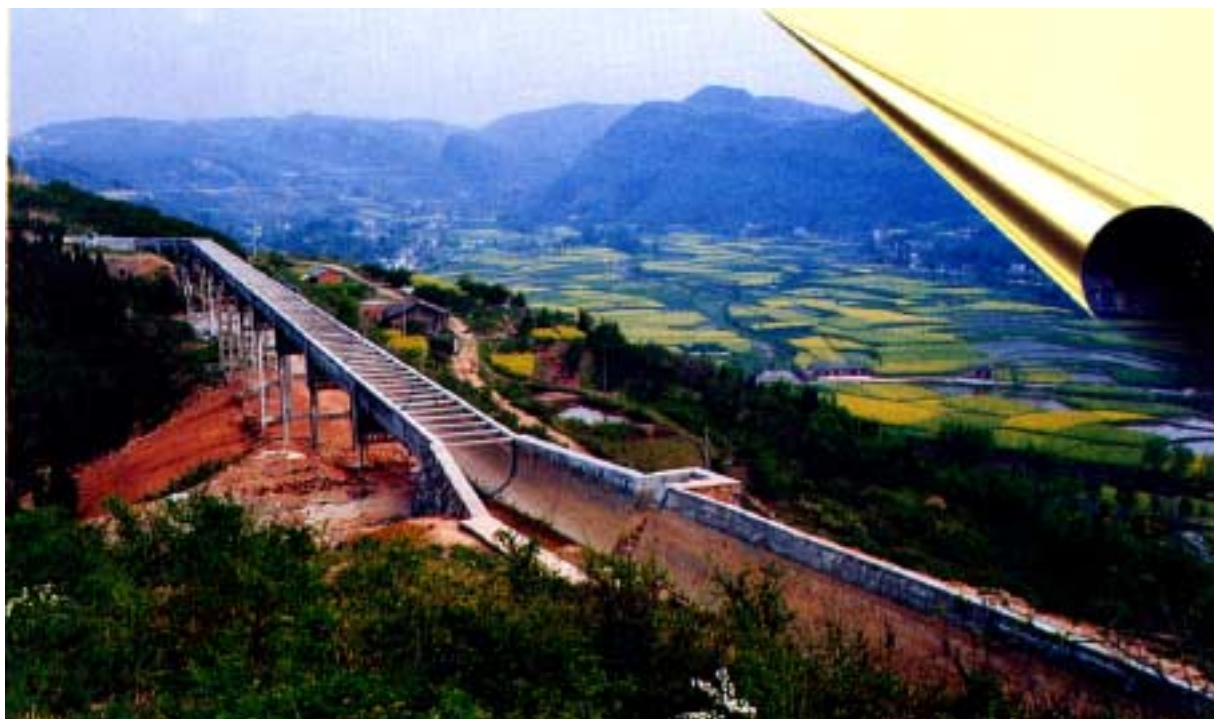


**Participatory Irrigation Management By Farmers**  
—Local Incentives for Self-Financing Irrigation and Drainage Districts in China



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## I. Introduction<sup>1</sup>

Participatory Irrigation Management (PIM) is internationally well known as a principle management concept with which reform of the agricultural water sector and transfer of irrigation management to farmers are undertaken. Over the past fifty years, expansion of irrigated agriculture has made an enormous contribution to feeding the world's expanding population. Yet in the meantime, the underfinancing and rapid deterioration of irrigation system have become a serious threat to the imperative of sustained increases in the productivity of irrigation systems in developing counties. Revenue shortfalls, together with perverse bureaucratic disincentives, has resulted in poor management of water deliveries, waterlogging, shrinking service areas, and deteriorating canals, drains, and structure. To counter the deteriorating situation, one development strategy after another has swept over the irrigation sectors for the last decades; and a common understanding among all the strategies is the need of institutional reform in light of participatory irrigation management. In China, one of the main reforms is the Self-Financing Irrigation and Drainage Districts (SIDD)<sup>2</sup> supporting farmer participation in local irrigation management.

In rural China as an agrarian society, irrigation is very important for agricultural production. Although irrigation accounts for less than forty percent of cultivated area in this country, the agricultural output of irrigation districts amounts to two thirds of that of the whole nation. For this reason, the Chinese government and farmers have invested immense resources in irrigation especially in the recent several decades. However, there still are many constraints and problems with irrigation systems, such as especially low system efficiencies averaging thirty-forty percent, massive waste of water, and low productivity of water used, that center round both lack of funds for irrigation maintenance and overhaul and poor irrigation operation and management. For decades, the irrigation systems/ districts in many places have become degraded not too long after their establishment, causing local irrigation conditions to deteriorate and farmers to suffer from shortage of water again.

To counter this irrigation deterioration, the SIDD model was developed in China in order to create and maintain a "virtuous cycle" of water delivery in irrigation districts, and to achieve sustainable use of water resources for agricultural development. As an irrigation management system, SIDD is structured mainly in two integrated parts: a water

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<sup>1</sup> This paper is an empirical study of the participatory reform in China rural water sector, on which the Bank's rural development projects have exerted great influences by playing the important pioneering roles in it. Thoughtful insights and helpful comments were given on an earlier draft of this paper from Richard Reidinger, Dan Gibson, Susan Shen, Liping Jiang, and Xiaokai Li for which many thanks are due.

<sup>2</sup> SIDD stands for Self-Financing Irrigation and Drainage Districts as originally set forth. In practice, it is found that "self-financing" is more suitable as a target for many places in the long than short run. For the practical reason, therefore, "self-managing" is put forward in the initial stage of the transfer process, as the first step towards self-financing. So, SIDD thus stands for Self-Managing Irrigation and Drainage Districts for now.

supply corporation (WSC) or organization (WSO)<sup>3</sup> serving as water supplier from the main headwork and the water user associations (WUAs) operating as the farmers' own water use organizations taking care of the lower distribution network on the ground. Water is treated as economic good to play the role of a commodity between the two parts, reflecting the buy- and-sale nature of a market. In this case, however, neither WSC nor WUA is profit-oriented entity but functions as a non-profit social/productive service for farmers as end users of irrigation water. By nature, the SIDD model is characterized by two meaningful transfer processes, namely, transfer of local irrigation management from government to farmers themselves, and transfer of the economic foundation of local irrigation system from a command economy to a market-oriented one.

The SIDD model was first introduced and studied in 1993, and established in Hubei and Hunan Provinces in 1995, under the World Bank assisted Yangtze River Basin Water Resources Project. Since then, more than 500 WUAs and 40 WSCs/WSOs have been established with charters and regulations in ten provinces on a pilot basis, supported under several World Bank assisted agricultural and rural development projects. Most WUAs have proven to be successful in terms of enhanced efficiency of local system operation and maintenance (O&M) and increased benefits to farmers. In Hubei, for instance, water delivery efficiency through branch and lateral canals has been enhanced by 50-100% under WUAs' management; and paddy yields have increased about 25-40kg per mu (equivalent to 1/15 ha.) on average. Because of both unit grain yield increase and irrigation water decrease, the grain output value per cubic meter of water has been enhanced from Y 0.47 to Y 1.70. Farmers are happy with the benefits and the participatory approach. In addition, since WSC charter requires that farmers from WUAs sit on WSC's board of directors, water users have voice even in WSC management. This has enhanced bottom-up participation in decision-making.

