

INSTITUTIONAL, MANAGEMENT AND PERFORMANCE CHANGES IN TWO IRRIGATION DISTRICTS: A CASE STUDY FROM HEBEI PROVINCE, P.R. CHINA

by

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Water control is the lifeblood of agriculture--Mao Zedong

INTRODUCTION

With a population exceeding 1.2 billion, China is very concerned about ensuring it can feed its population. In this regard, irrigated land is critically important as 65% of the food grains, 75% of the cash crops and 90% of the vegetables are produced on irrigated land. In addition, irrigation districts supply 70-80% of the drinking water for people and livestock in rural areas (Chen and Ji, 1994).

As one of the oldest societies in the world, irrigation in China has a very long history with documented development of large scale irrigation schemes as far back as 605 B.C. By 1949, China had approximately 16 million ha of irrigated land. After the founding of the People's Republic of China, a major push was made to rehabilitate existing irrigation systems in order to reestablish the system of food production that had been disturbed during the long civil war. From the 1950s to 1970s many new irrigation systems were developed. The majority of medium and large systems existing today were developed during this period. As a result of the massive investment, irrigated area expanded rapidly to almost 48 million ha by 1992. This includes 144 large irrigation districts of over 20,000 ha of effective irrigation area each covering 7.9 million ha in total. There are 5,198 medium size irrigation districts (between 667-20,000 ha) covering 13.3 million ha. Large and medium systems serve about 47% of the total irrigated area in the country.

Small reservoirs, ponds, and pumping schemes with an area less than 667 ha are managed by local organizations. Since the 1970s, tubewell technology has been widely distributed to exploit the vast underground water resources that exist in the country (Liu, et al, 1994). Small-scale irrigation accounts for 27% of the irrigated area in China, while other smaller irrigation systems including tubewells are managed by farmers. The area under farmer managed irrigation in China is approximately 26% of the total area (Ministry of Water Resources, 1991).

By the late 1970s, problems associated with China's dramatic irrigation development program were beginning to manifest themselves. As a result of poor management and inadequate maintenance, irrigation systems in China were showing signs of structural deterioration and declining productivity. Substandard irrigation construction and ineffective management, combined with poor national and local economic conditions, held irrigation performance far below actual potential.

During the period of rapid irrigation expansion, from the 1950's to the 1970's, agricultural production and irrigation management were collectivized. The post-Mao reforms introduced by Deng Xiao Ping from the early 1980's introduced a new era of economic liberalization which opened the Chinese economy to the outside world. These new policies reduced the dependence of irrigation districts on the government and encouraged local financial and managerial self-reliance. However, at the beginning of the economic reforms, irrigation management agencies found it difficult to adjust to the reforms. As a result, irrigated area in China declined. After ten years of effort, the declining trend in irrigated area was reversed (Chen and Ji, 1994).

Similar to the situation in China, since the mid 1980's there has been a world wide trend to transfer complete or limited authority for irrigation management and financing from government agencies to local organizations, especially cooperatives and water users associations (Johnson, forthcoming). Irrigation management transfer has taken many forms in different countries but one common element has been a reduction of the role of the government and a corresponding expansion in the role of farmers and non-governmental organizations in irrigation management (Vermillion, 1992). In order to determine how policy reforms of the 1980s in China have been translated into new local institutional arrangements and management practices, and have led to changes in irrigation performance, the International Irrigation Management Institute (IIMI) and the Shijiazhuang Institute of Agricultural Modernization (SIAM) have carried out a collaborative research project in two medium-scale irrigation districts, Nanyao and Bayi, in Hebei Province in the North China plain.

The overall objectives of the study were: (1) to identify and document management policy changes before and after the economic reforms; (2) to document the process by which transfer of management responsibility have occurred; and (3) to assess the impacts of these changes on systems performance and financial sustainability. The purpose of this paper is to present preliminary findings related to the impacts of these changes on institutional arrangements, irrigation management and system performance.

SAMPLE IRRIGATION DISTRICTS¹

The two irrigation districts selected for the research study are located in Shijiazhuang Prefecture of Hebei Province. Bayi Irrigation District (Bayi ID) is located in Yuanshi County while Nanyao Irrigation District (Nanyao ID) is located in Pingshan County, both of which are near 38°N latitude. The location of these counties within Hebei Province can be seen in Figure 1.

Bayi ID

The arable land area of Bayi ID is 10,415 ha. Within the district most of the soil is loamy with a medium level of soil fertility. Average annual rainfall is 544 mm, with the majority of this concentrated from June until September. However, the annual amount varies widely, from as low as 250 mm to over 1,200 mm.

The source of water for the district is the Bayi Reservoir with an overall capacity of 73.87 million m³. The development of Bayi ID was started in 1959 with the construction of the Bayi Reservoir. Originally, the design area was 13,000-20,000 ha. Starting in 1961, only a fraction of the design area was irrigated. By 1967 the construction of the reservoir was completed and the irrigated area rose to 5,333 ha. The main canal is 5.4 km long with two main branch canals of 13.5 km in total length. Primary canals are 16 km long and the secondary canals extend 104.4 km. Within the system there are over 1,400 structures. There has been no rehabilitation since 1976 when a limited amount of canal lining was done on the main canal and some of the branches. Figure 2 illustrates the canal layout of the irrigation district.

The Bayi Reservoir was not able to provide all the irrigation water required for Bayi ID. Consequently, a canal from the Gangnan Reservoir--a large reservoir on the Mountain Taihang--was started in 1970 and completed in 1976. Since the completion of the Yingang Canal, Bayi ID has been able to purchase water from Gangnan Reservoir. This transbasin conveyance project ensures irrigation water for Bayi ID. Twenty to thirty million m³ of water is purchased annually.

This material is primarily taken from Chapter 2 Physical and Agricultural Context of Nanyao and Bayi Irrigation Districts, of the draft final report for the collaborative study between SIAM and IIMI, *Changing Patterns of Irrigation Management in North China: Case Studies from Hebei Province*.

In addition to surface water, the groundwater table is about 17 m below the surface. In order to tap this resource, there are 1,074 tubewells within the command area. About 4,000 ha can be conjunctively irrigated with both canal and well water. However, due to overpumping the water table in the county fell dramatically during the 1980s. In 1979 the average depth to the water table was 11.9 meters, while in 1993 the depth to the water table was 25.5 meters. In some areas it declined at the rate of 1.1 m/year while in other areas it declined in excess of 1.5 m/year. The pumping rate is 120 million m³ while the annual recharge is 100 million m³. In order to address this problem, since 1989 the district has received about 20 million m³ each year from the Yehe River in an attempt to stabilize groundwater levels within the county. In 1989, the district paid Yuan² 0.7 per 100 m³ and in 1991, 1992, and 1993 they paid Yuan 1.1 per 100 m³ for this water.

The population in Bayi ID is approximately 90,200 which includes 18,531 male laborers and 13,808 female laborers. There are off-farm employment opportunities as well as agricultural income, and therefore the income in Bayi ID was 670 yuan in 1991, while the average in Shijiazhuang Prefecture was 650 yuan. The literacy rate within the district is estimated at 80%.

Nanyao ID

Nanyao ID was designed in 1957 and in 1958 construction was started. Funds for purchasing materials were provided by the townships and volunteer labor was provided by the villages. Therefore the degree of government subsidy in the system was very small. There was a significant amount of rehabilitation in 1977-80, with almost all the labor coming from the farmers. The county contributed 200,000 yuan for materials only.

Within Nanyao ID the total arable land area is 3,333 ha. The soils in Nanyao are a sandy loam with lower levels of fertility than Bayi ID. Average annual rainfall is 535 mm, with the majority of the moisture concentrated in the period from June until September. However, the annual amount varies widely, from as low as 200 mm to over 950 mm. The water source for Nanyao is the Yehe River, which originates on the Shanxi Plateau and passes through Pingshan County before joining the Hutuo River. The average discharge of the river is 100 m³/s, although during the flood season discharge increases to 500 m³/s and during the dry season decreases to 20-50 m³/s.

Exchange rates for the Chinese yuan for the last six years have been one US dollar equals: 4.72 yuan (1989); 5.22 yuan (1990); 5.34 yuan (1991); 5.78 yuan (1992); 8.8 yuan (1993); and 8.6 yuan (1994).

Designed discharge at the head of the main channel is 15 m³/s. Within the irrigated area of 2,473 ha, the total length of main canal, branch canals and sub-branch canals is 111.5 km, of which 39.6 km is lined. The main canal is 30.3 km with 18.6 km lined. There are 339 structures within the system and total water discharge varies from 10.4 million to 59.4 million m³/year. System level water use efficiency is 53%. Figure 3 presents the canal layout of the irrigation district.

The population in Nanyao ID is 35,545 with 7,112 male laborers and 5,405 female laborers. Income is almost exclusively from agriculture and was 414 yuan/capita in 1991. The literacy rate is approximately 77%.

AGRICULTURAL PRODUCTION

Once irrigation water was available, agriculture production in the two districts shifted from rainfed to irrigated crops. In Bayi and Nanyao, winter wheat and summer maize are the main two crops, with cotton, vegetables, water melon and fruit orchards making up the other major crops. In addition, a small area is planted in rice in Nanyao ID. Table 1 presents the detailed area of the different crops as well as the percentages of the total.

As the climate in the area is hot and wet in the summer and dry and cold in the winter, rainfall during June to September is about 80% of the total annual rainfall. From October to May, the growing season for winter wheat, only about 150 mm of rainfall is available. As this is far below the requirements for wheat, irrigation is required. Generally, rainfall during the summer is sufficient for a maize crop and no irrigation is required during normal and above normal rainfall years. Table 2³ presents the winter moisture regime for the two irrigation districts. As can be seen in the table, a wheat crop generally requires at least 350 mm of supplemental moisture.

