to be the "rate of irrigation guarantee" *(guan'gai baozheng lu)*.[22] This rate, expressed as a percentage, consists of the percent of years during which the irrigation facilities will provide the amount of water "needed" by crops. According to the *Agricultural Dictionary* (NYC 1979, 345), irrigation districts primarily growing upland (dryland) crops should have a rate of guarantee of at least

60 percent, while those mainly growing rice should have one of at least 80 percent.

On-farm Water Resources (NTSL 1977, 66) presents a more refined breakdown of the "irrigation design standards currently used in China," noting that, in general, they are higher in the south, in gravity irrigation (rather than lift irrigation) districts, in large rather than medium-sized projects, and in regions where paddy predominates.

Water-deficient regions	
focusing on upland crops	50–75 percent
focusing on rice	70–80 percent
Water-abundant regions	
focusing on upland crops	70–80 percent
focusing on rice	75–95 percent

Many irrigation districts in China do not appear to come up to these design standards. Even where they are attained, the standards in some areas allow for a water deficiency as frequently as every second year.

The use of different standards of guarantee for different parts of the country makes interprovincial comparisons difficult. For example, although one would expect irrigated fields in the wetter southeastern part of the country to have a higher rate of guarantee than those in the northwest, and bunded fields to have a more demanding standard than upland fields, the opposite tendency shows up in the figures for stable, high-yield fields, which are based in part on rates of guarantee (see subsequent paragraphs). It is possible that the different standards overcompensate for natural differences.

The rate of irrigation guarantee is commonly used in the design of large and medium irrigation projects and those with multiple uses because of its compatibility with rates of guarantee of nonirrigation water uses. It also obviates the practical difficulties of calculating the principal alternative measure, which is the number of days of drought resistance *(kanghan tianshu)*. This is commonly used in small irrigation districts and for on-field works because even nonspecialists find the concept comparatively easy to understand (NTSL 1977, 67). The drought-resistance standard consists of the number of days an irrigation facility can supply crop water needs in the absence of rain and still yield a bumper harvest. According to one source,

> *The National Program for Agricultural Development* (NADP—drafted in the 1950s) recommends that "the drought resistance capability of irrigation facilities be raised to 30–50 days, in keeping with the dissimilarity of conditions in different places; places which are suited to the development of double-cropped rice should raise the standard to 50–70 days in order to guarantee a harvest." In 1973, the Ministry of Water Resources and Electric Power, acting according to the "stipulated standards for several kinds of water control" set down in *The Program*, stipulated that the statistical standard for irrigated area be a drought resistance capacity of 30–50 days for areas with upland crops or single-crop rice, but in general 50–70 days for double-cropped rice areas. In recent years, some upland crop and single-crop rice districts with plentiful water sources have been able to reach a drought resistance capacity of 50–70 days, while some double-cropped rice districts have been able to reach 70–90 days. (NTSL 1977, 67)

To be useful, drought-resistance measures require accurate data on drought occurrences. But, at least during some periods, data on all kinds of "natural disasters" (*zaiqing*) appear to have been of questionable precision. For example, in Heilongjiang Province,

> especially during the ten years of chaos (1966–76), and even at present, when they develop their work on agricultural regionalization, a number of districts throughout the province have felt that the collection and analysis of natural disaster data are disorderly, incomplete, and inaccurate, so that it is difficult to determine what the objective situation is now. (HLJRB, 15 March 1981, 2)

Guaranteed Irrigated Area *(baozheng guan'gai mianji)*

In a limited number of cases, figures have been given for "guaranteed irrigated area" that appear to be different from other measures. In particular, guaranteed irrigated area is lower than effectively irrigated area, indicating the use of a higher standard of guarantee.

An unofficial source (*Ming Bao*, 14 April 1983) reported that Guangdong had 38.9 million *mu* of irrigated land, but that 6.1 million *mu* of farmland had not reached the standards of guaranteed irrigation. This implies that the guaranteed irrigated area in 1982 was 32.8 million *mu*. It is likely that these figures are based on Ministry of Water Resources (MWR) reports. The MWR figure for effectively irrigated area in 1983 was 38.66 million *mu*, compared with the State Statistical Bureau (SSB) figure of 30.66 million *mu*. As noted earlier, Guangdong has one of the highest disparities between the SSB and MWR series.

A report in *China Water Conservancy* (ZGSL, February 1983) makes a clear distinction between effectively irrigated area and a lower figure for guaranteed irrigated area in Guangxi, the "autonomous region" to the west of Guangdong. MWR national summary report categories published in the *China Water Conservancy* for 1983–88 do not include guaranteed irrigated area figures, however (Table A.14).

Unofficial "reference" materials for 1949–84 supplied by the Water Resources Bureau of Shanxi Province[23] show more complete series for guaranteed irrigation and actually irrigated area than for effectively irrigated area. The guaranteed irrigated area for each year is below the effectively irrigated area and usually, but not always, larger than the actually irrigated area (Table 4).

Stable, High-Yield Fields *(gaochan wenchan tian)*

The more complete term for this category is "fields with stable, high yields despite drought or excess surface water" *(han, lao baoshou gaochan wenchan tian)*. These are defined as:

> Of the effectively irrigated area, the cultivated area with complete irrigation facilities and a high resistance to natural disasters. When relatively large droughts or excess surface water [*lao*] occur, irrigation can be guaranteed in drought conditions and excess surface water can be drained. In addition, the unit area (crop) yield reaches or exceeds the requirements of the NADP under the conditions of a normal year. (*Xibei Nongxueyuan* 1981, 130)

Table 4 Irrigated area series, Shanxi Province, 1949–84

Year	Effectively irrigated area	Guaranteed irrigated area	Actually irrigated area
		(million *mu*)	
1949	(3.79)	1.54	1.32
1950	(4.11)	2.44	2.10
1951	(5.13)	2.74	2.54
1952	(6.09)	3.02	3.10
1953	(6.37)	3.27	3.50
1954	(6.56)	3.42	3.33
1955	(7.01)	3.72	3.78
1956	(8.03)	4.10	4.28
1957	(8.74)	4.46	4.49
1958	(9.51)	5.28	5.21
1959	(9.88)	5.61	5.42
1960	(10.08)	5.78	5.55
1961	(10.46)	5.87	5.18
1962	(10.91)	6.04	5.58
1963	(11.67)	6.96	6.14
1964	(12.29)	7.54	6.73
1965		8.07	7.43
1966		9.41	9.10
1967		9.65	8.71
1968		9.82	8.64
1969		10.24	8.63
1970		11.04	9.63
1971		11.95	10.63
1972		12.95	10.98
1973	15.74	13.97	12.64
1974	17.12	14.94	13.38
1975	17.98	15.75	14.36
1976	18.71	16.37	14.18
1977	19.28	17.08	15.18
1978	18.83	16.36	15.72
1979	17.12	14.27	15.14
1980	17.36	14.31	15.03
1981	17.20	13.73	14.19
1982	17.17	13.66	14.70
1983	17.26	13.70	14.04
1984	17.18		14.38

Source: Shanxi Province water resource authorities cited in Chen (1987). The 1949–64 effectively irrigated area figures appeared in the source with parentheses. This suggests that they were derived by the author, or were, in some other respect, regarded as less reliable by the author.
Blank cell = Data not available.

This appears to be the most stringent irrigation-related category. Besides the significant inclusions of drainage and a high drought-resistance capability (100 days in Guangdong Province, for example), it appears to require a high annual crop yield, in excess of the targets specified in the NADP for different regions of the country (6 tons per hectare, 3.75 tons per hectare, or 3 tons per hectare, going roughly from southeast to northwest).

The area with stable, high-yield fields (SHYF) has been the second most commonly reported irrigation-related area statistic, after effectively irrigated area.[24] According to Zhang Yue (1984), SHYF is a MOA-SSB category, not used by the MWR. The MWR does issue a national SHYF figure each year, however (Table A.14). SHYF figures have been published in some of the provincial agricultural yearbooks.

The relationship between SHYF and effectively irrigated area in 1987 and 1988 is shown in Tables A.15 and 5. In 1987, 70 percent of China's effectively irrigated area and 84 percent of its actually irrigated area were considered to be stable with high yields. These are up from 1980, when SHYF constituted only about one-half of the effectively irrigated area. This is probably due to the intervening increase in per-*mu* grain yields. In five instances (Liaoning, Henan, Guizhou, Hubei, and Shanghai), SHYF area exceeded that recorded as actually irrigated.

ACTUALLY IRRIGATED AREA

The actually irrigated area *(shiji guan'gai mianji)* is defined as "that cultivated area actually irrigated in a given year, not including the area where temporary measures are adopted to resist drought" (Chen 1980, 45).[25] This category is therefore a subset of the effectively irrigated area, which is defined in terms of fixed facilities, and therefore does not include some areas that actually receive irrigation in a given year.

None of the three most commonly used measures of irrigated area indicate the intensity of water use. A single, modest and supplemental watering of a hectare of farmland planted with a summer monsoon crop (cotton or maize, e.g.) receives the same weight among irrigated area data as a hectare receiving a dozen or so waterings during two or three seasons of sequentially planted crops, which, like rice, may have heavy total water requirements. Irrigated area may also

Table 5 Provinces ranked by percent of irrigated area designated stable, high-yield fields, 1987

Province	Stable high-yield fields as percent of effectively irrigated area	Province	Stable high-yield fields as percent of actually irrigated area
Shanghai	94.29	Liaoning	109.05
Ningxia	85.95	Henan	108.41
Liaoning	83.46	Guizhou	107.47
Guizhou	82.03	Hubei	107.29
Gansu	81.04	Shanghai	100.22
Guangxi	80.75	Ningxia	97.09
Hunan	79.89	Guangxi	97.04
Hubei	78.73	Anhui	96.20
Guangdong	73.89	Gansu	94.41
Jiangxi	72.99	Jiangsu	88.54
Shandong	72.86	Shandong	88.15
Beijing	71.31	Jilin	84.30
Anhui	70.59	Hunan	84.01
Jiangsu	68.73	Guangdong	83.67
Fujian	68.19	Sichuan	79.19
Henan	67.95	Beijing	77.75
Zhejiang	67.68	Jiangxi	76.25
Jilin	66.61	Shaanxi	75.90
Sichuan	66.44	Neimenggu	75.01
Yunnan	65.21	Qinghai	74.90
Hebei	64.49	Fujian	74.02
Neimenggu	61.93	Yunnan	72.45
Xinjiang	61.81	Zhejiang	69.41
Shaanxi	61.20	Hebei	69.07
Tianjin	59.41	Tianjin	68.24
Qinghai	59.28	Xinjiang	66.07
Shanxi	51.94	Heilongjiang	65.64
Heilongjiang	45.76	Shanxi	62.78
Xizang	0.00	Xizang	0.00
CHINA	69.50	CHINA	83.70

Source: ZGSL (October 1988, 38). See Table A.15.

include dry season crop land, notably winter wheat area. Table 6 demonstrates this diversity for "actually irrigated area." In 1985, the amount of water supplied each irrigated *mu* in Shanghai, a triple crop rice-rice-wheat area, was nearly nine times as much as in Shanxi.

Surprisingly, agricultural water use per *mu* in 1985 was only about one-third greater in the provinces where bunded

Table 6 Agricultural water use, by province, 1985

Province	Agricultural water supplied (million m³)	Actually irrigated area (million *mu*)	Water supply per irrigated *mu* (m³)
Shanghai	7,900	3.85	2,051.95
Ningxia	7,200	3.85	1,870.13
Heilongjiang	9,800	8.71	1,125.14
Guangxi	19,900	18.04	1,103.10
Xinjiang	40,300	39.31	1,025.18
Neimenggu	17,000	16.86	1,008.30
Guangdong	32,000	32.90	972.64
Jiangsu	37,300	48.31	772.10
Gansu	8,000	10.57	756.86
Fujian	9,100	12.38	735.06
Hubei	20,900	29.85	700.17
Liaoning	7,200	10.30	699.03
Yunnan	8,300	12.57	660.30
Hunan	24,600	38.27	642.80
Jiangxi	16,300	25.43	640.98
Guizhou	3,800	5.96	637.58
Beijing	2,900	4.56	635.96
Zhejiang	13,400	22.68	590.83
Jilin	4,500	8.07	557.62
Qinghai	1,200	2.40	500.00
Anhui	12,600	26.76	470.85
Sichuan	11,700	32.11	364.37
Shaanxi	4,600	14.04	327.64
Hebei	15,000	49.25	304.57
Henan	9,700	32.98	294.12
Shandong	14,800	51.95	284.89
Tianjin	1,100	4.25	258.82
Shanxi	3,200	13.86	230.88
Xizang	na	na	na
CHINA	364,300	580.07	628.03

Source: ZGSL (October 1986, 27; November 1986, 32).
na = Data not available.

fields predominate than in the dryland regions (712 cubic meters versus 521 cubic meters). This is largely due to a very high water-use rate in the dry border regions of Xinjiang (1,025 cubic meters per *mu*) and the northeast (957 cubic meters per *mu*) and to a low rate in Sichuan (364 cubic meters per *mu*). The large water usage in the former is possibly due to a high evapotranspiration rate and to the greater variability in precipitation, necessitating more intensive and frequent irrigation. Sichuan's rate may reflect unusual inadequacy among the province's water sources: 1985 was the year a local drought seriously affected yields on 22.7 million *mu*, about one-quarter of the province's cultivated area (ZGNCTJ87, 243–44).[26]

With these exceptions, water use in 1985 was significantly higher in bunded field regions. The south (802 cubic meters per *mu*), east (724 cubic meters per *mu*), and southwest (706 cubic meters per *mu*) were all well above Qinghai (500 cubic meters per *mu*), the northwest (364 cubic meters per *mu*), and the north (290 cubic meters per *mu*).

CATEGORIES USED AT THE PROJECT LEVEL: THE PEOPLE'S VICTORY CANAL

Greater insight into how irrigated area is calculated in practice may be obtained by examining a specific project in greater detail. In so doing, the complexity of calculating meaningful irrigation figures becomes clearer. For example, the categories used at a project level may differ from those reported to higher levels, in keeping with specific requirements of managing a given project.

The People's Victory Canal in Xinxiang Municipality, Henan, is one of China's most famous, thoroughly studied,[27] and best-operated irrigation projects. It diverts water from the left bank of the Yellow River (Huang He) near Zhengzhou. Within its command area are China's first people's commune (at Qiliying) and the Farmland Irrigation Research Institute under the joint jurisdiction of the MWR and the Chinese Academy of Agricultural Sciences. The People's Victory Canal uses at least four measures of irrigated area: designed area,

area actually irrigated during the year, irrigated area multiplied by the number of irrigations over the year *(quannian guan'gai muci)*, and the largest area irrigated at a single time *(zuida yici guan'gai mianji)*. The People's Victory Canal does not appear to use guaranteed irrigated area or SHYF.

The designed area is identical to the project control area. The actually irrigated area is calculated as the total of the most extensive single irrigation during the year on each of the five main canal systems. The relationship between these categories is illustrated in Table 7, covering the years 1976–80.[28]

These figures illustrate several interesting points. First, actually irrigated area (cultivated land receiving irrigation at least once during the year) in the People's Victory Canal was about one-sixth below designed area, averaging 83 percent of the latter during the period covered. This is well within the 81–86 percent national average reported in more recent years by the MWR (Table A.14).

Second, in some years, such as 1978, all five main canal systems cover their maximum area simultaneously. In other years, they are not so clearly synchronized, perhaps indicating the adoption of a rotation system among them.

Third, the average number of irrigation turns (from sur-

Table 7 Irrigation measures in the People's Victory Canal, 1976–80

Year	Irrigated area: Designed (*mu*)	Irrigated area: Actual (*mu*)	AIA / DIA	Maximum area in a single irrigation (*mu*)	MAX / AIA	Total area irrigated (*mu*)	TOTAL / AIA
1976	600,000	510,500	0.85	454,600	0.89	2,514,900	5.01
1977	600,000	470,600	0.78	416,700	0.89	1,761,600	3.74
1978	600,000	503,000	0.84	502,900	1.00	2,955,100	5.87
1979	600,000	489,400	0.82	448,400	0.92	3,207,000	6.55
1980	600,000	525,500	0.88	496,900	0.95	3,270,100	6.22

Source: Niu and Liu (1987, 161).
AIA = Area actually irrigated. DIA = Designed irrigated area.
MAX = Maximum area in a single irrigation.
TOTAL = Total area irrigated, which is equal to the number of irrigations multiplied by the average area actually irrigated.
AIA/DIA, MAX/AIA, and TOTAL/AIA are ratios.

face sources) varies considerably from year to year (from 3.7 to 6.6). Since the 1952–81 average for the People's Victory Canal is 3.50, the number of turns has clearly increased in recent years.

As comprehensive as these figures are compared to the national series, at least two qualifications are in order. First, they do not include well irrigation, which is managed on a much more decentralized basis and is not under direct control of the Canal administration. The source of the foregoing data describes some coordination of well and canal usage but does not provide specific figures for well irrigation.[29] It may be supposed that the area irrigated by wells is inversely correlated to that receiving surface water. Thus the fluctuation in actually irrigated area (total irrigated area × irrigations and average number of turns in the region served by the People's Victory Canal) is probably not as severe as indicated in Table 7.

Second, the amount of water used in each irrigation is not indicated in the preceding figures. This can vary considerably, depending on climate, cropping, soil characteristics, water availability, alternative uses of other factors (especially labor), and the need for environmental control. At the People's Victory Canal, environmental considerations are critical to control siltation of the channel and soil salinization. Another table in the same source indicates that the average surface water used per turn at the Canal ranged from 114 cubic meters per *mu* in 1959 to 269.6 cubic meters per *mu* in 1977 (Niu and Liu 1987, 51).

These levels of water use are considerably higher than the irrigation norms for specific crops mentioned earlier in this section because those figures do not include transmission losses. These are quite high at the People's Victory Canal where the average "irrigation water utilization rate" (presumably an indicator of overall irrigation efficiency) ranged over the period from 20.07 percent in 1971 to 52.63 percent in 1959, roughly in inverse proportion to the gross usage figures cited earlier, which were measured at the main Canal outlet (RMSLQ 1985, 15).

REPORTING BIASES

In addition to problems of definition and measurement, irrigated area figures have been subject to a number of reporting biases and problems of interpretation. These include underreporting, exaggeration, ex post revisions, information lost during communication, and the occasional use of relative rather than absolute figures in press reports.

Underreporting

The cultivated area is known to be substantially underreported, perhaps by more than 20 percent (Travers 1982, 483).[30] In some cases, irrigated area may be underreported as well. Although localities are supposed to report all projects, even those built by communes and brigades, sometimes they do not. The MWR, surveying Fujian Province in the early 1970s, found 200,000 more projects there than had been reported (Nickum 1977, 23).

Exaggeration

On the other hand, as elsewhere in the world, reporting units, especially above the farm producer level, may avoid the problems involved in actual measurement by reporting excessively high figures, by substituting, for example, the original designed irrigated area for the effectively irrigated area.

Exaggeration was clearly a serious problem during the Great Leap Forward "statistical fiasco of 1958."[31] Nationwide, the area reported under irrigation increased by 92 percent in one year (1958), from 520 million *mu* to 1,000 million *mu* (Table A.1). The single significant digit in the latter indicates its approximate nature. Since provincial reports add up to "only" about 800 million *mu*, Beijing appears to have boosted the total reported to it by as much as 25 percent.

Provinces differed widely in their 1958 hyperboles. The rice-growing provinces of Sichuan, Hubei, and Zhejiang reported quite modest increases in irrigated area over 1957 of 4.6 percent, 6.1 percent, and 6.8 percent, respectively, while

Qinghai, Shaanxi, Hebei, Henan, and Guizhou, all but the last dryland provinces, claimed increases of 233 percent, 157 percent, 141 percent, 133 percent, and 113 percent, respectively (derived from Table A.13).

One reason for this disparity is that most of the bunded field provinces already had a large percent of their cultivated land under irrigation, while the dryland provinces were predominantly rainfed. Only 0.20 percent of Shandong's cultivated area was counted as irrigated in 1957.

Unlike some other indicators, the percentages of unirrigated land claimed as recently brought under irrigation among the paddy provinces exhibit no obvious differences from those of the provinces where paddy is a smaller proportion of cultivated and irrigated land. The largest claims by this measure among the provinces just cited were by Henan, 89 percent, Guizhou, 89 percent, Zhejiang, 76 percent, Qinghai, 74 percent, and Hebei, 44 percent. The other provinces made comparatively modest claims: Liaoning, 15 percent, Shaanxi, 8 percent, Hunan, 6 percent, Hubei, 6 percent, Sichuan, 4 percent, and Shandong, 0.3 percent (Table 8).[32]

Revisions

A further complication in evaluating intertemporal changes in irrigated area is the revision of data for earlier periods. For example, a more recent official source (ZGTJNJ88, 233) give national figures for 1952 and 1957 that are 7 percent and 27 percent below those reported in the 1960 compendium *Ten Great Years* (SSB 1960; Table A.1). Both sets of numbers are from the SSB, so the disparity is unlikely to be from different reporting systems.[33]

Provinces appear to have made a number of adjustments, which have not been matched in the national aggregates. For example, a number of provinces report or imply figures for 1949 and immediately thereafter which are below those gathered from the more contemporaneous Chinese press in *Provincial Agricultural Statistics for Communist China* (PAS 1969), yet the latter are more consistent with the *Ten Great Years* (SSB 1960) aggregate of 240 million *mu* that was reiterated in *China Reconstructs* (April 1979).[34]

Data for categories other than irrigated area have apparently been readjusted as well. In particular, stable, high-yield field figures for previous years appear to have been downgraded, sometimes more so than those for irrigated area. Table 9 compares provincial reports during the 1970s with the 1980

Table 8 Percent change in percent of cultivated area under irrigation, 1957–78

Province	1978 relative to 1957	1965 relative to 1957	1978 relative to 1965
Anhui	30	-13	50
Beijing	2,111	202	631
Fujian	0	0	0
Gansu	4,686	3,150	47
Guangdong	3	4	-1
Guangxi	3	23	-16
Guizhou	-4	-9	5
Hebei	133	10	111
Heilongjiang	67	-48	219
Henan	30	-88	945
Hubei	31	-2	33
Hunan	4	4	0
Jiangsu	44	-3	49
Jiangxi	-7	-2	-5
Jilin	129	-65	557
Liaoning	268	-27	406
Neimenggu	56	19	32
Ningxia			15
Qinghai			11
Shaanxi	550	195	120
Shandong	30,067	9,083	229
Shanghai	56	23	27
Shanxi	91	16	64
Sichuan	4	2	1
Tianjin	45		
Xinjiang	-1	1	-2
Xizang			
Yunnan	8	2	6
Zhejiang	11	0	11

Source: Derived from Chinese Academy of Sciences data in ZGNYDL (1980, 77–79). See Table A.16.
Blank cell = Data not available.

figures from more recent publications. In some cases, part of the difference may be because of an actual decline in the area cultivated. The expansion of urban and residential construction has often been at the expense of the best land (see p. 71). It is safe to assume, however, that the bulk of the readjustment stems from reevaluations of the area with stable, high-yield fields.

Transmission Losses

Compounding the problem of unclear reporting biases of basic-level units is the information loss due to aggregation (e.g., rounding), to editorial carelessness, and, in the case of data reported in English, to translation error. For example, reports from the Foreign Broadcast Information Service consist mainly of rapid translations of recorded radio reports, with much room for mistakes.

