RESEARCH REPORT

No. 2010-RR8

Social Capital, Local Government, and the Management of Irrigation Systems in Northwest China

Dr. Shun Wang
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China faces a growing water shortage problem. To help policymakers tackle this significant challenge, a new EEPSEA study has assessed one of the country's key water management initiatives: Water User Associations (WUAs). WUAs are user-based, participatory organizations that manage and conserve a village's irrigation water. The study is the work of Dr. Shun Wang from the Department of Economics at the University of British Columbia.

The study finds that there has been relatively poor implementation of the WUA policy in China. The main reason for this failure is the fact that local government agencies have not been effective at involving water users properly. The study finds that stronger communities that have more 'social capital' often enhance the operation of WUAs; it recommends ways in which this can be capitalized upon.

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May 2010

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The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support research and training in environmental and resource economics. Its objective is to enhance local capacity to undertake the economic analysis of environmental problems and policies. It uses a networking approach, involving courses, meetings, technical support, access to literature, and opportunities for comparative research. Member countries are Thailand, Malaysia, Indonesia, the Philippines, Vietnam, Cambodia, Lao PDR, China, and Papua New Guinea.

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SOCIAL CAPITAL, LOCAL GOVERNMENT, AND THE MANAGEMENT OF IRRIGATION SYSTEMS IN NORTHWEST CHINA

Shun Wang

EXECUTIVE SUMMARY

Shortage in irrigation water has become a serious problem in rural China. Governments are trying to build more Water User Associations (WUAs) to improve the management of irrigation water. Better management would reduce the agricultural use of water and allocate more water to protect the environment, especially in arid and semi-arid areas where the ecological environment is very fragile. Therefore, it is important to know how WUAs have been organized, whether they have had contributions to water management, as well as how satisfied water users are. This report is among the first to characterize the situation of WUAs in northwest China. This report has three contributions.

First, the report shows a relatively poor implementation of the reform to transfer management to WUAs in China. Many of the villagers did not even know that WUAs existed. The poor implementation of the reform program implies that water users were not officially entitled to the rights to manage these resources.

Second, the report shows that the quality of local government was the main determinant of users' awareness on the existence of WUAs. This result implies that a more responsible government is needed to improve the efforts in implementing the reform or/and in transferring power to water users. Moreover, the awareness of users about the WUAs and the quality of government both had positive effects on the performance of WUAs. These combined facts suggest that a more responsible local government not only has direct positive contribution to the performance of WUAs, but that it also affects performance by increasing awareness among community members.

Third, the coefficients of social capital and/or that of the interaction terms of social capital and awareness were significant in many of the regression models on the performance of WUAs and on the satisfaction of water users. The results suggest that social capital could affect the performance of WUAs. Considering that the coefficients of trust aggregated at the administrative village level were not significant in all the models, we can conclude that only the trust in the densely-connected community could be useful for community management. This result suggests that defining the boundary of common pool resources at the natural village level is very important for social capital to be effective.

1.0 INTRODUCTION

1.1 Background

The rising shortage of water in China has been identified as one of the main obstacles for environmental conservation and poverty reduction (World Bank 1998; Zhang 2000). To cope with the scarcity problem, the Chinese government has conducted several approaches. First, it has invested a lot in infrastructure to develop new water resources. Records show that over 100 billion US dollars has been expended on infrastructure since the 1950s (Wang 2000). However, this huge investment has not proven to be as effective as expected (Lohmar *et al*. 2003). There is a plan to invest more than 50 billion US dollars in moving water from the Yangtse River Valley to northern China, yet the extremely high cost of the project demonstrates the difficulty of developing water resources for North China. Second, the Chinese government has spent a lot of efforts in promoting water-saving technologies. However, most of these sophisticated water-saving technologies have not been successful.