Influenced by the positive results of the SIDD pilots, many other places beyond the World Bank supported projects have adopted similar approach in improvement of local irrigation management—especially the participatory methods of WUA—to enhance efficiency and effectiveness of local irrigation system. Calling for the PIM reform in the water sector, Ministry of Water Resources of China (MWR) has been promoting the dissemination and extension of SIDD/WUA as a good example to use throughout the country. As a result, there now roughly are 2,000 WUAs in total spreading over most provinces in China.

## **II. Emergence of the SIDD Concept**

Alongside unfolding of the economic reform in rural China in the 1980s, constraints and problems in irrigation systems were increasingly recognized. In 1990, in order to resolve degradation problems of the irrigation systems, a study on the prospects

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<sup>3</sup> WSC as a legal person is chartered under the national Company Law. In the course of the water sectoral reform, however, in most cases the existed administrative water supply units would change to the restructured water supply organizations (WSO) in the first place in accordance with local socio-economic conditions, which will continuously develop to be the corporations alongwith growth of the market-oriented economy in rural China.

for a “virtuous cycle” of the hydro-economy was initiated by MWR nation-wide. It was then explicitly realized in the water sector that, on the basis of a command economy controlled by the central government, management of irrigation systems was often fragmented between the various levels of government administration, rather than being unified on the basis of hydraulic units which was necessary for high system delivery efficiencies. Under this administrative management, first of all, water prices were decided as too low and too arbitrary to cover the costs of water or there might be no water charge at all in some places. As a result, each newly established irrigation system became another burden added to the government administration, while government had no more funds for the O&M of any of them. Secondly, there often appeared to be “gray water charges” which were collected in the name of water charge but used for other purposes than irrigation, which contributed to inadequate maintenance and worsened the situations of both water supplier and user. Moreover, water charges actually paid by farmers were generally levied on an area basis per mu (not on the volumetric basis), which discouraged efficient water use by farmers and led to much waste of water.

What is more, while all the irrigation systems were the government property under the administrative control of government, farmers actually had no say about them though they had invested large labor and capital inputs. This situation made farmers less care for, as well as less interested in, system maintenance, but merely care about water delivery in a pragmatic manner. Lack of farmers’ feeling of ownership and inadequate farmer participation thus contributed to low irrigation management efficiency, low system maintenance incentives, low water charge collections, and high level of conflict among water users in the peak irrigation season. On the whole, when analyzing all the difficulties and problems, it became apparent that although the design and condition of the physical systems play an important part in irrigation inefficiency, the more fundamental and difficult issue was irrigation management.

The SIDD concept was initiated to address many of these management issues comprehensively during the preparation of the Bank supported Yangtze Basin Water Resources Project in Hubei and Hunan provinces in the early 1993. The project included improvement of four large-scale irrigation systems in Hubei, and construction of two new large-scale systems in Hunan. Under the efforts of the Bank task team together with its Chinese counterparts, project preparation was guided not only to deal with physical system, but also to address institutional improvement for a sustainable development of local irrigation. As the task team leader wrote in a paper, “Participatory Irrigation Management Reform: SIDD in China,”<sup>4</sup> detailed field preparation work indicated that there were significant management weaknesses in the irrigation systems, such as fragmentation of management among different administrative units, lack of overall responsibility and authority for efficient irrigation system performance, inadequate collection of water charges directly from farmers, “disappearance” of water charges collected into the general government financial system, and poor or non-existent management of local irrigation networks. The poor performance of the system followed by the “vicious cycle” of system deterioration was fully evident. The problem was to

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<sup>4</sup> The Bank task team leader Mr. Reidinger’s paper was written for the conference of Water Users’ Participation in Irrigation Management and SIDD Reform, held in Tieshan, Hunan, in July 2000 (as mentioned later). The first two parts of the present paper mostly summarize from that paper.

design and develop an institutional system to strengthen management at both the lower distribution network level and the main system level.

The task team found an answer from Hubei for improving management at the lower end of the systems. There in fact were some experimental cases managed by the farmers themselves for years in which farmer “water user groups” were organized and given responsibility for the local irrigation distribution networks. These experiments had produced quite good results in water delivery and lateral canal maintenance, and showed the high potential for farmer group management at the distribution network level. Their main weaknesses were that the farmer groups were not permanent organizations and had to be re-established each year, and the group leaders were appointed by local officials rather than being elected so as to be responsible to the farmers themselves. Nevertheless, what was significant by the groups is the tendency of farmers’ participation in local irrigation management and the management was thus being handed over to an organization which they saw as their own. With elective institutional development and support, such groups could become formal Water User Associations (WUAs) which were farmer-managed, and permanent legal persons. The WUAs, however, did not deal with the serious problems identified in main system management and operation.

Hunan provided the solution to the problem of main system. The situation in Hunan were quite different from Hubei because the irrigation systems were to be newly constructed; and at Tieshan Irrigation District the government had already decided to establish a “Tieshan Water Supply Corporation” or Tieshan WSC, to take unified management for the main system by which the WSC would exert multiple functions to provide water for both rural and urban areas. However, a serious question was how the WSC could deliver and sell water efficiently to thousands of individual small farmers, given the fact that local administrative villages were usually not an irrigation-effective institution to deal with.<sup>5</sup> The answer was the WUAs from the Hubei experiments.

The SIDD concept was thus born in China, provided by combining Hubei’s WUAs for operation of the distribution network with the Hunan’s WSC for the main system, and supported and developed as a component under the Yangtze Basin project. In the SIDD areas, WUAs purchase water from the WSC according to the number of cubic meters used, and the WSC measures water deliveries at the WUA headgate, usually at the branch/lateral head, in the presence of WUA representatives. Water deliveries to the WUAs by the WSC are governed by water sales agreements between the parties which specify the rights and responsibilities of both. Because water deliveries are charged volumetrically, WUA farmers have a strong incentive to use water more efficiently and reduce waste. WUAs collect water charges from their member farmers, and buy water from the WSC on behalf of their members based on water demand. WUAs are registered as legal persons with the support of the local government, and WSCs are chartered under the national Company Law. Because WUAs are registered as legal persons, they can also

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<sup>5</sup> Villages as the mass social organization usually have to deal with all the community matters comprehensively and not specifically. Especially, the villages are not necessarily formed on the hydraulic basis (some may be while most are not), it is quite difficult for them to coordinate irrigation matters beyond the village boundaries but within one water distribution network.

contract, lease, or auction the operation and maintenance of their canals and facilities if necessary.