Typographical errors appear even in the official statistical compendia. For example, the *China Agricultural Yearbook 1981* (ZGNYNJ81, 66) gives a figure of 10.727 million *mu* for the 1980 effectively irrigated area of Shanxi Province. That this should be 16.727, as indicated in Table A.12, is clear from the Shanxi figures given elsewhere for 1978 and

Table 9 Comparison of provincial irrigation reports, 1970s and 1980

Province	1970 reports	1981 report for 1980
Fujian	1975 EIA is ¾ of CA; SHYF is over ½ of CA	EIA is 68% of CA; SHYF is 32% of CA
Guangdong	1974 IA is 38 million *mu*; SHYF is 27 million *mu*	EIA is 31.619 million *mu*; SHYF is 22.826 million *mu*
Henan	1974 IA is ½ CA; SHYF is 40% of CA	EIA is 49.5% of CA; SHYF is 27.4% of CA
Hunan	1975 SHYF is 30 million *mu*	SHYF is 23.4 million *mu*
Jiangsu	1975 SHYF is 30 million *mu*, 40% of CA	SHYF is 31.328 million *mu*, 44.9% of CA

Sources: 1980 data from ZGNYNJ81, 66–67. 1970s data for Fujian from Joint Publications Research Service, U.S. Dept. of Commerce, 27 August 1975; for Guangdong, FBIS, 18 October 1974; for Henan, FBIS, 27 December 1974; for Hunan, RMRB, 30 December 1975; for Jiangsu, FBIS, 10 February 1976.

EIA = Effectively irrigated area.
CA = Cultivated area.
SHYF = Stable, high-yield fields.
IA = Irrigated area of unspecified type.

1981, and from the 6.000 million *mu* discrepancy between the 673.321 million *mu* national total and the 667.321 million *mu* derived by summing the individual provincial figures in the original table.

In another example, the Ningxia Hui Autonomous Region Rural Sample Survey Team (QJNXNC 1985, 48) listed Ningxia's 1978 irrigated area as 2.40 million *mu*. This was subsequently corrected to 3.40 million *mu* (Table A.12). It is unlikely that typographical errors are a significant, systematic or common source of bias, however.

Relative Reports

The official press has frequently reported both absolute and relative increases in irrigated area and in previously irrigated area that have been improved. Sometimes both categories are merged in reporting: irrigation was extended or improved on a reported number of *mu*. In principle it is useful to know the extent of improvements in an existing irrigated area, as these may be of greater significance to production than increases in irrigated area on marginal farmland. Still, to be

Table 10 Irrigation added during the Sixth Five-Year Plan period (1981–85)

Year	Increase in effectively irrigated area		Irrigated area improved	Increase in area irrigated by pump		Outfitted pump wells added
	Gross	Net		Total	By new pump wells[a]	
1981	8.6203	–4.710[b]	27.46	8.111	5.5529	140,000
1982	8.2480	–5.960[b]	26.67	12.446	6.1773	171,000
1983	10.3840	–1.760[c]	29.79	10.813	5.6652	176,000
1984	13.6990	–2.190[c]	29.00	10.000	5.0000	153,000
1985	13.0000	–7.010[c]	29.00	10.000	5.0000	150,000
Total	53.9513	–12.780[b]	141.92	51.370	27.3954	790,000
Yearly average	10.7900	–2.556[b]	28.38	10.270	5.4790	158,000

Sources: ZGSL (February 1986, 22); ZGSLNJ91, 653; ZGTJNJ91, 299.

Note: Data on net increase in effectively irrigated area are from Ministry of Water Resources and State Statistical Bureau sources. Otherwise, data are from the Ministry of Water Resources.

a. Figures include data for the increase in area drained by pumps.

b. Figures are from State Statistical Bureau sources. Ministry of Water Resources data are not available.

c. Figures are from the Ministry of Water Resources. The State Statistical Bureau data for these years show an *increase* in 1983 of 7.01 million *mu* and *decreases* in 1984 and 1985 of 2.86 million *mu* and 6.26 million *mu*, respectively.

useful for analytical purposes, the nature of improvement would have to be specified more precisely. The primary function of the reports seems to be to show levels of activity, not outcomes. As Table 10 shows, the area reported as "improved" during the Sixth Five-Year Plan (1981–85) was about three times as large as the gross increase in effectively irrigated area. In net terms, total irrigated area actually declined during this period.

Reports between the mid-1960s and the early 1970s often vary widely in the magnitudes they claim or imply, especially when they report relative changes. For example, there are two separate figures for Henan's 1965 irrigated area: 15 million *mu* (FBIS, 24 May 1972, D2–D3) and 21 million *mu* (FBIS, 4 October 1972, B1). A 1966 source implies an even lower figure by claiming that the "over 20 million" *mu* of 1966 is an increase of 10 million *mu* over the previous year (USHKAA, micro file reel 2, frame 125). Similar disparities apply to the figures for Neimenggu in 1964 and Sichuan in 1972.

In general, basing estimates on relative reports, a necessity during the 1960s and 1970s, may cause more problems than the practice is worth, particularly given the proliferation of more complete and consistent statistical publications during the last fifteen years.

COMPARISON OF DATA SERIES FROM PROVINCIAL YEARBOOKS

In recent years, an increasing number of provincial statistical yearbooks have been published. Table A.12 presents data on irrigated area from these sources for twenty-one of China's twenty-nine province-level units. A comparison of these figures with those released at the time (Table A.13) shows a widespread discounting of the earlier data for all years from 1953 to 1974. For 1958 and 1959, and possibly in some areas (notably Anhui and Sichuan) in 1957, this is clearly the result of a regeneration of a more plausible set of figures for the Great Leap Forward period. While the causes of differences for other years among pre-1979 data reports cannot be unequivocally identified, several explanations are offered for consideration.

An Adjustment to Reflect Higher Standards

In briefings, Chinese officials have noted that standards of irrigation have become stricter over time. If this were the case, one would expect to observe either a decrease in the relative differences over time, if standards were tightened progressively (ignoring, for reasons already discussed, the Great Leap Forward period during the late 1950s), or a noticeable adjustment at a time when a single tighter standard was applied.

Neither of these effects is evident in the record for the three provinces with recently published complete series from 1949 onward:[35]

- The relative disparities in the two data series for Hebei were as wide in the early 1970s as in the early 1960s—and much wider in absolute terms. In 1975 and 1978 the contemporary figures reported were actually lower than those published more recently for those years. After 1980, the provincial series merged with the SSB figures published in the national yearbooks, not because of stiffer standards but due to a standardization in reporting systems.
- For Anhui, the gap closed significantly after 1972 but later than in Hebei.
- For Jilin, the disparity between present and published data is reversed altogether. The recent figures for 1955–58, the only years available for comparison between 1953 and 1974, are all higher than those originally released. The reason for this anomaly is not clear, but may be connected to Jilin's occasional boundary shifts.

Most probably, the tightening in standards refers to the increase in the average amount of water applied to each irrigated plot that has accompanied increases in the cropping ratio, especially when this has involved an addition of winter crops that require more substantial irrigation (Zhang 1984). On the other hand, there are indications that the standards applied in the field may not have become any stricter. For example, in Hebei in 1980 it was reported that "some irrigation districts can only irrigate one or two times a year" (HBSLGK 1980). Clearly, however, an adjustment has been made, usually downward, perhaps as part of the "unification" of standards in 1980.

Difference in Reporting Systems and Categories

According to Zhang Yue, one of China's most knowledgeable hydraulic engineers, several categories of irrigated area were reported by the production teams before 1980. Since then, basic production units have only reported effectively irrigated area figures. This is in accord with the observations of Tuan and Crook (1983), provided that stable high-yield field is not counted as an irrigated area measure per se.

Form of Presentation

Most figures for the pre-1978 period (including those assembled in PAS 1969) were issued haphazardly, commonly imbedded in provincial press reports. In addition, as noted in the previous section, year-to-year changes were often reported in relative or incremental terms. Where, as probable in the PAS collection, these are used to reconstruct absolute figures, there is a danger of overestimation.

A good illustration of this is an Anhui report that in 1983 the province added 4.913 million *mu* of new irrigated area and improved irrigation on 23.837 million *mu* (AHJJNJ84, 252). The reported increment in irrigated area is a gross value. The same source (AHJJNJ84, 157) reports a net decline of 687,000 *mu* in 1983 irrigated area. In other words, the increase of 4.9 million *mu* was more than offset by the removal of 5.6 million *mu* of land formerly classified as irrigated.

Figures for gross *decrease* in irrigated area were rarely published until recently. One notable exception is a remarkable table published in the *China Water Conservancy* (ZGSL) on 1984 province-by-province decreases in irrigated area, with a breakdown by the cause of decline (see p. 70, "Sources of Decline").

SUMMARY

There are two basic types of irrigated area measures: "command area" and "actual." Command area measures, such as "effectively irrigated area," "guaranteed irrigated area," and "stable, high-yield field," estimate how much land could be adequately irrigated with existing facilities under normal conditions. What is considered "adequate" and "normal" varies considerably. There are different standards for the required level of probability (e.g., adequate water during 50, 70, or 80 years within a century). In addition, irrigation requirements depend on rainfall and temperature, cropping patterns, timing and method of application, soils and slope, and level of other inputs such as labor and management. Measures of actually irrigated area are less hypothetical, but they give no indication of the frequency or intensity of watering; and they do not include areas actually watered outside of command areas. At the project level, more complete measures are sometimes collected, but these do not appear to be standardized and seem to be prone to problems of omission.

Further eroding the reliability of irrigated area statistics, especially before 1979, are numerous reporting biases: incentives to underreport; exaggeration (especially during the Great Leap Forward); and various revisions of old data at the provincial and national level. Also, problems arise in presentation: inconsistent rounding, typographical errors, faulty translations, and the like. Analytical errors are often perpetuated or increased when estimates based on relative reports are made by the Chinese press or the Chinese and international research communities. This report relies on published absolute figures and does not generate data from reports of relative increases.

TRENDS SHOWN BY PUBLISHED DATA

This section uses various series for effectively irrigated area to delineate the pattern of irrigation development since 1949, both nationally and regionally. Using the perceived decline in irrigated area in the early 1980s as an example, it shows some of the analytical traps and political uses of reliance on reported irrigated area aggregates. The regional and provincial breakdown indicates the wide variety of development patterns that are obscured by national aggregates. Figure 3, a schematic diagram of irrigated areas by province, shows the relative importance of the various provinces, municipalities, and autonomous regions for China as a whole.

NATIONAL TRENDS

Table A.1 presents estimates for China's total irrigated area before 1949 and reported totals from then until 1991. The latter are presumably all effectively irrigated area figures. Since 1983, both the SSB and MWR series have been published regularly.

These figures show a restoration of the prewar irrigated area during the early 1950s, followed by a rapid increase after 1955. This was due to the mass mobilization campaigns, which accompanied collectivization and communization and which were focused on the construction of surface water systems, especially reservoirs and diversions.

As noted in the previous section, reported data were exaggerated during the Great Leap Forward, notably in 1958 but probably in 1957 as well. Subsequently issued SSB data for 1957 (ZGTJNJ86, 149) indicate a downward adjustment of 21 percent (and of 6 percent for 1952). No revision was published for 1958. The same source indicates that Great Leap projects, primarily reservoirs, did increase irrigated area, but that the subsequent extension of pumping brought considerably more new farmland under irrigation.

In the early 1960s, development was concentrated on surface pumping in low-lying, rice-growing southern areas such as the Pearl River (Zhu Jiang) and Yangtze (Chang Jiang) deltas. In the late 1960s and early to mid-1970s, the focus was on pump wells in north China. Since these wells normally brought irrigation to formerly unserved areas, their impact on irrigated area totals was particularly significant and highly concentrated regionally. This may be seen by comparing the 1965–78 column of Table 8, which reconstructs Chinese Academy of Sciences data to show percent changes over time in the proportion of cultivated land that is irrigated, with Table 1, which lists provinces by number of

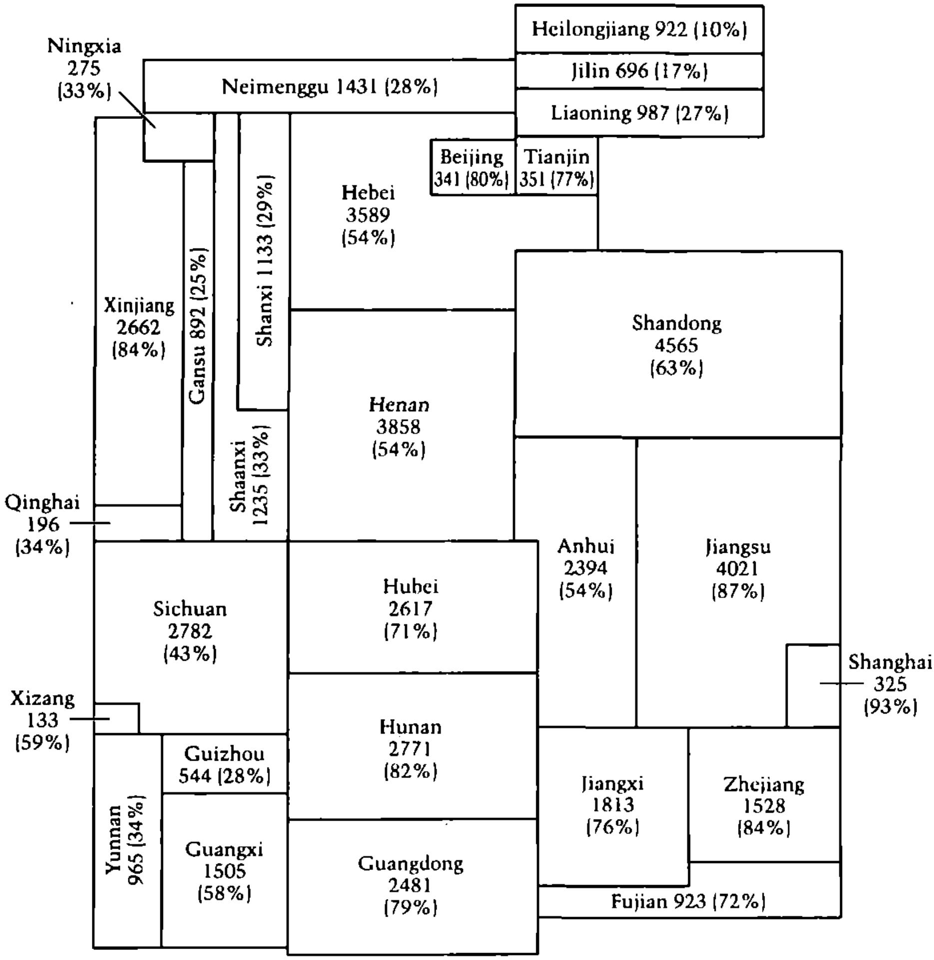

Figure 3 Schematic diagram of irrigated areas by provinces, municipalities, and autonomous regions, 1985 (Source: MWREP 1987, 29). Size of box is proportional to size of effectively irrigated area in province. Numbers appearing in each province indicate the effectively irrigated area in units of 1,000 hectares. Figures in parentheses indicate effectively irrigated area as percentages of provincial cultivated area.

tubewells in 1987.[36] Provinces with the highest growth rates are all in the north and all invested in pump wells.

By 1976, the irrigated area had basically stabilized. After that, there was a small but well-publicized decline, which caused concern in official circles during the mid-1980s, followed by a recovery to new peak levels in 1990 and 1991. This issue is discussed in detail later in the section.

INTERTEMPORAL TRENDS AND PATTERNS BY REGION

While coverage is still not adequate to permit generalization of national trends during blackout periods, notably the 1960s, three provinces (Hebei, Jilin, and Anhui) provide complete year-by-year series for effectively irrigated area all the way back to 1949; and Shanghai offers one for the entire period since its establishment in 1957 as a separate province-level municipality. A complete series of numbers for guaranteed irrigated area and actually irrigated area is available for Shanxi (Table 4). In addition, comprehensive figures for all provinces for selected years have been published by the MWR (Table A.2). Together, these allow a rough description of post-1949 trends by region (see Figure 4). Even from the cursory examination that can be provided here, it is clear that what constitutes irrigated area and how it has developed vary widely over the Chinese landscape.

The North (Shandong, Henan, Hebei, Beijing, and Tianjin)

The north, comprised of the three provinces and two province-level municipalities that encompass the North China (Huang-Huai-Hai) Plain, has the largest irrigated area of the seven regions delineated in Appendix 1. Its irrigation is predominantly dryland, devoted primarily to the growing of winter wheat (Table A.16). In 1988, Shandong, Henan, and Hebei had three of the four largest irrigated areas in China (Jiangsu was second), together nearly one-quarter the national total. They also have 70 percent of China's pump wells (Table 1).

The most complete series in the north is for Hebei. That province showed a jump of 14 percent in 1952 from a rela-

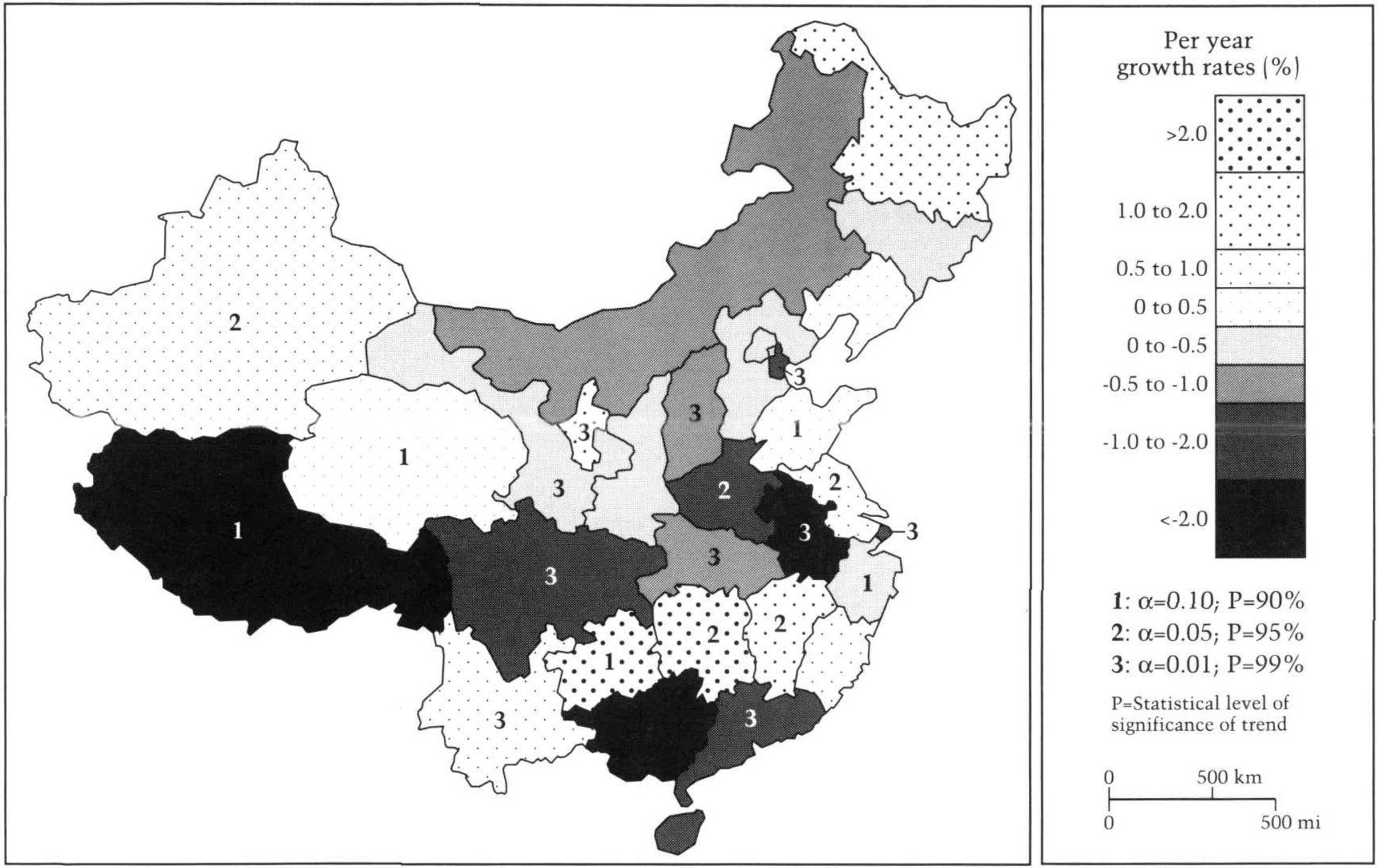

Figure 4 Per year growth rates in effectively irrigated area, 1980–87 (Source: Calculated from data in Table A.11)

tively low level and then increased more significantly from 1956 to 1959 with collectivization and the Great Leap. Most of these gains were short-lived, however, even according to revised figures. The canals and reservoirs that Hebei (and Shandong) built in the North China Plain during the Great Leap Forward disrupted the natural drainage systems, leading to a major reduction in the command area of those projects, and to serious environmental effects, notably increased flooding and salinization.

In 1963, the year of a major flood in the Hai River basin, irrigated area fell to slightly below the 1956 level. It is unclear from the Hebei yearbook (HBJJTJ85, 429) whether the separation of Beijing and Tianjin from Hebei in 1959 has been factored out of the figures it provides. If not, the 1963 figure was still higher than that for 1956, but probably not by much. The Hai River Basin Project, circa 1964–74, provided an effective passive drainage system, while the development of pump wells in the latter half of the 1960s and the early 1970s allowed a renewed rapid expansion of the area under irrigation. Hebei saw year-to-year jumps of 26 percent in 1965, 31 percent in 1966, 6 percent in 1968, 9 percent in 1970, 8 percent in 1973, 7 percent in 1974, and 7 percent in 1975. The reported area peaked in 1979, at 55.06 million *mu*.

Figure 5, based on MWR figures in Tables A.2–A.8 and A.15, indicates that Hebei's pattern of irrigated area development in the post-1949 period was similar to that of Shandong and Henan, increasing rapidly from a very low base in the 1950s, declining slightly thereafter until the mid- to late-1960s, when the spread of pump wells led to a major jump in irrigated area. Hebei's irrigated area, which had been the most extensive of the three provinces in the earlier period, did not increase as rapidly as that of Henan and, especially, Shandong during this period.

The Chinese Academy of Sciences figures presented in Table 8 show this in a slightly different way. They indicate that the percentage of cultivated area under irrigation increased between 1965 and 1978 by 945 percent in Henan, 631 percent in Beijing, and 229 percent in Shandong, compared with 111 percent in Hebei. Shandong's irrigated area continued to grow during the early 1980s, due partly to increased diversions from the Huang He (Yellow River). But Henan, which, together with Shandong, irrigates 1.33 million hectares with Huang He water (MWREP 1987, 63), experienced little growth in irrigated area during the 1980s, much as Hebei, which does not have access to the Huang He (Figure 5).

With respect to area actually irrigated, Hebei ranks high, both in absolute and in percentage terms, while Henan consistently reports a relatively low proportion of its effectively irrigated area being actually irrigated (Tables A.3–A.8 and A.15). Shandong lies in between. At this level of generality, it is hard to explain the difference.

The Northeast (Neimenggu, Liaoning, Heilongjiang, Jilin, and Ningxia)

Like the north, the northeast is primarily dryland agriculture, but it is irrigated far less extensively. Heilongjiang, with

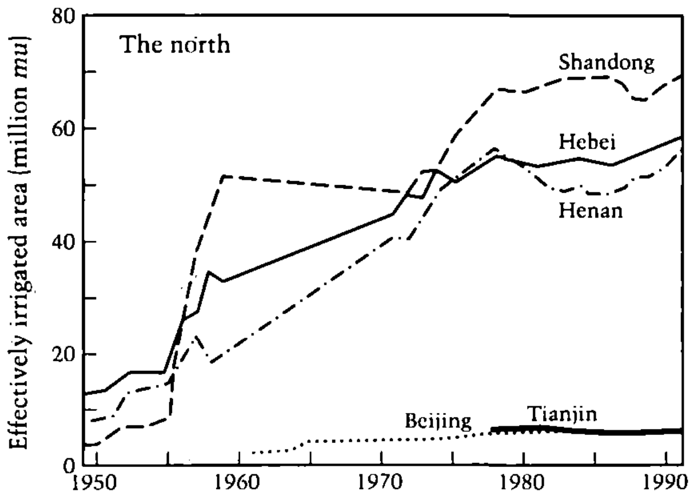

Figure 5 Irrigated area trends by region: The north, 1949–91 (Source: Ministry of Water Resources of the People's Republic of China). Years without observations filled in through linear extrapolation. See figures in Table A.2 for 1949–79 and Tables A.3–A.8 for 1983–91.

the largest reported cultivated area in China (133 million *mu* in 1986), also has the lowest ratio of cultivated area under irrigation (8 percent) (Table 11). Jilin's ratio is second lowest (18 percent), followed by Neimenggu and Liaoning (21 percent each). Ningxia is only slightly more irrigated (31 percent) (Table 11). In consequence, while the northeast, as delineated here, has the largest cultivated area of the seven regions, its irrigated area is second lowest (above only that of the northwest).