The water requirements for maize are in stark contrast to the water requirements for wheat. As can be seen in Table 3, during the average year moisture from rainfall is such that it actually exceeds the evapotranspiration requirements. Therefore, in many years maize does not require irrigation. In order to ensure that maize has sufficient moisture, farmers often relay plant the maize in the wheat and then germinate the maize seeds using moisture from the last irrigation on the wheat. In this case, the last irrigation for wheat has a dual purpose. However, during dry years maize will often require one or two irrigations to obtain high yields.

³Note: Tables 2 and 3 were developed by using the UNFAO CROPWAT program, as part of the collaborative SIAM-IIMI case studies.

IRRIGATION MANAGEMENT CHANGES DUE TO RURAL REFORMS

Organization of irrigation under the collectives

Before the Peoples' Communes were dismantled in 1983 (Shue, 1984), they were at the top of a three-level arrangement for organizing agricultural production and distribution and irrigation development and management. Communes were generally the size of townships and consisted of 10 to 15 production brigades. A brigade generally consisted of several production teams which were the basic units for organizing agricultural production. Teams consisted of 10 to 20 households. Payments to farmers in cash and goods were made on the basis of the amount of work points farmers earned through their farm labor and attendance at communal works activities, including irrigation construction and maintenance.

Irrigation development and management was directed by county level water resources (or "conservancy") bureaus, under the Ministry of Water Resources. At the irrigation system level, bureau staff coordinated irrigation management with the aid of labor assignments made by the commune. During the 1950's, 60's, and 70's about two-thirds of government funds allocated to the water sector were for construction and one-third were for operations (Gitomer, forthcoming). Subsidies from both central and provincial funds and from communes supported the management of irrigation systems. General labor on irrigation systems was paid by communes in work points. Irrigation managers were salaried officials of the county water resources bureau. The costs of irrigation O&M not paid by commune revenues was generally funded by the Ministry of Water Resources.

Change at the National Level

As a result of inefficiencies and declining central government revenues available for investment in rural development, two sets of policy changes had a major impact on the rural sector.

- The first policy change, which is really a package of several reforms, was the ***production responsibility system (PRS)*** that replaced the Peoples' Communes in the early 1980's. Under the PRS, households were allocated long-term leases on farm land that had previously been communal production land and were free to organize their own

production and marketing, decisions that were previously made by the production team. In addition, individual households could retain profits from their production. The government encouraged this change, by providing a general 50 percent increase in the grain procurement price.

- The second policy change was a general retrenchment of public investment. Government investment in the countryside, particularly in capital construction, dropped dramatically. Government subsidies for irrigation construction declined by over 60% from 3.49 billion yuan in 1979 to 1.3 billion yuan in 1981 (Gitomer, *ibid*). Between 1979 and 1985 government irrigation construction investment declined as a percent of gross domestic product from 0.87% to 0.21%.

While the change to the PRS system (combined with the higher grain purchase prices) resulted in an immediate increase in agricultural output, the precipitous decline in government subsidies to the local level, combined with a disruption of the communal organization of irrigation maintenance, led to a 2% decline in irrigated area. Between 1979 and 1985 net irrigated area was reduced from 45 to 44.04 million ha.

The reforms initially led to confusion within the irrigation sector. During the early 1980's there were widespread reports of chaos, water conflicts and rapid deterioration of irrigation infrastructure. Farmers wished to work their fields rather than volunteer labor to maintain irrigation infrastructure. With the new economic incentives, farmers were interested in increased output, which required higher quality irrigation service. Yet, as a result of the reforms there was confusion within the villages and the agencies about roles and responsibilities. As government personnel no longer had the authority to force farmers to volunteer their labor for irrigation related work, irrigation systems fell into disrepair. In addition, theft and stealing of water occurred as there was no effective enforcement system.

With the improvement of markets for agricultural inputs and outputs, the communes began to obstruct input and output flows rather than facilitate them. As it became obvious that there was a basic conflict between the incentives of family farms and the communes, this led to a second stage of reforms; that of dismantling the communes, which was effectively accomplished by the end of 1983 (Gitomer, 1994). Observing the impacts of these policy changes, in the

early 1980's the government began introducing a third series of reforms, starting with relatively modest measures and moving to progressively more fundamental changes.

- The first reform was the ***work post responsibility system (WPRS)*** introduced in the early 1980's. This was an attempt to introduce a system of incentives to water resources bureau officials to improve their work productivity. It was seen as a counterpart to the agricultural production responsibility system. Monetary bonuses and penalties were introduced in annual work performance evaluations amounting to 20% or more of base salaries. For collective-owned systems, a revolutionary reform system was implemented, the ***economic contract responsibility system (ECRS)***. Although originally limited to small irrigation systems, in many cases, elements of the ECRS have also been implemented within larger government irrigation systems. The county water resources bureaus remained intact with the demise of the communes.
- After collectivization the Ministry of Water Resources added a lower tier below the county level, the ***water resources stations*** which were created to replace production brigade functions at the township level.
- ***Village irrigation management groups (VIMGs)*** were created at the village level following the demise of the multi-functional production teams. These were to be under the jurisdiction of village governments but were managed and financed independently from the village government.

Two more far-reaching reforms were introduced through national regulations, both of which were decreed in 1985. These were:

- 1) The national ***Regulation on Water Fees***. The regulation on water fees stated the principle that revenues for operations and maintenance of irrigation districts should come mainly from fees collected from water users. The precise level of fees should be determined at the system level according to the local cost of O&M. However central and provincial governments continue to place ceilings on the maximum level of fees which can be charged to farmers, thus even with 100% collection rates, fees generally did not provide for the full cost of O&M, let alone for rehabilitation and capital replacement costs. The water fee regulation supported

development of a widespread tri-partite system of resource mobilization. This included a fixed area fee (based on the area irrigated by a farmer), a volumetric fee (based on estimated volume of water diverted into a farmer's field), and an annual labor contribution⁴ for system maintenance.

- 2) The State Council *Regulation on Diversified Sideline Enterprises*. Irrigation districts often had underutilized assets and resources which had potential economic value. There was generally a gap between the level of resources which could be raised by the irrigation fees (because of political reluctance to require farmers to pay for the full cost of irrigation service) and the actual costs of operations and maintenance. By the 1980's salaries of irrigation district officials were dropping in real terms below alternative employment opportunities in rural China and skilled staff were leaving the service due to low salaries and poor working and housing facilities in irrigation districts. In order to bridge the gap between the limited revenue which could be raised from fees and the amount needed for O&M and to boost salaries and facilities for irrigation workers, the government introduced the concept of diversified sideline enterprises into the irrigation sector. Irrigation districts were encouraged to develop sideline enterprises to raise additional revenue. Profits from these businesses were to cross-subsidize the costs of irrigation management. By 1988 it was official policy that no central or provincial government funds could be used for regular O&M in irrigation districts.

These broad national policy reforms were partly the result of a combination of financial and managerial pressure at the national level and "a process of experimentation and trial and error" at the local level (Gitomer, 1994 and 1985). They resulted in a variety of organizational arrangements throughout China at the level of irrigation districts. A central aspect of improved water resource management has been the issue of financing. Significant efforts have been made to encourage lower level water conservancy bureau and irrigation district officials to achieve financial independence from the Central and Provincial Governments. Local financing approaches include (Turner and Nickum, 1994):

- 1) increasing irrigation fees and collection rates;
- 2) stimulating investment from private sources;
- 3) creating joint stock cooperatives;

⁴This is not a minor input. Chen and Ji (1994) estimate that contributed farmer labor constitutes more than one-third of the total value of resources invested in existing irrigation districts.

- 4) borrowing from domestic and international banks;
- 5) soliciting aid from international organizations; and
- 6) establishing and managing sideline economic enterprises to earn additional income.

In some instances, irrigation districts are being managed by small, locally-contracted "irrigation management firms" which receive multi-year contracts from villages or irrigation districts, depending on the level of management involved (Svendsen and Vermillion, 1992)

Organizational Changes in Nanyao and Bayi Districts

The third area of reform was a significant change in the role of the VIMGs. Under the commune system, operations and maintenance of the districts was handled first by water conservancy groups, created in 1964. These were soon absorbed financially and managerially by the collectives and later, villages. Irrigation staff interviewed in this study reported that under the commune system responsibility was often confused and coordination was difficult because irrigation matters were handled by busy multi-functional production brigades and later, by village committees. Irrigation district staff had little authority relative to the communes. When the production responsibility system replaced the collectives, water resource stations and village committees replaced brigades and production teams, respectively.

As part of the reforms begun in the early 1980s, VIMGs were organized in Pingshan and Yuanshi counties to take over direct responsibility for managing irrigation. A VIMG generally has about three to five members, selected by the farmers in a village. VIMGs normally have a head, a deputy (who inspects canals for problems or damages), a treasurer, a head of water fee collection and a head of maintenance. Their duties are to clean canal sections which pass through the village (normally branch canals and below), distribute water among village farmers, collect water charges ("under the supervision of the ID"), ensure proper passage of water through the canals and maintain, organize schedules among farmers for water delivery and protect field-level irrigation facilities of the county water conservancy bureau (WCB). The VIMG head often is also an official on the village committee. Each VIMG staff has responsibility for coordinating water distribution between roughly 200 households farms.