### III. Farmers' Participation through WUAs

#### WUAs Initiate Local Mobilization

The first WUA was established in June 1995 at Hongmiao branch canal in Zhanghe No. 3 Main Canal Irrigation District, Hubei Province. In the following couple of years, 12 WUA pilots were established in this district, and some more also in the other project districts including those in Hunan. As a project component, intensive preparation work had been done for WUA

initiation including a socio-economic survey for each of the pilots, village meetings and household interviews for project information dissemination and farmer consultation, and local water and land resources mapping for contrasting the hydraulic boundaries with existing township/village irrigation management. Farmers warmly welcomed the project incentives for improvement of both canal system and its management. On



Participatory Mapping and Design

the hydraulic basis, they grouped themselves to take responsibility for their own irrigation matters. The water user groups (WUGs) were demarcated upon lateral canals as the first step. Each of these groups then elected its head as their representatives (some large groups may have two for each) in the water users' conference held on the branch level for a WUA's establishment. Farmers were mobilized in their groups to discuss local irrigation needs and their expectations for changes, and to review and finalize the WUA charter and regulations in the conference. In accordance with the WUA charter, a WUA executive committee was elected among farmers by the water users' conference, including Chairman, vice-chairmen, and another one to three committee members. The committee presented its ideas and working plan for the first year to the conference for discussion and approval; and thus the WUA was formally established. Chart 1 shows the basic institutional structure of a typical WUA. As the WUAs were initiated by the Yangtze Basin Project in Hubei and Hunan, their extension later on in other provinces went through the similar process under local farmers' enthusiasm and mobilization.

The WUAs were farmer water users' organization specifically focusing agricultural irrigation and drainage. Farmers were mobilized through WUAs for their own sake. Moreover, their such mobilization also brought about new impetus and fresh air to local village routine works. Villages felt happy with WUAs as an "organized hand" helping deal with irrigation matters and local system maintenance. In many cases, villages voluntarily offered their material resources to WUA establishment, either lending or renting offices, or providing the working space with some furniture. Villages also often



helped mobilize the community human resources for both the WUA conference and the executive committee election. In most cases, both as mass social organizations, WUAs and villages held different matters in rural folk lives, and they were hence not in a competitive situation but actually in cooperation with each other. In fact, they shared the work for the same interests of rural communities. This condition helped farmer participation and WUA operation.



Election of the Executive Committee of WUA

### **WUA Operation**

While WUAs were established to take over the O&M of the branch system, their skills for irrigation management needed to be strengthened. The project authorities and local water bureaus constantly held training programs for farmers on water delivery, facility maintenance, and financial management, which helped enhance the WUAs' operational capacities in the transfer process of local irrigation systems. Each year the WUA committee made plans and reported them to the water users' conference, regarding the amount of water needed, irrigation schedule, facility building or repairing, and the related labor and finance arrangement. It then signed a contract with the water supplier (either WSC/WSO wherever established or local water supply unit) for water buying, and coordinated the water supplier in the irrigation seasons in water delivering, measuring, as well as water charge submitting. When irrigating, the WUA coordinated water delivery among the lower, middle, and upper reaches, and the committee members organized water guards from the WUGs for a unified water-taking control along the canals. The amount of water sale to the WUA was calculated on the basis of volumetric measuring at the in-take of the branch; and wherever the measurement capacity was available on the lateral level, WUA internal water delivery was also calculated volumetrically to the WUGs. Within the groups, in most cases farmers calculated water use according to the farm area of individual households, because of the lack of water measurement at the on-farm level. In turn, water charges were collected by the WUA based on the water use at the



Irrigation Training Course of WUA members

household, group, to association levels; and then were directly submitted to the water supplier according to the contract.<sup>6</sup> Both the water and money flows became efficient, transparent, and satisfactory to both water users and suppliers. The normal WUA operation and the related financial conditions can be exemplified from tables 1 and 2 that show the records of 11 WUAs' operation in Tieshan District monitored by an evaluation team from the Wuhan University.

Water charges per se, however, could not be changed too much or too soon though in most cases water charges were still far below the water costs. In Hubei, for example, the water charges were Y 0.022-0.0385 per cubic meter for now while the water costs would be Y 0.106-0.133 varying in different areas. Hunan was more or less similar, where the water charges were Y 0.032 per cubic meter and the estimated water costs would be Y 0.10-0.15. In Xinjiang, the water prices were even lower, such as Y 0.01 to 0.02 per cubic meter at present; and the water costs were calculated to be about Y 0.04-0.058 under local conditions. The reason for the discrepancy between the current water charges and water costs was apparent. On the one hand, both the national and provincial policies on agricultural production restrained irrigation water from becoming a commodity just overnight. On the other hand, farmers also did not really like the idea to raise water charges, because they already suffer from the heavy burdens of taxes, fees, and compulsory labor sharing.<sup>7</sup>

Nevertheless, the water charges at this time were able to be formally acknowledged as necessary to be classified separately from other fees and taxes;<sup>8</sup> and this in fact was a fundamental step for treating water as a commodity later, as well as for helping straighten out the current irrigation management with more self-governing and self-financing concerns. As analyzed earlier, management of irrigation systems was too much fragmented into government administration on various levels, which made both water control and water charges complicated and beyond the pure economic term. Although the pilot SIDDs normally did the cost-recovery studies under different circumstances, in the overall situation it was still restricted to have the water charges based on the full water costs for the moment. In most cases, therefore, the WUA-collected water charges could not really cover any overhaul and depreciation but O&M of a branch system at most.

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<sup>6</sup> In many places submission of water charges is separated to be twice a year. The first time submission is normally before irrigation, about 40-50% of the estimated total; and the second is after harvest when farmers become more capable of paying.

<sup>7</sup> In fact, in some cases to make water price based on unit water costs does not necessarily mean increase of the total water charges for the amount of water farmers have used. If irrigation operation becomes efficient and water is saved under good management, the overall amount of water used will be reduced and the total water charges may not necessarily exceed the previous level. Especially if the "gray parts" of water charges can be cut off, water charges per se actually take only quite low percentage in farm productive costs as a whole. Bared to WUA operation, what farmers really like is the transparent water charges.

<sup>8</sup> Water charges in lots of cases were levied in kind with the agricultural taxes or other fees together, through the village and township. It is therefore quite difficult in many cases to figure out what charges are actually collected under the name of water charges. The SIDD model tries to clarify water charges independently only on two levels: the water supplier (WSC/WSO) and the water user (WUA), cutting off all the administrative interference.



When collecting water charges, however, most WUAs decided to add 5-10% to the water charges required by the water supplier in order to meet some of their own operation expenses, as discussed and agreed by the WUA conference.<sup>9</sup> As for canal/facility maintenance, repairing, or building, WUAs then sometimes called for additional voluntary funds collection or labor input among their members, if their conferences agreed. These exercises reflect WUAs' proactive attitudes in confronting constraints, and their spontaneous initiatives in paving the way for better irrigation management as well as for their own existence.

#### IV. WUAs' Beneficial Results

Farmers' participation in irrigation management through WUAs has changed the degraded situation of local systems in many aspects. In turn, farmers themselves also directly benefit from the changes, and these arouse their further incentives for involvement in a sustainable development of the local system in the long run.