Jilin is the middle of China's three northeast provinces, in what was once termed Manchuria. Together with its sister provinces Heilongjiang and Liaoning and the more westerly Gansu Province and Ningxia Hui Autonomous Region, Jilin has been affected by at least two major boundary shifts with Neimenggu, by which territory was removed from the latter in 1969 and returned in 1979 (see Appendix 2). These shifts are likely to have affected irrigated area substantially only in the case of Jilin, however, and, to a much lesser extent, Liaoning. Any assessment of intertemporal trends in statistical data for Jilin should therefore consider whether the data have been adjusted to compensate for these transfers. In part because of the boundary problem, Ningxia and Neimenggu have been included for present purposes in the northeast.[37]

Incomplete irrigated area series are available from provincial yearbooks for Liaoning (covering 1949, 1952, 1953, 1957, 1962, 1965, and 1970–88), Heilongjiang (covering 1949, 1952, 1957, 1962, 1965, 1970, and 1975–87), and Ningxia (covering 1952, 1957, 1958, 1962, 1965, 1970, and 1975–87). Like the Jilin series, none of these show any unusual declines in irrigated area between 1978 and 1979 or between 1979 and 1980, so it would be safe to assume that appropriate adjustments have been made, and that the series apply to post-1979 boundaries.

The three northeast provinces indicate similar magnitudes and trends in irrigated area. Their data show sharp peaks during the Great Leap Forward, followed by a collapse back to the levels of the mid-1950s. The provincial data exhibit

Table 11 Ratio of effectively irrigated area to cultivated area, 1986

Province or region	Effectively irrigated area	Cultivated area	Ratio of irrigated to cultivated area	Provincial rank order	Ratio of irrigated to cultivated area
	(million *mu*)				
Beijing	5.06	6.285	0.805	Shanghai	0.981
Tianjin	5.11	6.615	0.772	Xinjiang	0.888
Hebei	53.31	98.880	0.539	Zhejiang	0.853
Shanxi	15.81	55.980	0.282	Hunan	0.832
Neimenggu	15.09	73.425	0.205	Beijing	0.805
Liaoning	10.96	52.935	0.207	Tianjin	0.772
Jilin	10.76	59.595	0.181	Jiangsu	0.771
Heilongjiang	10.80	133.035	0.081	Jiangxi	0.767
Shanghai	4.90	4.995	0.981	Fujian	0.731
Jiangsu	53.07	68.865	0.771	Shandong	0.653
Zhejiang	22.45	26.310	0.853	Guangdong	0.639
Anhui	31.38	66.210	0.474	Hubei	0.635
Fujian	13.70	18.750	0.731	Xizang	0.548
Jiangxi	27.21	35.460	0.767	Hebei	0.539
Shandong	68.20	104.460	0.653	Guangxi	0.527
Henan	48.19	104.985	0.459	Anhui	0.474
Hubei	33.79	53.175	0.635	Henan	0.459
Hunan	41.58	49.965	0.832	Sichuan	0.430
Guangdong	28.70	44.910	0.639	Yunnan	0.348
Guangxi	20.25	38.460	0.527	Shaanxi	0.347
Sichuan	40.94	95.115	0.430	Ningxia	0.311
Guizhou	7.98	27.945	0.285	Qinghai	0.291
Yunnan	14.50	41.640	0.348	Guizhou	0.285
Xizang	1.83	3.330	0.548	Shanxi	0.282
Shaanxi	18.68	53.850	0.347	Gansu	0.237
Gansu	12.39	52.200	0.237	Liaoning	0.207
Qinghai	2.46	8.445	0.291	Neimenggu	0.205
Ningxia	3.69	11.865	0.311	Jilin	0.181
Xinjiang	40.61	45.750	0.888	Heilongjiang	0.081
North	179.87	321.225	0.560		
Northeast	51.29	330.855	0.155		
Northwest	46.87	162.030	0.289		
Chang Jiang	123.14	193.245	0.637		
South	64.85	89.970	0.721		
Southwest	111.51	193.470	0.576		
West	87.70	161.175	0.544		

Sources: Walker (1988, 622–23). Data from contemporary sources. See Table A.11.

rapid increases following the nadir around 1963. Especially for Liaoning, this upward trend continued through the 1970s, although with some significant swings, especially in Liaoning and Heilongjiang. Liaoning's irrigated area peaked in 1978; that of Jilin and Heilongjiang, in 1981.

Neimenggu and Ningxia exhibit a somewhat different pattern, with much steadier development. Projects executed in Neimenggu during the Great Leap (such as the Sanshenggong Diversion from the Huang He, completed in May 1961)[38] appear to have given its irrigated area an enduring boost. Irrigated area peaked in 1979, followed by a steady decline until 1986, when it began to increase again (Tables A.11 and A.12). Irrigated area in Ningxia has had some short-term fluctuations, with a gradual but relatively steady long-term upward trend (Tables A.2, A.11, and A.12). Ningxia's consistent year-to-year increase runs counter to the pattern exhibited by irrigation data for most provinces during the 1980s (Tables A.12 and A.13).

Figure 6 shows clearly that the MWR data in Table A.2

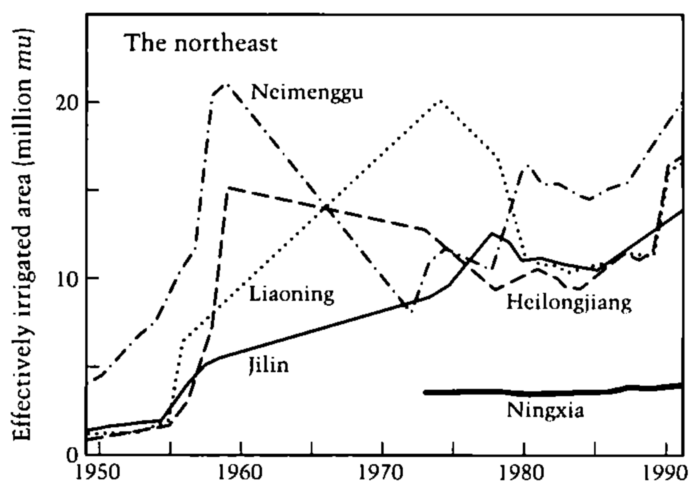

Figure 6 Irrigated area trends by region: The northeast, 1949–91 (Source: Ministry of Water Resources of the People's Republic of China). Years without observations filled in through linear extrapolation. See figures in Table A.2 for 1949–79 and Tables A.3–A.8 for 1983–91.

have not been adjusted for the 1969 and 1979 boundary shifts. Before 1969, Neimenggu had by far the largest irrigated area in the region. During the 1970s these data indicate a considerable decline in irrigated area, both in absolute terms and relative to Liaoning and Jilin. In 1979, Neimenggu recaptured the lead with a single-year net increment of 5.6 million *mu*, while Jilin's effectively irrigated area fell by 4.6 million *mu*. Liaoning's irrigated area also declined, by a lesser but still significant 3.5 million *mu*.

In general, the pattern of development of irrigation in the northeast appears to have been more erratic than elsewhere. One reason for this is the relative insignificance of irrigation to the region's agriculture, which relies on summer dryland crops.[39] This marginality may have been a factor in the apparent revision by the MWR of its effectively irrigated area figures, which was greatest for Liaoning, Jilin, and (in percentage terms) Xizang, following the 1976 joint audit (Table A.2; Figure 6).

The northeast provinces differ significantly in their water sources. Liaoning is the only one of the three with an above-average percentage (46 percent) of irrigated area dependent on reservoirs (Table 12). It also has more outfitted pump wells (as of 1987) than the other two: 70,000 compared to 55,000 for Heilongjiang and 39,000 for Jilin (Table 1). If a command area of 70 *mu* is assumed for each outfitted pump well,[40] estimates of irrigation by source in the three northeast provinces can be completed (Table 12).

Table 12 Irrigation by source in the northeast, 1987

Province	Total irrigated area	Area irrigated by reservoirs	Area irrigated by pump wells	Residual
		(million *mu*)		
Heilongjiang	14.49	1.84 (13)	4.33 (30)	8.32 (57)
Jilin	11.29	3.09 (27)	2.94 (26)	5.26 (47)
Liaoning	14.67	6.88 (46)	5.61 (38)	2.38 (16)

Sources: ZGNYNJ88, 234, 367–71; ZGSL (October 1988, 38).
Note: Figures in parentheses are percentages of total irrigated area. The residual column is calculated by deducting area irrigated by reservoirs and area irrigated by pump wells from total irrigated area. Data for total irrigated area are from the MWR system.

Both Neimenggu and Ningxia rely largely on the Huang He for irrigation. In Neimenggu, about 70 percent of the irrigated area is concentrated in the Hetao region of the Huang He and in the lower plains reaches of the Western Liao He (NNSZY 1982, 187).[41] According to MWR figures, the Hetao Diversion Project at Sanshenggong commands approximately 7 million *mu* (MWREP 1987, 32, 62–63). This is about one-third the effectively irrigated area reported by the MWR, or 45 percent of that reported by the SSB system (Table A.5). Ningxia is even more heavily dependent on the Huang He, with 3 million *mu* of irrigated area managed by the Qingtong Gorge Reservoir on the river's mainstream (MWREP 1987, 62). Because of the predominance of the Qingtong, Ningxia leads all provinces in the percent of its irrigated area fed by reservoirs (73 percent) (Table 13).

The Northwest (Shaanxi, Shanxi, and Gansu)

The dry northwest shares many characteristics with the northeast. Like Neimenggu and Ningxia, the Huang He and its tributaries are important water sources in all three provinces, although groundwater, extracted by pump wells, is also significant in Shaanxi and Shanxi. Like the northeast region as a whole, most (71 percent) of the arable land in the northwest is not irrigated and that which is, is devoted largely to dryland crops.

The most consistent and rapid increase in irrigated area over the three decades after 1949 was in Shaanxi. Although the Weibei region north of Xi'an has a long history of irrigation, Shaanxi as a whole had the smallest irrigated area of the northwest provinces during the 1950s. Gansu, which had the largest irrigated area in the early 1950s, stagnated until the mid-1960s and fell behind the other two. Shanxi, which began in 1949 with almost the same irrigated area as Shaanxi, developed more rapidly than the latter in the 1950s, but slowed down thereafter. From 1965 to 1975 the two provinces appear to have had virtually identical reported irrigated areas. Shanxi declined thereafter, perhaps because of statistical readjustments stemming from the 1976 audit, while

Shaanxi continued to rise slightly during the late 1970s, peaking between 1979 and 1983 (MWR series).

All three provinces show a major jump in irrigated area between 1965 and the mid-1970s (Figure 7). As in the north, this would appear to be associated with the development of pump wells (Table 1). Using the 1985 national average figure of 70 *mu* per outfitted well,[42] pump well-based irrigated area

Table 13 Provincial rankings by reservoir command area and capacity, 1989

Province	Reservoir effectively irrigated area (million *mu*)	Province	Storage capacity (km³)	Province	Storage capacity per irrigated *mu* (m³)
Hunan	23.45	Hubei	50.001	Jilin	9,583
Hubei	22.05	Henan	49.376	Henan	4,734
Jiangsu	17.63	Guangdong	44.602	Liaoning	4,148
Guangdong	15.87	Zhejiang	33.433	Heilongjiang	3,418
Sichuan	14.49	Liaoning	30.280	Zhejiang	2,880
Xinjiang	13.99	Jilin	29.994	Guangdong	2,810
Anhui	13.74	Hunan	29.122	Beijing	2,763
Hebei	12.12	Jiangxi	23.147	Hubei	2,268
Zhejiang	11.61	Guangxi	21.769	Tianjin	2,181
Jiangxi	10.90	Shandong	19.201	Jiangxi	2,124
Henan	10.43	Jiangsu	19.023	Neimenggu	2,102
Guangxi	10.39	Anhui	18.130	Guangxi	2,095
Shandong	10.25	Hebei	14.263	Gansu	2,036
Liaoning	7.30	Sichuan	11.813	Guizhou	1,966
Yunnan	6.09	Beijing	9.303	Shandong	1,873
Shanxi	5.63	Gansu	8.552	Fujian	1,632
Shaanxi	4.25	Fujian	6.837	Anhui	1,320
Gansu	4.20	Yunnan	6.698	Hunan	1,242
Fujian	4.19	Heilongjiang	6.630	Hebei	1,177
Beijing	3.37	Neimenggu	5.970	Yunnan	1,100
Ningxia	3.18	Xinjiang	5.755	Jiangsu	1,079
Jilin	3.13	Guizhou	5.152	Shaanxi	1,008
Neimenggu	2.84	Shaanxi	4.285	Sichuan	815
Guizhou	2.62	Shanxi	3.932	Shanxi	698
Heilongjiang	1.94	Tianjin	2.516	Ningxia	549
Tianjin	1.15	Ningxia	1.746	Xinjiang	411
Qinghai	0.59	Qinghai	0.201	Qinghai	341
Xizang	0.00	Xizang	0.000	Xizang	na
Shanghai	0.00	Shanghai	0.000	Shanghai	na

Source: Calculated from data in ZGNYNJ90, 388, 403. See Table A.17.
na = Data not available.

estimates for that year are 8.4 million *mu* for Shaanxi, 5.4 million *mu* for Shanxi, and 2.4 million *mu* for Gansu. These comprise 114 percent, 116 percent, and 44 percent, respectively, of the reported expansion in effectively irrigated area between 1965 and 1985. Thus pump wells in Shaanxi and Shanxi may have partially displaced or replaced other water sources, including shallow groundwater.

Alternatively, the reports for pump-well irrigation could be exaggerated. Figures accompanying those presented in Table 4 show Shanxi's 9.01 million *mu* increase in guaranteed irrigated area from 1965 to its peak in 1977 are divided among project types as follows: gravity irrigation districts, 2.00 million *mu*; wells, 3.19 million *mu*; (surface) pumping stations, 3.29 million *mu*; and small-scale water facilities, 0.53 million *mu*. The subsequent decline of more than 3 million *mu* in guaranteed irrigated area by 1983 was similarly distributed across all sources (Chen 1987).

The year-to-year Shanxi data presented in Table 4 are interesting, not only for providing the only complete series

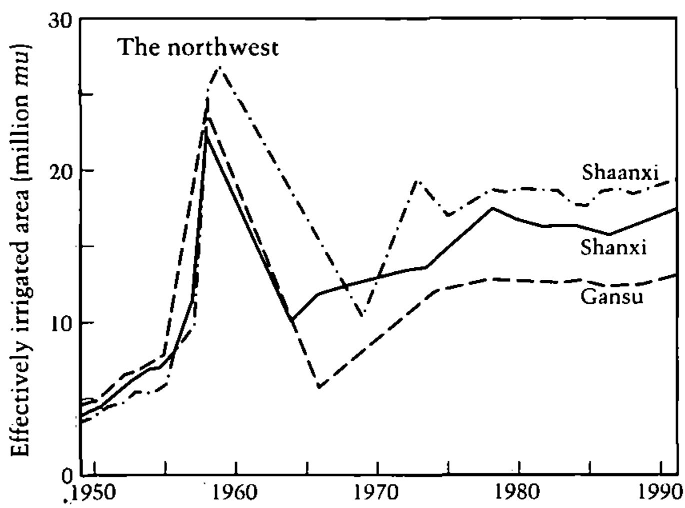

Figure 7 Irrigated area trends by region: The northwest, 1949–91 (Source: Ministry of Water Resources of the People's Republic of China). Years without observations filled in through linear extrapolation. See figures in Table A.2 for 1949–79 and Tables A.3–A.8 for 1983–91.

for guaranteed and actually irrigated area, but also because of the incompleteness of the series for effectively irrigated area. Effectively irrigated area figures for 1949 to 1964 are enclosed in parentheses, probably indicating that they are reconstructions, while no figures are presented for 1965–72. The presentation of "hard" numbers for guaranteed and actually irrigated area in the earlier period may indicate that these were the categories used at that time by Shanxi's water resource authorities. The disruption of the Cultural Revolution may explain the gap in effectively irrigated area reports after 1965.

The East (Jiangsu, Hubei, Anhui, and Shanghai)

The east spans the transition zone between rice-growing and nonrice-growing areas. It is relatively well developed economically and agriculturally, especially in coastal Jiangsu and Shanghai. Except for Jiangsu, where the irrigated area has continued to grow in the 1970s and 1980s, the region's irrigated area had stabilized by the early 1970s (see Figure 8).

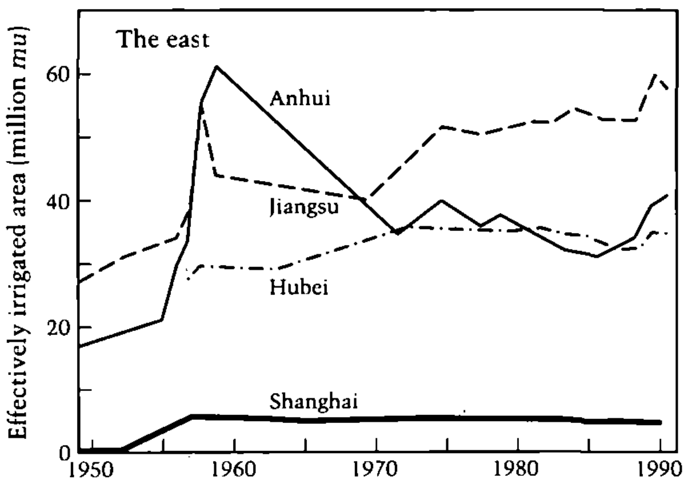

Figure 8 Irrigated area trends by region: The east, 1949–91 (Source: Ministry of Water Resources of the People's Republic of China). Years without observations filled in through linear extrapolation. See figures in Table A.2 for 1949–79 and Tables A.3–A.8 for 1983–91.

Nearly two-thirds (64 percent) of the cultivated area in the east is irrigated, second only to the south. In Shanghai, virtually all farmland has been under irrigation (98 percent), all of it powered by electricity. Anhui, an inland province with much of its territory in the north, is at the other extreme, with less than one-half the cultivated area irrigated. Yet this proportion is high compared to much of the rest of the country.

Continuous series are available for both Anhui and Shanghai. The provincial yearbook for Anhui shows an unusually smooth increase in irrigated area through 1979, with no sharp changes, after which a gradual decline is evidenced. (Only 1965 registered a year-to-year increase slightly in excess of 10 percent.) This growth curve is suspiciously uniform, undoubtedly the result of ex-post smoothing. The scattered figures we have from contemporary sources are much higher, especially but not exclusively in the late 1950s. They are also more erratic. Nevertheless, it is probable that the adjusted, smoothed figures are closer to the actual situation than the previous reports. Since southern Anhui lies in the historically developed rice-growing Jiangnan region, new irrigation is most likely to have been concentrated in the north, a poor region on the southern part of the North China Plain.

During the Great Leap Forward, both Anhui and Hebei stressed the construction of reservoirs. Hebei is on the northern section of the Plain, with a flatter topography and a high water table. In Anhui, the key project was China's largest reservoir-based irrigation district (or integrated set of districts), the Pi-Shi-Hang. While Hebei also built reservoirs in its mountains, no single source has been as dominant, or as consistent, as the Pi-Shi-Hang. On the contrary, Hebei has turned to a mix of water sources and delivery systems, which have often proven unsustainable.

Anhui, with its deeper water table, has benefited much less from pump wells. Since pump-well construction occurred in waves, the growth in Hebei's irrigated area, although more substantial over the long run than Anhui's, has also been more erratic. Until 1965, the two provinces had comparable irrigated areas; since 1966, Hebei's has been far greater.

Shanghai, China's most productive rice-growing delta, had a surprisingly low irrigated area in 1957, according to these figures. Growth is shown to be particularly rapid during the Great Leap Forward and in the difficult years immediately following it, when most provinces leapt backwards.[43] Shanghai then evidenced relatively moderate and steady (and statistically significant) expansion throughout the 1960s and the early 1970s. After peaking at 5.34 million *mu* in 1974–77, irrigated area declined slowly but consistently. Since virtually all (96–99 percent) of Shanghai's cultivated area is irrigated, this decline is directly associated with a reduction in agricultural land.

The South (Guangdong, Zhejiang, and Fujian)

Dominated by rice culture, the three southern provinces have the highest irrigation-to-cultivation ratio of the seven regions (72 percent). Unlike the northern dryland regions, they have shown few remarkable changes in irrigated area since 1962 (Figure 9). Between the Great Leap Forward endpoints of 1957

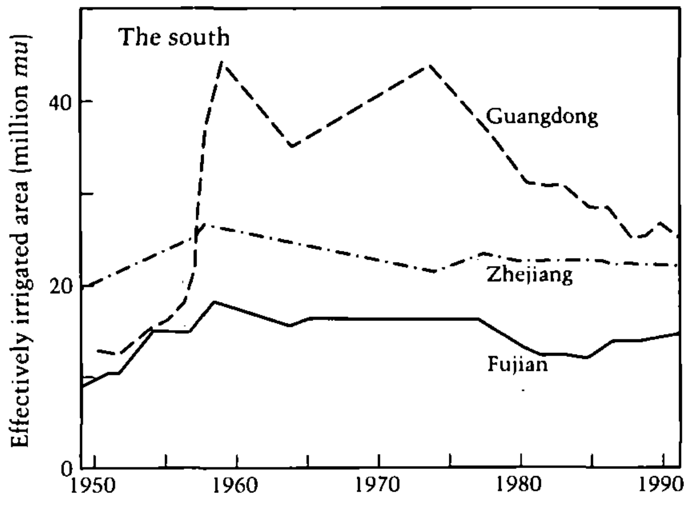

Figure 9 Irrigated area trends by region: The south, 1949–91 (Source: Ministry of Water Resources of the People's Republic of China). Years without observations filled in through linear extrapolation. See figures in Table A.2 for 1949–79 and Tables A.3–A.8 for 1983–91.

and 1962, irrigated area increased by 17 percent (Guangdong) to 24 percent (Fujian), but in Guangdong and Zhejiang this was, to some extent, a recovery from a previous decline.

The Southwest (Hunan, Jiangxi, Guangxi, Yunnan, and Guizhou)

In the southwest, the development pattern of Hunan and Jiangxi as described by MWR statistics has been similar to that of the south: irrigated area is high (now 83 percent and 77 percent of cultivated area) and stable (except for an unusually low 1949 figure). The reason is the same as for the south: the traditional dominance of rice culture. Jiangxi showed more of an upward trend in the 1952–62 period, but like Hunan and unlike more northern provinces, experienced a decline in the 1965–72 period. Irrigated area in the other three provinces increased during that time. The pattern of irrigated area development for all five southwest provinces was similar during the 1970s (Figure 10). They enjoyed steady increases until 1976, followed by stability or decline, the latter perhaps an outcome of the audit.

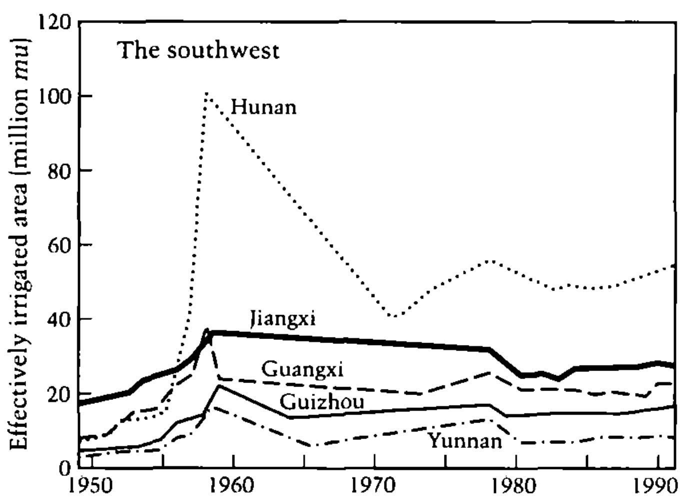

Figure 10 Irrigated area trends by region: The southwest, 1949–91 (Source: Ministry of Water Resources of the People's Republic of China). Years without observations filled in through linear extrapolation. See figures in Table A.2 for 1949–79 and Tables A.3–A.8 for 1983–91.