At present, in Nanyao ID in Pingshan County, the top two levels of canals are managed by the irrigation district and the third and lower-level canals are now managed by VIMGs. Nanyao ID has five levels of canals (as do most districts in both counties). The district office has two tiers, the main office and four sections which are subdivisions of the system (Figure 4). Nanyao ID has 30 staff members plus 5 temporary workers. All receive their total salaries from

the water charge. The main office has three managerial sections, canal measurement, engineering and irrigation, and financial and administrative. Nanyao has 40 VIMGs. It has not yet developed any sideline enterprises under a "Diversified Management Division."

Bayi ID has four tiers of organization: 1) the main office, which oversees the entire system and operates the reservoir; 2) five technical and administrative units, 3) four sections, which manage the main and branch canals and liaise with VIMGs, and 4) the VIMGs (Figure 5). Bayi ID (including the Reservoir) has a total of 67 staff, 20 of whom have temporary status. Thirty-two staff are performing water management functions (12 are engineers) and 35 are in the "Diversified Management Division," producing revenues from sideline enterprises. All 32 staff in the Irrigation Management Division (IMD) are ID employees and receive all of their salaries and pensions from Bayi ID, not the county water conservancy bureau. None of the staff are civil servants under the water conservancy bureau. Hence the irrigation district is an independent public utility, not part of the government bureaucracy. Bayi ID has two divisions, Irrigation Management (which is responsible for O&M and technical matters) and Diversified Management (which manages sideline enterprises). The district has 45 VIMG's.

In both districts functions of the section level staff are to:

- 1) adjust gates along the main canal (gates along branches are operated by VIMGs);
- 2) maintain the main canal (mainly by planning and coordinating farmer labor);
- 3) pass announcements from the irrigation district or county water conservancy bureaus to villages (especially informing villages about section-level meetings for scheduling water deliveries between villages);
- 4) settle disputes between villages over water use (disputes often occur over which village irrigates first); and
- 5) encourage VIMGs to pay water fees on time.

POST-REFORM MANAGEMENT PRACTICES IN THE TWO IRRIGATION DISTRICTS

Performance Standards

Under the work post responsibility system, yearly personnel evaluations of district and water conservancy bureau staff are required. For irrigation district staff these include an assessment of water fee collection rates, the quality of

maintenance work and water distribution. Both Nanyao and Bayi make annual assessments of staff and district management performance according to the same basic set of eight "economic norms" (or performance standards) promoted by the work post responsibility system. They vary in how they calculate points, bonuses or fines. Assessment is done at the level of individual staff, section offices, divisions and at the district office level. The eight criteria used are: irrigation efficiency, proportion of structures which are functional, balance of income and expenditures, total water use, irrigated area, water use efficiency, irrigation schedule targets and crop yields obtained.

Performance standards are set for each of these criteria and percentage figures are used to measure levels of achievement relative to that standard. If a staff gets a rating below 60%, no annual salary bonus is given and salary is reduced by one grade for that year. In these two districts, this has not happened yet. Table 4 shows the system of performance measures used in Nanyao ID in 1993. The rating was 96.5% of potential. In comparison with problems of advancing siltation and deterioration, this rating lends some support to Nickum's argument (1985) that the water fee assessment system in China is only used in a modest way to remind staff not to shirk duties too much. Scores tend to be stable in most years. The overall annual performance rating for Nanyao ID increased from 81 points in 1987 to 96.5 points in 1993. This was likely a combination of some "rating inflation" and real improvements.

Apparently as a gesture to increase work incentives, Nanyao recently decided that from 1994 onwards, if a staff member is ranked below 79% they get no bonus and the salary will be reduced by one grade. For scores above 79%, the higher the score the higher the bonus. Staff grades generally increase according to seniority, promotion and performance ratings according to the guidelines of the National Personnel Ministry. Grade levels determine salary. The Labor Ministry designates base salary levels for all kinds of positions, even in financially independent irrigation districts.

Irrigation fees

Water rates and, therefore, actual water costs to the farmers have gone up significantly since the mid 1980s when the reforms were implemented. This is based on the principle, *He who benefits must take responsibility for management and make investments*. In both sample districts, irrigation water fees are a combination of a fixed fee based on irrigated area, and a volumetric fee based on water used. For Nanyao ID the rates are 1.5 yuan/100 m³ and 112.5 yuan/ha, while Bayi ID presently charges 7.19 yuan/100 m³ and 15 yuan/ha. In

Nanyao, volumetric charges are only charged at the main canals as they do not have measuring devices at the sub-branch level. Therefore, at the Village Irrigation Management Group (VIMG) level farmers are charged a flat rate of yuan 225 per ha for irrigation water.

Figure 6 illustrates the historical trend of water fees for the two districts. This data is in constant 1991 Chinese yuan so the significant increases are real, not just reflections of inflation in the Chinese yuan. As can be seen, in Nanyao the rate based on volumetric flow is less than the 225 yuan per ha. The additional funds collected are used to pay lower level irrigation staff and provide incentives to the VIMGs to ensure they collect 100% of the water fees (Johnson, et al, 1994).

In Nanyao, if the VIMG collects 100% of the fee by the end of March, the VIMG retains 5% of it. If they collect 100% by the end of April, the VIMG retains only 3%. If the VIMG collects less than 100% by May then the VIMG must pay a fine of an additional 3% of the remaining amount uncollected. The entire fee for the year is collected once a year, in February, 10 days before the first irrigation. Fee collection rates for 1993 were 97%, 90% and 95% for each of three sections.

In Baiyi before 1984 the water fee was only a fixed area fee so the use of water was very inefficient. The volumetric water fee was introduced after 1984 as part of the reforms. The Hebei Province standard rate for the volumetric fee was 3.0 yuan per 100 m³, but since Baiyi ID purchases water from the Baiyi Reservoir and sometimes from another county (Pingshan) and have more than 100 kms of canal to supply this water to the district, they have a higher fee based on the actual higher costs for water. The Baiyi Reservoir and ID propose a fee level which is approved by the county government, based on the provincial standard modified to take into account actual local costs. In this respect, the water fee standards seem to be considered more as guidelines than rules.

In about two-thirds of the villages in Nanyao ID, the VIMG collects water fees from individual farmers, in the other third the villages produce enough off-farm collective income that the village committee pays all of the water fees charged to the village and often also pays for other agricultural taxes, educational fees and village fees. For example, Dong Hui She village has successful collective enterprises, including a brick factory, fertilizer bag production plant and fruit orchard. Eighty percent of the factory workers are also farmers from the village. Workers are paid on a piece rate basis. Dong Hui She village paid 100% of its water fee by March 5 in 1992 and 1993 and thereby received a 5% rebate.

Bayi ID collects the water fee from farmers, through the VIMGs, three to five days before the village's scheduled water turn. The VIMG broadcasts with megaphones announcements of pending water delivery three to five days in advance, reminding farmer to come and pay their water fee before delivery. Two members of the VIMG wait at a designated location for farmers to come and pay. At least two VIMG staff must together receive water fees. A receipt is issued to farmers upon payment. Normally 90% of the farmers pay the fee in advance of the water delivery. Others still get water but must pay afterwards or they won't be allowed the next water turn until they pay--but this is reportedly "very rare."

Compensation of VIMG staff is sometimes from the village committee funds and sometimes from a village-levied surcharge on the water fee. Compensation to VIMG staff ranges from 400 to 1,000 yuan between different villages, varying by the size of village irrigated area, amount of work required and differences in wealth between villages. Most villages in Bayi ID have a surcharge on the water fee of about 2 to 5% to pay for the cost of compensation for VIMG staff.

Financial Management

Under the collectives or village committees, general commune or village revenues subsidized routine irrigation costs. Central and provincial level funds are now only available for construction and rehabilitation on a cost-sharing basis with villages or farmer groups. Financing routine operations and maintenance has always been the responsibility of the irrigation districts and farmers. Officials report that neither Nanyao nor Bayi ID have ever received central government funds for routine operations and maintenance.

While no funds are provided by the government for O&M, between 1988 and 1992 the county water conservancy bureau provided 519,000 yuan (approx. US \$85,000) to Bayi ID for canal lining and extension. This amount was one-third of the total expended. As required matching investments, the same amount was invested by both Bayi ID and member villages (mainly in the form of labor), respectively.

In 1992 Nanyao ID's total budget was approximately 365,000 yuan (about US \$ 63,000), 350,000 yuan of which was from the collection of current and back accounts for water fees. Expenditures totalled 341,500 yuan, including a 36,500 yuan repayment of its 1991 budget deficit. Nanyao spent 36,500 yuan to purchase supplemental water from the Yehe river. Therefore, Nanyao had a budget surplus in 1992 of approximately 13,500 yuan.

Between 1984 and 1992 Bayi's Diversified Management Division produced 400,000 yuan (approx. US \$60,000) in profits. Of this, 260,000 yuan (65%) was submitted to the ID office to finance water management. The other 140,000

yuan (35%) went to salaries and bonuses for staff of the Diversified Management Division, many of whom are spouses of ID staff. In 1992 total revenues from irrigation fees in Bayi ID amounted to 873,000 yuan, while total revenues (i.e., profits) from sideline enterprises amounted to 103,000 yuan. This total income of 976,000 yuan (approx. US \$ 168,000) produced a surplus of 258,000 yuan (US \$45,000) over total expenditures of 718,000 yuan (US \$ 124,000). Purchase of water constituted 375,000 yuan or 52% of total expenditures.