##### Reduced Irrigation Costs

WUA control of local irrigation saved both water and labor, as well as shortened irrigation time cycle. In the irrigation season, water was delivered in proper order and on time under WUA arrangement in coordination with individual users on the one hand and with the water supplier on the other. It is also for sure that the WUAs helped system improvement in both the main canals and lower distribution networks, because farmers also invested labor inputs and funds in building and maintaining the system which they viewed as their own matters now. Furthermore, because water was volumetrically calculated and charged, farmers themselves began to use water in a more cautious manner. As a result, irrigation costs were reduced in multiple ways. For instance, in Zhanghe No. 3 Main Canal and Dongfeng Irrigation Districts, two of the major subproject areas in Hubei under the Yangtze Basin Project, water delivery efficiency and capacity through branch and lateral canals was enhanced by 50-100% in Zhanghe and 30-50% in Dongfeng on average. The average time in one irrigation rotational term (usually more than four terms per year) was thus shortened from previous 12-15 days to 5-7 days in Zhanghe, and in Dongfeng, it was shortened by 5 days or so, and in the best case by 10 days. For example, in the Baihe East Branch WUA area, the irrigation delivery rotational

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<sup>9</sup> Under helps from some research institutions like Wuhan and Hehai universities and the Water Resources Bureaus, the pilot SIDD/WUAs in different provinces were able to have primary water cost analysis at the WUA level so as to have some basic idea about their O&M costs that might be added by themselves to the current water charges. The formula provided by Hehai to calculate water costs at the WUA level is as follows:

$$C_{nk} = C_n + U_{nk}/(W_{nk} \bullet \eta_{nk})$$

in which

$C_{nk}$ : water costs of WUA

$C_n$ : water price from WSC

$U_{nk}$ : all the irrigation-related expenses by WUA during the accounting term (e.g. one year)

$W_{nk}$ : the measured amount of water at the in-take of the branch canal the WUA bought from WSC

$\eta_{nk}$ : the water delivery efficiency of the branch canal system.

period used to be more than 20 days and now was about 10 days under the WUA management.

In the meantime, because of smooth water delivery under WUA control, water guard labor in the irrigation season was also much reduced. The saving rate in less labor time needed was about 50-80% in Zhanghe and 50-90% in Dongfeng. On an average, one WUA could save about 1,548 labor days year round compared to before. The largest saving was 6,024 labor days (Hongtu WUA, which was equivalent to about Y 120,000 in labor costs). In Baihe East WUA, water guards for one irrigation term were reduced from about 70 to 20 people, and a total of 2,900 labor days was saved in a whole year. In Qiyang WUA, water guards were reduced from 150 to 20; while in Zhaoshan WUA labor day was sharply reduced from about 1,000-2,000 to 100-200 per year. While all the time and labor were much saved, water was saved, too. On the average, each WUA saved about 1.18 million cubic meters of water year round, and the highest was 5.57 million in Dongfeng. In Zhanghe, according to its records in 2000, the annual amount of water used was reduced 15-25% in the whole WUA covered areas. In addition, in the SIDD pilot areas in the five prefectures in Xinjiang Uygur Autonomous Region, annual water saving in 1999 was averaged as 1.09 million cubic meters for each WUA, while the highest was 2.22 million in Hetian Prefecture.

Moreover, in order to keep saving time, labor, and water during irrigation operation, WUA management had also to be able to maintain the physical system in good shape regularly. Most WUAs could make timely plans for taking good care of canals and facilities on an annual basis; and organize labor and capital input in facility building and repairing in accordance with their priority in needs. Their exercise for system maintenance was sometimes cooperated with local authorities' support as well. To mention just a few, from 1997 when Zhaoshan WUA established in Hubei through 2000, the WUA organized 35,000 labor days and Y 25,000 of funds inputs for its branch repairing; while Jingtang WUA in Hunan invested 16,000 labor days and collected Y 94,000 for its three branches/laterals improvement during 1998-99. Like unified water delivery during the irrigation season, there appeared to be a unified maintenance under WUA system in terms of unified arrangement of repairing time, standards, and activities. As a result, the physical system under the WUA management were normally maintained and rehabilitated much better than before, and the whole local irrigation system was hence able to be revitalized in a "virtuous development cycle."

## **Increased Outputs**

The WUA's beneficial results were expressed in not only irrigation costs reduction but output increase of agricultural production as well. As reported by an independent investigation team from the Chinese Academy of Agricultural Science (CAAS) which did special field research on WUA operation in Hubei during 2002 summer, WUAs exerted positive impact on paddy yield enhancement in particular and played effective part in agricultural outputs in general (cf. Report by Mrsser. Hu, Zhang and Liu). Because water was delivered timely and adequately when farming needed, unit yield of grain was able to increase. In Dongfeng, paddy yield was increased about 25 kg per mu at average in the whole district. In Zhanghe, the average crop yields were increased about 40 kg per mu. More concretely, the grain yields per mu were enhanced from 722.1 kg before WUA to

764.0 kg after, about a 6% increase, among which about 2.5% was owing to irrigation improvement (others were due to agricultural technical reasons). Meanwhile, because both the unit grain yields increased and the amount of irrigation water decreased, as mentioned earlier, the grain output value per cubic meter of water was enhanced from Y 0.47 to Y 1.70 on the average, for which irrigation improvement contributed Y 0.58 per cubic meter (Y 1.70 is about the price of 1.70 kg of paddy in 2000 in China, comparable to 1.60-2.00 kg of grain output per cubic meter of irrigation water in the U.S.). Table 3 shows an overall comparison between the situations before and after WUA establishment in four branch canal areas in Jimen municipality/prefecture, Hubei province.

Moreover, because of improvement of the system and management, extension of irrigated area were realized and more grain was able to be produced in the new irrigated land. In this regard, Zhanghe subproject expanded the 15% irrigation area in the whole district. Given all the factors of output increase, overall farmers gained a net income increase of about Y 15-20 per mu on the average, and about Y 10-15 per mu after deducting WUA operating costs. In Dongxiajiang WUA in Liuduzhai District, Hunan, for example, there were 5,000 mu of paddy of which 3,000 mu could not be irrigated and had hence to do merely the single-cropping by rainfall. After WUA establishment and canal improvement, a total of 4,000 mu of paddy was adequately irrigated for double-cropping, and the incremental later paddy added to the year yields about 250 kg per mu. Furthermore, because of also the better canal system and management, land irrigation for individual households in Zhanghe district became to rely upon more canal water than pumping water from local ponds or rivers as before, given the fact that pumping water was much more expensive. The water charges were hence reduced from the pumping rate Y 20-40 per mu (depends on the pumping lift) to the canal rate Y 12-15 per mu. This was also an important matter in making farmers happy.

### **Pro-Poor Helps**

Besides the benefits from cost reduction and output increase, there certainly is the significance of SIDD/WUA establishment in light of pro-poor intervention strategy. First of all, some the irrigation districts were located in the poverty areas, such as Liuduzhai in Hunan and all those in Hetian, Kashi, Kerkzi in the southern Xinjiang. Given the fact that in most WUA areas, farmers became able to at least secure their harvests each year with improved water services no matter how the weather changed, it is for sure that the new system contribute greatly to local poverty alleviation. Moreover, in the general cases, the poorer and weaker households would also gain some additional family-specific benefits from the WUA system. For instance, a major cause of poverty in rural households is lack of laborers. The households lacking able-bodied male laborers or headed by women usually had particular difficulties with access to water because they were physically weaker in individual competition for irrigation water in the old system. Under the WUA which operated on democratic principles, however, these households were assured of proper water share from a unified water delivery, and they were hence helped by the WUA to overcome their disadvantageous situation in this regard.

Also, some disabled people took similar advantages of WUAs to their irrigation matters. For instance, a disabled marriage couple with two school-age children previously had to pay Y 200 for a water guard in the irrigation season in Zhanghe under traditional

irrigation system. After the WUA developed in this area, the water guard issue was uniformly arranged by the WUA and they saved the special payment. Another poor family in Yindan District could only use some left over water after others finished their irrigation. Under WUA's help, they now cultivated 3 mu of paddy land from which they earned Y 800 year round. The SIDD/WUA system thus functions as an local reciprocal irrigation community to provide its members with equal opportunities for irrigated agricultural production under a community-based development.