In response to the systemic failures of supply-oriented water projects managed by the government, some development organizations and NGOs have advocated the principle that irrigation systems are best managed by organized and empowered farmer communities. Ostrom (1990) presents many cases where resource users have been able to manage the common pool resources well. Since the 1980s, some developing countries have started to move irrigation management responsibilities from the government to farmer organizations or other private entities to improve the efficiency of water use, as well as to alleviate the financial burden of water projects (Vermillion 1997).

China's government began to implement water management reform based on this international experience since the 1990s. Besides contracting canal networks to individuals, irrigation ministries have also appreciated the formation of Water User Associations (WUAs) as another method of water management. WUAs are defined as water users-based, participatory organizations that are set up to manage the village's irrigation water. They are organized to provide services according to users' preferences and demands, with users involved in the construction, operation, and maintenance of infrastructures and water allocation. The most significant difference between the traditional management scheme and the formation of WUAs is that the latter's members can make decisions without being challenged by external government authorities.

In 2006, more than 20, 000 WUAs have been formed in over 30 provinces in China as documented by the Ministry of Water Resources. WUAs are generally organized at three levels in China: irrigation district, administrative village, and natural village. An irrigation district means that the district uses water from the same source, such as a reservoir, river, or main irrigation canal. An administrative village is the smallest bureaucratic entity which generally administers a couple of natural villages that spontaneously and naturally exist.

The outcomes of WUAs in China have fallen below expectations. An important factor in the poor performance is poor implementation of the standard structure (Nian 2001; Wang *et al*. 2005). It is still the local village committees and water officials instead of water users who play key roles in determining the actual management structure of WUAs. The government officials' lack of awareness on the importance of users' participation in the management of WUAs, or their reluctance to transfer their power to water users, are being blamed for deviating the actual institutional arrangements from the standard ones (Shah *et al. 2004*; Wang *et al.* 2005).

In some areas, WUAs are formed in name only. The only change is that the village leaders get extra titles as WUA managers. However, the water users themselves are not even aware that these WUAs exist. In other areas, WUAs have some characteristics of standard WUAs. At least, water users know they are WUA members; they also know the difference between the operation of WUAs and the traditional management scheme. Even though WUAs at administrative village level are still managed by former or current local government officials, WUAs at natural village level are managed by leaders elected by water users. Hence, the latter have some influence on water management.

1.2 Research Objectives

Community governance theory of common pool resource predicts that user groups with close connections can manage the resource well if all the users are given the rights to manage it (Ostrom 1990). Hence, there is a need to know whether social capital is effective and how the quality of local government affects the performance of the WUAs, in China.

The overall goal of this research was to empirically analyze how the institutional arrangements and water users' participation behaviors in WUAs varied with levels of social capital and the quality of local government. In the research, water users' characteristics and the availability of other water sources such as rainfall were controlled. Specifically, there were four objectives:

[1] To document the degree of self-governance of WUAs, water users' participation behaviors, outcomes of water allocation, as well as indicators of social capital in local communities;

[2] To estimate the effects of social capital and the quality of government on the degree of self-governance of WUAs;

[3] To estimate the effects of social capital and the degree of self-governance of WUAs on water users' participation behaviors and water use; and

[4] To characterize the environmental impact of water allocation.

The outcome of this study will help officials to improve the implementation of the water management reform and the efficiency of water use. These moves would help reduce poverty and improve the water users' welfare in the countryside since almost all of them belong to the lowest income class in China. Moreover, the move may also mitigate the negative impact of agricultural water use on the environment.

2.0 METHODOLOGIES

2.1 Background of the Research Area

This project made a cross-sectional analysis based on household surveys done in Gansu province in northwest China. Gansu province was chosen as the research area because of three reasons. First, the province is one of the first provinces transforming the traditional management scheme to WUAs. The province began implementing the reform on water management since 2001 to combat water shortage. News or government reports show that the reform has achieved significant success.

Second, the province is one of the districts that experiences great shortage in irrigation water. The rainfall available for agricultural use is very scarce: the perennial average rainfall ranges from 100 mm to 250 mm, while the perennial average evaporation ranges from 1, 600 mm to 2, 600 mm.