Agriculture in Guangxi, Guizhou, and Yunnan is less dependent on irrigation than in Hunan and Jiangxi. In the latter two, dryland dominates. In Yunnan, a significant amount of rice is grown without irrigation. As a region, the southwest relies heavily on reservoirs and less on power for its irrigation.

The West (Sichuan, Xinjiang, Qinghai, and Xizang)

Agriculture and irrigated area in the west are concentrated in two provinces, Sichuan and Xinjiang. Over the past three decades total MWR irrigated area and its long-term pattern of development have been roughly the same in each, but with a number of short-term differences (Figure 11). Unlike most of China's other provinces, both had their most rapid growth during the 1950s. Since then, Sichuan's irrigated area total has fluctuated above and below the more stable total for Xinjiang, where agriculture is much more dependent on irrigation. At 89 percent, Xinjiang's irrigation-to-cultivation ratio is second only to that of Shanghai, while less than one-

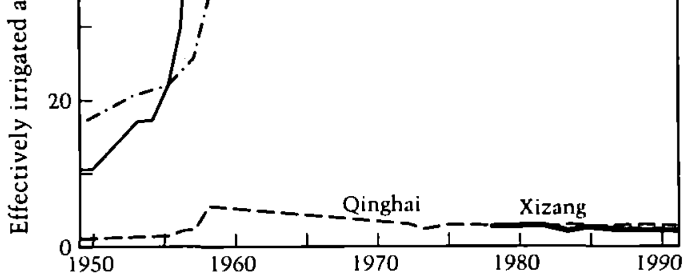

Figure 11 Irrigated area trends by region: The west, 1949–91 (Source: Ministry of Water Resources of the People's Republic of China). Years without observations filled in through linear extrapolation. See figures in Table A.2 for 1949–79 and Tables A.3–A.8 for 1983–91.

half (43 percent) of Sichuan's farmland is irrigated. Xizang irrigates 55 percent of its farmland, while most of Qinghai, on the upper reaches of the Huang He and the Chang Jiang (Yangtze), is dryland. Irrigated area in Qinghai, as in Xinjiang and Sichuan, increased rapidly during the 1950s but has since remained largely stable. The record for Xizang does not extend into the 1950s.

The west is the region most dependent on gravity irrigation. Sichuan, with the greatest reliance of the four on power, at 20 percent of irrigated area, is well below the national average on this dimension (Table 14).

THE 1980s DECLINE AND RECOVERY OF IRRIGATED AREA

Much concern was registered both from within China and by outside observers about the decline in irrigated area during the 1980s. For example,

> A new compulsory labor service system is being introduced in China's rural areas to organize farmers to repair and improve old water facilities.
>
> The system is part of the national effort to step up production by increasing irrigated farmland, which shrank by an annual average of nearly 200,000 hectares (3.0 million *mu*) between 1981 and 1985 and by 62,000 hectares (930,000 *mu*) in 1986. (Nie 1987, 1)
>
> Water conservancy facilities in rural areas are falling into disrepair. Since the implementation of the responsibility system, farmers who were once organized have been scattered and are fully occupied with farming on the patches of land contracted to them. Not enough capital and workers can be mobilized to repair the old and build new facilities. This will pose a threat to agricultural production in the future. (*China Daily* 1989a)
>
> Sichuan used to have a good irrigation network. However, these water conservancy works have not been given enough attention and proper management has been difficult since the province adopted a contract system in farming and mass irrigation projects. (*China Daily* 1989b)
>
> Water conservancy . . . has been neglected in recent years, resulting in a decrease in irrigated farmland.

More than 930,000 hectares of irrigated farmland have been lost since 1980, according to Li Boning, former Vice-Minister of Water Resources . . . .

If the State fails to attach more importance to water conservancy, the consequences could be unimaginable, he warned. (Li and Gao 1989)

Irrigation works are not being maintained, and here and there some of the Yangtze dike system are crumbling into the water. (Feldman 1987, 4)

Table 14 Provincial ranking by extent of power irrigation, 1989

Province	Power irrigated area as % of irrigated area	Province	Electric power as % of irrigated area	Province	Electric power as % of power irrigated area
Tianjin	100.0	Tianjin	91.0	Beijing	99.9
Hebei	91.6	Beijing	84.6	Sichuan	97.3
Jiangsu	90.3	Liaoning	72.1	Shaanxi	95.6
Liaoning	89.0	Shanxi	69.1	Yunnan	95.5
Shandong	87.7	Jiangsu	64.9	Ningxia	95.2
Beijing	84.7	Zhejiang	63.0	Shanxi	94.8
Jilin	77.9	Shaanxi	59.7	Gansu	94.0
Zhejiang	75.5	Hebei	57.8	Tianjin	91.0
Shanxi	72.9	Anhui	53.3	Guizhou	87.1
Henan	72.9	Jilin	48.7	Zhejiang	83.4
Anhui	72.0	Neimenggu	45.6	Guangdong	83.1
Shaanxi	62.5	Shandong	40.4	Qinghai	81.5
Hubei	61.9	Henan	37.6	Liaoning	81.0
Neimenggu	61.6	Hubei	35.2	Neimenggu	74.1
Heilongjiang	55.0	Gansu	33.6	Anhui	74.1
Hunan	49.2	Hunnan	33.0	Jiangsu	71.9
Gansu	35.7	Guangdong	26.5	Jiangxi	69.8
Guangdong	31.9	Heilongjiang	23.6	Hunnan	67.0
Sichuan	22.1	Sichuan	21.5	Xinjiang	65.2
Jiangxi	22.0	Ningxia	20.5	Hebei	63.1
Ningxia	21.5	Jiangxi	15.3	Jilin	62.5
Fujian	19.7	Yunnan	13.9	Guangxi	56.9
Guangxi	18.8	Guangxi	10.7	Hubei	56.9
Yunnan	14.5	Fujian	10.2	Fujian	51.7
Xinjiang	11.3	Guizhou	9.8	Henan	51.5
Guizhou	11.3	Qinghai	8.8	Shandong	46.0
Qinghai	10.8	Xinjiang	7.4	Heilongjiang	42.9
Xizang	5.5	Xizang	0.0	Xizang	0.0

Source: Calculated from data in ZGNYNJ90, 388, 403. See Table A.17.

A State Council office communique, which reported on a legal document promulgated on 17 October 1985 (ZHFG49–85, 394–97), declared that the irrigated area had fallen by 7.31 million *mu* between 1981 and 1984. The chief reasons given for the decline were a slackening in leadership, inadequate operation, maintenance, and repair, aging and "ailing" projects, and destruction by human agency. The communique called for remedial action.

Behind these factors were the widespread replacement of collective (production team) field management by the household "production responsibility system"; the concomitant elimination of the work point system, a low-cost, easily administered means of mobilizing rural labor for construction and maintenance (Nickum 1978); a severe cutback in the budget allocated to project construction and maintenance beginning in 1980; the aging of a large number of projects, especially reservoirs built in the late 1950s and pump wells dug in the late 1960s and 1970s; and the occupation of farmland for nonagricultural purposes following growth in the industrial, commercial, and residential sectors of the economy.

Certainly growth in the overall irrigated area paused in the late 1970s and 1980s. Nonetheless, the published figures presented here indicate that the claims of the communique and the press of a perilous drop in irrigation capability should be considered with caution.

Specifically, the amount of decline claimed in the communique is just over 1 percent of the total irrigated area in three years, not in itself very significant. The 14–15 million *mu* drop for 1981–86 implied in the 1987 Nie report is about 2 percent of the total. The 1986 figure cited, 930,000 *mu*, is a significant deceleration in the rate of decline compared with the immediately preceding years.

Second, SSB reports show a total net decline of less than 2 million *mu* (from 668.6 million *mu* to 666.8 million *mu*) between 1981 and 1984, followed by a further drop of 6,256,000 *mu* in 1985 (to 660.5 million *mu*) but an increase of 2.85 million *mu* in 1986, followed by an additional 2.66

million *mu* in 1987 (Table A.1). The 1983 SSB total was actually greater than the 1981 figure, indicating that while there may have been a downward trend, it was certainly not a steady one. More recently, SSB reported a 1989 total which was the highest in the 1980s (673.76 million *mu*) (see Table A.1).

The claims of the communique and Nie would appear therefore to be based on MWR data.[44] Unfortunately, we do not have the national MWR totals for 1981. Each of the three years after 1983 showed a decline, however, with a total drop of 10.1 million *mu* (1.4 percent) by 1986. Consistent with Nie's report and the SSB totals, most of this fall occurred in 1985, the year the communique was issued.

Finally, the decline in irrigated area reported by the SSB was considerably more rapid before 1981 than thereafter, falling from 675.3 million *mu* in 1977 to 668.6 million *mu* in 1981 (Table A.1). Actually, after reaching a nadir in 1985, both MWR and SSB national figures increased steadily, with only minor slippage in 1988. This modest decline, 390,000 *mu* (SSB) or 790,000 *mu* (MWR), can hardly have been adequate cause by itself for the alarms of 1989.

In October 1989, the State Council issued a resolution on on-farm water control construction that provided for increases in funding and corvee obligations devoted to irrigation (ZGSLNJ90, 25–27). The 1989 effectively irrigated area statistics jumped by about 1 percent over those of 1988. In the two years since then, MWR figures have increased slightly and those published by the SSB have risen considerably. As noted earlier, the leap forward among the SSB data is primarily a paper phenomenon, due to further unification at the provincial level in favor of the MWR figures.

Sources of Decline: A 1984 Survey

One of the complexities in evaluating statements of decline in irrigated area is that some land naturally goes out of irrigation each year. To keep total irrigated area relatively constant, therefore, an equivalent amount of new land has to be brought under irrigation. Thus it is possible that China's leaders were basing their dire warnings, at least in part, on changes in the amount or quality of the land going out of irrigation. For example, if fertile suburban land were being replaced by remote marginal plots, then net irrigated area would have to increase in order to prevent net agricultural decline. Unfortunately, the standard categories do not shed much light on the significance of this effect.

Table A.18 does show rare MWR figures on the causes of decline in irrigated area in 1984, 1989, and 1990. Clearly, however, specific figures are very approximate. For example, in 1984 seven provinces reported no irrigated land was lost to construction, while Sichuan, Qinghai, Xinjiang, and Anhui attribute all or most of their declines to "other causes."

Nonetheless, a number of conclusions can be drawn from the 1984 survey. First, one-sixth of the reported decline was a purely statistical adjustment, related to "water (sources) being inadequate or absent for a long time."

Second, an additional 35 percent of the reported decline stemmed from pump wells becoming inoperative, or inoperative wells no longer being reported as operating. Most (56 percent, or 3.2 million *mu*) of this was in the single province of Hebei, which also reported more than one-fourth of the total national decline. Given the concentration of pump wells on the North China Plain, it is interesting that the province reporting the second greatest loss in pump well area (Heilongjiang, 750,000 *mu*) is not located in north China.

Institutional change may, indeed, have been a factor in accelerating the demise of many wells, through inadequate specification of ownership and use rights, for example, leading to overuse and neglect of maintenance. But it is not all that clear that these problems are any more salient now than under the previous collective management system (Nickum 1988, 90–91). One indication that the decline in pump well irrigated land was more technical (due to age) than institutional in origin is that the area irrigated by other sources and reported as inoperative accounted for less than one-half that by pump wells (14 percent). This includes loss due to damage of installations.

Third, despite much publicity in the press concerning the loss of farmland to residences and industry, only 5 percent of land was reported as occupied by construction. Much more may be hidden in the 30 percent covered by "other causes," however.

Finally, the reported extent of decline varied considerably from province to province, both in total and by cause. Heilongjiang reported a single-year drop of 11.32 percent; Jiangxi, only 0.25 percent. In general, irrigated area fell more in predominantly dryland provinces than in those growing mostly rice, indicating the relative fragility of irrigation in the former. There are some important exceptions, however: Anhui, Sichuan, Shanghai, and Guizhou all had above-average declines, while Xinjiang, Qinghai, Henan, Beijing, and Shanxi were below average.

Declines due to construction were concentrated in Beijing, Tianjin, and Shanghai; those due to inoperative pump wells, in the northeast and north (especially Hebei); and to deliberate destruction in Guizhou, Guangxi, Jiangxi, Gansu, Guangdong, Shanxi, and Shaanxi. Xinjiang, Qinghai, Sichuan, Fujian, Anhui, and Hunan all attributed more than one-half of their losses to "other causes." Damage by human agents may also have constituted a significant share of the unattributed causes, considering the pattern established by provinces that provided a more detailed breakdown.

The first two *China Water Resources Yearbooks* have published breakdowns of sources of decline in 1989 and 1990 using categories identical to 1984, indicating that these figures have probably been gathered for a number of years for internal purposes. While there is considerable year-to-year variation in total levels and in breakdowns within certain provinces, the overall orders of magnitude attributed to different sources have not changed. This indicates that the primary causes for decline are aging (especially of tubewells) and unsustainable uses. While there may be cause for concern in these areas, diversion of land for other uses, such as construction, is apparently far from the most significant factor behind reductions in irrigated area.

Province-Level Trends: Regression Results

The available data therefore do not show a clear nationwide trend of decline in irrigated area. Instead, there is much variation over time and space. In a period as short as the 1980s decade, endpoint bias may be significant. With complete SSB data from 1980 to 1987, it is possible to calculate time series regressions by province. The results are presented in Table 15 and Figure 3. A simple linear regression fits as well as or

Table 15 Provincial growth rates of effectively irrigated area, 1980–87

Province	Trend growth rates (%/year)
Guizhou	2.68 *
Hunan	2.15 **
Jiangxi	1.67 **
Heilongjiang	1.37
Ningxia	1.27 ***
Yunnan	0.99 ***
Fujian	0.82
Xinjiang	0.56 **
Jiangsu	0.54 **
Qinghai	0.46 *
Shandong	0.36 *
Liaoning	0.25
Hebei	–0.01
Beijing	–0.14
Jilin	–0.16
Shaanxi	–0.20
Zhejiang	–0.25 *
Gansu	–0.42 ***
Shanxi	–0.64 ***
Hubei	–0.92 ***
Neimenggu	–0.99
Shanghai	–1.04 ***
Henan	–1.10 **
Sichuan	–1.77 ***
Guangdong	–1.78 ***
Tianjin	–1.78 ***
Anhui	–2.22 ***
Xizang	–2.50 *
Guangxi	–5.10

Source: Calculated from data in Table A.11.
Note: Estimated by dividing regression coefficients derived from ordinary least squares estimation by mean values of the sample. Levels of confidence used are 90% (*), 95% (**), and 99% (***).

better than a log-linear regression, indicating the general absence of a cumulative trend over the period.

Over these seven years, twelve of China's twenty-nine provinces showed an upward trend in irrigated area. Of the remaining seventeen provinces where the irrigated area showed a tendency to decline, the drop was less than 1 percent per year in ten and statistically different from zero (at a 95 percent level of significance) in nine. If 1981 is used as the base, following the communique, the negative trend is slightly less widespread, with only sixteen provinces showing declines, nine of them significant at 95 percent.

So Why the Concern?

Of more concern to Chinese policy makers than the magnitude of decline per se seems to be the pattern of decline (especially in the north) and the lack of increase in irrigated farmland. Until the mid-1970s, irrigated area naturally increased from year to year. Irrigation is seen as a principal means of ensuring increases in food production. This is commonly translated into a felt need to increase the area under irrigation, to as much as 930 million *mu* in the year 2000 (Liu 1984, 69) in order to produce a targeted 500 million metric tons of grain in that year.

This concentration of attention on irrigated area per se indicates either that people take the category too seriously or that they have a gloomy assessment of alternatives such as more intensive or effective irrigation or better use of other inputs. Consideration of these alternatives poses a problem in economics that irrigated area statistics per se are not very useful for analyzing.

Also, pointing to the decline in irrigated area is a way of calling attention to problems in the water sector. It can be used to exhort farmers to cooperate more in project construction and operation. More important, as implied in the quote from the former Vice-Minister of Water Resources cited earlier in the chapter, it can be used as a means of lobbying for increases in government funding for water-related projects that go well beyond irrigation. The sharper decline shown by the MWR data serves these ends better than the ups and downs of the SSB series.

The Recovery

State allocations of funds to water investment jumped after 1986. As already noted, both the SSB and MWR effectively irrigated area totals have increased. By 1991, the MWR figure was higher than all previous years except for 1982, 1983, and possibly 1980 and 1981, for which published figures are not yet available (Table A.1). The SSB total was at a record level, not counting 1958, but, as noted, this was due to the 1990 adjustment and possibly a further consolidation in 1991.

Longer-term provincial level trends shown by regression analysis for the years 1980–91 indicate significant declines in effectively irrigated area (more than 1 percent per year with a 99 percent confidence level) only in the most rapidly developing, heavily urban coastal provinces of Guangdong, Tianjin, and Shanghai. While this is a natural reflection of a shift in the economic structure under rapid growth, there is some indication that the "quality" of irrigated area may be declining as high-yielding multiple crop fields in coastal regions go out of irrigation and less productive single-crop fields in inland regions are added to the total. Thus those who wish to worry may still have cause to worry, but they would make a better case by appealing to indices other than national irrigated area.

SUMMARY

One of the main messages of this section, and a principal subtheme earlier, is that national trends in irrigated area are dominated by what is going on in individual provinces or regions. In fact, there is rarely a geographically consistent nationwide trend. For example, as noted earlier, the wartime decline prior to 1949 was concentrated in Sichuan, Yunnan, and Guizhou. Post-1949 "restoration" to the prewar national aggregate actually appears to have involved net increases in other parts of China, as those three provinces continued to lag in recovery.

To demonstrate the necessity to look beneath the national numbers, this section delineated intertemporal trends in irrigated area by region. The north relies heavily on pump wells installed during the 1960s and 1970s. Irrigation is much less significant in the northeast and northwest, and its development has been erratic. The east, spanning the transition zone between rice and nonrice areas, has a varied but generally highly developed irrigation, much of it originating in the 1950s and 1960s. The rice-dominant south has shown few remarkable changes in irrigated area since 1962. The southwest exhibited much variation among provinces before 1970, general increases during the early 1970s, and stability or decline since. Most of the increase in irrigated area in the west, dominated by development in Sichuan and Xinjiang, was in the 1950s.

To demonstrate some of the uses and possible abuses of aggregate irrigated area statistics, this section dwelt on the perceived decline in total irrigated area in the early 1980s, which caused much concern among officials. In actuality, there was no demonstrably clear, nationwide downward trend at that time. There was great variation among provinces, however, with many actually showing an upward trend during 1980–87.

Further, and more fundamentally, many other problems of definition and interpretation bring into question the statistical basis for claiming a decline at all. For example, about one-half of the drop in 1984 can be attributed to statistical adjustments such as deleting inoperative wells and land that had failed to receive water for a long time. In recent years, even MWR total irrigated area figures have increased slightly, and the alarm among public officials and the media has abated. But without more economically meaningful data, it is hard to assess this turnaround in numbers.

A century ago, Otto von Bismarck, the first chancellor of Germany, is reputed to have likened politics to sausage—

you can enjoy the final product more if you don't know much about how it was made. Perhaps one should not question too closely what goes into the preparation of irrigated area statistics. Having done so, however, it is necessary to consider in the concluding section the implications for those who wish to work with these numbers.

SUMMING UP WITH IMPERFECT MEASURES

China's irrigated area statistics rank among the world's most comprehensive, consistent, frequently reported, and, presumably, accurate data. Nonetheless, they are prone to many problems of definition and agency bias, which China shares with the rest of the world[45] and which pose a number of difficulties to the outside analyst and, probably, the governmental decision maker.

In particular, command area figures such as "effectively irrigated area" are the most widely used, presumably because their measurement costs are the lowest, not requiring extensive out-of-office investigations. Yet they are also probably the least useful measure of the importance of water in producing actual crops in particular cropping seasons.

Command area figures do not measure the area actually irrigated in a given year (still less a given cropping season). They do not indicate the degree of crop moisture deficiency or how well it is met. They say nothing about the types of crops or the technical or economic efficiency of application. Unirrigable land is carried on the books for a long time because facilities are no longer functioning (or never did work) or water is no longer available—and audits are infrequent.

Agencies delivering water tend to overstate their reach, while farmers and village-level form fillers may downplay irrigation capacity, to keep the tax collectors at bay. These countervailing biases are reflected in the reports of the MWR and SSB systems, respectively. It is impossible, and probably not all that meaningful, to declare one series superior to the other. When the figures are "unified" at the provincial level, as they are in about one-third of the cases, neither system's data appear consistently to dominate the unification. What the unification process does do, however, is to further complicate interprovincial comparability within each system.

One response to problems in interpreting effectively irrigated area, especially within the Ministry of Water Resources, has been to assemble a number of other data series, such as "actually irrigated area," "stable, high-yield fields," "guaranteed irrigated area," and numbers and capacities of specific kinds of water sources and delivery systems. At the project level, exemplified by the People's Victory Canal, more detailed, project-specific series are maintained. These have their own problems of measurement, some but not all organizationally determined, and make comparability even more difficult.

The original purpose of this research was to assemble a set of figures as complete and consistent as possible from among those reported for irrigated area in post-1949 China. A second purpose was to discuss the problems of measurement entailed in compiling irrigated area statistics, especially but not exclusively in the Chinese context. A third and subordinate purpose was to explain how the figures have been used in policy formation, and how they can be used for analytical purposes.

In general, the primary utility of these numbers to an outside analyst is probably to explain water-related policy decisions in China, and to track roughly trends in irrigated area at a provincial or regional level. Richer explanations require disaggregation below the national level, use of measures supplemental to those primarily associated with command areas, and, most important, full consideration of what the figures mean and how they came to be.

Bases for Grouping Provinces

To analyze its irrigated area, China can be partitioned in a number of ways. Three are considered in this appendix, in decreasing order of aggregation. The most fundamental division in China is between areas where rice-growing bunded fields predominate and those where dryland crops, especially wheat and maize, are the principal crops. Another method is to divide the country by the frequency of the natural moisture deficit (discussed on 21 ff.) into those areas where irrigation is always necessary (perennial), often necessary (unsteady), and primarily supplementary.

For most purposes in this monograph, and especially in examining more closely the differences in development patterns within China, a more detailed breakdown into seven regions was adopted. Because provinces are the basic reporting unit considered in the monograph, these regions consist of groups of provinces with similar geographical and irrigation characteristics. While within-group variation remains considerable, it is generally less than between groups. Regional grouping allows a broader perspective than that which is obtained from simply tracking each individual province.

BY TYPE OF IRRIGATION

The sharpest division in China's irrigated agriculture is between bunded field and irrigated dryland. Provinces are either predominantly dryland, although dryland crops are often grown in bunded fields during the nonrice season. Because provincial farm area is rarely broken down by bunded field and dryland on a comparable nationwide basis, it was necessary to use the reconstructed 1978 data in Table A.16 to subdivide China's provinces according to the percent of irrigated area in bunded fields.

Predominantly Bunded Field

- *More than 90 percent:* Sichuan, Hunan, Guangdong, Jiangxi, Fujian, Guizhou, Guangxi, Zhejiang, and Yunnan (9 provinces)
- *More than 70 percent:* Ningxia, Shanghai, Hubei, Jiangsu, and Anhui (5 provinces)

Predominantly Dryland

- *From 30 to 40 percent:* Jilin, Liaoning, and Heilongjiang (3 provinces)
- *From 10 to 20 percent:* Shaanxi, Beijing, and Henan (3 provinces)
- *Under 10 percent:* Tianjin, Shandong, Hebei, Xinjiang, Shanxi, Gansu, Neimenggu, Qinghai, and Xizang (9 provinces)

The breakdown between bunded field and dryland provinces is also a division between north and south, with only two exceptions: Ningxia, which has bunded fields along the Yellow River; and Xizang (Tibet), which is too dry for bunded field crops. There is unlikely to have been any change in the classification of any province, especially between the two macrocategories, since 1978.