## V. Farmers' Incentives for SIDD Development

### Farmers' Incentives for Changes as Encouraged through WUA

In the past, almost all the irrigation districts fell into the bad shape while the lower end of the water system was even worse. In general, the branch canals and below, i.e. the irrigation distribution networks, were demarcated to be the township properties (while those on the upper levels belonged to the district authorities and the water management bureau of county or prefecture), yet in most cases nobody in fact was financially capable of taking care of them on the township level. Subsequently, the canal systems were deteriorated and irrigation water delivered became less and less, from which farmers suffered greatly. However, in many places farmers could not bear with the deterioration, and they tried to reshape the local system and reorganize themselves for a better management on the water issues. In Hubei province, as mentioned before, farmers' water use/management groups occurred at the bottom of the irrigation districts in the 1980s,

taking over the lateral-branch management. The heads of the groups were usually recommended by village heads/councils among farmers and appointed by township water management stations; but the way the groups took care of the irrigation system was no longer administrative but tended to focus on farmers' urgent needs. Cangku in Zhanghe District and Huanglin in Dongfeng District were the distinctive ones among the groups, and later all of them developed as very successful WUA models under the Yangtze Basin Project (even though Huanglin WUA was actually located outside the project areas).



Canal Cleaning by WUA members

In the meantime, the same things also happened in Hunan. Farmers were so eager for water to come that they organized themselves in advance for labor input and fund collection in cooperation with the irrigation project design and preparation. Such as in Feishiyuan WUA in the Liuduzhai Irrigation District, farmers themselves decided to make a 548 meters long tunnel through a hill as well as a 8.48 km long branch so as to connect with a sub-main that was constructed under the Yangtze project, and thus to introduce

water directly to their hilly field. For this exercise, farmers collected Y 874 per person on an average among themselves. In Shenlongyan WUA, the first pilot in Liuduzhai, farmers extended 784 meters from the originally designed 5.7 km long Shenlongyan branch for the need in the edge area of the low reaches; and they made extra labor input and funds by themselves for this extension. In Changtang WUA in the Tieshan Irrigation District, farmers used their best knowledge on local situation to redesign the system by reducing 7.5 km from the total length of the Changtang branch, and then the canal deploy became more reasonable to local circumstance while the project costs were also reduced.

In these cases, all the decisions were unanimously supported by all villagers because water supply was the first priority of the whole communities and everyone worked together with one mind on this issue. There still were many similar cases where WUAs were established to organize farmers' participation in planning and implementation of their local canal and facility construction. Farmers proactively joined in these exercises because they



Branch Canal Repairing Under WUA Management

wanted water; and they wanted water not only for now but also for the future. For this end they hence hoped their canals to be taken care and maintained well. Farmers might use irrigation facilities before, but they were not their own nor taken good care. Farmers experienced and understood that their such immediate interests had got to be looked after by nobody but themselves, and now here was the chance to do so with the SIDD approach. As the words put on the office wall of Dongxiajiang WUA (Liudozhai District, Hunan) read, "The canals are our own because they are both built and managed by ourselves!" It was the WUA that empowered farmers to be able to realize their wills, through its inner mechanisms of self-governing and self-financing management as stipulated in its charter and regulations. By the same token, as described in the preceding paragraphs, it was the WUA-managed local irrigation system that brought about great benefits to farmers as the rewards for their vast inputs and self-managing.

### **WSC/WSO Development**

According to the SIDD design, farmer participation in irrigation management is not only through WUA at the bottom but via WSC on the top part of the SIDD system as well. On the Board of Directors of WSC, WUAs as water user should take about 20-40% seats so as to be able to participate systematically in steering management of the irrigation district as a whole. This indeed takes place in Tieshan District where the WSC has developed among the most advanced. Among its 11 board members, four are the WUAs' chairmen as the water user's representatives on the Board. All other WSCs which are structured in accordance with the WSC charter also have farmers/WUAs' representatives on their boards, such as the Baihe WSC (Dongfeng District) in Hubei

Province, Zaohe WSC in Jiangsu Province, Liuduzhai WSC in Hunan Province, Changli WSC in Hebei Province, etc. Chart 2 shows the institutional structure of WSC as required by its Charter. Given more constraints and complexities in commercialization of irrigation water and institutional reform of the water supplier under the current rural circumstances, overall WSC establishment has not been as common as WUAs thus far, and WSCs' self-financing management has not been completely achieved as yet. Instead, to cooperate with WUA development, WSOs have been established in many places in the early stage in the SIDD reform process. The WSO is not a corporation in either financial or legal sense, but it is structured and operated as a self-governing entity and separated from the governmental administrative system. In this light, the "self-governing" of both WSC/WSO and WUA, as they are all doing right now, is actually the first step in practice toward their "self-financing" in the future.

## **VI. Challenges and Constraints in SIDD Development**

Farmers' incentives for changes in irrigation operation and management are the basis of the pilot SIDD reform, which the development projects have endeavored to encourage and nurture. The challenges now for both the development projects and farmers are how to spread the pilot over wide areas, as well as to deepen the reform where it has started. At the present stage, most SIDD/WUAs are established on a project-supported basis, with favorable policies and funds. This condition is necessary for the pilots, yet it may not be always available for all the irrigation and drainage districts. Moreover, the established SIDD/WUAs may be project-initiated but should not be project-bound. They must be able to continue by standing on their own feet when the projects are completed. For this end, three major constraints are found from empirical experience that may restrict the SIDD reform to meet the challenges in some areas. The following paragraphs will discuss these constraints in detail.

### **The Top-down vs. Bottom-up Approaches**

In some places, the local water resources authorities and irrigation district managements conventionally treat the SIDD as a top-down approach to the water sectoral reform, as if they carried out the water resource administration on the basis of a command economy. For several decades, the irrigation and drainage districts have adopted a top-down approach to management of water delivery/drainage and system maintenance, and this approach has been so deeply inserted into the management concept that it tends to retard real understanding of the current reform and hence to distort it.

For instance, a large-sized irrigation district in central China becomes quite famous for its SIDD reform in recent years, under the energetic support and extra efforts by the district authorities and local government. One WSC and more than a dozen of WUAs have been established, while more are planned to cover the whole district. The district authorities and WSC take primary responsibility for almost all reconstruction costs (including all facilities and installations on the branch and lateral levels, with farmers providing labor input for civil works), for water measuring, and for changing the flow of water charges from the original channel of village-township-district to that of WUA/village-WSC. In doing so, the WSC assigns its staff as the WUA accountants to



measure water at the lateral level within WUA areas, and to collect water charges directly from water users or villages. In addition, in some WUAs, their chairmen or vice-chairmen are staff members or employees of the township water stations, though they are also elected by village cadres and representatives. It is believed by the WSC and the district authorities that all the methods they adopt for “WSC plus WUA” operation would ensure good services for local farmers. Indeed, many farmers feel an improvement good because, unlike before, there is somebody who is responsible for water delivery to each household’s field and water is now measured and hence could be used carefully and saved properly. Moreover, transparency of water charges is enhanced since, as some farmer representatives point out, direct submission of water charges to the WSC would reduce possibilities for the township to add other extra fees to the water charges, while farmers are informed of any changes in the water charge composition.