At the level of Hebei Province, in 1992 a total of 450 million yuan (US \$52.3 million) gross income was raised province-wide by the Water Conservancy Bureau from diversified sideline enterprises. Sixty-six million yuan (US \$7.7 million) of it was invested in construction and rehabilitation of water projects. These enterprises also provided employment for 13,155 people.

PERFORMANCE IMPACTS OF THE RURAL REFORMS

Although there is no question that the rural reforms have resulted in significant changes in the way water resources and, in particular, irrigation are managed in China, the critical question is whether these changes have resulted in improvements in performance. In this section, performance impacts of rural reforms are examined in terms of three aspects: agronomic changes, financial sustainability, and hydrologic efficiency.

Agronomic Changes

As indicated earlier, access to irrigation water significantly changed the cropping patterns in the two districts. Before construction of the irrigation districts in Bayi and Nanyao, the main crops were maize and other spring sown crops such as spiked millet, sweet potatoes, buckwheat, and beans, which are all drought tolerant crops. Very little winter wheat was grown. During the 1980s, after the irrigation systems had been established and were working well, the percentage of irrigated winter wheat and maize in the cropping system reached its highest levels. Recently, however, farmers have shifted to growing more cash crops such as watermelon, vegetables and fruit trees in order to maximize their income.

Prior to development of Bayi and Nanyao irrigation districts, farmers living in the two regions consumed all their grain production within the household. In fact, in dry years the Government was forced to provide grain to the rural families in the area at below market prices. After the irrigation systems were constructed, irrigated grain production increased significantly. As a result, the farmers sold 1/6th of their winter wheat and 1/10th of their maize production in

Nanyao ID and 1/3rd of their winter wheat and 1/10th of their maize production in Bayi ID to the Government. With the development of the agricultural production responsibility system there has been sufficient grain after providing their quota to the Government for farmers to have grain for consumption and still have grain to sell on the local market.

Currently in Bayi ID about 1.5 T/ha of wheat is sold to the Government, about 1.5 T/ha is left for farm family consumption and 1.0 t/ha is sold on the free market. For maize about 10% of the total production is sold to the Government, about 65% is sold on the free market and the remainder is used for animal feed. In Nanyao ID, about 0.75 T/ha winter wheat is sold to government, the remainder is left for family consumption and only a small percentage is sold on the open market. For maize, about 0.75 T/ha is sold to the Government, half of the remainder is sold on the open market and the remaining stock is used for animal feed.

As a result of increased yields, facilitated by access to irrigation water, chemical fertilizers and pesticides, and new high yielding seed varieties, net returns per hectare have increased significantly. Table 5 compares the yields, input levels and net incomes for Bayi and Nanyao IDs for the 1950s, 1960s, 1970s, and 1980s. As can be seen, the annual combined per ha production of wheat and maize (for the two seasons) has increased from 1,125 kg in 1960 to 11,905 kg in 1992 for Bayi ID and from 5,250 kg in 1972 to 8,500 kg in 1992 in Nanyao ID. At present, the net income for the two seasons of wheat and maize is 4,200 yuan/ha for Bayi ID and 3,300 yuan/ha for Nanyao ID. Thus, development of the irrigation systems, combined with implementation of the rural reforms, has resulted in impressive improvements in net income in the two districts. Bayi ID, due to its higher yields, has been able to sustain its growth in net income, while Nanyao ID has seen a drop off of net income as annual per ha production of wheat and maize has stagnated during the 1990s.

Financial Sustainability

Central to the transfer of irrigation management, development and reform has been the issue of financing. In this process it has been critical that farmers and irrigation officials alike recognize that irrigation water is not a free good, but a valuable production resource. Since the implementation of the rural reforms, education and propaganda schemes have been used to educate users and suppliers of agricultural water about the importance of financial stability to ensure long-term security of irrigation supplies.

Prior to the reforms, water fees were paid by the communes and thus "collection rates" were always 100 percent. However, as the reforms were instituted, collection rates dropped drastically as there was confusion within the irrigation systems about management responsibility. Improved management services and extensive education programs have been used as a mechanism to increase water fee levels as well as collection rates. These approaches have been successful as water fee collection increased from 4.36 hundred million yuan in 1984 to 18.3 hundred million yuan in 1991 and in 1992 they doubled to 35.7 hundred million yuan (all in current yuan). In addition to increased fee levels, collection rates increased from 30 percent in 1984 to 70 percent in 1991 (Turner and Nickum, 1994). The reduction in subsidies and the obvious necessity to increase local funding to support operation and maintenance (O&M) expenses also served to improve fee collection in many areas.

Fee levels and collection rates dropped initially after de-collectivization and then gradually rose as the reforms took effect. In Nanyao ID the water fee collection rate was 100% until 1984 while it was paid by the commune. After, 1984, when the rural reforms were first introduced, due to the confusion and an actual reduction in irrigation service, combined with an increase in the volumetric water fee, the collection rate fell to 85 percent. It fell even further during the period from 1988 to 1991 as the district struggled with instituting a revised management system, including the WPRS. It wasn't until 1993 that the collection rate rose above 90 percent (95 percent). The case of Bayi ID is even more striking. Again the collection rate for irrigation water fees was 100 percent while paid by the commune. When the rural reforms were first introduced in 1983, the water fee collection rate fell to 5 percent. It rose to 80 percent the following year and has been close to 100 percent since then.

Nanyao is a water surplus area and both buys and sells water. However, the increases in O&M costs due to the reforms have forced the actual per ha water costs to increase. As can be seen in Figure 7 the steadily increasing water costs have encouraged conservation in water use, thus per ha water use has declined significantly since the early 1980s.

Expenditures and revenues have both increased since the implementation of the economic reforms. As indicated earlier, one of the mechanisms encouraged to address the need for additional revenue is the development of supplemental market-oriented enterprise. Nanyao ID is in a poorer area than Bayi and it began implementing the reforms later. It has still not developed any sideline enterprises. Officials of the ID express a desire to establish sideline enterprises, but report difficulty in raising initial capital and getting organized.

Bayi ID's Diversified Management Division was created in 1984. By 1994 it has become highly diversified. It has 11 kinds of sideline business:

- 1) survey and design of small scale irrigation projects;
- 2) fitting of water pipes and taps;
- 3) repair of farm machinery and irrigation and drainage equipment;
- 4) well boring and pump installation;
- 5) building construction;
- 6) small restaurant;
- 7) bicycle repair shop;
- 8) agricultural products store;
- 9) cobblestone production facility;
- 10) cement tile and pipe factory; and
- 11) talcum powder.

Since 1984 Bayi ID has received many prizes and awards from the county, prefecture and province for its successful Diversified Management Division (Wu, 1994).

Within the district, the ratio of gross income from water fees to gross income from enterprises is 5:3. In terms of net income, the ratio is 2:1. Of the 67 employees in the irrigation district, 30 work in water management while 37 are involved in enterprise management. For diversified enterprise management, targets are established based on anticipated net profit. These are normally negotiated between the irrigation district and the enterprise managers. Up to the level of the target, all profits go to the irrigation district. Profits above the target are retained by the enterprise and are usually distributed as profit-sharing among the enterprise employees. In 1992, the irrigation district received 103,000 yuan in enterprise profits. The businesses also provide employment for family members of district staff (as well as others) and thereby enhance the standard of living of staff families.

In the past Nanyao ID has been able to remain financially stable without requiring other income. However, with constantly increasing expenditure levels, the district is actively exploring alternative revenue possibilities.

Hydrologic Performance

One of the most important hydrologic relationships in irrigation management is that between available water and land. In this context, one of the primary tasks facing irrigation system managers is to match area to be irrigated with the current water supply. Other things being equal, good managers will try to

maximize the area served while producing acceptable yields on all of the area. Viewed another way, the manager's task is to make each available unit of gross water supply go as far as possible.

In Nanyao, irrigated area has remained almost constant for the last 20 years, suggesting that this is the maximum service area of the system, yet water supply has shown considerable variability over this period (Figure 7). These two facts taken together indicate that water supply is not constraining in Nanyao. Following the canal lining program during the 1977-80 period, it can be seen in Figure 7 that water deliveries increased sharply before beginning a steady decline from the 1982 peak of almost 60 million cubic meters. Because area irrigated held steady during this period, the result is reflected in the figure as a steady and dramatic decline in the duty of water supplied in Nanyao. Water use per unit area today is only one-third of the amount supplied in the early 1980s.

In Bayi, which is located in flatter terrain, only a fraction of the potential command is irrigated, and area irrigated has fluctuated considerably from year to year. Data clearly reflect the impacts of the completion of the Yingang supply channel from Gangnan Reservoir in 1976, as irrigated area increased dramatically in the following two years, peaking at around 6,600 hectares. In subsequent years, area stabilized at around 4,500 hectares. Figure 7 illustrates the main canal discharge, which also increased substantially after 1976, but then shows a continuing downward trend from 1979 to the present. Irrigation duty figures in Figure 8 show more variability than do those for Nanyao, but have declined somewhat from peak years.

Even though both systems have shown declining duties over their lifetimes as they come to use water more efficiently, duties in Nanyao are still about double those in Bayi, even though rainfall and cropping patterns are similar. This provides an interesting comparison as clearly Nanyao has much more water than Bayi, yet output per irrigation in water-rich Nanyao is only about one-third that in Bayi as Bayi produces about 3 kg/m^3 of water, while Nanyao manages only around 1 kg/m^3 .

Although the levels of other input use must be considered in making a valid comparison of this type, these results are suggestive of greater production efficiency in Bayi. It should be remembered that Bayi is producing almost 12 tons of grain/hectare with this water, while the annual output in Nanyao is only about 8.5 tons/hectare. A challenge which must be faced in this region is the development of institutions and pricing and marketing systems which will move water from less efficient systems to more efficient ones.