BY IRRIGATION REQUIREMENT

The Ministry of Water Resources divides China into the following three zones, according to the need for irrigation:

- *Perennial Irrigation Zone:* Northwest China, including the middle reaches of the Huang He;
- *Unsteady Irrigation Zone:* Huang-Huai-Hai Plain and northeast China; and
- *Supplementary Irrigation Zone:* Middle and lower reaches of the Chang Jiang, Zhu Jiang, and Min Jiang, and part of southwest China (MWREP 1987, 17).

Provinces with growing areas primarily in the perennial irrigation zone (where average annual precipitation is below 400 mm) are Xinjiang, Ningxia, and Neimenggu. Those primarily in the unsteady irrigation zone (with annual precipitation between 400 mm and 1,000 mm) are Heilongjiang, Jilin, Liaoning, Hebei, Beijing, Tianjin, Shanxi, Shandong, Shaanxi, Henan, Yunnan, Qinghai, and Xizang. The supplementary irrigation zone (where annual precipitation exceeds 1,000 mm) comprises all or the bulk of the cultivated area of Sichuan, Hubei, Hunan, Jiangxi, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi, and Guizhou. Gansu has cultivated land in both the perennial and unsteady zones, while Anhui and Jiangsu straddle the unsteady and supplementary zones.

BY REGION

A more disaggregated classification, based on geographical groupings of provinces, is by the following seven regions:

1. *The north:* Beijing, Tianjin, Hebei, Shandong, and Henan (5 provinces)
2. *The northeast:* Neimenggu, Liaoning, Jilin, Heilongjiang, and Ningxia (5 provinces)
3. *The northwest:* Gansu, Shaanxi, and Shanxi (3 provinces)
4. *The east:* Shanghai, Jiangsu, Anhui, and Hubei (4 provinces)
5. *The south:* Zhejiang, Fujian, and Guangdong (3 provinces)
6. *The southwest:* Jiangxi, Hunan, Guangxi, Guizhou, and Yunnan (5 provinces)
7. *The west:* Sichuan, Xinjiang, Qinghai, and Xizang (4 provinces)

These are divided roughly according to geographical location and type and level of irrigation development. Neimenggu and Ningxia are included in the northeast because of similarities in irrigation and to mitigate difficulties caused by boundary changes.

Note on Neimenggu and Jilin Boundary Shifts

In July 1969, substantial portions of eastern and western Neimenggu (Inner Mongolia) were ceded to Heilongjiang, Jilin, Liaoning, Gansu, and Ningxia. These areas were returned to Neimenggu in July 1979.

Three *meng* (leagues), corresponding to prefectures, and three additional *qi* (banners), corresponding to counties, were transferred back and forth on those two dates (ZRGXQJ 1980, 15):

Hulun Buir Meng:	to and from Heilongjiang
Jirem Meng:	to and from Jilin
Ju Ud Meng:	to and from Liaoning
Ejin Qi:	to and from Gansu
Alxa Zuo Qi:	to and from Ningxia
Alxa You Qi:	to and from Gansu

Of all these, the only one containing significant irrigated agricultural lands is Jirem Meng, which encompasses the western Liao River Plain. This Plain is the second largest irrigated region in Neimenggu, containing 20 percent of the autonomous region's irrigated area. The largest region, the Hetao Plain, has 44 percent (NNSZY 1982, 188–89).

Recently, provincial yearbooks have been published for Jilin, Heilongjiang, Liaoning, and Ningxia, all of them with effectively irrigated area numbers for 1978, which have been adjusted for the 1979 boundary shifts (see Table A.12). A comparison of these figures with the apparently unadjusted ones in the *Compendium of China's Agricultural Geography* (ZGNYDL 1980) indicates significant transfers from both Jilin (3.89 million *mu*) and Liaoning (4.04 million *mu*) and much smaller ones from Heilongjiang (0.34 million *mu*) and Ningxia (0.21 million *mu*).

The transfer from Liaoning is more statistical than real, however. The implied total transfer from other provinces to Neimenggu would be 8.48 million *mu*, not counting Gansu, making a total of at least 18.25 million *mu* for Neimenggu's 1978 irrigated area using current boundaries. Subsequent SSB data (e.g., 16.56 million *mu* for 1980) indicate that while not impossible, this figure is probably 1–2 million *mu* too high (Table A.11).

The problem probably lies in the data series for 1978 used by the Chinese Academy of Sciences (CAS). That series appears to be either from the MWR system or one using similar bases. Published figures for 1983 and 1985 (Tables A.3 and A.4) indicate that MWR data are systematically higher than those of the SSB for most provinces. While irrigated area figures from the two systems are the same in Jilin, indicating they are "unified" at the provincial level there, they are substantially different for Neimenggu, Heilongjiang, Liaoning, and, to a lesser degree, Ningxia.

Using the average disparities for 1983 and 1985 to adjust the CAS figures appears to overcorrect, however. The resultant figures (for Liaoning, 12.27 million *mu*; for Heilongjiang, 6.61 million *mu*; for Ningxia, 3.19 million *mu*; and for Neimenggu, 6.73 million *mu*) imply net transfers *from* Neimenggu to each of the indicated provinces, except Jilin. Clearly, even with the relatively abundant data base available in the early 1990s, no precise estimate can yet be made of the effects of these boundary shifts on the distribution of irrigated area.

Supplementary Tables

Table A.1 National irrigated area figures, 1400–1991

	Irrigated area						
	State Statistical Bureau		Ministry of Water Resources				
Year	ZGTJNJ	Earlier	ZGSLNJ	Earlier	Other sources	As Percent of cultivated area	Per rural capita
			(million *mu*)				(*mu*)
1400					130.00	35.0	(2.00)
Early 1930s					398.00	27.0	(0.80)
1932					320.00		
1949		240.00	238.93	238.93		16.3	
1950		250.00					
1951		280.00					
1952	299.38	320.00	290.03	317.37		17.9	0.59
1953		330.00					
1954		350.00					
1955		370.00					
1956		480.00					
1957	410.08	520.00	375.07	410.81		22.4	0.69
1958		1,000.00					
1962	458.18		430.45	461.16		27.9	0.77
1965	495.82		480.54	480.54		30.9	0.80
1970		540.00					
1972				609.67	639.00		
1973				660.00			
1974				657.16			
1975		649.25	691.81	713.95		46.3	0.89
1976		681.95		681.95			
1977		675.32		722.80			
1978	674.48	674.48	720.80	726.83		48.3	0.89
1979	675.05	675.05	724.78	724.42		48.6	0.89

Table A.1 *(continued)*

	Irrigated area						
	State Statistical Bureau		Ministry of Water Resources			As Percent of cultivated area	Per rural capita
Year	ZGTJNJ	Earlier	ZGSLNJ	Earlier	Other sources		
	(million *mu*)						(*mu*)
1980	673.32	673.32					
1981	668.61	668.61					
1982	662.65	662.65	729.95			49.4	0.87
1983	669.66	669.66	728.19	728.19		49.4	0.87
1984	666.80	666.80	726.00	726.00		49.4	0.87
1985	660.54	660.54	718.99	718.99		49.4	0.86
1986	663.39	663.39	718.09	718.09		49.7	0.80
1987	666.05	666.05	719.50	719.50		50.0	0.84
1988	665.64	665.64	718.71	718.71		50.0	0.83
1989	673.76	673.76	725.06			50.5	0.83
1990	711.04	711.04	725.84	725.84		50.6	0.81
1991	717.33	717.33		726.99		51.2	0.82

Sources: The State Statistical Bureau (SSB) figures under the column ZGTJNJ for 1952, 1957, 1962, 1965, and 1978–90 are from ZGTJNJ91, 331. The 1991 figure is from ZGTJNJ92, 343. The earlier SSB figures are from SSB (1960, 130); for 1975, 1977, 1978, and 1979, from ZGNYJJ81, 133.

The Ministry of Water Resources (MWR) figures under the column ZGSLNJ are from ZGSLNJ91, 653. The earlier MWR figures for 1949, 1952, 1957, 1962, 1965, and 1972–79 are from a table provided by the Planning Office of the Ministry of Water Resources. The figure for 1983 is from ZGSL March 1985, 33; for 1984, ZGSL June 1986, 34; for 1985, ZGSL November 1986, 32; for 1986, ZGSL July 1987, 28; for 1987, ZGSL October 1988, 38; for 1988, ZGSL July 1989, 37.

The estimates from other sources for 1400 and the early 1930s are from Perkins (1969, 64, 216, 225, 236). Perkins' irrigated area figures for the early 1930s are from Buck (1937). Buck's data do not include some outlying regions (a downward bias), and may be skewed toward the more prosperous areas of China proper, which are more likely to have been irrigated (an upward bias). The lower figure for 1932 is based on Cressey (1934, 37), with some adjustment for omitted regions. The figures for 1972 and 1973 are from Perkins (1975, 360).

The data for irrigated area as percent of cultivated area and irrigated area per rural capita are given directly in ZGSLNJ91, 653. The figures for 1400 and the early 1930s are from Perkins (1969), and for 1991, from ZGSL (1992, 647).

Figures in parentheses are estimates.

Blank cells = Data not available.

Table A.2 Effectively irrigated area figures from the Ministry of Water Resources, 1949–79

Province	1949	1952	1957	1962	1965	1972	1973	1974	1975	1976	1976a	1977	1978	1979	76/76a
								(million *mu*)							
Beijing	0.13	0.20	0.58	1.61	3.44	4.37	4.50	4.69	4.88	5.09	4.96	5.14	5.13	5.11	1.026
Tianjin	0.37	0.50	0.73	na	na	1.41	1.41	4.46	4.97	5.14	5.13	5.55	5.71	5.78	1.002
Hebei	12.35	15.96	30.77	25.01	30.24	46.48	51.38	49.71	53.50	55.30	52.26	54.46	54.90	55.06	1.058
Shanxi	3.68	5.84	9.88	10.69	11.35	14.05	15.74	17.12	17.98	18.70	16.00	17.03	18.83	17.12	1.169
Neimenggu	4.16	6.49	9.00	15.66	17.40	8.76	12.59	13.31	14.04	14.74	10.86	14.99	13.81	19.41	1.357
Liaoning	1.09	1.53	5.40	4.72	5.68	15.35	19.41	22.45	25.54	23.01	17.49	18.12	18.80	15.40	1.316
Jilin	1.30	1.73	5.54	3.67	3.49	13.99	14.21	16.15	17.84	19.62	15.00	15.95	15.48	10.89	1.308
Heilongjiang	1.91	1.86	4.26	4.88	3.90	7.10	11.10	9.90	10.36	13.27	11.00	13.40	12.67	12.25	1.206
Shanghai	0.13	0.13	5.74	5.40	5.00	5.26	5.33	5.34	5.32	5.32	5.32	5.34	5.30	5.24	1.000
Jiangsu	30.93	31.40	33.79	38.76	38.82	47.66	51.12	51.69	54.46	56.65	54.74	56.86	57.22	58.55	1.035
Zhejiang	20.40	20.83	18.11	21.91	21.37	22.44	21.63	21.74	22.04	22.26	22.26	22.41	22.58	22.80	1.000
Anhui	17.50	20.07	19.69	23.29	24.43	36.15	36.31	38.04	39.83	42.00	36.16	41.71	39.42	40.84	1.162
Fujian	10.18	10.51	11.61	14.43	16.00	15.04	15.35	15.13	15.51	15.93	12.36	13.07	13.34	13.86	1.289
Jiangxi	13.26	19.60	23.06	28.68	30.00	24.05	26.11	27.08	27.76	28.26	28.26	27.32	27.86	28.36	1.000
Shandong	3.66	6.52	16.19	15.68	23.24	48.56	51.56	54.31	57.07	60.59	60.59	64.05	66.22	67.04	1.000
Henan	7.40	11.84	20.05	18.18	21.38	40.91	51.27	56.93	58.07	61.36	55.00	59.09	60.30	59.23	1.116
Hubei	8.00	21.84	20.39	27.61	33.81	39.89	38.23	39.30	39.30	39.86	34.83	38.11	38.97	39.37	1.144
Hunan	15.18	36.63	39.93	38.20	40.68	36.00	37.26	39.06	40.14	40.53	38.00	40.11	40.44	40.56	1.067
Guangdong	30.00	30.72	29.24	34.19	34.26	36.28	36.72	37.19	37.66	38.33	38.33	38.68	39.02	39.37	1.000
Guangxi	12.51	15.32	11.91	12.76	13.70	20.00	21.52	22.28	23.64	24.44	22.77	24.29	24.51	24.14	1.073
Sichuan	11.06	15.53	32.00	40.00	33.63	31.78	37.86	39.33	40.03	42.07	39.12	42.32	43.53	44.58	1.075
Guizhou	2.85	3.39	4.17	4.35	6.15	7.51	7.77	8.26	8.95	9.55	7.37	8.47	8.46	8.61	1.296
Yunnan	4.44	5.20	11.58	11.77	12.80	13.50	14.12	14.95	15.27	15.48	13.26	13.58	14.00	13.90	1.167
Xizang	na	na	na	2.05	2.75	2.29	2.29	2.69	2.69	3.03	2.51	1.99	2.26	2.29	1.207
Shaanxi	3.53	4.89	7.82	9.39	11.16	15.58	16.37	16.98	17.97	18.82	18.82	19.58	19.41	19.72	1.000
Gansu	6.04	7.93	6.45	6.73	7.98	10.98	11.71	13.01	14.12	14.64	14.46	14.89	12.96	12.85	1.012
Qinghai	0.75	0.97	1.73	1.90	2.13	2.34	2.43	2.47	2.52	2.62	2.49	2.70	1.83	2.72	1.052
Ningxia	na	na	3.24	2.99	3.13	3.40	3.53	3.71	3.55	3.71	3.50	3.79	3.88	3.76	1.060
Xinjiang	16.12	19.94	27.95	36.65	37.90	38.50	38.33	38.33	38.94	39.75	39.10	39.80	38.99	35.61	1.017
CHINA	238.93	317.37	410.81	461.16	495.82	609.63	657.16	685.61	713.95	740.07	681.95	722.80	726.83	724.42	1.085

Source: SLTJZL (ca. 1979).

Note: The 1976a figures are from an audit (*heshi*) carried out by the State Planning Commission, the Ministry of Agriculture and Forestry, and the Ministry of Water Resources. The 76/76a column consists of ratios calculated by dividing the 1976 column by the 1976a column. All other figures are in million *mu*.

na = Data not available.

Table A.3 A comparison of Ministry of Water Resources and State Statistical Bureau irrigated area figures, 1983

Province	Irrigated area MWR	Irrigated area SSB	Absolute difference between MWR and SSB	Difference as percent of MWR	Actually irrigated area: Area	Percent of MWR	Percent of SSB
	(million *mu*)				(million *mu*)		
Beijing	5.18	5.15	0.03	0.60	4.78	92.28	92.83
Tianjin	5.49	5.48	0.01	0.22	4.14	75.41	75.58
Hebei	53.90	53.65	0.25	0.47	48.48	89.94	90.37
Shanxi	17.26	16.51	0.75	4.33	14.04	81.34	85.02
Neimenggu	21.77	15.30	6.47	29.74	17.11	78.59	111.86
Liaoning	14.03	10.15	3.89	27.69	9.54	68.00	94.04
Jilin	10.74	10.74	0.00	–0.01	6.61	61.55	61.54
Heilongjiang	13.53	9.47	4.07	30.04	7.38	54.55	77.97
Shanghai	5.19	5.19	0.00	–0.06	4.40	84.78	84.73
Jiangsu	59.44	52.43	7.01	11.79	46.08	77.52	87.89
Zhejiang	22.88	22.88	0.00	0.00	22.40	97.90	97.91
Anhui	37.98	33.43	4.56	11.99	24.81	65.32	74.23
Fujian	13.59	12.29	1.30	9.59	13.01	95.73	105.88
Jiangxi	27.08	27.08	0.00	–0.01	25.96	95.86	95.86
Shandong	68.04	68.04	0.00	0.00	55.71	81.88	81.88
Henan	58.94	48.15	10.79	18.31	38.94	66.07	80.88
Hubei	39.56	34.98	4.58	11.58	28.62	72.35	81.83
Hunan	41.60	41.60	0.00	0.00	38.62	92.84	92.84
Guangdong	38.66	30.66	8.00	20.69	34.45	89.11	112.35
Guangxi	23.20	21.05	2.15	9.25	20.64	88.97	98.03
Sichuan	45.79	45.79	0.00	–0.01	35.58	77.70	77.70
Guizhou	8.90	6.79	2.11	23.73	6.98	78.43	102.83
Yunnan	14.38	14.38	0.00	0.01	12.34	85.81	85.83
Xizang	1.82	1.82	0.01	0.27	na	na	na
Shaanxi	19.61	18.59	1.03	5.23	12.99	66.24	69.90
Gansu	13.27	12.69	0.58	4.37	10.64	80.18	83.85
Qinghai	2.90	2.36	0.54	18.72	2.50	86.21	106.07
Ningxia	3.89	3.50	0.39	9.97	3.71	95.37	105.94
Xinjiang	39.57	39.54	0.03	0.09	40.29	101.82	101.91
Total	728.19	669.66	58.53	8.04	590.75	81.13	88.22

Sources: ZGSL (March 1985, 33); ZGNYNJ84, 160.
MWR = Ministry of Water Resources irrigated area data.
SSB = Data published by the State Statistical Bureau.
na = Data not available.

Table A.4 A comparison of Ministry of Water Resources and State Statistical Bureau irrigated area figures, 1985

Province	Irrigated area MWR	Irrigated area SSB	Absolute difference between MWR and SSB	Difference as percent of MWR	Actually irrigated area: Area	Actually irrigated area: Percent of MWR	Actually irrigated area: Percent of SSB
	(million *mu*)				(million *mu*)		
Beijing	5.11	5.08	0.03	0.67	4.56	89.24	89.83
Tianjin	5.27	5.24	0.03	0.53	4.25	80.65	81.08
Hebei	53.83	53.59	0.24	0.45	49.25	91.49	91.90
Shanxi	17.00	16.19	0.81	4.78	13.86	81.53	85.62
Neimenggu	21.46	14.47	6.99	32.55	16.86	78.56	116.48
Liaoning	14.80	10.86	3.94	26.62	10.30	69.59	94.84
Jilin	10.44	10.44	0.00	–0.04	8.07	77.30	77.27
Heilongjiang	13.83	10.19	3.64	26.30	8.71	62.98	85.45
Shanghai	4.87	5.03	–0.16	–3.20	3.85	79.06	76.60
Jiangsu	60.31	53.82	6.49	10.76	48.31	80.10	89.76
Zhejiang	22.92	22.92	0.00	0.00	22.68	98.95	98.95
Anhui	35.91	31.59	4.32	12.03	26.76	74.52	84.71
Fujian	13.84	11.81	2.03	14.65	12.38	89.45	104.81
Jiangxi	27.19	27.19	0.00	0.01	25.43	93.53	93.54
Shandong	68.48	68.48	0.00	0.00	51.95	75.86	75.86
Henan	57.87	47.85	10.02	17.32	32.98	56.99	68.93
Hubei	39.25	34.40	4.85	12.36	29.85	76.05	86.77
Hunan	41.57	41.50	0.07	0.17	38.27	92.06	92.22
Guangdong	37.21	29.07	8.14	21.87	32.90	88.42	113.16
Guangxi	22.58	20.22	2.36	10.44	18.04	79.89	89.21
Sichuan	41.73	41.73	0.00	0.01	32.11	76.95	76.95
Guizhou	8.16	7.19	0.97	11.90	5.96	73.04	82.90
Yunnan	14.47	14.47	0.00	–0.03	12.57	86.87	86.85
Xizang	2.00	2.00	0.00	0.00	na	na	na
Shaanxi	18.52	17.69	0.83	4.50	14.04	75.81	79.38
Gansu	13.38	12.47	0.91	6.79	10.57	79.00	84.76
Qinghai	2.94	2.40	0.54	18.37	2.40	81.63	100.00
Ningxia	4.12	3.58	0.54	13.18	3.85	93.45	107.63
Xinjiang	39.93	39.07	0.86	2.16	39.31	98.45	100.62
Total	718.99	660.54	58.45	8.13	580.07	80.68	87.82

Sources: ZGSL (November 1986, 32); ZGTJNJ86, 157.
na = Data not available.

Table A.5 A comparison of Ministry of Water Resources and State Statistical Bureau irrigated area figures, 1987

Province	Irrigated area MWR	Irrigated area SSB	Absolute difference between MWR and SSB	Difference as percent of MWR	Actually irrigated area: Area	Actually irrigated area: Percent of MWR	Actually irrigated area: Percent of SSB
	(million *mu*)				(million *mu*)		
Beijing	4.95	5.07	–0.12	–2.42	4.54	91.72	89.55
Tianjin	5.10	5.11	–0.01	–0.20	4.44	87.06	86.89
Hebei	54.29	54.09	0.20	0.37	50.69	93.37	93.71
Shanxi	16.79	16.16	0.63	3.75	13.89	82.73	85.95
Neimenggu	21.04	15.57	5.47	26.00	17.37	82.56	111.56
Liaoning	14.87	11.53	3.34	22.46	11.39	76.53	98.70
Jilin	11.29	11.29	0.00	0.0	8.92	79.01	79.01
Heilongjiang	14.49	11.49	3.00	20.70	10.10	69.70	87.90
Shanghai	4.90	4.90	0.00	0.00	4.61	94.08	94.08
Jiangsu	60.82	52.78	8.04	13.22	47.21	77.62	89.45
Zhejiang	22.40	22.44	–0.04	–0.18	21.84	97.50	97.33
Anhui	36.58	32.35	4.23	11.56	26.84	73.37	82.97
Fujian	13.83	13.83	0.00	0.00	12.74	92.12	92.12
Jiangxi	27.32	27.32	0.00	0.00	26.15	95.72	95.72
Shandong	67.21	67.21	0.00	0.00	55.55	82.65	82.65
Henan	58.60	48.75	9.85	16.81	36.73	62.68	75.34
Hubei	38.70	33.17	5.53	14.29	28.40	73.39	85.62
Hunan	39.98	39.98	0.00	0.00	38.02	95.10	95.10
Guangdong	36.69	27.82	8.87	24.18	32.40	88.31	116.46
Guangxi	22.29	20.61	1.68	7.54	18.55	83.22	90.00
Sichuan	41.18	41.18	0.00	0.00	34.55	83.90	83.90
Guizhou	8.07	8.07	0.00	0.00	6.16	76.33	76.33
Yunnan	14.60	14.60	0.00	0.00	13.14	90.00	90.00
Xizang	1.94	1.94	0.00	0.00	1.50	77.32	77.32
Shaanxi	18.89	18.89	0.00	0.00	15.23	80.62	80.62
Gansu	13.13	12.51	0.62	4.72	11.27	85.83	90.09
Qinghai	3.07	2.47	0.60	19.54	2.43	79.15	98.38
Ningxia	4.27	3.80	0.47	11.01	3.78	88.52	99.47
Xinjiang	42.21	41.11	1.10	2.61	39.49	93.56	96.06
CHINA	719.50	666.04	53.46	7.43	597.92	83.10	89.77

Sources: ZGSL (October 1988, 38); ZGNYNJ88, 234.