In the district/WSC authorities’ opinion, they have established a uniform management system to control local irrigation operation better than before. This might be true in the sense that a top-down control of the irrigation district as a whole would certainly favor the district administration (or the WSC) to take over everything. The WUAs, as the major embodiment of local participation and self-financing management, however, does not perform well in the administrative hierarchy of the irrigation district. In some WUAs, farmers other than village leaders or village representative do not even know or hear about the WUA, not to mention the SIDD concept and functions. Instead of consulting with farmers and mobilizing their initiative for WUA establishment, the district authorities tend to do all the work for farmers. Although well-intended, farmers think as a result that the WSC sends somebody to take care of the water delivery; and the WUA executive committee members seem to feel they receive their salary/subsidy also from the WSC and not from farmers themselves. It is most probably true that the WSC and district authorities have done many good things for local farmers (as the government did in the past 50 years), but without farmers’ informed participation, these good things simply look like the governmental and may not last long because farmers feel no “ownership” – it is not their but the government’s responsibility to operate local irrigation system, which is exactly the same old problem that the current reform intends to solve.

In sum, the top-down approach might be good for a uniform control at the upper level, but it proves to be not good for a sustainable development. In some places, it is true that SIDD/WUA establishment is not based on meaningful consultation and informed participation as it should be but simply becomes governmental activities, that tends to make decision for farmers while giving little voice to them on their own matters. The CAAS team’s report also points out that in its investigating areas (e.g. ten WUAs in the Zhanghe and Dongfeng irrigation districts in Hubei) quite a few WUA representatives and chairmen were not really elected by farmers, as the majority of farmers did not attend the election meeting. This kind of exercise just uses the SIDD form but pulls out its soul of the bottom-up participation; and it hence becomes a main lesson in the SIDD reform. When Vermillion discusses irrigation sector reform in Asia, he points out there is a need of transfer from the worn irrigation development paradigm with its “patronage with participation” to a new paradigm of “partnership with empowerment,” in order to dislodge the “malignant equilibrium” of those currently existed entrenched interests (cf. Vermillion’s presentation in the Six INPIM International Conference, April 2002). In China case, the new paradigm is truly needed to foster in order to keep the WUA’s

reform nature. What will be helpful in this regard is emphasis of the four key principles of WUA summarized from most of the WUAs' set-up. The four key WUA principles can be presented as follows:

- The WUA is farmers' own irrigation organization (farmers elect, farmers manage, farmers make decisions, etc.);
- It is organized on the basis of hydraulic boundaries;
- It adopts volumetric water charges based on water measurement; and
- It has rights and capability to collect water charges and submit them to the water supplier, for both sustainable use of water resources and its own self-managing/financing costs.

### **Local Township's Supportiveness**

Government support proves to be a key for SIDD development. It is no doubt now that governments on the central, provincial, and county levels would very much like to straighten out the chronic problems in the water sector and encourage the management reform for the sectoral further development. However, things at the township level, the lowest end of the government administration, appear to be more complex. The township authorities have to deal with various things together directly on the ground, including agricultural production, social services, grassroots development, tax levies, etc., while the township governmental body is normally much overstuffed that becomes indispensably to rely on not just its fiscal allocation but more local collection (such as extra levies and fees). In this light, more efforts need to be made for any line clean-up at the township level.

It is hence not surprising that in quite a few project areas, township authorities feel reluctant to support (if not openly oppose) the SIDD/WUA changes, due to their own vested interests (such that water charge flow may change channels, they may lose some privileges, or WUAs may cause more extra works, etc.). As a stakeholder in the development process, local township government has played a key role in SIDD establishment; and different attitudes of the township authorities have indeed made uneven development of the SIDD/WUA pilots. After all, township administration is a quite developed control network, and neither any technical line agencies, development projects, nor NGOs could work well in rural China without township cooperation. Therefore, besides farmer mobilization, working on township authorities with reform propaganda and training program becomes the starting point for most pilot WUAs. In this regard, it is believed that multiple efforts are still needed in the water sectoral reform training of the township staff in many places alongside the government reorganization at the lowest level which has been underway recent years. Meanwhile, as proved in practice, both substantial central/provincial policy support and good demonstration of pilot WUAs will also help make sense for township supportiveness.

### **Water Charges Issue**

It is well recognized that water charges is now a bottle neck for SIDD development and extension. As described in the preceding pages, few SIDD pilots could have water

charges based on full water costs at present. In the SIDD cost-recovery analyses done for the pilots in Hubei, Hunan, and other places, water costs may be resolved into three levels, on which level A comprises the primary costs of operation and maintenance (O&M), level B comprises O&M plus overhaul, and level C comprises A and B plus depreciation as the full costs. On average, most SIDDs are now able to, or trying to, collect the water charges on at least the A level, which would keep the system running during the transfer process. For the whole water charges, however, there are still more constraints as expressed in a couple of aspects in practice.

The first one is in the policy regard. Although the State Development Planning Commission (SDPC) and Ministry of Water Resources (MWR) encourage the water price reform to meet the full water costs, some provincial governments keep their own policies of ceiling price for irrigation water, in order to “protect agriculture and farmers from too high production costs.” Especially, when the central government reiterates in recent years the order to add no any burdens on farmers’ livelihoods, increase of the water charges becomes simply impossible in many places, even though it is unfortunately misconstrued. In fact, the water charges are a totally different matter from illegal fees and levies, but apparently it is often dealt with very sensitively and cautiously in many cases, and is even manipulated by some specific local authorities to be an obstacle of the reform process. In actuality, increase of the water charges to normal level is very much in line with the notion of protecting farmers and agricultural production in the long run.

The other aspects include variety of local conditions under which the ways of water cost calculation are different and the ways of water charge submission also vary. In fact, there was basically no official concern on water costs of the lower distribution network in most places before, and hence no water charges would be expected to cover O&M of the lower network (let alone the overhaul and depreciation). This is one of the reasons for the deteriorative situation of the branch/lateral canals and on-farm work. However, with WUAs, farmers have to start to calculate and handle these costs of lower level by means of increasing water charges for their own costs; and it is farmers themselves who have taken steps first in the water price reform. As mentioned before, for their self-managing of local system O&M, WUAs normally collect the water charges about 5-10% more than what required by WSC/WSO and the local price bureau. In some places, WUAs can keep this increment before they submit the water charges. In some other places, however, WUAs have to fix in advance the increment into the water price as a whole to be verified by the local price bureau, and submit the whole collected water charges to WSC/WSO, for the sake of avoiding “price abuse.” They may get the increment returned afterwards, but this would not help build but decrease their independent self-managing and self-financing capacity. Yet, still worse, in some places where the township authorities’ attitudes are not that favorable, WUAs still have to submit the water charges to township rather than water supplier, or are even restrained from collecting the water charges at all!

On the whole, it is not unusual to have various constraints and challenges in the reform process. And indeed, from the administrative point of view, the SIDD/WUA system, though very young, also needs some external monitoring mechanism for its operation and finance. To this end, local bureaus of water resources, civil affairs, and auditing all should come to assist (not control) in monitoring of development, and providing services for local society reflects the government responsibilities for social

development. First of all, farmers' endeavors are essential for WUA development. Meanwhile, the water sector line agencies' supports are the backbone for promoting the SIDD reform as a whole. Gathering all the efforts together to create a favorable social environment, it is evident that high-level policy and budget supports including the necessary legal framework are also needed, which is important for both SIDD/WUA stabilization and extension.