CONCLUSION

National level policy reforms promoting local financial and managerial self-reliance have been adopted, although in a somewhat variable manner, in both Nanyao and Bayi IDs. Nanyao ID has been slower in introducing the volumetric water fees and creating village irrigation management groups. It has still not yet developed sideline enterprises. Bayi ID started its first sideline enterprises in 1982. Nanyao ID has a relatively abundant, river-based supply of water and has often been in a water surplus situation. Bayi ID is water deficit and must purchase large amounts of water each year. This dependence on water purchasing, together with the greater ability of farmers to pay (due to higher productivity), may be the driving influences for development of sideline enterprises in Bayi and more concern about improving water use efficiency. Both Nanyao and Bayi ID's have implemented rules and practices which create various financial incentives and accountability mechanisms aimed at enhancing water use efficiency and the transparency of financial accounting and water delivery (Vermillion, et al, 1994).

It is apparent that the reforms are producing more viable local management of irrigation. They provide reasonably clear delineation of responsibilities, water rights and linkage between rights to water and paying for it. Where sideline enterprises have developed they are helping to stem the flow of skilled staff out of the irrigation sector by improving facilities and standards of living for families of irrigation district staff and water resources officials. They are also allowing the districts to keep water costs down by cross subsidy.

Farmers must pay the water fee in advance in order to receive water. If they do not in fact receive water their fee is refunded. Within limits, farmers may pay a higher level of fee to receive more water. In Bayi ID, this appears to be a powerful mechanism which achieves an impressive level of performance of water and financial management. The village acts as a mediating guarantor to see that these rules apply to the individual farmer. This appears to be resulting in gradual enhancement of self-reliance of irrigation districts. However, as indicated in Nanyao ID, it is apparent that some irrigation districts may need external technical and financial support services to implement volumetric water delivery, fee assessment and diversified sideline enterprises.

The Water Law enacted in 1988 introduced a water extraction permit system, new authority to apply sanctions against water use violations at local levels, and procedures for mediating water disputes. The Law establishes measurable water rights and facilitates the allocation of water between sectors

through buying and selling. However implementation of the new Law has proceeded slowly. By 1993 only 11 provinces or autonomous regions had passed implementing regulations for the Law. Over the next decade competition for water across economic sectors will force adoption of the Water Law by the remaining provinces.

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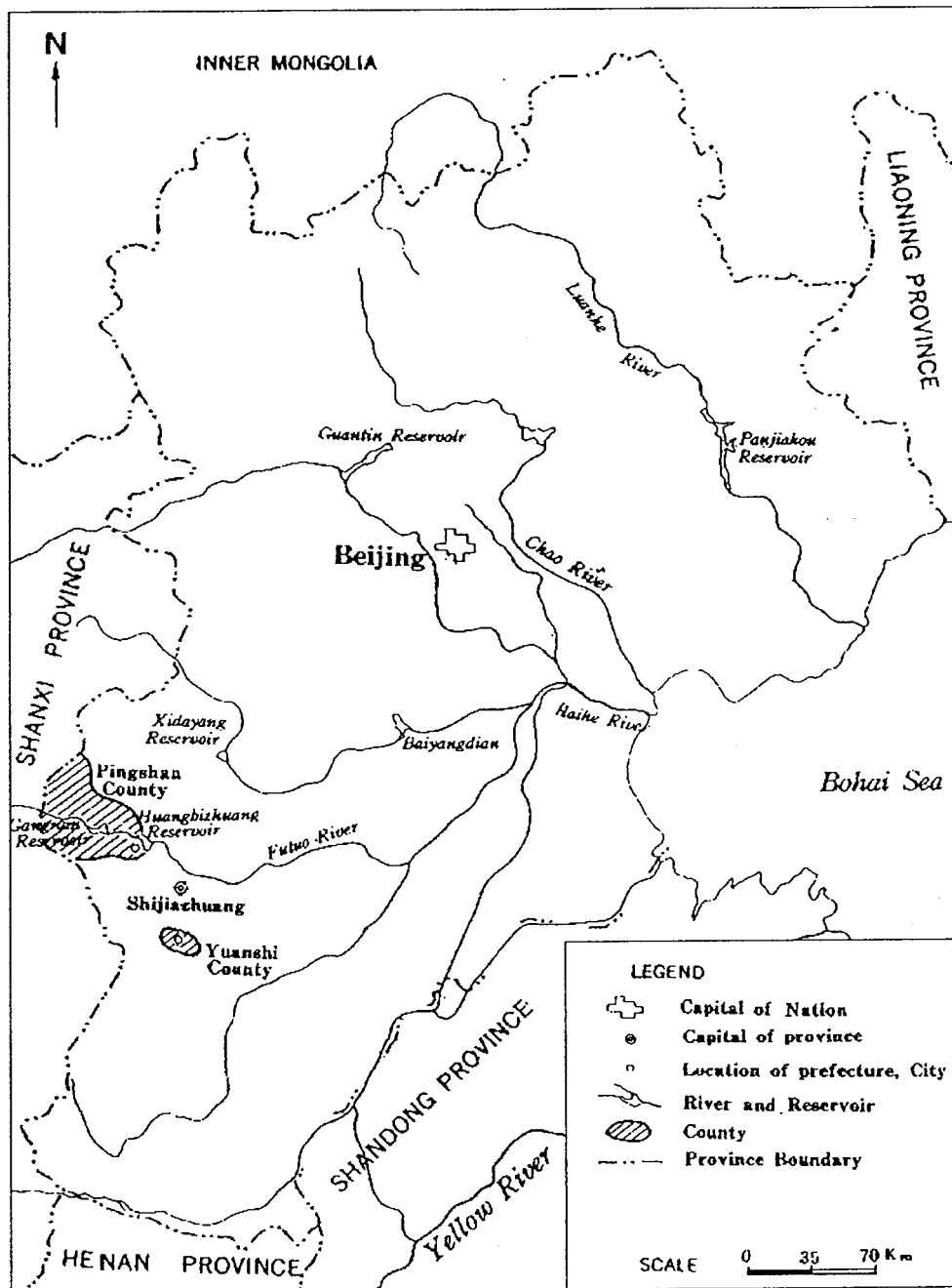