Table A.6 A comparison of Ministry of Water Resources and State Statistical Bureau irrigated area figures, 1988

Province	Irrigated area		Absolute difference between	Difference as percent	Actually irrigated area		
	MWR	SSB	MWR and SSB	of MWR	Area	Percent of MWR	Percent of SSB
	(million mu)				(million *mu*)		
Beijing	4.92	5.07	–0.15	–3.05	4.59	93.29	90.53
Tianjin	5.12	5.14	–0.02	–0.39	4.45	86.91	86.58
Hebei	54.81	54.44	0.37	0.68	50.27	91.72	92.34
Shanxi	16.66	16.48	0.18	1.08	14.15	84.93	85.86
Neimenggu	21.40	16.19	5.21	24.35	19.10	89.25	117.97
Liaoning	14.85	11.44	3.41	22.96	12.00	80.81	104.90
Jilin	11.62	11.62	0.00	0.00	9.19	79.09	79.09
Heilongjiang	14.88	11.09	3.79	25.47	9.62	64.65	86.74
Shanghai	4.85	4.85	0.00	0.00	4.58	94.43	94.43
Jiangsu	60.30	52.46	7.84	13.00	49.28	81.72	93.94
Zhejiang	22.26	22.26	0.00	0.00	21.76	97.75	97.75
Anhui	37.27	33.22	4.05	10.87	30.38	81.51	91.45
Fujian	13.86	13.86	0.00	0.00	12.69	91.56	91.56
Jianxi	27.26	27.26	0.00	0.00	26.12	95.82	95.82
Shandong	64.84	64.84	0.00	0.00	55.39	85.43	85.43
Henan	58.71	50.38	8.33	14.19	47.71	81.26	94.70
Hubei	38.45	32.60	5.85	15.21	30.66	79.74	94.05
Hunan	40.05	40.00	0.05	0.12	37.24	92.98	93.10
Guangdong	36.12	27.23	8.89	24.61	31.40	86.93	115.31
Guangxi	22.33	20.06	2.27	10.17	18.21	81.55	181.01
Sichuan	41.43	41.43	0.00	0.00	35.11	84.75	84.75
Guizhou	8.17	8.17	0.00	0.00	6.17	75.52	75.52
Yunnan	14.84	14.84	0.00	0.00	13.32	89.76	89.76
Xizang	1.81	1.81	0.00	0.00	0.00	0.00	0.00
Shaanxi	18.57	18.57	0.00	0.00	15.29	82.34	82.34
Gansu	13.32	12.58	0.74	5.56	11.33	85.06	90.06
Qinghai	3.13	2.45	0.68	21.73	2.37	75.72	96.73
Ningxia	4.36	3.83	0.53	12.16	3.88	88.99	101.31
Xingjiang	42.52	41.47	1.05	2.47	40.27	94.71	97.11
Total	718.71	665.64	53.07	7.38	616.53	85.78	92.62

Sources: ZGSL (July 1989, 38); ZGNYNJ89, 433.

Table A.7 A comparison of Ministry of Water Resources and State Statistical Bureau irrigated area figures, 1989

Province	Irrigated area MWR	Irrigated area SSB	Absolute difference between MWR and SSB	Difference as percent of MWR	Actually irrigated area: Area	Actually irrigated area: Percent of MWR	Actually irrigated area: Percent of SSB
	(million *mu*)				(million *mu*)		
Beijing	4.90	5.08	–0.18	–3.67	4.59	93.67	90.35
Tianjin	5.13	5.13	0.00	0.00	4.45	86.74	86.74
Hebei	55.58	55.24	0.34	0.61	52.06	93.67	94.24
Shanxi	16.82	16.72	0.10	0.59	14.52	86.33	86.84
Neimenggu	22.03	17.30	4.73	21.47	19.75	89.65	114.16
Liaoning	15.24	11.40	3.84	25.20	12.34	80.97	108.25
Jilin	12.54	12.54	0.00	0.00	9.89	78.87	78.87
Heilongjiang	15.36	11.66	3.70	24.09	10.86	70.70	93.14
Shanghai	4.81	4.81	0.00	0.00	4.20	87.32	87.32
Jiangsu	60.12	52.97	7.15	11.89	48.58	80.81	91.71
Zhejiang	22.22	22.22	0.00	0.00	21.63	97.34	97.34
Anhui	38.37	34.56	3.81	9.93	29.42	76.67	85.13
Fujian	13.91	13.66	0.25	1.80	12.99	93.39	95.10
Jianxi	27.39	27.39	0.00	0.00	26.48	96.68	96.68
Shandong	65.33	65.33	0.00	0.00	57.32	87.74	87.74
Henan	58.65	51.52	7.13	12.16	36.70	62.57	71.23
Hubei	38.48	32.96	5.52	14.35	29.01	75.39	88.02
Hunan	40.11	40.11	0.00	0.00	37.05	92.37	92.37
Guangdong	35.97	27.49	8.48	23.58	31.55	87.71	114.77
Guangxi	22.39	19.95	2.44	10.90	18.07	80.71	90.58
Sichuan	41.77	41.77	0.00	0.00	35.04	83.89	83.89
Guizhou	8.23	8.23	0.00	0.00	6.16	74.85	74.85
Yunnan	15.30	15.30	0.00	0.00	13.58	88.76	88.76
Xizang	1.81	1.81	0.00	0.00	1.30	71.82	71.82
Shaanxi	18.71	18.62	0.09	0.48	15.30	81.77	82.17
Gansu	13.41	12.62	0.79	5.89	11.53	85.98	91.36
Qinghai	3.20	2.51	0.69	21.56	2.42	75.63	96.41
Ningxia	4.47	3.86	0.61	13.65	4.09	91.50	105.96
Xingjiang	42.81	40.90	1.91	4.46	39.55	92.38	96.70
Total	725.06	673.67	51:39	7.09	610.43	84.19	90.61

Sources: ZGSL (July 1989, 38); ZGNYNJ89, 433.

Table A.8 A comparison of Ministry of Water Resources and State Statistical Bureau irrigated area figures, 1990

Province	Irrigated area MWR	Irrigated area SSB	Absolute difference between MWR and SSB	Difference as percent of MWR	Actually irrigated area: Area	Actually irrigated area: Percent of MWR	Actually irrigated area: Percent of SSB
	(million *mu*)				(million *mu*)		
Beijing	4.93	5.03	-0.10	-2.03	4.63	93.91	92.05
Tianjin	5.19	5.19	0.00	0.00	4.50	86.71	86.71
Hebei	56.59	56.38	0.21	0.37	52.61	92.97	93.31
Shanxi	17.07	17.02	0.05	0.29	14.83	86.88	87.13
Neimenggu	23.10	18.77	4.33	18.74	19.76	85.54	105.27
Liaoning	15.89	15.89	0.00	0.00	12.69	79.86	79.86
Jilin	13.33	13.23	0.10	0.75	10.51	78.84	79.44
Heilongjiang	16.18	16.18	0.00	0.00	11.89	73.49	73.49
Shanghai	4.80	4.80	0.00	0.00	4.26	88.75	88.75
Jiangsu	59.56	59.56	0.00	0.00	48.06	80.69	80.69
Zhejiang	22.16	22.16	0.00	0.00	21.57	97.34	97.34
Anhui	39.50	39.50	0.00	0.00	31.18	78.94	78.94
Fujian	14.00	14.00	0.00	0.00	12.95	92.50	92.50
Jianxi	27.55	27.55	0.00	0.00	26.55	96.37	96.37
Shandong	66.95	66.95	0.00	0.00	57.91	86.50	86.50
Henan	53.25	53.25	0.00	0.00	37.89	71.15	71.15
Hubei	35.50	34.86	0.64	1.80	30.70	86.48	88.07
Hunan	40.14	.40.14	0.00	0.00	37.10	92.43	92.43
Guangdong	36.00	29.06	6.94	19.28	32.03	88.97	110.22
Guangxi	22.63	22.36	0.27	1.19	18.79	83.03	84.03
Sichuan	42.09	42.09	0.00	0.00	36.25	86.12	86.12
Guizhou	8.25	8.25	0.00	0.00	6.21	75.27	75.27
Yunnan	15.81	15.81	0.00	0.00	14.32	90.58	90.58
Xizang	1.95	1.90	0.05	2.56	0.00	0.00	0.00
Shaanxi	18.94	18.95	-0.01	-0.05	15.94	84.16	84.12
Gansu	13.65	12.82	0.83	6.08	11.85	86.81	92.43
Qinghai	3.26	2.57	0.69	21.17	2.46	75.46	95.72
Ningxia	4.70	3.90	0.80	17.02	4.38	93.19	112.31
Xingjiang	42.87	42.87	0.00	0.00	39.74	92.70	92.70
Total	725.84	711.04	14.80	2.04	621.56	85.63	87.42

Sources: ZGSLNJ91, 654; ZGTJNJ91, 332.

Table A.9 Reconstituted preunification Ministry of Water Resources and State Statistical Bureau irrigated area totals, 1983–90

	1983	1985	1987	1988	1989	1990
			(million *mu*)			
Reported MWR EIA	728	719	720	719	725	726
Reconstituted MWR EIA	745	722	737	723	746	716
Difference	–17	–3	–18	–5	–21	10
Reported SSB EIA	670	661	666	661	674	711
Reconstituted SSB EIA	656	643	654	630	666	674
Difference	14	18	12	30	8	37
MWR EIA unified	(33)	(26)	(35)	(32)	(34)	(65)
SSB EIA unified	(35)	(28)	(37)	(35)	(36)	(67)
MWR AIA	591	580	598	617	610	622

Sources: The figures are calculated from data in ZGSL (March 1985, 33; November 1986, 32; October 1988, 38; July 1989, 37; January 1991, 38); ZGNYNJ84, 160; ZGNYNJ86, 157; ZGNYNJ88, 234; ZGTJNJ89, 433; ZGTJNJ90, 403; ZGTJNJ91, 332; and ZGSLNJ91, 654. See Tables A.3–A.8.

EIA - Effectively irrigated area.

AIA - Actually irrigated area.

Figures in parentheses represent percentages of effectively irrigated area reported by each system that are identical to those reported by the other system.

The data are defined or calculated as follows:

$$\Sigma_{i=1}^{29} A_{iM} = A_M; \quad \Sigma_{i=1}^{29} E_{iM} = E_M; \quad \Sigma_{i=1}^{29} E_{iS} = E_S;$$

$$\Sigma_{i=1}^{n} E_{iM} = \Sigma_{i=1}^{n} E_{iS} = E'_U; \quad \Sigma_{i=n+1}^{29} E_{iM} = E'_M;$$

and $\Sigma_{i=n+1}^{29} E_{iS} = E'_S$; where

$E'_U + E'_M$ is reported MWR EIA;

$E'_U + E'_S$ is reported SSB EIA; and

E_S is reconstituted SSB EIA;

where A refers to AIA; E refers to actual EIA; n refers to number of unified provinces; E' refers to reported EIA; and for subscripts, M refers to MWR, S refers to SSB, and U refers to unified provinces.

(1) Set $A_M / E_M = \beta_M$ and $A_M / E_S = \beta_S$,

(2) Assume $A'_M / E'_M = \beta'_M = \beta_M$ and $A'_M / E'_S = \beta'_S = \beta_S$.

(3) Then $E_M = \beta'_M A_M$ and $E_S = \beta'_S A_M$.

For assumption (2) to hold when $E_M > E_S$, it is necessary but not sufficient for

(4) $\beta'_S > \beta^*_S > \beta^*_M > \beta'_M$, where

$$\beta^*_S = A_M / (E'_U + E'_S) \quad \text{and} \quad \beta^*_M = A_M / (E'_U + E'_M).$$

This condition holds for the first five years (e.g., in 1989, .917 > .906 > .842 > .819), but for 1990, when $\beta'_M > \beta^*_M$ (.868 and .856, respectively), indicating some atypicality in the remaining ununified provinces, causing $\beta'_M > \beta_M$.

Table A.10 Estimates for 1978 irrigated area

Province	Cultivated area: Percent of national total	Cultivated area: Total	Percent bunded	Bunded fields	Dry cultivated land: Total	Dry cultivated land: Percent irrigated	Dry cultivated land: Irrigated dryland	Effectively irrigated area
				(million *mu*)				
Beijing	(0.43)	6.41	(10.5)	0.67	5.73	(77.2)	4.43	5.10
Tianjin	(0.47)	7.00	(6.9)	0.48	6.52	(76.0)	4.96	5.44
Hebei	(6.71)	99.98	(1.6)	1.60	98.38	(54.1)	53.22	54.82
Shanxi	(3.94)	58.71	(0.3)	0.18	58.53	(27.6)	16.15	16.33
Neimenggu	(2.75)	40.98	(0.2)	0.08	40.89	(23.7)	9.69	9.77
Liaoning	(4.71)	70.18	(8.1)	5.68	64.49	(17.3)	11.16	16.84
Jilin	(5.08)	75.69	(6.0)	4.54	71.15	(11.7)	8.32	12.87
Heilongjiang	(9.23)	137.53	(2.6)	3.58	133.95	(4.2)	5.63	9.20
Shanghai	(0.36)	5.36	(88.5)	4.75	0.62	(100.0)	0.62	5.36
Jiangsu	(4.68)	69.73	(58.9)	41.07	28.66	(31.3)	8.97	50.04
Zhejiang	(1.84)	27.42	(80.5)	22.07	5.35	(30.0)	1.60	23.67
Anhui	(4.49)	66.90	(39.0)	26.09	40.81	(25.1)	10.24	36.33
Fujian	(1.30)	19.37	(80.9)	15.67	3.70	(0.0)	0.00	15.67
Jiangxi	(2.54)	37.85	(81.6)	30.88	6.96	(0.0)	0.00	30.88
Shandong	(7.34)	109.37	(2.3)	2.52	106.85	(59.4)	63.47	65.98
Henan	(7.20)	107.28	(6.0)	6.44	100.84	(49.2)	49.61	56.05
Hubei	(3.79)	56.47	(52.0)	29.36	27.11	(21.9)	5.94	35.30
Hunan	(3.46)	51.55	(78.2)	40.32	11.24	(0.0)	0.00	40.32
Guangdong	(3.25)	48.43	(75.0)	36.32	12.11	(0.0)	0.00	36.32
Guangxi	(2.58)	38.44	(64.1)	24.64	13.80	(7.1)	0.98	25.62
Sichuan	(6.69)	99.68	(49.7)	49.54	50.14	(0.0)	0.00	49.54
Guizhou	(1.91)	28.46	(41.9)	11.92	16.53	(0.4)	0.07	11.99
Yunnan	(2.74)	40.83	(37.3)	15.23	25.60	(5.9)	1.51	16.74
Xizang	(0.22)	3.28	(0.0)	0.00	3.28	(70.4)	2.31	2.31
Shaanxi	(3.87)	57.66	(4.4)	2.54	55.13	(29.4)	16.21	18.74
Gansu	(3.58)	53.34	(0.3)	0.16	53.18	(23.7)	12.60	12.76
Qinghai	(0.60)	8.94	(0.0)	0.00	8.94	(26.6)	2.38	2.38
Ningxia	(0.90)	13.41	(19.2)	2.57	10.84	(9.6)	1.04	3.61
Xinjiang	(3.20)	47.68	(2.3)	1.10	46.58	(92.3)	43.00	44.09
CHINA	(99.86)	1,487.91	(25.6)	380.00	1,107.91	(30.1)	334.10	714.11

Source: Derived from ZGNYDL (1980, 77–79). The 1978 provincial cultivated area percentages of the national total, as well as the 1978 provincial percentages of cultivated fields that were bunded, appear in the source. Provincial cultivated area totals and the provincial totals of bunded fields are calculated using these percentages and the national cultivated area total of 1,490 million *mu*. The provincial area totals for dry (nonbunded) cultivated land are calculated by subtracting the provincial area totals for bunded fields from provincial cultivated land totals. 1978 irrigated dryland totals are calculated using the calculated dryland totals and the 1978 percentages of dry cultivated land that were effectively irrigated, which appeared in the source. Provincial effectively irrigated area figures are calculated by summing calculated data for irrigated dryland and bunded fields.

Note: Percentages appear in parentheses. All other data are in million *mu*. China columns do not necessarily sum to appropriate totals due to rounding.

Table A.11 Irrigated area figures from contemporary sources, 1931–91

Province	1931	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
							(million *mu*)								
Beijing														1.65	
Tianjin															
Hebei		12.31	12.91	13.58	15.97	16.11	16.19	16.79	25.77	27.00	65.00	63.00			
Shanxi	3.63	3.68	4.43	4.91	5.84	6.39	7.12	7.23	8.38	11.30	22.23				
Neimenggu		4.27	4.47	5.26	6.30	6.97	7.70	8.78	10.94	12.06	20.70	21.00			
Liaoning		0.91	1.12				1.38	1.90	6.30	7.30					
Jilin		1.30			1.65			1.98	3.96	4.86	5.37				
Heilongjiang		0.81					1.51	1.64	2.70	4.50	7.42	15.13			
Shanghai															
Jiangsu	35.57	27.30			30.97				34.00	38.30	54.91	43.90			
Zhejiang		19.50	20.25							25.00	26.70				
Anhui	20.83	17.00						21.13	28.40	34.00	55.00	61.00			
Fujian	11.99	8.60		10.27	10.50	12.50	15.00			14.80	18.04				
Jiangxi	23.66	16.71				21.40	25.20	26.00	27.26	29.00	34.40	35.22			
Shandong	2.40	3.53	3.57	5.40	6.60	6.70	7.20	8.00	24.00	37.00		51.00			
Henan	7.80	7.20		8.40	12.75	13.20		14.51		43.00	100.00				
Hubei	26.27									28.00	29.70				
Hunan	28.84						36.30	41.00	41.67						
Guangdong	24.69		12.90	12.60	12.60	13.80	15.13	15.85	17.40	20.90	35.90	44.00			
Guangxi		7.08		8.60	12.30	14.75	15.58	16.81	21.85	24.96	36.96	24.78			
Sichuan	42.22	11.00	11.00			16.50	17.00	21.35	30.50	55.35	57.90				
Guizhou	9.51	2.85			4.35			4.70	7.82	7.93	16.90				
Yunnan	12.04	4.43			4.68	5.18		7.68	11.40	12.30	15.00	22.38			
Xizang															
Shaanxi	3.11	3.53	3.78	4.51	4.89	5.70	5.45	5.96	8.24	9.73	25.00	26.65			
Gansu	3.86	4.82	5.03	5.79	6.49	6.86	7.40	8.10	13.00	18.00	24.00	22.00			
Qinghai		0.75		0.80	0.86		1.12	1.02	1.57	1.66	5.53				
Ningxia	1.43														
Xinjiang		16.12	16.81	18.10	19.55	20.42	20.99	21.50	23.32	25.77	33.73	37.40			

Table A.11 *(continued)*

Province	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
							(million *mu*)								
Beijing	2.19		3.45								4.00				
Tianjin															
Hebei	36.00								45.00	48.00	47.00	53.00	50.00		
Shanxi		10.20		12.00								13.97			
Neimenggu										8.00	10.47	11.86			
Liaoning												20.00			
Jilin												9.00			
Heilongjiang											12.80				
Shanghai															
Jiangsu							40.00					50.00	51.00		
Zhejiang												21.60			
Anhui										35.00			40.00		
Fujian		15.60	16.20												
Jiangxi															
Shandong										48.00	52.00	53.00			
Henan									40.00	40.00		48.00			
Hubei	29.52										36.00				
Hunan				40.80											
Guangdong		35.00										43.50			
Guangxi															
Sichuan															
Guizhou				6.00											
Yunnan		13.00													
Xizang															
Shaanxi							10.50		14.95		19.50		17.00		
Gansu				6.00								12.00			
Qinghai										2.50	1.95		2.50		
Ningxia											3.50				
Xinjiang													36.00		

(continued)

Table A.11 *(continued)*

Province	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
							(million *mu*)							
Beijing	5.10		5.11	5.12	5.09	5.15	5.14	5.08	5.06	5.07	5.07	5.07	5.03	4.86
Tianjin	5.50		5.69	5.69	5.61	5.48	5.41	5.24	5.11	5.11	5.15	5.13	5.19	5.21
Hebei	54.80		54.33	53.22	53.42	53.65	53.77	53.59	53.11	54.09	54.43	55.24	56.38	57.59
Shanxi	17.40		16.73	16.60	16.50	16.51	16.54	16.19	15.81	16.16	16.47	16.72	17.02	17.24
Neimenggu	10.50		16.56	15.57	15.40	15.30	14.71	14.47	15.09	15.57	16.19	17.30	18.77	19.84
Liaoning	16.90	14.20	11.40	10.77	10.85	10.15	10.44	10.86	10.96	11.53	11.45	11.40	15.89	16.34
Jilin	12.80		10.96	11.17	11.00	10.74	10.67	10.44	10.76	11.29	11.63	12.54	13.23	13.85
Heilongjiang	9.20		10.06	10.47	10.10	9.47	9.35	10.19	10.80	11.49	11.10	11.66	16.18	16.77
Shanghai	5.40		5.24	5.20	5.21	5.19	5.13	5.03	4.90	4.90	4.85	4.81	4.80	4.78
Jiangsu	50.10		51.19	51.84	52.14	52.43	53.95	53.82	53.07	52.78	52.46	52.97	59.56	57.75
Zhejiang	23.40		22.87	22.85	22.88	22.88	22.94	22.92	22.45	22.44	22.26	22.22	22.16	22.14
Anhui	36.30	37.78	36.57	35.90	34.71	33.43	32.41	31.59	31.38	32.35	33.23	34.56	39.50	40.79
Fujian	15.70		13.22	12.54	12.19	12.29	12.06	11.81	13.70	13.83	13.86	13.66	14.00	14.10
Jiangxi	30.90		25.04	25.07	23.83	27.08	27.18	27.19	27.21	27.32	27.26	27.39	27.55	27.72
Shandong	66.30		66.11	66.51	67.23	68.04	68.32	68.48	68.20	67.21	64.85	65.33	66.96	68.28
Henan	56.00		53.04	50.82	48.98	48.15	49.18	47.85	48.19	48.75	50.39	51.53	53.25	55.51
Hubei	35.30		35.18	35.58	35.58	34.98	34.64	34.40	33.79	33.17	32.60	32.96	34.87	34.96
Hunan	40.30		36.24	36.22	35.56	41.60	41.63	41.50	41.58	39.98	40.00	40.11	40.14	39.19
Guangdong	36.30		31.62	31.13	30.72	30.66	29.71	29.07	28.70	27.82	27.23	27.50	29.07	28.26
Guangxi	25.60		21.49	21.20	21.09	21.05	20.75	20.22	20.25	20.61	20.07	19.95	22.36	22.53
Sichuan	49.50		45.34	45.54	45.65	45.79	44.57	41.73	40.94	41.18	41.43	41.77	42.09	42.40
Guizhou	12.60		6.85	6.76	6.57	6.79	6.23	6.19	7.98	8.07	8.18	8.23	8.25	7.68
Yunnan	16.70	13.70	13.70	13.78	13.86	14.38	14.42	14.47	14.50	14.60	14.84	15.30	15.81	16.23
Xizang	2.30		2.23	2.19	2.06	1.82	1.68	2.00	1.83	1.94	1.80	1.81	1.90	1.70
Shaanxi	18.70	18.65	18.72	18.74	18.71	18.59	17.69	17.69	18.68	18.89	18.57	18.71	18.95	19.25
Gansu	12.80		12.80	12.74	12.70	12.69	12.71	12.47	12.39	12.51	12.59	12.62	12.82	13.01
Qinghai	2.40	2.46	2.39	2.39	2.38	2.36	2.38	2.40	2.46	2.47	2.45	2.51	2.57	2.63
Ningxia	3.60	3.61	3.49	3.42	3.48	3.50	3.54	3.58	3.69	3.80	3.84	3.86	3.90	3.98
Xinjiang	44.10		39.16	39.58	39.16	39.54	39.64	39.07	40.61	41.11	41.48	40.90	42.87	42.75

Table A.11 *(continued)*

Sources: Figures for 1931 are from Cressey (1934, 97), which cites C. C. Chang (1932). Because of significant boundary changes, some of China's figures have been omitted from the table. Those are Heilongjiang, 0.382 million *mu*; Jilin, 1.426 million *mu*; Liaoning, 0.878 million *mu*; Rehe (Jehol), 0.240 million *mu*; Charhar, 1.855 million *mu*; Suiyuan, 1.400 million *mu*; and Hebei, 8.467 million *mu*.

Figures for 1949–59 are from reports, primarily from the Chinese press, assembled in PAS (1969).