## VII. Conclusion: the SIDD Future with Its PIM Nature in China

### SIDD as a Vehicle for Farmers' Participation and Empowerment

Started with the Yangtze Basin Water Resources Project and continued with the Tarim Basin Rehabilitation Project II, Irrigated Agriculture Intensification Loan II, Water Conservation Projects, Guazhong Irrigation Improvement Project, Jiangxi Integrated Agriculture Modernization Project and others, the SIDD model has developed and extended in many places in line with the government reform strategy in rural China.

Experience learned from the SIDD/WUA practice shows that local farmers not only benefit from these development projects, but more significantly, they are making the benefits durable by participating in and controlling over the development process. The SIDD/WUA system just provides an organizational mechanism in this process to ensure farmers' control rights. Moreover, as their own organization and tool, SIDD/WUA are also used by farmers to regulate their steps in managing local irrigation operation and maintenance, in compliance with their common interests in rural communities. In doing so, farmers are able to build capacity to manage their internal irrigation community; meanwhile, they also have stronger voice in local society of which they are a part.



Putting up WUA's Sign to Celebrate  
WUA Establishment and Empowerment

An example from Cangku WUA, Hubei, would further explain the meaning of farmers' empowerment through SIDD/WUA in local irrigation management. In 2000, when the peak irrigation season passed and the water charge submission was completed, Cangku WUA was asked by its township authorities to collect additional water charges of 20,000 cubic meters from each of the six villages the WUA covered, for the sake of the township use for some non-irrigation matter. On behalf of all the WUA members, chairman of Cangku WUA pointed out that this requirement would violate the WUA irrigation regulation and encroach on farmers' interests; and he hence firmly rejected it. According to the WUA charter, as a legal person, WUA is the physical system's owners

(in some places it has the use rights, instead), and holds the rights on the system O&M and all the decision-making related to local irrigation. The WUA conference authorizes WUA chairman and the executive committee to operate the system, and examines the O&M performance and financial results under guidance of the WUA regulations. In the Cangku case, farmers are well aware of these WUA principles and operational regulation through which they are empowered. Instead of just waiting for water and funds, or merely obeying the top-down order and instruction like before, farmers in many places under WUAs are eagerly seeking and gradually grasping self-governing and self-financing of local irrigation matters. On the whole, the SIDD reform model, as enthusiastically supported by farmers, has come to realize the real meaning of development, that is, development should be materialized not only with benefits to local society, but more importantly, with local people's empowerment.

### **The SIDD Future in China**

In early July 2000, supported by the World Bank, the British DFID, as well as MWR, China Irrigation Districts Association (CIDA) called a national conference of Water Users' Participation in Irrigation Management and SIDD Reform, which was attended by over 200 representatives from most of the large irrigation/drainage districts and research institutions in more than 20 provinces and municipalities. This conference was held in Tieshan, Hunan, the irrigation district whose development had drawn great domestic and international attention by combination of physical system improvement and management reform under the World Bank supported Yangtze Basin Project. For better discussing and exchanging knowledge and experience in rehabilitation of irrigation/drainage districts, all representatives visited Tieshan WSC and WUAs and learned from them as the advanced examples in participatory irrigation management as well as industrialization of water conservation. Summaries and learnings from this conference gave further impetus to the reform movement in the water sector.

As one of the efforts for the reform and sustainable irrigation development, MWR started in late 2000 a national rehabilitation program of the middle and large sized irrigation and drainage districts by means of prioritizing combination of both institutional reform and canal system amelioration. This program occurs on the basis of numerous lessons and experience accumulated thus far, and represents a common understanding in the water sector to target the very weakness of the irrigation management and to answer the future challenges as mentioned above. The WUA model is a major one of the PIM approaches MWR has recommended for the institutional reform in this program.<sup>10</sup> In the meantime, a SIDD Training Textbook, co-edited by the State Office of Comprehensive Agricultural Development, Ministry of Finance (MOF), and the Office of Comprehensive Agricultural Development, MWR, was published by 2001. This book was edited on the basis of SIDD development experience from a number of rural development projects covering over a dozen of provinces in China. As the water sector reform further unfolds

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<sup>10</sup> The other approaches to farmer participation in this program include the auction, contract, and rent of some small irrigation schemes and facilities, like ponds, wells, etc., to individual farmers. But the MWR more and more realizes that it is better to have farmers control over these public goods collectively than individually.

in rural China, this publication helps guide SIDD implementation and development in not only the World Bank supported projects but also nationwide.

Under multiple collaborations, the way the SIDD/WUA model has paved for reform has thus been firmly confirmed. In his speech to whole China's provincial Water Resources Bureau directors in September 2001, Minister of MWR particularly raised three points to support the WUA approach to management of small scale irrigation schemes (the lower distribution networks): 1) There is a need to extensively promote WUAs through which farmers are able to participate in construction and management of rural small scale irrigation schemes and systems, and which are conducive to encourage farmers' initiatives and to overcome constraints in water charge collection; meanwhile, ownership of the small irrigation schemes/systems should be with WUAs; 2) Management responsibility of the small irrigation schemes/systems should be also with WUAs, while the ways of management may vary with local circumstances; and 3) Local governments should support WUAs and help them improve their systems, but should not take over.

A 2002 combinative investigation research of water prices in one hundred large- and middle-sized irrigation and drainage districts by MWR and the State Development Planning Commission (SDPC) reviewed the roles of the established WUAs in these districts. This investigation supported the Minister's view and recommended to regularize WUA status and functions in irrigation management, and then to broadly expand WUAs on the basis of extensively mobilizing farmers' incentives and strengthening coordination between local water sector and township authorities (cf. Report by SDPC and MWR team, China Water Resources Newspaper, November 2002). In practice, Jinmen municipality, where the Hubei first SIDD pilot was located, set forth the legal provisions for WUA management that was approved in 2002 by the Municipal People's Congress. Again, as another pilot demonstration in Hubei Province, the SIDD/WUA system has started to be legislated now for further development in China.

On the whole, the participatory irrigation management reform as expressed in SIDD practice has been increasingly understood after several years of efforts, and it will be broadly extended over whole China in the foreseeable future. Although the SIDD/WUA form may vary with different local conditions, its participatory and transformative principle will be realized universally in all irrigation/drainage districts' rehabilitation. In this regard, the SIDD model is appreciated for its pioneering contribution to the water sector reform for a sustainable rural development.