Figure 1 Hebei Province Showing Location of Pingshan and Yuanshi Counties

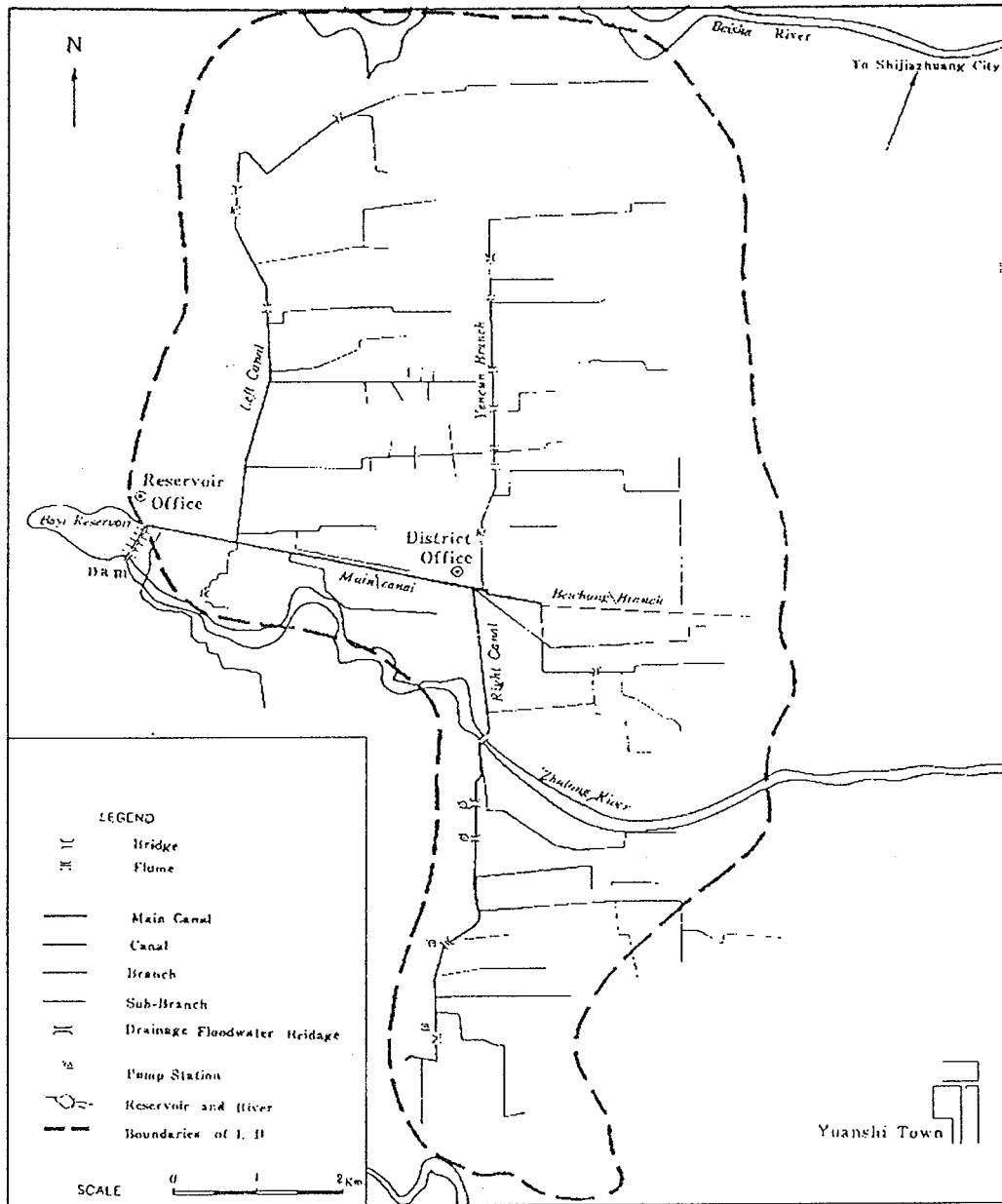


Figure 2 Canal Schematic Layout for Bayi Irrigation District

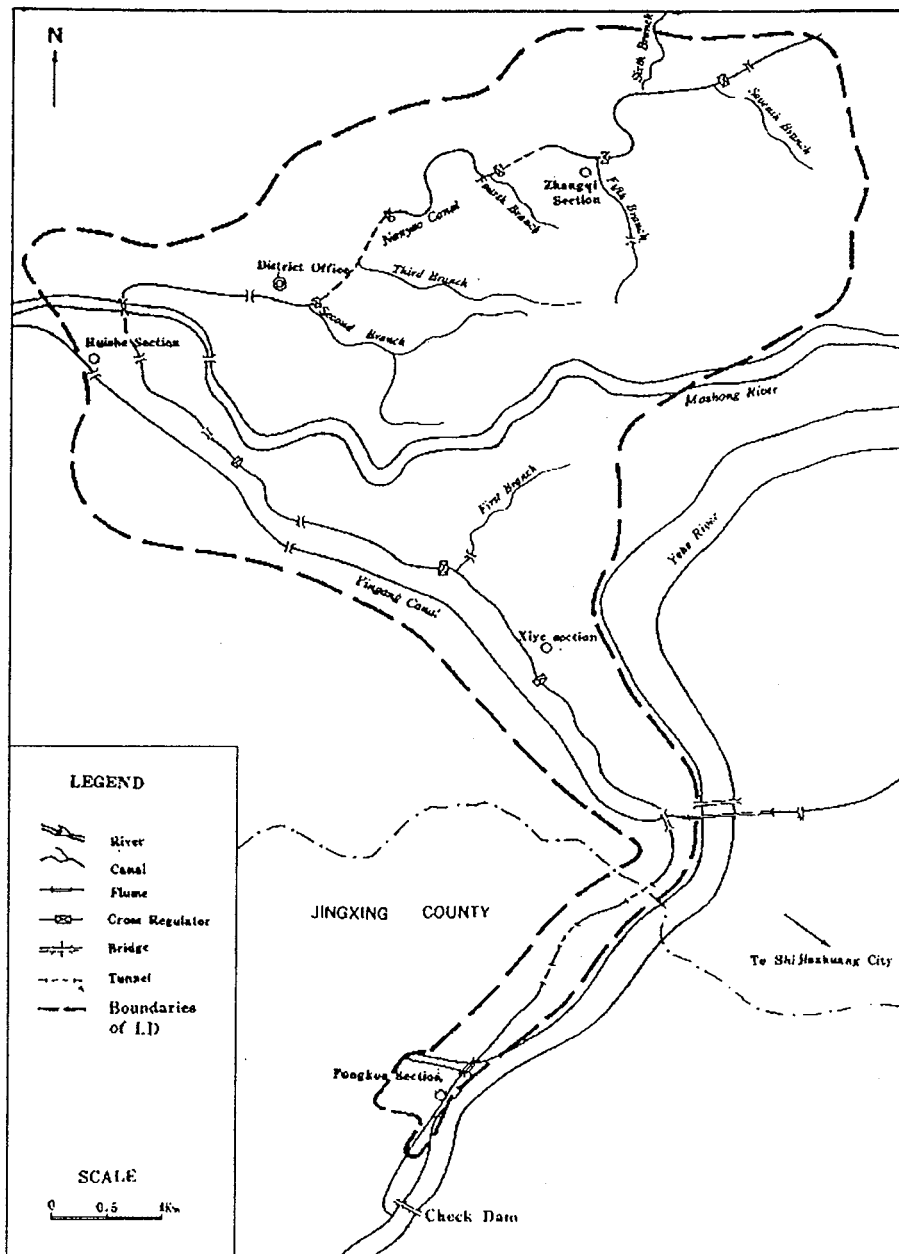


Figure 3 Schematic Canal Layout for Nanyao ID

Irrigation District Main Office
Director (1), Deputy Director (2)

Permanent Staff 30

Temporary Staff 5

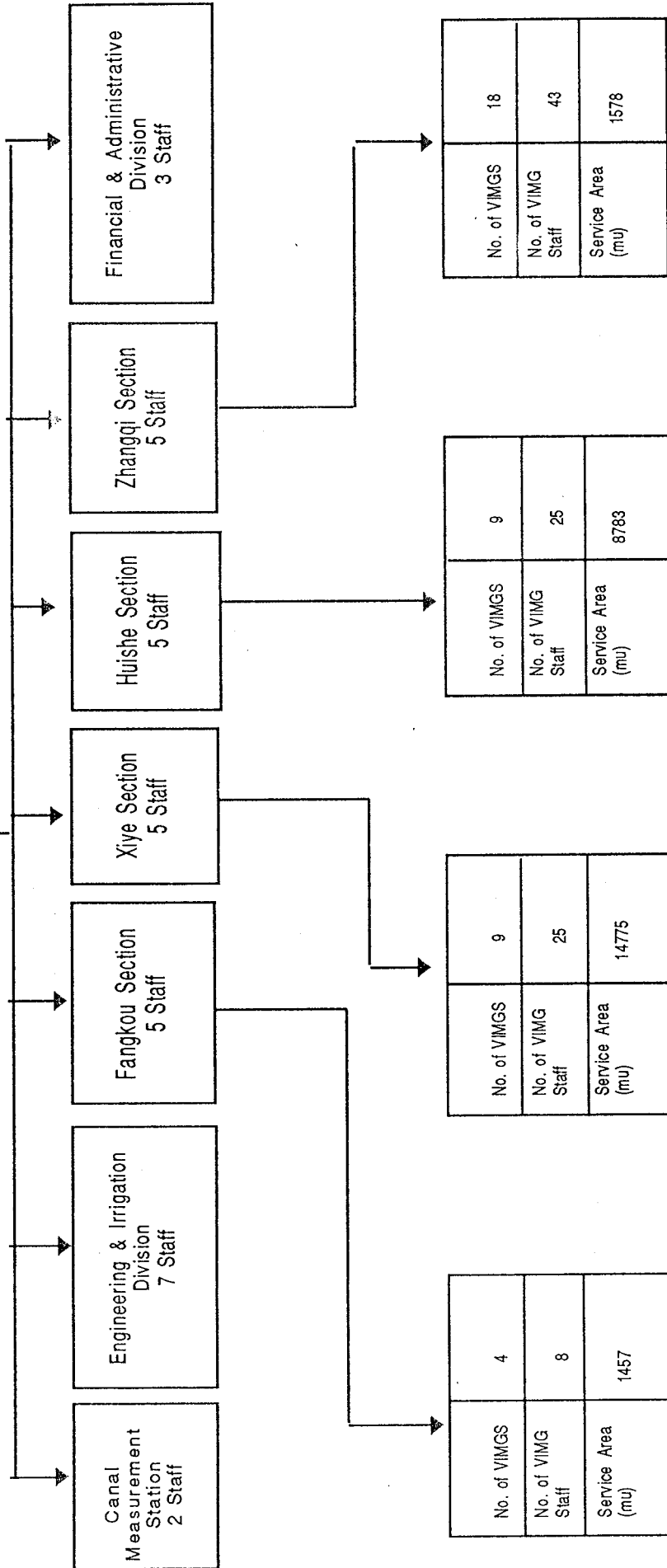
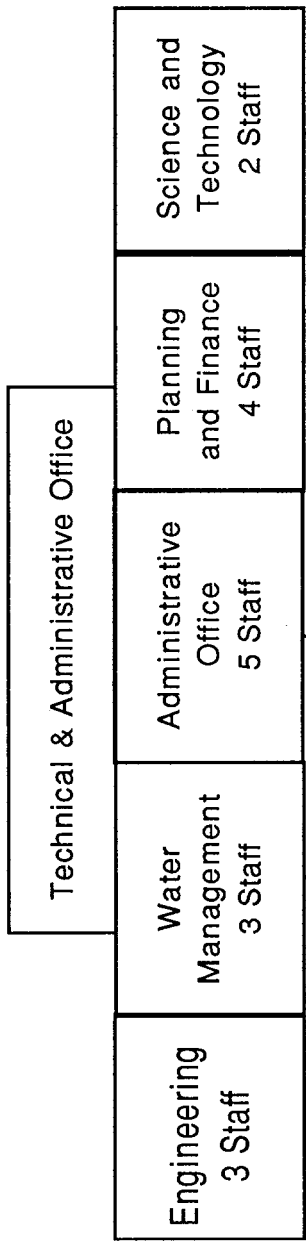


Figure 4. Organizational Chart for Nanyao Irrigation District, Pingshan County, Hebei Province

Irrigation District Main Office
Director (1), Deputy Director (2)



Irrigation Management Section

Name of Section	Branch Canal	First Sub-Branch	Second Sub-Branch	Last Sub-Branch
Staff	3	3	3	3
Villages Served	6	6	15	16