The sources for figures for Anhui in 1972 and Qinghai in 1973 have been misplaced. The 1974 figure for Jiangsu was provided to the U.S. Water Delegation in Nanjing on 4 September 1974; it may refer to 1973. Aside from these, sources for the period 1960–75 are all from Chinese press reports. For Beijing, the figure for 1961 is from SCMP 29181; for 1963, SCMP 3157; for 1965, SCMP 3568; for 1973, FBIS, 30 August 1973. For Hebei, the figure for 1963 is from SCMP 2932; for 1971 and 1972, RMRB, 11 January 1973, 1; for 1973, FBIS, 21 November 1973; for 1974, RMRB, 10 January 1975; for 1975, FBIS, 15 September 1975. For Shanxi, the 1964 figure is from USHKAA on microfilm reel 2, frame 171; for 1974, FBIS, 3 December 1974. For Neimenggu, the 1972 figure is from FBIS, 2 June 1972; for 1973, FBIS, 30 June 1975; for 1974, FBIS, 30 January 1975. For Liaoning, the 1974 figure is from FBIS, 24 September 1974. For Jilin, the 1974 figure is from FBIS, 11 October 1974. For Heilongjiang, the 1973 figure is from FBIS, 8 May 1973. For Jiangsu, the 1970 and 1975 figures are from FBIS, 10 February 1976. For Zhejiang, the 1974 figure is from FBIS, 2 October 1974. For Shandong, the 1972 figure is from FBIS, 9 January 1973; for 1973, FBIS, 16 January 1974; for 1974, RMRB, 10 January 1975. For Henan, the 1971 figure is from FBIS, 24 May 1972; for 1972, FBIS, 4 October 1972; for 1974, RMRB, 10 January 1975. For Hubei, the 1963 figure is from SCMP 455; for 1973, FBIS, 29 August 1973. For Hunan, the 1966 figure is from USHKAA on reel 2, frame 185. For Guangdong, the 1964 figure is from USHKAA on reel 2, frame 151; for 1974, FBIS, 18 October 1974. For Guizhou, the 1965 figure is from SCMP 3605; for 1966, USHKAA on reel 2, frame 158. For Yunnan, the 1964 figure is from USHKAA on reel 2, frame 199. For Shaanxi, the 1969 and 1971 figures are from FBIS, 18 January 1971; for 1975, FBIS, 12 September 1975. For Gansu, the 1966 figure is from USHKAA on reel 2, frame 133; for 1974, FBIS, 22 March 1974. For Xinjiang, the 1975 figure is from *China Reconstructs*, February 1976, 16.

Figures for 1978 have been calculated from data given in ZGNYDL (1980, 77–79). Those for 1979 are from ZGGK80 (1981, 248, 264, 281, 312, and 383).

Figures for 1980 and subsequent years are from ZGNYNJ81, 66–67; ZGNYNJ82, 80; ZGNYNJ83, 115; ZGNYNJ84, 160; ZGNYNJ85, 218; ZGNYNJ86, 266; ZGNYNJ87, 341; ZGNYNJ88, 377; ZGNYNJ89, 342; ZGNYNJ90, 403; ZGNYNJ91, 423; and ZGTJNJ91, 344. The almanac for a given year provides figures for the previous year and usually for the year before. In all cases, except perhaps ZGNYNJ81 (1980 figures), the data were supplied by the State Statistical Bureau.

Blank cell = Data not available.

Table A.12 Irrigated area figures from provincial yearbooks published in the 1980s, 1949–88

Province	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
							(million *mu*)							
Beijing														
Tianjin														
Hebei	11.54	11.91	12.72	14.44	14.97	15.36	15.47	20.30	23.66	31.07	31.80	29.28	22.78	20.36
Shanxi	3.79	4.41	5.13	6.09	6.37	6.56	7.01	8.03	8.74	10.73	11.24	11.28	9.62	9.65
Neimenggu														
Liaoning					1.83				5.40					3.01
Jilin	1.30	1.47	1.54	1.73	1.64	1.87	2.10	4.97	5.54	7.40	5.29	3.86	2.66	2.31
Heilongjiang	1.90			2.04					4.48					2.35
Shanghai									0.47	0.69	1.37	2.47	3.21	3.67
Jiangsu														
Zhejiang														
Anhui	12.34	12.52	12.90	13.73	14.06	14.57	15.08	15.78	16.71	16.98	18.11	18.32	18.87	19.96
Fujian														
Jiangxi														
Shandong														
Henan														
Hubei														
Hunan	17.99			23.07					26.66					29.77
Guangdong														
Guangxi		7.69	7.79	8.02	8.66	9.17	9.75	11.86	13.10	16.70	16.88	11.90	12.34	14.14
Sichuan									15.98					20.54
Guizhou														
Yunnan									6.67					11.77
Xizang														
Shaanxi														
Gansu														
Qinghai	0.75			0.97					1.73					1.90
Ningxia				2.23					3.24	3.47				3.02
Xinjiang														

Table A.12 *(continued)*

Province	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
							(million *mu*)							
Beijing														
Tianjin														
Hebei	20.24	20.83	26.31	34.41	33.61	35.47	36.96	40.17	41.94	43.21	46.67	49.71	53.30	52.26
Shanxi	10.29	10.60	10.53	13.16	12.59	12.42	12.48	12.85	13.27	13.60	13.99	14.95	15.64	16.31
Neimenggu														
Liaoning			4.59					9.46	9.02	8.83	9.45	10.54	11.07	11.20
Jilin	2.24	2.53	3.07	3.55	3.83	4.01	4.24	4.91	4.94	5.20	6.10	7.12	8.30	9.01
Heilongjiang			2.69					5.52					5.86	7.69
Shanghai	3.93	4.12	4.26	4.27	4.54	4.75	4.83	4.96	5.14	5.26	5.31	5.34	5.34	5.32
Jiangsu														
Zhejiang														
Anhui	20.90	21.21	23.63	24.57	25.91	26.67	27.61	30.04	30.71	30.45	32.71	34.17	35.78	36.98
Fujian														
Jiangxi														
Shandong														
Henan														
Hubei														
Hunan			32.45					35.15					38.75	
Guangdong								30.09					34.14	
Guangxi	14.17	14.35	14.65	15.51	16.24	16.80	17.79	18.71	19.87	18.44	20.42	21.01	21.93	22.77
Sichuan			23.96											
Guizhou														
Yunnan			12.80						11.45	12.02	12.74	12.80	13.00	13.26
Xizang														
Shaanxi														
Gansu														
Qinghai			2.12				2.42						2.49	
Ningxia			3.13					2.86					3.42	3.43
Xinjiang														

(continued)

Table A.12 *(continued)*

Province	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
						(million *mu*)						
Beijing				5.12	5.12	5.10	5.15	5.14	5.08	5.06	5.07	5.07
Tianjin							5.48	5.41	5.24	5.11	5.24	
Hebei	54.43	54.90	55.06	54.27	53.22	53.42	53.65	53.77	53.59	53.31	54.08	54.44
Shanxi	17.03	16.39	16.82	16.73	16.60	16.50	16.51	16.54	16.19	15.81	16.16	16.48
Neimenggu										15.09	15.57	
Liaoning	12.71	12.80	12.05	11.40	10.77	10.85			10.86	10.96	11.53	11.44
Jilin	9.14	8.98	8.56	10.96	11.17	11.00	10.74	10.67	10.44	10.76	11.29	11.62
Heilongjiang	9.51	8.86	9.01	9.71	10.48	10.06	9.47	9.35	10.19	10.80	11.49	11.09
Shanghai	5.34	5.30	5.24	5.24	5.20	5.21	5.19	5.13	5.03	4.90	4.90	4.85
Jiangsu												
Zhejiang												
Anhui	37.68	39.61	40.84	40.07	40.16	38.73	37.98					33.22
Fujian										13.70	13.82	
Jiangxi										27.21	27.32	27.25
Shandong												64.84
Henan											48.75	50.38
Hubei							34.98	34.64	33.17	33.79	34.40	
Hunan		40.37	40.96	41.14	41.30	41.40	41.60	41.63	41.67	41.58	39.98	40.05
Guangdong		32.09		31.54		30.72	30.56	29.70	29.07	28.70	27.82	25.22
Guangxi	21.86	22.06	21.92	21.49	21.20	21.09	21.05	20.75	20.22	20.25	20.61	20.06
Sichuan		43.04	44.58	45.35	45.54	45.66	45.80		41.73	40.95	41.18	41.43
Guizhou												
Yunnan	13.38	13.57	13.56	13.70	13.78	13.86	14.38	14.42	14.47	14.50	14.60	
Xizang												1.81
Shaanxi												
Gansu										12.39	12.51	
Qinghai		2.46		2.39					2.40	2.46	2.47	
Ningxia	3.39	3.40	3.51	3.49	3.42	3.48	3.50	3.54	3.63	3.69	3.80	
Xinjiang											41.11	41.47

Table A.12 *(continued)*

Sources: Figures for Beijing are from BJSHJJ85, 312; BJSHJJ87, 504; BJSHJJ88, 412; BJSHJJ89, 362; BJGJST81–85, 144; for Tianjin, from TJTJNJ85, 95; TJTJNJ88, 139; for Hebei, from HBJJTJ84, 429; HBJJTJ88, 446; HBJJTJ89, 379; for Shanxi, from SXTJNJ89, 205; for Neimenggu, from NMTJNJ88, 186; for Liaoning, from LNJJTJ83, 445; LNJJTJ87, 523; LNJJTJ89, 503; for Jilin, from JLSHJJ87, 130; JLSHJJ88, 167; JLSHJJ89, 173; for Heilongjiang, from HLJJTN88, 231; HLJJTN89, 203; for Shanghai, from SHTJNJ83, 171; SHTJNJ88, 214; SHTJNJ89, 240; for Anhui, from AHSQ49-83, 275-277; AHTJNJ89, 171; for Fujian, from FJTJNJ88, 143; for Jiangxi, from JXTJNJ88, 101; JXTJNJ89, 84; for Shandong, from SDTJNJ89, 110; for Henan, from HNJJTJ89, 213; for Hubei, from HBTJNJ85, 183; HBTJNJ88, 415; for Hunan, from HNTJNJ82, 127; HNTJNJ87, 96; HNTJNJ89, 77; for Guangdong, from GDTJNJ84, 136; GDTJNJ85, 126; GDTJNJ87, 142; GDTJNJ88, 125; GDTJNJ89, 107; for Guangxi, from GXTJNJ88, 96; GXTJNJ89, 95; for Sichuan, from SCTJNJ83, 122; SCTJNJ88, 149; SCTJNJ89, 149; for Yunnan, from YNTJNJ88, 246; for Xizang, from XZSJTN89, 197; for Gansu, from GSTJNJ88, 134; for Qinghai, from QHSJTN88, 154; for Ningxia, from NXTJNJ87, 136; *NXTJNJ88, 169*; for Xinjiang, from XJTJNJ89, 116.

Blank cell = Data not available.

Table A.13 Differences between contemporary sources and recent provincial reports for irrigated area, 1949–88

Province	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
							(million *mu*)							
Beijing														
Tianjin														
Hebei	0.77	1.00	0.86	1.53	1.14	0.83	1.32	5.47	3.34	33.93	31.20			
Shanxi	-0.11	0.02	-0.22	-0.25	0.02	0.56	0.22	0.35	2.56	11.50				
Neimenggu														
Liaoning									1.90					
Jilin	-0.00			-0.08			-0.12	-1.01	-0.68	-2.03				
Heilongjiang	-1.09								0.02					
Shanghai										-0.69				
Jiangsu														
Zhejiang														
Anhui	4.66						6.05	12.62	17.29	38.02	42.89			
Fujian														
Jiangxi														
Shandong														
Henan														
Hubei														
Hunan														
Guangdong														
Guangxi			0.81	2.48	6.09	6.41	7.05	9.99	11.86	20.26	7.90			
Sichuan									39.38					
Guizhou														
Yunnan														
Xizang														
Shaanxi														
Gansu														
Qinghai	-0.00													
Ningxia														
Xinjiang														

Table A.13 (continued)

Province	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
							(million *mu*)							
Beijing														
Tianjin														
Hebei	15.76								3.06	4.79	0.33	3.29	-3.30	
Shanxi		-0.40		-1.16								-0.98		
Neimenggu														
Liaoning												9.46		
Jilin												1.88		
Heilongjiang														
Shanghai														
Jiangsu														
Zhejiang														
Anhui										4.55			4.22	
Fujian														
Jiangxi														
Shandong														
Henan														
Hubei														
Hunan														
Guangdong														
Guangxi														
Sichuan														
Guizhou														
Yunnan														
Xizang														
Shaanxi														
Gansu														
Qinghai													0.01	
Ningxia														
Xinjiang														

(continued)

Table A.13 *(continued)*

Province	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
						(million *mu*)						
Beijing				-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
Tianjin							0.00	0.00	-0.00	-0.00	-0.13	
Hebei		-0.10		0.06	-0.00	-0.00	0.00	-0.00	-0.00	-0.00	0.00	-0.01
Shanxi		1.01		-0.00	0.00	-0.00						-0.01
Neimenggu										0.00	0.00	
Liaoning		4.10	2.15	0.00	-0.00	0.00			0.00	0.00		-0.01
Jilin		3.82		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Heilongjiang		0.34		0.34	-0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.01
Shanghai		0.10		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jiangsu												
Zhejiang												
Anhui		-3.31	-3.06	-3.50	-4.26	-4.02	-4.55					-0.01
Fujian										-0.00	0.00	
Jiangxi										0.00	0.00	0.01
Shandong												
Henan											0.00	0.01
Hubei							-0.00	0.00	1.23	-0.00	-1.23	
Hunan		-0.07		-4.90	-5.08	-5.83	0.00	0.00	-0.07	-0.00	0.00	-0.05
Guangdong		4.21		0.08		-0.00	0.10	0.00	0.00	-0.00	0.00	0.00
Guangxi		3.54		0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	0.01
Sichuan		6.47		-0.00	-0.00	-0.01	-0.00	44.57	-0.00	-0.01	-0.00	0.00
Guizhou												
Yunnan		3.13	0.14	-0.00	0.00	-0.00	-0.00	0.00	0.00	0.00	-0.00	
Xizang												0.00
Shaanxi		18.70										
Gansu										-0.00	-0.00	
Qinghai		-0.06		-0.00					-0.00	0.00	-0.00	
Ningxia		0.20	0.10	0.00	0.00	0.00	0.00	0.00	-0.05	0.00	0.00	
Xinjiang											0.37	-0.57

Table A.13 *(continued)*

Sources: Calculated from Tables A.11 and A.12 by subtracting data from provincial yearbooks published in the 1980s (Table A.12) from that of contemporary sources (Table A.11).

Blank cell = Data not available.

0.00 = Data available from contemporary sources and recent provincial reports. Figures from contemporary sources are larger than or equal to that found in 1980s provincial reports, but the difference is less than 5000 *mu*.

–0.00 = Figures from provincial reports published in the 1980s are larger, but the difference is less than 5000 *mu*.

Table A.14 Ministry of Water Resources reporting categories, 1983–91

Category	1983	1984	1985	1986	1988	1989	1990	1991
Irrigated area (million *mu*)		747.98	741.65					
Forestland irrigated area (million *mu*)	18.15	12.36	12.72	18.82	23.42	24.84	26.78	
Irrigated pastureland (million *mu*)		9.62	9.94	9.55	10.48	11.04	11.48	
Effectively irrigated area (million *mu*)	728.19	726.00	718.99	718.09	718.71	725.06	725.84	726.99
Stable, high-yield area (million *mu*)	491.57	495.57	493.06	497.32	503.56	509.91	515.48	
Tubewell irrigated area (million *mu*)	170.12	169.22	166.98	163.04	168.25	171.53	176.09	
Area irrigated or drained by pump (million *mu*)	469.29	463.71	458.01	465.45	460.94	465.48	468.38	
Pump irrigated area only (million *mu*)	390.69	392.74	394.47	395.19	400.93	405.57	408.53	
Actually irrigated area (million *mu*)	590.75	599.00	580.07	599.07	617.83	610.43	621.56	
As percent of effectively irrigated area	81.0	83.0	81.0	83.0	86.0		86.0	
Area subject to flooding (million *mu*)	360.99	363.53	363.10		365.22	366.38	367.00	360.00
Flood-prone area controlled (million *mu*)	283.01	265.99	278.76	281.41	285.87	288.44	290.05	292.00
As percent of subject area	78.0	76.0	76.8	77.0	78.3	78.7	79.0	80.2
Saline-alkaline cultivated land (million *mu*)	110.36	109.97	115.39		115.08	113.08	113.09	114.80
Improved saline-alkaline cultivated land (million *mu*)	65.87	67.11	68.54	69.35	72.45	73.25	74.93	75.00
As percent of subject area	60.0	61.0	59.0	61.0	63.0	64.8	66.0	67.1
Area subject to erosion (million *mu*)	1,800.0	1,800.0	1,940.0		2,010.0	2,020.0	2,050.0	2,100.0
Erosion-prone area controlled (million *mu*)	640.0	670.0	700.0	719.0	770.0	780.0	790.0	805.0
As percent of subject area	36.00	37.00	36.00		38.31	38.61	39.00	34.40
Irrigation districts								
>10,000 *mu* (thousands)	5.288	5.319	5.281	5.299	5.302	5.331	5.363	5.539
>300,000 *mu* (thousands)	0.143	0.140	0.137	0.141	0.146	0.150	0.148	0.163

Table A.14 *(continued)*

Category	1983	1984	1985	1986	1988	1989	1990	1991
Reservoirs (thousands)	86.567	84.998	83.219	82.716	82.937	82.848	83.387	83.793
Capacity (billion cubic meters)	420.8	429.2	430.1	443.2	450.4	461.7	466.0	424.8
Large reservoirs (thousands)	335	338	340	350	355	358	366	361
Capacity (billion cubic meters)	300.7	306.8	307.6	319.9	325.2	335.7	339.7	297.1
Medium reservoirs (thousands)	2.367	2.387	2.401	2.415	2.462	2.480	2.499	2.524
Capacity (billion cubic meters)	64.0	65.8	66.1	66.6	68.1	68.8	69.0	69.8
Small reservoirs (thousands)	83.865	82.273	80.478	79.951	80.120	80.010	80.522	80.908
Capacity (billion cubic meters)	5.61	5.66	56.40	56.70	57.10	57.20	57.30	57.90
Embankments (thousand kilometers)	170.0	170.0	177.0	185.045	203.0	217.0	226.0	233.0
Protected cultivated area (million *mu*)	508.23	531.88	465.90	474.99	484.95	479.49	474.23	474.30
Water gates (thousands)	24.980	24.862	24.816	25.315	26.319	26.739	27.649	
Large (thousands)	0.263	0.290	0.284	0.299	0.300	0.308	0.316	
Medium (thousands)	1.912	1.941	1.967	2.032	2.060		2.126	
Small (thousands)	22.805	22.631	22.565	22.984	23.959		25.207	
Tubewells outfitted (million)	2.410	2.400	2.370	2.364	2.520	2.630	2.730	
Guaranteed irrigation-drainage machinery (million horsepower)	78.76	81.00	80.78	80.15	64.37	66.35	68.05	
Fixed irrigation-drainage stations (thousands)	475.0	478.0	462.0	456.0	461.0		474.0	
Turbine pump stations (thousands)	28.191	27.621	23.724	22.605	21.128		20.309	
Drinking water problems solved								
For people (million)	66.60	75.90	84.67	93.89	114.87	123.14	132.77	
For livestock (million)	39.91	43.19	46.10	55.76	67.56	73.03	79.06	

Table A.14 *(continued)*

Category	1983	1984	1985	1986	1988	1989	1990	1991
Water supplied by projects (billion cubic meters)		429.0	481.9					
Flood and drought disasters								
Area affected (million *mu*)	423.76	396.76	557.80		672.80			
Disaster area (million *mu*)	200.00	184.47	285.28		321.47			
Flood-affected area (million *mu*)	182.43	159.48	212.96		179.24			
Flood disaster area (million *mu*)	86.21	80.42	134.24		91.92			
Drought-affected area (million *mu*)	241.33	237.28	334.84		493.56			
Drought disaster area (million *mu*)	113.79	104.05	150.94		229.55			

Sources: ZGSL (May 1985, 34; June 1986, 34; July 1987, 27; September 1989, 13; January 1991, 38); 1989 figures for number and capacity of medium and small reservoirs are from *ZGTJNJ90*, 350; *ZGTJNJ91*, 345.

Note: ZGSL (July 1987) gives 294 large water gates for 1985. It also reports controlled erosion area as 4.791 square kilometers and irrigation and drainage machinery as 59.79 million kilowatts. These have been converted to conform with previous categories. Data for 1989 are from SSB.

Blank cell = Data not available.

Table A.15 Effectively irrigated area, actually irrigated area, and stable, high-yield fields, 1987

		Actually irrigated area		Stable high-yield fields		
Province	Effectively irrigated area	Total	As percent of effective area	Total	As percent of effective area	As percent of actual area
			(million *mu*)			
Beijing	4.95	4.54	91.7	3.53	71.3	77.8
Tianjin	5.10	4.44	87.1	3.03	59.4	68.2
Hebei	54.29	50.69	93.3	35.01	64.5	69.1
Shanxi	16.79	13.89	82.7	8.72	51.9	62.8
Neimenggu	21.04	17.37	82.5	13.03	61.9	75.0
Liaoning	14.87	11.38	76.5	12.41	83.5	109.1
Jilin	11.29	8.92	79.0	7.52	66.6	84.3
Heilongjiang	14.49	10.10	69.7	6.63	45.8	65.6
Shanghai	4.90	4.61	94.1	4.62	94.3	100.2
Jiangsu	60.82	47.21	77.6	41.80	68.7	88.5
Zhejiang	22.40	21.84	97.5	15.16	67.7	69.4
Anhui	36.58	26.84	73.4	25.82	70.6	96.2
Fujian	13.83	12.74	92.1	9.43	68.2	74.0
Jiangxi	27.32	26.15	95.7	19.94	73.0	76.3
Shandong	67.21	55.55	82.6	48.97	72.9	88.2
Henan	58.60	36.73	62.7	39.82	68.0	108.4
Hubei	38.70	28.40	73.4	30.47	78.7	107.3
Hunan	39.98	38.02	95.1	31.94	79.9	84.0
Guangdong	36.69	32.40	88.3	27.11	73.9	83.7
Guangxi	22.29	18.55	83.2	18.00	80.8	97.0
Sichuan	41.18	34.55	83.9	27.36	66.4	79.2
Guizhou	8.07	6.16	76.3	6.62	82.0	107.5
Yunnan	14.60	13.14	90.0	9.52	65.2	72.5
Xizang	1.94	1.50	77.3	0.00	0.0	0.0
Shaanxi	18.89	15.23	80.6	11.56	61.2	75.9
Gansu	13.13	11.27	85.8	10.64	81.0	94.4
Qinghai	3.07	2.43	79.2	1.82	59.3	74.9
Ningxia	4.27	3.78	88.5	3.67	85.9	97.1
Xinjiang	42.21	39.49	93.6	26.09	61.8	66.1
CHINA	719.50	597.92	83.1	500.24	69.5	83.7

Source: ZGSL (October 1988, 38).