Chart 1  
WUA Institutional Structure

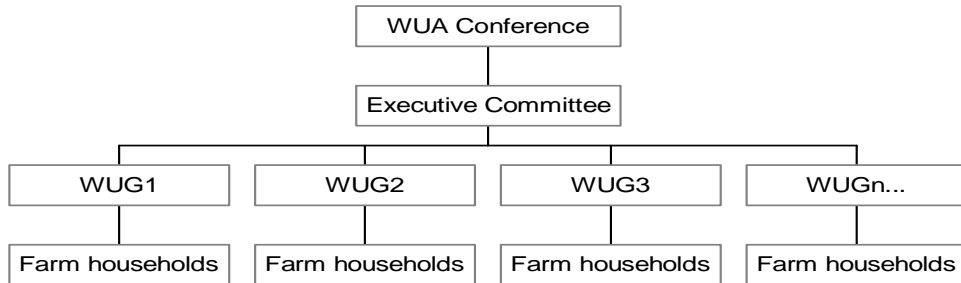


Chart 2  
WSC Institutional Structure

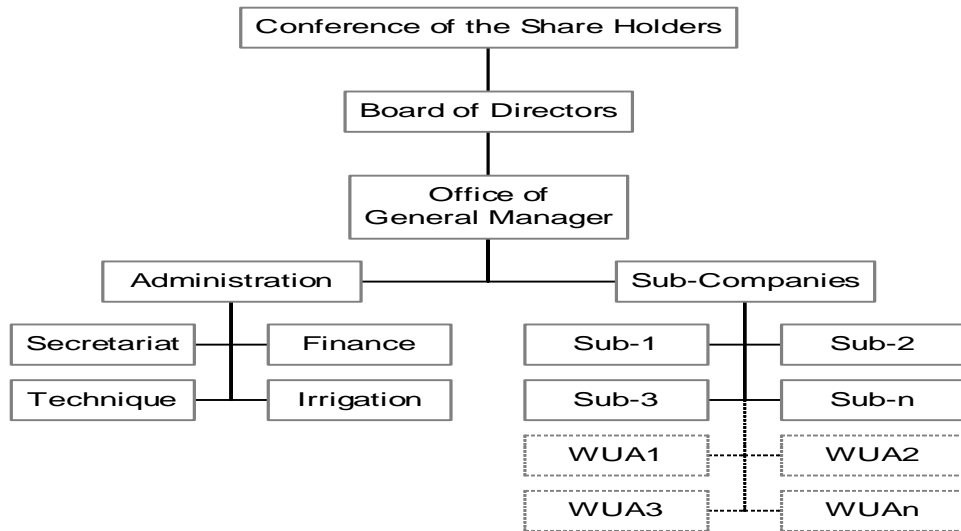


Table 1

## The Basic Operational Finance Situations of the Eleven WUAs in Tieshan, 1999

Names	Annual Incomes (Y'000)						Annual Expenses (Y'000)					Grain Prod. 1000kg	Unit Yield Kg/m <sup>u</sup>	Water Used 1000c <sup>m</sup>
	Water Charges	For main-tenance	Labor input	Other income	Allo-cation	Sum	Main-tenance	Over-head	Ope-ration	Other Expen.	Sum			
Changtang	68	120	300	24	10	522	475	14	14	18	521	3867	730	3100
Xingfu	54	30	60	5	70	219	143	22	17	7	189	2952	720	2980
Kangwang	37	60	20	7	20	144	83	18	24	5	130	1381	695	1400
Sanhe	84	20	30	14	70	218	109	56	25	7	197	2590	700	1950
Hedong	73	40	20	21	180	334	229	43	24	7	302	6693	695	6370
Qingyun	19	40	300	3	100	462	428	13	11	3	455	1190	700	15000
Xongshi	49	13	10	3	8	83	21	21	18	7	67	2387	724	2030
Baiyangtien	49	20	20	19	60	168	148	24	19	5	196	3682	700	4500
Luoping	68	60	50	7	40	225	132	35	19	5	191	1292	680	1720
Jingtang	83	10	20	6	10	129	40	34	32	5	111	3638	750	3800
Xitang	95	300	1200	35	1310	2940	2802	56	27	19	2904	5450	720	11300
Total	679	713	2030	144	1878	5444	4610	7	229	87	5263	35120	7814	54150

Information source: Tieshan Irrigation District Authority, Hunan Province.

Table 2

The Basic Operational Finance Situation of the Eleven WUAs in Tieshan Monitored for Three Years, 1997-99

Years	Annual Incomes (Y'000)						Annual Expenses (Y'000)					Balance Y'000	Grain Prod. 1000kg	Unit Yield Kg/ mu	Water Used 1000 c.m.
	Water charges	For main- tenance	Labor input	Other income	Allo- cation	Sum	Main- tenance	Over- head	Ope- ration	Other Expen.	Sum				
1997	366	2090	3200	60	1834	7550	7100	185	121	45	7450	+101	21350	694	21850
1998	512	1488	1235	105	1267	4610	3987	259	202	61	4510	+97	28840	688	29410
1999	679	713	2030	144	1878	5440	4610	337	229	87	5260	+181	35120	710	54150
3-year sum	1557	4291	6467	308	4979	17600	15696	781	552	194	17220	+380	85310	2092	105410
Annual average	519	1430	2156	103	1660	5870	5232	260	184	65	5740	+127	28430	697	35140
Average per mu	Y 12.8	Y 35.2	Y 53.1	Y 2.5	Y 40.9	Y 145	Y 128.8	Y 6.4	Y 4.5	Y 1.6	Y 141	+Y 3.1	697 kg		865 c.m.
Percentage	9%	24%	37%	2%	28%	100%	91%	5%	3%	1%	100%				

Information source: Tieshan Irrigation District Authority, Hunan Province.

Table 3  
 Statistical Comparison of the Production Costs and Outputs  
 Before and After the Four Sample WUAs' Establishment in Jinmen, Hubei Province, 1998

Items Time Period	WUA Names	Irrigated Areas (1000 mu)	Water Amount Used c.m/mu	Average Unit Yields ricekg/mu	Average Produc. Costs Cny/mu	The cost Compo sition			Average Output Value Cny/mu	Average Profits Cny/mu	Average Output value Cny/c.b.	Cost vs. Output %	Irrig. Effi- cient rate %	Water Guard Costs Cny/mu	Water Charge in prod costs %
						Seeds, Fertilizer, Pesticides Labor Cny/mu	Water Charges Cny/mu	Other Collect- ive charges Cny/mu							
Before:	Hong Miao	5.2	430.0	750.0	272.6	181.0	11.8	80.0	485.8	213.2	0.50	56.0	80	3.90	4.3
1990	Cang Ku	10.5	457.0	785.0	319.4	200.0	14.4	105.0	473.7	154.3	0.34	67.0	70	2.00	4.5
—	Chen Ji	11.4	266.7	725.0	220.0	114.6	5.4	100.0	293.6	73.6	0.28	75.0	70	3.40	2.5
1994	Ya Pu	13.1	278.6	628.5	239.2	130.8	8.4	100.0	451.0	211.8	0.76	53.0	65	1.90	3.5
After:	Hong Miao	5.2	380.0	800.0	386.6	263.0	17.2	106.0	873.0	486.4	1.28	44.0	85	1.50	4.5
1995	Cang Ku	10.5	333.3	856.0	483.3	340.0	23.3	120.0	1064.7	518.4	1.74	45.0	85	1.26	4.8
—	Chen Ji	11.4	211.4	761.0	374.3	242.3	12.0	120.0	788.9	415.6	1.96	47.0	85	2.00	3.2
1997	Ya Pu	13.1	233.6	641.9	386.7	205.0	10.7	174.4	815.4	425.7	1.82	48.0	80	1.24	2.8

Note: "Cny" stands for the Chinese monetary unit "Yuan" (as "Y"); and "mu" is the Chinese area unit, equal to 1/15 ha.  
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