Diversified Management Section

Bulking Materials & Cement Pipeline Manufacturing Plant 19 Staff	Hydrologic Drilling Team 4 Staff	Service Department of Water Conservation 3 Staff
atering Trade & Repair Business 9 Staff		

No. of VIMGS	6
No. VMG Staff	19
Service Area (mu)	8992

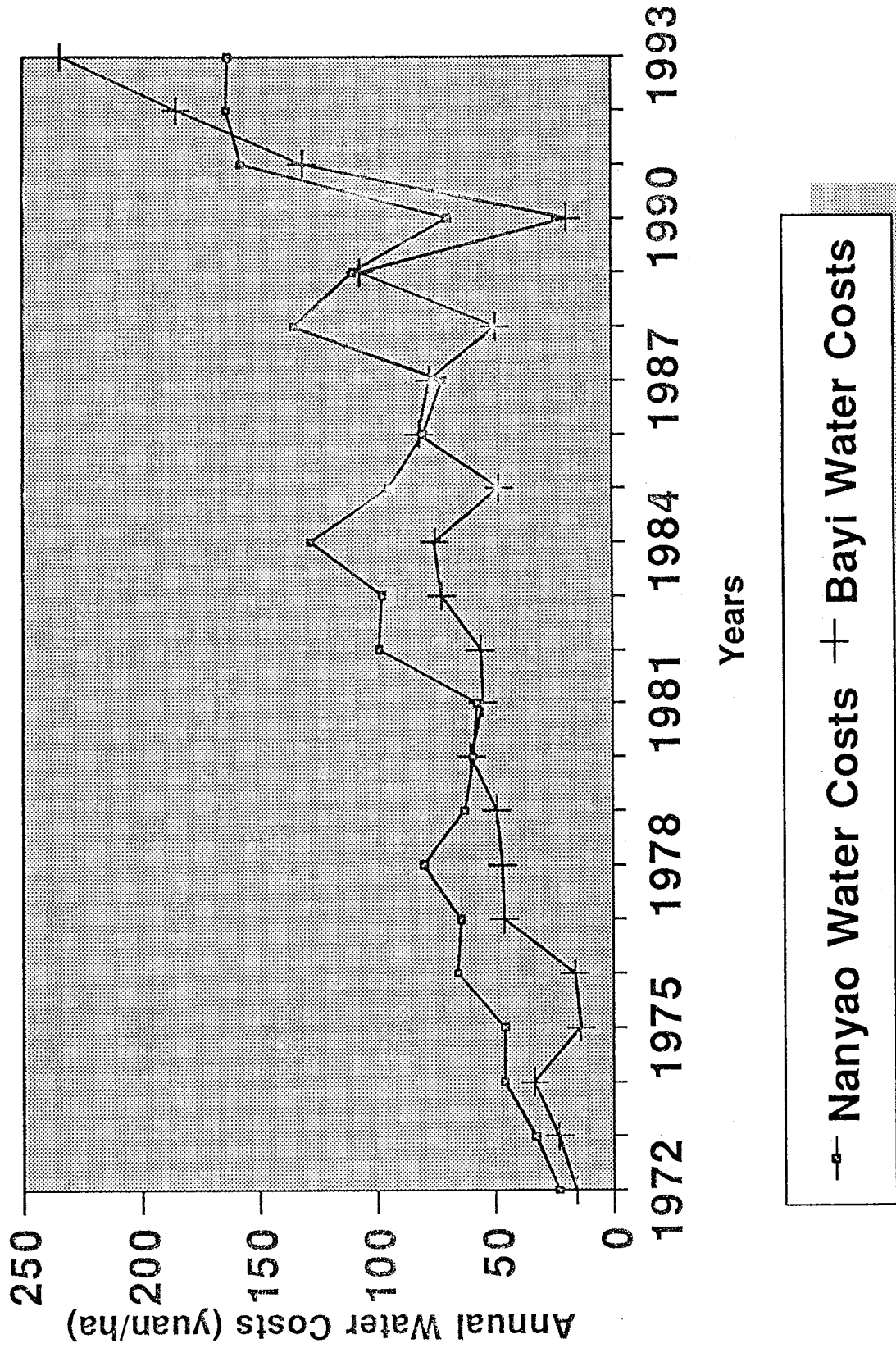
No. of VIMGS	8
No. VMG Staff	38
Service Area (mu)	21700

No. of VIMGS	15
No. VMG Staff	53
Service Area (mu)	27484

No. of VIMGS	16
No. VMG Staff	73
Service Area (mu)	42858

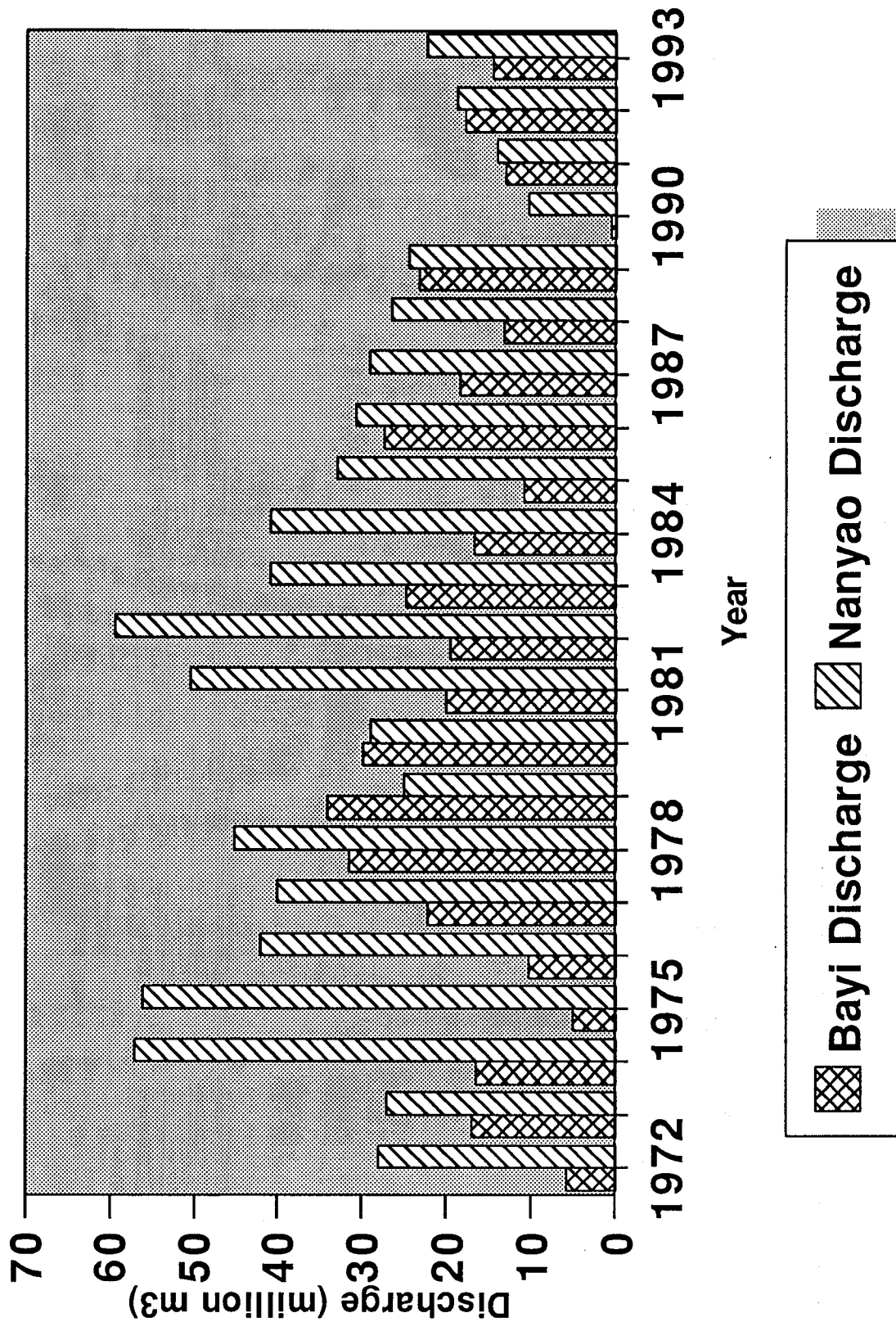
Figure 5. Organizational Chart for Baiy irrigation District, Yuanshi County, Hebei Province