Table A.16 Provincial ranking according to 1978 irrigated area, bunded area, and irrigated dryland

Province	Total irrigated area	Bunded area	Irrigated dryland	Province	Total irrigated area	Bunded area	Irrigated dryland	Province	Total irrigated area	Bunded area	Irrigated dryland
Shandong	65.98	2.52	63.47	Sichuan	49.54	49.54	0.00	Shandong	65.98	2.52	63.47
Henan	56.05	6.44	49.61	Jiangsu	50.04	41.07	8.97	Hebei	54.82	1.60	53.22
Hebei	54.82	1.60	53.22	Hunan	40.32	40.32	0.00	Henan	56.05	6.44	49.61
Jiangsu	50.04	41.07	8.97	Guangdong	36.32	36.32	0.00	Xinjiang	44.09	1.10	43.00
Sichuan	49.54	49.54	0.00	Jiangxi	30.88	30.88	0.00	Shaanxi	18.74	2.54	16.21
Xinjiang	44.09	1.10	43.00	Hubei	35.30	29.36	5.94	Shanxi	16.33	0.18	16.15
Hunan	40.32	40.32	0.00	Anhui	36.33	26.09	10.24	Gansu	12.76	0.16	12.60
Anhui	36.33	26.09	10.24	Guangxi	25.62	24.64	0.98	Liaoning	16.84	5.68	11.16
Guangdong	36.32	36.32	0.00	Zhejiang	23.67	22.07	1.60	Anhui	36.33	26.09	10.24
Hubei	35.30	29.36	5.94	Fujian	15.67	15.67	0.00	Neimenggu	9.77	0.08	9.69
Jiangxi	30.88	30.88	0.00	Yunnan	16.74	15.23	1.51	Jiangsu	50.04	41.07	8.97
Guangxi	25.62	24.64	0.98	Guizhou	11.99	11.92	0.07	Jilin	12.87	4.54	8.32
Zhejiang	23.67	22.07	1.60	Henan	56.05	6.44	49.61	Hubei	35.30	29.36	5.94
Shaanxi	18.74	2.54	16.21	Liaoning	16.84	5.68	11.16	Heilongjiang	9.20	3.58	5.63
Liaoning	16.84	5.68	11.16	Shanghai	5.36	4.75	0.62	Tianjin	5.44	0.48	4.96
Yunnan	16.74	15.23	1.51	Jilin	12.87	4.54	8.32	Beijing	5.10	0.67	4.43
Shanxi	16.33	0.18	16.15	Heilongjiang	9.20	3.58	5.63	Qinghai	2.38	0.00	2.38
Fujian	15.67	15.67	0.00	Ningxia	3.61	2.57	1.04	Xizang	2.31	0.00	2.31
Jilin	12.87	4.54	8.32	Shaanxi	18.74	2.54	16.21	Zhejiang	23.67	22.07	1.60
Gansu	12.76	0.16	12.60	Shandong	65.98	2.52	63.47	Yunnan	16.74	15.23	1.51
Guizhou	11.99	11.92	0.07	Hebei	54.82	1.60	53.22	Ningxia	3.61	2.57	1.04
Neimenggu	9.77	0.08	9.69	Xinjiang	44.09	1.10	43.00	Guangxi	25.62	24.64	0.98
Heilongjiang	9.20	3.58	5.63	Beijing	5.10	0.67	4.43	Shanghai	5.36	4.75	0.62
Tianjin	5.44	0.48	4.96	Tianjin	5.44	0.48	4.96	Guizhou	11.99	11.92	0.07
Shanghai	5.36	4.75	0.62	Shanxi	16.33	0.18	16.15	Guangdong	36.32	36.32	0.00
Beijing	5.10	0.67	4.43	Gansu	12.76	0.16	12.60	Sichuan	49.54	49.54	0.00
Ningxia	3.61	2.57	1.04	Neimenggu	9.77	0.08	9.69	Jiangxi	30.88	30.88	0.00
Qinghai	2.38	0.00	2.38	Qinghai	2.38	0.00	2.38	Hunan	40.32	40.32	0.00
Xizang	2.31	0.00	2.31	Xizang	2.31	0.00	2.31	Fujian	15.67	15.67	0.00

Source: Figures from ZGNYDL (1980, 77–79). See Table A.10.

Table A.17 Provincial irrigation by water source, 1989

Province	Effectively irrigated area[a]	Reservoir irrigation area	Reservoir as percent of effective area	Storage capacity	Ratio of storage capacity to reservoir irrigation area	Powered irrigation Total	Diesel[b]	Electric
	(million mu)			(km³)		(million mu)		
Beijing	5.08	3.37	66.3	9.303	2,763	4.30	0.00	4.30
Tianjin	5.13	1.15	22.5	2.516	2,181	5.13	0.46	4.67
Hebei	55.24	12.12	21.9	14.263	1,177	50.61	18.67	31.94
Shanxi	16.72	5.63	33.7	3.932	698	12.20	0.64	11.56
Neimenggu	17.30	2.84	16.4	5.970	2,102	10.65	2.76	7.89
Liaoning	11.40	7.30	64.0	30.280	4,148	10.15	1.20	8.22
Jilin	12.54	3.13	25.0	29.994	9,583	9.77	1.93	6.11
Heilongjiang	11.66	1.94	16.6	6.630	3,418	6.41	3.66	2.75
Shanghai	4.81	0.00	0.0	0.000	na	4.81	0.00	4.81
Jiangsu	52.97	17.63	33.3	19.023	1,079	47.81	13.45	34.36
Zhejiang	22.22	11.61	52.3	33.433	2,880	16.78	2.79	13.99
Anhui	34.56	13.74	39.8	18.130	1,320	24.88	6.45	18.43
Fujian	13.66	4.19	30.7	6.837	1,632	2.69	1.30	1.39
Jiangxi	27.39	10.90	39.8	23.147	2,124	6.02	1.82	4.20
Shandong	65.33	10.25	15.7	19.201	1,873	57.32	30.93	26.39
Henan	51.52	10.43	20.2	49.376	4,734	37.55	18.20	19.35
Hubei	32.96	22.05	66.9	50.001	2,268	20.39	8.79	11.60
Hunan	40.11	23.45	58.5	29.122	1,242	19.75	6.52	13.23
Guangdong	27.49	15.87	57.7	44.602	2,810	8.76	1.48	7.28
Guangxi	19.95	10.39	52.1	21.769	2,095	3.76	1.62	2.14
Sichuan	41.77	14.49	34.7	11.813	815	9.22	0.25	8.97
Guizhou	8.23	2.62	31.8	5.152	1,966	0.93	0.12	0.81
Yunnan	15.30	6.09	39.8	6.698	1,100	2.22	0.10	2.12
Xizang	1.81	0.00	0.0	0.000	na	0.10	0.10	0.00
Shaanxi	18.62	4.25	22.8	4.285	1,008	11.63	0.51	11.12
Gansu	12.62	4.20	33.3	8.552	2,036	4.51	0.27	4.24
Qinghai	2.51	0.59	23.5	0.201	341	0.27	0.05	0.22
Ningxia	3.86	3.18	82.4	1.746	549	0.83	0.04	0.79
Xingjiang	40.90	13.99	34.2	5.755	411	4.63	1.61	3.02
Total	673.67	237.39	35.2	461.731	1,945	391.59	125.72	265.88

Source: ZGNYNJ90, 388, 403.
na = Data not available.
a. Data from SSB.
b. Includes all hydrocarbon fuel injector pumps, primarily diesel.

Table A.18 Gross reduction in effectively irrigated area and sources of decline in 1984, 1989, and 1990

Province	Reduction in 1984	Reduction in 1989	Reduction in 1990	Sources of decline in 1984: Facilities[a]	Pump-wells[b]	Water[c]	Construction[d]	Other
	(million *mu*)			(percent of total decline)				
Beijing	0.0648	0.0537	0.0379	1	10	42	23	24
Tianjin	0.1584	0.0565	0.0641	0	39	20	41	0
Hebei	4.3223	2.5793	2.2502	1	73	18	0	7
Shanxi	0.2946	0.1007	0.1131	38	17	24	12	9
Neimenggu	0.5377	0.2974	0.6235	18	43	17	0	22
Liaoning	0.3209	0.1627	0.2315	9	46	21	1	23
Jilin	0.3266	0.0665	0.0590	6	46	46	0	2
Heilongjiang	1.5317	0.3011	0.2963	11	49	3	0	37
Shanghai	0.1697	0.0400	0.0100	0	0	0	66	34
Jiangsu	0.6007	1.0703	1.1065	13	5	54	13	15
Zhejiang	0.0637	0.1255	0.1798	0	0	28	28	44
Anhui	1.6478	0.1914	0.6117	16	17	9	1	57
Fujian	0.0954	0.1266	0.0564	4	2	11	4	79
Jiangxi	0.0689	0.0728	0.0711	61	0	20	6	13
Shandong	1.4415	2.5519	0.8770	16	29	33	9	13
Henan	0.2912	1.7776	7.2110	24	37	14	16	9
Hubei	0.2495	0.3100	3.3900	4	0	23	24	48
Hunan	0.1222	0.0888	0.1544	13	0	9	22	56
Guangdong	0.2430	0.3491	0.1519	45	0	20	21	13
Guangxi	0.1085	0.1855	0.0583	65	2	9	3	21
Sichuan	1.4615	0.0270	0.0421	1	0	3	4	92
Guizhou	0.2303	0.0744	0.1670	77	0	0	0	23
Yunnan	0.1926	0.0856	0.0865	27	0	25	13	34
Xizang								
Shaanxi	1.5358	0.1727	0.2023	37	14	8	7	34
Gansu	0.0702	0.0815	0.0169	53	25	9	5	8
Qinghai	0.0105	0.0112	0.0087	0	0	0	0	100
Ningxia		0.0130	0.0844	0	0	0	0	0
Xinjiang	0.1018	0.2817	0.7920	0	0	0	0	100
CHINA	16.2618	11.2545	18.9536	14	35	16	5	30
CHINA	Sources of decline in 1989			18	35	14	10	23
CHINA	Sources of decline in 1990			19	22	13	10	36

Sources: ZGSL (July 1985, 23); ZGSLNJ90, 636; ZGSLNJ91, 656.

Blank cell = Data not available.

a. Destroyed or abandoned.

b. Abandoned.

c. Inadequate or unavailable for a long period.

d. Land occupied by construction.

1. Since then, the State Statistical Bureau figure has been increased to 47 million hectares, while the Ministry of Water Resources total has remained at 48 million hectares.

2. Cropping figures are commonly presented in terms of sown area (*bozhong mianji*), while irrigation is usually measured by cultivated (or arable) land (*gengdi*). Sown area is greater, due to multiple cropping.

3. The Ministry of Water Resources was formerly known in English as the Ministry of Water Conservancy. The Chinese name was the same: *Shuilibu*. From 11 February 1958 to 15 February 1979, and from 7 March 1982 to 12 April 1988, the MWR was merged with the Ministry of Electric Power (now superseded by the Ministry of Energy Resources) to form the Ministry of Water Resources (Conservancy) and Electric Power.

4. Formerly the Ministry of Agriculture, Animal Husbandry and Fisheries.

5. The Statistics Press was restored as the China Statistics Press in May 1980 (Wang 1986, 358).

6. Tuan and Crook only present the English translation. The original Chinese report probably includes wells with diesel pumps, as well as those with electric motors.

7. Fraudulent reporting of statistics by local officials was revealed to be a problem in a nationwide campaign against the practice launched in April 1989. The focus of the campaign, which followed a three-month survey by the SSB, the Ministry of Supervision, and the Bureau of Legislative Affairs of the State Council, was on numbers reported for grain output, farmers' incomes, industrial output, investment in fixed assets, hotel and government building projects, price indexes, and the purchasing power of institutions (*China Daily*, 1 April 1989, 3).

8. By comparison, in the United States, the Irrigation Census is only carried out roughly every decade by the Agriculture Division of the Bureau of the Census. Beginning in 1910, the Irrigation Census was conducted in 1920, 1930, 1940, 1950, 1960, 1978, and 1987. The methods used are far from labor-intensive. For the Irrigation Census covering calendar year 1978, report forms were mailed late in December 1978 to more than 12,000 irrigation organizations identified as possibly supplying water to farms and ranches for irrigating agricultural land. Four mail follow-ups were conducted, followed by telephone follow-ups to large complex organizations (Garkey and Chern 1986, 68).

9. Reports for 1980, 1981, and 1982 have not been collected, however. The available sources do not cover this period.

10. For a description of these categories, see pp. 28–37.

11. The categories were effectively irrigated area; actually irrigated area; irrigated forests and orchards; irrigated pasture; stable, high-yield field area; power irrigation; pump irrigation and drainage area; and area irrigated by turbine pumps (ZGSL, October 1988, 38).

12. The two published by April 1993 were ZGSLNJ90, covering statistics up to and including 1989, and ZGSLNJ91, which covers 1990 data. Notably, these yearbooks provided an amended, usually reduced, series of national figures for effectively irrigated area before 1983 (see Table A.2).

13. See the discussion that follows, especially p. 21, "What Irrigated Area Measures Measure."

14. Effectively irrigated area is "level land which has water sources and complete sets of irrigation facilities to lift and move adequate water for irrigation purposes under normal conditions" (ZGTJNJ81, 512–13). For further elaboration, see p. 28.

15. The 1976 adjustments for the four provinces were as follows: Heilongjiang, 20 percent; Liaoning, 32 percent; Neimenggu, 36 percent; and Guangdong, no adjustment, as noted in the text.

16. An official definition of a "completed" pump well (*peitao jidian jing wanhou*) could not be located. It appears to be a slightly more restrictive subcategory of "outfitted" pump wells, averaging about 90 percent of the latter figure.

17. Nonirrigated bunded fields are rare. They are probably most common in Yunnan Province, where the 2.6 million *mu* of "thunder fields" constituted 15 percent of the 17.4 million *mu* of bunded fields in 1987 and the identical percentage of the 17.9 million *mu* of bunded fields in 1978 (YNTJNJ88, 212).

18. These extremes are usually estimated hydrologically from past records and are themselves imprecise predictors of future conditions. The possibility of global climatic change, either cyclical or secular, makes their long-run predictability even less reliable. Since hydrological observations are finite, $P = 0$ and $P = 1.0$ are asymptotic.

19. In practice, crop water requirements are rarely less than the no-stress minimum at M_t. Where water is plentiful, a more water-using cropping system, such as one using wet rice, will usually be adopted. Also, in China, precipitation and length of growing season tend to be positively correlated; where there is more water, more crops are likely to be grown. Finally, growing season shortages occur occasionally even where total annual precipitation is high, especially in a monsoonal climate such as China's.

20. Depending on the shape of the loss function, the crop decline avoided thereby may not offset the cost of constructing and maintaining an irrigation system. This is especially so when the "deficit" can be made up by improvements in management.

21. For definitions of "command area" and "rate of guarantee," see pp. 27 and 29.

22. This is known elsewhere as *the probability of non-exceedence* (Mark Svendsen, personal communication).

23. See Chen Jian (1987).

24. During the 1980s, actually irrigated area came to be reported more frequently than before, and may have moved into second place.

25. The definitions for SHYF, effectively irrigated area, and actually irrigated area are given from different sources because a single source that included each of them was not located. The same problem may confront those responsible for reporting these figures.

26. "Seriously affected" refers here to that area recorded as *chengzai*, defined as where crop production declines by at least 30 percent below that of a "normal year" (*changnian*) (ZGTJNJ88, 276).

27. Two studies involving U.S. scholars are Anderson and Maass (1983) and Fiering and Yuan (1983).

28. The table in the original text provides data for 1952 through 1981.

29. Fiering and Yuan (1983, 15) cite figures of 5,500 wells in the People's Victory Canal command area, with conjunctive use covering 300,000 *mu*, or about one-half. Cai (1988, 86) gives the conjunctive use area as 27,000 hectares, or 400,000 *mu*. One source (RMSLQ 1985, 36) notes reluctance by farmers to use more expensive well water when surface water is available. Nickum (1988) observed the same phenomenon in another Huang He diversion area downstream in northwest Shandong Province.

30. Stone (1988, 774) elaborates on some problems involved with statistics on cultivated area. Few yearbooks publish figures for cultivated area, although sown area data are widely available.

31. So termed by Li (1962, 83–108) in his analysis of the breakdown of the agricultural and industrial statistical reporting systems.

32. These estimates and observations are derived from data in Table 8, assuming no change in cultivated area between 1957 and 1958.

33. Zhang Yue (1984) claimed that there had been no readjustment of 1949–50 figures, but that there were more numerous reporting systems before 1980.

34. In 1975, Guangxi claimed an irrigated area of 2.0 million *mu* for 1950. This was well below the previously recorded 7.08 million *mu* for 1949 and 8.60 million *mu* for 1951 (*Peking Review*, 14 November 1975, 22). (PAS sources were, for 1949, *Guangxi Ribao*, 4 October 1959, and, for 1951, *Nanfang Ribao*, 1 March 1952.) Later, Guangxi's effectively irrigated area for the "early period of Liberation" (presumably 1949–50) was given as 4.25 million *mu*, of which 3.38 million *mu* were guaranteed (ZGSL, February 1983, 7).

In the mid-1960s, Shanxi's 1949 irrigated area was given as 2.94 million *mu*. This was down from the previously reported 3.68 million *mu* (USHKAA, reel 2, frame 171). (The PAS source for 1949 was RMRB, 22 December 1956, 1.)

Shandong gave its effective irrigated area at the end of 1974 as 36 million *mu*, fourteen times that of the early period of Liberation, implying a somewhat smaller magnitude than the previous 3.53 million *mu* for 1949 and 3.57 million *mu* for 1950 (FBIS, 21

July 1976, E7). (PAS sources were, for 1949, *Huabei jingji dili* [North China economic geography], 123–29, and, for 1950, RMRB, 1 June 1952.)

Sichuan reported a 1972 irrigated area of 38 million *mu*, seven times that of 1949. The areas recorded in PAS for 1949 and 1950 were both 11.00 million *mu*, roughly double the revised figure (FBIS, 15 December 1972). (The PAS source for both years was *Xinhua banyuekan* [New China semimonthly] 18, 25 September 1957, 129.)

35. For a description of the trends indicated by those data series, see the next section.

36. The totals for tubewells have not changed appreciably since the 1970s. Also, the categories are not quite comparable, as Table 8 is presented in relative growth terms and Table 1 lists absolute numbers. Putting the figures in comparable terms by adjusting for size of province would probably make the rank ordering in the two tables more similar.

37. They also share with the three northeast provinces the property of having a relatively small proportion of their cultivated area under irrigation.

38. See MWREP (1987, 62–63) and NNSZY (1982, 188).

39. In recent years, however, Jilin has increased its rice area in order to increase its grain output, much of which is shipped to southern parts of China (*China Daily*, 2 October 1989, 2).

40. Calculations based on a table presented in MWREP (1987, 43) yield a 1985 national average irrigated area of 65.84 *mu* for diesel-operated pump wells and 72.76 *mu* for electrically operated pump wells, with a pooled mean of 70.46 *mu*.

41. The lower reaches of the western Liao He are in the portion of Neimenggu transferred to Jilin during 1969–79. See Appendix 2.

42. This may be slightly conservative. The northwest, with an abundance of coal and hydropower, relies on electricity for 90–95 percent of its power used in irrigation (Table A.17). As noted previously, the national average for electrically powered wells is 72.76 *mu*.

Furthermore, another source (SXJJ 1985, 129) claims that the province's pump wells, dug to a depth of 100–270 meters, have an "efficiency" (*xiaolu*) of 200–400 *mu*. Pump wells in Shanxi's six major basins, it noted, irrigated 7.59 million *mu*, 94 percent of that for the entire province. This is well above the 5.4 million *mu* estimated here.

43. Neimenggu was another exception in this period (see "The Northeast," this section).

44. They are unlikely to be based on declines net of new additions to irrigated land, as those are much larger: 16 million *mu* in 1984 alone (Table A.18). The source of Nie's figures is not entirely clear, however. While the 62,000-hectare (930,000 *mu*) decline Nie cites for 1986 is close to the 60,000 hectares (900,000 *mu*) shown in the MWR totals, the 30,000 *mu* difference is difficult to explain by rounding, given the greater precision of the MWR figures.

45. Such problems plague key indices critical to policy-making, especially those that measure capacity. For two recent explorations of the problem of measuring other variables in a non-Chinese content, see Carpenter (1990) on biophysical measures of sustainable development, and Blejer and Cheasty (1991) on fiscal deficits.

Chinese References

Yearbooks in the Chinese language are commonly designated by abbreviations (up to six letters) of the title and sometimes include the last two digits of a date that appears in the title. These abbreviations are recognized by members of the Chinese research community.

AHTJNJ89 *Anhui tongji nianjian 1989*
(Anhui Statistical Yearbook 1989)

BJSHJJ85 *Beijing shehui jingji tongji nianjian 1985*
(Beijing Yearbook of Social and Economic Statistics 1985)

BJSHJJ87 *Beijing shehui jingji tongji nianjian 1987*
(Beijing Yearbook of Social and Economic Statistics 1987)

BJSHJJ88 *Beijing shehui jingji tongji nianjian 1988*
(Beijing Yearbook of Social and Economic Statistics 1988)

BJSHJJ89 *Beijing shehui jingji tongji nianjian 1989*
(Beijing Yearbook of Social and Economic Statistics 1989)

FJTJNJ88 *Fujian tongji nianjian 1988*
(Fujian Statistical Yearbook 1988)

GDTJNJ84 *Guangdongsheng tongji nianjian 1984*
(Guangdong Province Statistical Yearbook 1984)

GDTJNJ85 *Guangdongsheng tongji nianjian 1985*
(Guangdong Province Statistical Yearbook 1985)

GDTJNJ87 *Guangdongsheng tongji nianjian 1987*
(Guangdong Province Statistical Yearbook 1987)

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GDTJNJ89 *Guangdongsheng tongji nianjian 1989*
(Guangdong Province Statistical Yearbook 1989)

GSTJNJ88 *Gansu tongji nianjian 1988*
(Gansu Statistical Yearbook 1988)

GXTJNJ88 *Guangxi tongji nianjian 1988*
(Guangxi Statistical Yearbook 1988)

GXTJNJ89 *Guangxi tongji nianjian 1989*
(Guangxi Statistical Yearbook 1989)

HBJJTJ84 *Hebei jingji tongji nianjian 1984*
(Hebei Yearbook of Economic Statistics 1984)

HBJJTJ85	*Hebei jingji tongji nianjian 1985* (Hebei Yearbook of Economic Statistics 1985)
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HBJJTJ89	*Hebei jingji tongji nianjian 1989* (Hebei Yearbook of Economic Statistics 1989)
HBTJNJ85	*Hubei tongji nianjian 1985* (Hubei Statistical Yearbook 1985)
HBTJNJ88	*Hubei tongji nianjian 1988* (Hubei Statistical Yearbook 1988)
HLJJTN88	*Heilongjiang jingji tongji nianjian 1988* (Heilongjiang Yearbook of Economic Statistics 1988)
HLJJTN89	*Heilongjiang jingji tongji nianjian 1989* (Heilongjiang Yearbook of Economic Statistics 1989)
HNJJTJ89	*Henan jingji tongji nianjian 1989* (Henan Yearbook of Economic Statistics 1989)
HNTJNJ82	*Hunansheng tongji nianjian (1982 nian)* (Hunan Province Statistical Yearbook [1982])
HNTJNJ87	*Hunan tongji nianjian 1987* (Hunan Statistical Yearbook 1987)
HNTJNJ89	*Hunan tongji nianjian 1989* (Hunan Statistical Yearbook 1989)
JLSHJJ87	*Jilin shehui jingji tongji nianjian 1987* (Jilin Yearbook of Social and Economic Statistics 1987)
JLSHJJ88	*Jilin shehui jingji tongji nianjian 1988* (Jilin Yearbook of Social and Economic Statistics 1988)
JLSHJJ89	*Jilin shehui jingji tongji nianjian 1989* (Jilin Yearbook of Social and Economic Statistics 1989)
JXTJNJ88	*Jiangxi tongji nianjian 1988* (Jiangxi Statistical Yearbook 1988)
JXTJNJ89	*Jiangxi tongji nianjian 1989* (Jiangxi Statistical Yearbook 1989)
LNJJTJ83	*Liaoning jingji tongji nianjian 1983* (Liaoning Yearbook of Economic Statistics 1983)
LNJJTJ87	*Liaoning jingji tongji nianjian 1987* (Liaoning Yearbook of Economic Statistics 1987)
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NXTJNJ87	*Ningxia tongji nianjian 1987* (Ningxia Statistical Yearbook 1987)

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TJTJNJ88 *Tianjin tongji nianjian 1988* (Tianjin Statistical Yearbook 1988)

XJTJNJ89 *Xinjiang tongji nianjian 1989* (Xinjiang Statistical Yearbook 1989)

XZSJTN89 *Xizang shehui jingji tongji nianjian 1989* (Tibet Yearbook of Social and Economic Statistics 1989)

YNTJNJ88 *Yunnan tongji nianjian 1988* (Yunnan Statistical Yearbook 1988)

ZGNYNJ81 *Zhongguo nongye nianjian 1981* (China Agricultural Yearbook 1981)

ZGNYNJ82 *Zhongguo nongye nianjian 1982* (China Agricultural Yearbook 1982)

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ZGNYNJ90 *Zhongguo nongye nianjian 1990* (China Agricultural Yearbook 1990)

ZGNYNJ91 *Zhongguo nongye nianjian 1991* (China Agricultural Yearbook 1991)

ZGSLNJ90 *Zhongguo shuili nianjian 1990* (China Water Resources Yearbook 1990)

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ZGTJNJ81 *Zhongguo tongji nianjian 1981* (Statistical Yearbook of China 1981)

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