**Figure 6 Per Ha Annual Irrigation Water Costs
Bayi and Nanyao Irrigation Districts**



Converted to 1991 Chinese Yuan

**Figure 7 Annual Main Canal Discharge
Nanyao and Bayi IDs (million m3)**



data provided by Nanyao and Bayi ID

**Figure 8 Annual Irrigation Duty
In Bayi and Nanyao IDs**

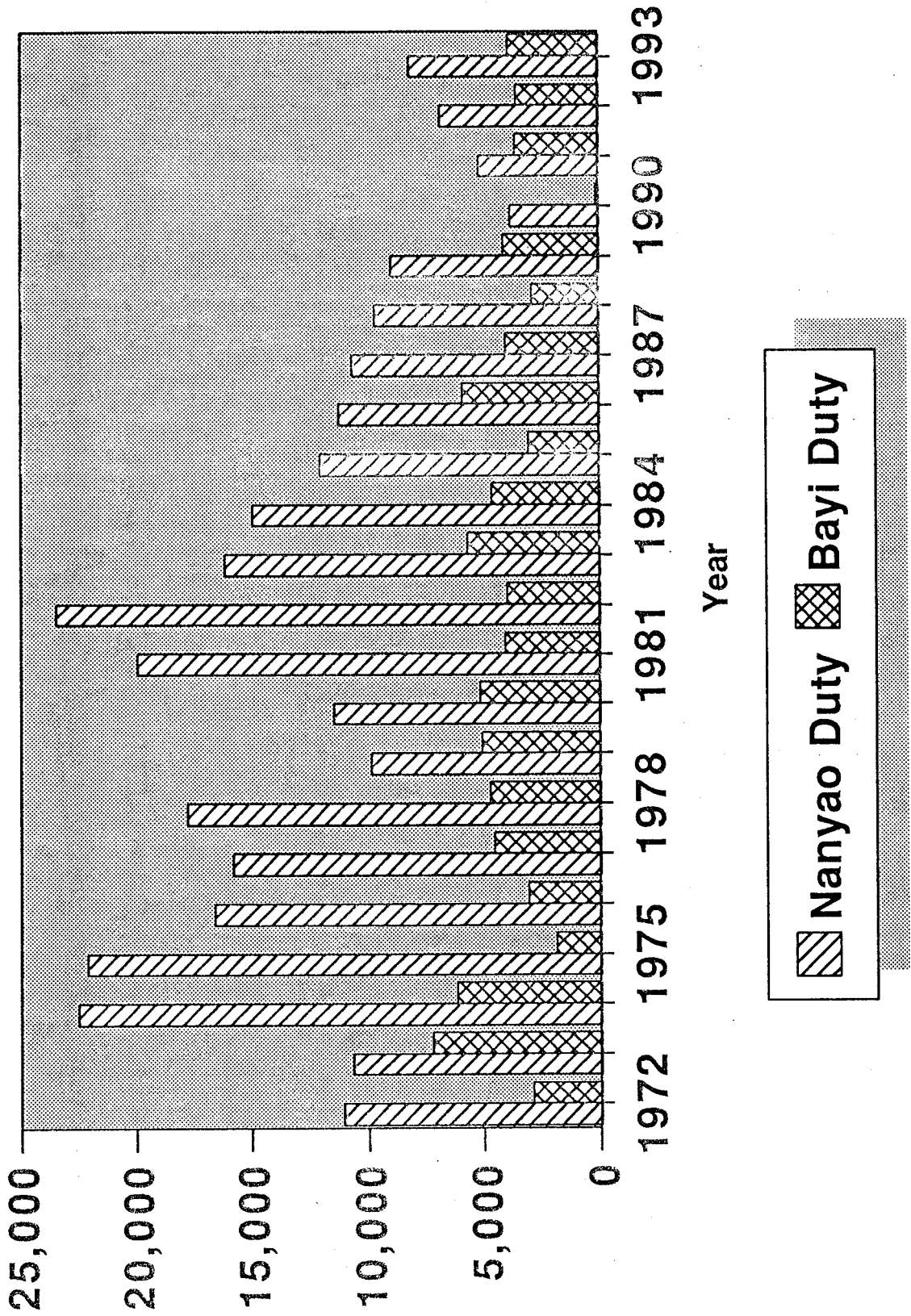


Table 1. Crop Patterns in Nanyao and Bayi I.Ds (Average in 1990s)

Crop	Bayi I.D		Nanyao I.D	
	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)
Winter - Wheat Maize	7738.9	74.3	2473.3	74.2
Cotton	1385.3	13.3	333.3	10.0
Vegetables	364.6	3.5	93.3	2.8
Rice	-	-	66.7	2.0
Water Melon	250.0	2.4	36.7	1.1
Fruit Orchard	177.1	1.7	10	0.3
Sweet Potato	166.2	1.5	180.0	5.4
Spiked Millet	93.7	0.9	50.0	1.5
Drug Plants	-	-	16.7	0.5
Beans	83.3	0.8	40.0	1.2
Sorghum	62.5	0.6	23.3	0.7
Others	104.2	1.0	10	0.3
TOTAL	10415.8	100	3333.3	100

Table 2. Patterns of Water Requirements for Winter Wheat

	Developing Stage	Before Over-wintering	Over Wintering	Turning Green to Jointing	Jointing to Heading	Heading to Maturity	Total
	Duration	1/10-30/11 61 days	1/12-28/2 90 days	1/3-31/3 31 days	1/4-30/4 30 days	1/5-10/6 41 days	263 days
Bayi I.D	ETp ⁴ mm	55.4	44.1	55.2	118.8	213.8	484.9
	Average Rainfall** (mm)	47.0	13.1	10.2	20.5	56.6	147.4
	Difference	8.4	31.0	45.0	96.1	157.2	337.7
Nanyao I.D	ETp ⁴ mm	50.7	44.1	57.9	118.5	219.6	498.9
	Average Rainfall*** (mm)	43.3	13.5	12.2	22.7	54.2	147.5
	Difference	17.4	30.6	45.7	93.9	166.4	351.4

Table 3. Patterns of Water Requirements for Maize

	Developing Stage	Early Growing Period	Jointing Period	Heading Period	Milky Period	Total
	Duration	10/6-30/6 20 days	1/7-30/7 30 days	1/8-20/8 20 days	21/8-20/9 31 days	102 days
Bayi I.D	ETp ⁴ mm	44	118.7	85.6	116.6	384.9
	38.8age Rainfall* * (mm)	38.82	142.2	110.1	87.89	378.9
	Difference	5.2	-23.5	-24.5	28.8	-14.0
Nanyao I.D	ETp ⁴ mm	43.2	118.7	81.3	116.3	359.5
	Average Rainfall* ** (mm)	34.7	147.1	99.3	88.8	369.9
	Difference	8.5	-28.4	-18.0	27.5	-10.4

Table 4 Annual Performance Assessment for Nanyao Irrigation District. 1993

Item	Planned (104m ³)	Actual (104m ³)	Potential Points	Points Awarded
Water Delivery				
Total discharge	4500	5600.6	4	4
Irrigation water	2000	2150.6	5	5
Delivery to Yingang canal	1500	3450	3	3
Water delivery days	300 days	307	3	3
Total points		actual	15	15
Irrigated Area				
Irrigated area	273.3	273.3	5	5
Irrigated area x times	12000	14000	5	5
Total points			10	10
Water Use Efficiency (WUE)				
WUE of main canals	0.715	0.715	4	4
WUE of branches	0.82	0.82	4	4
WUE of sub-branches	0.91	0.91	4	4
WUE of whole canal system	0.534	0.534	4	4
Total points			16	16
Irrigation Duty and Efficiency				
Irrigation duty at the head of the main canal(m ³ /ha)	1522.5	1519.5	3	3
Irrigation duty at the outlet of sub-branches (m ³ /ha)	892.5	892.5	2	2
Irrigation duty in field (m ³ /ha)	813	811.5	2	2
Annual gross irrigation water per ha.	6870	7875	3	3
Irrigation efficiency at the head of main canal (ha/m ³ /s)	56.7	56.8	3	3
Irrigation efficiency at the outlet of sub-branches (ha/m ³ /s)	96.9	97.1	2	2
Total points			15	15
Rate of Functional Structures				
Structures	447	447	4	4
Canals and branches (km/number)	48	48	3	3
Total points			7	7
Maintenance				
Lined canals (km)	10	10	6	4
Silt clearance (km/number)	271/62	271/62	4.5	4.5
Structures maintained (number)	35	35	4.5	4.5
Total points			15	13
Income and Expenditure				
	US\$	US\$		
Total income	31,395.3	38,372.1	5	5
Total expenditure	26,744.2	36,627.9	5	5
Operating and managing cost	20,930.2	56,046.5	3	3
Annual maintenance cost	5,813.95	12,558	3	3
Total points			16	16
Crop Yield Assessment				
Grain	3262.5	3045	2	1
Wheat	4425	4605	2.5	2.5
Cotton	600	585	1.5	1
Total points			6	4.5

Grand total potential points = 100
 Grand total of points awarded = 96.5

**Table 5 Inputs and Outputs from Farming
Bayi and Nanyao IDs**

Item	Bayi ID					Nanyao ID				
	1950s	1960s	1970s	1980s	1990s	1950s	1960s	1970s	1980s	1990s
Chem. Fert (yuan/ha)		8	187.5	740	1535		8	187.5	645	1260
Pesticide (yuan/ha)			7.5	105	135			7.5	150	150
Manure/1 (yuan/ha)	30	30	45	55	55	30	30	45	75	75
Seed (yuan/ha)	150	180	200	210	390	150	180	200	210	390
Labor/2 (yuan/ha)	270	270	300	310	270	270	270	300	350	380
Machinery (yuan/ha)			10	157.5	322.5			10	150	202.5
Water Fee (yuan/ha)		6	8	50	240				52.5	225
Total Input (yuan/ha)	450	494	758	1628	2948	450	488	750	1633	2683
Avg Yield (T/ha)	1.05	1.6	3.6	8.8	11	0.9	1.4	3.7	7.6	7.6
Market Price/3 (yuan/ha)	0.66	0.87	0.67	0.58	0.69	0.66	0.87	0.67	0.58	0.69
Total Output (yuan/ha)	693	1392	2412	5104	7590	594	1218	2479	4408	5244
Net Income (yuan/ha)	243	898	1654	3477	4643	144	730	1729	2776	2562

/1 manure price = 1 yuan/m³ for 50s, 60s and 70s, 2 yuan/m³ for 80s and 90s

/2 market price using 0.4 x wheat price + 0.6 x cotton price

/3 labor = 0.3 yuan/day in 50s and 60s, 0.5 yuan/day in 70s and 1 yuan/day in 80s and 90s.