Shortage in water imposes significant constraint on the economic development of the province. As of now, the province is one of the less developed in the 31 provinces of China. With an annual GDP per capita in 2009 of 12,882 Chinese Yuan (approximately 1,886 USD with an exchange rate of 6.83:1), it ranked 30^{th} among the 31 province-level regions in mainland China.

Third, the environment in the province is very vulnerable and sensitive to water use. For example, the Minqin Oasis at the end of Shiyang River in the province can change into a desert if there is not enough water supplemented to Shiyang River.

The field work for this research was conducted in the three river basins in Gansu province, Northwest China. The three rivers were the Yellow, Shiyang, and Heihe; the latter two are inner continental rivers. In most regions, traditional flood irrigation is still the irrigation technology, but surface water and underground water are also being used in other areas.

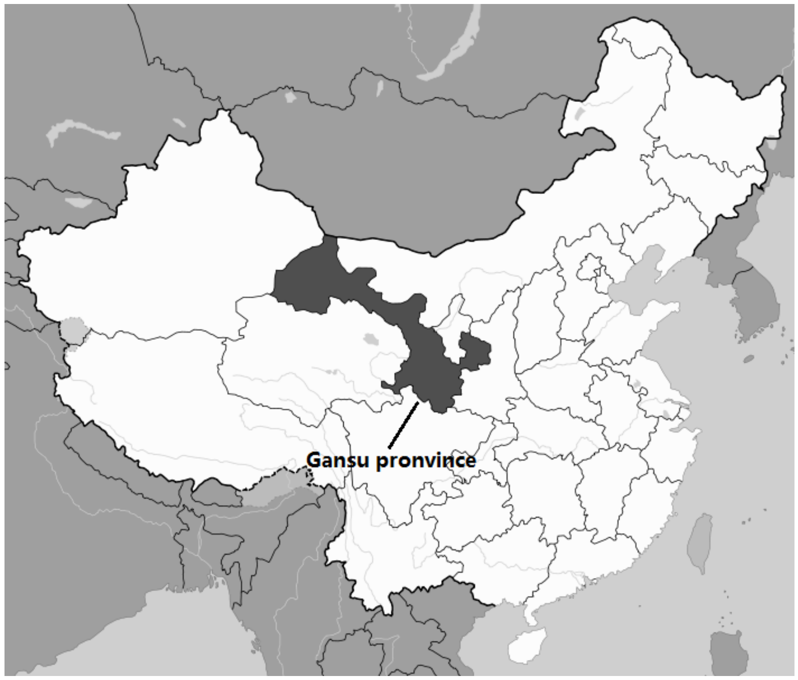

Figure 1. The map of Gansu province in China

2.2 Data Collection

2.2.1 Recruitment and training of enumerators

To serve as enumerators, I recruited twelve senior undergraduate students and graduates from Lanzhou University. Six of them had experiences in conducting household surveys. Classroom lectures were held to familiarize them with the research topic, relevant theories, and the household questionnaires.

2.2.2 Sampling method and sample size

To select the irrigation districts in the provinces, I first chose counties that have implemented WUA reforms based on secondary documents from the provincial government and from the Internet. It turned out that most of the counties that have implemented the reform were distributed along the main rivers in Gansu province. There were four major rivers in the province located from South-East to North-West, namely: Yellow, Shiyang, Heihe, and Shule. The Shule River Basin was not covered because the agricultural population was lower than the other sites. Further, the population density was only two people per square kilometer, which made sampling difficult.

In the other three river basins, I followed the following sampling procedures: First, I randomly selected three counties along the Yellow and Heihe River and two counties along the Shiyang River. The counties were located from the upstream to the downstream of the three rivers. This method of sampling provided enough variation among regions, capturing characteristics of geography, hydrology, and government policies. Second, I chose one irrigation district from each county. Third, I randomly chose administrative villages with WUAs within each district.

Figure 2. The map of research areas in Gansu province

2.3 Research Methods

2.3.1 Factor analysis

Factor analysis is a statistical method used to characterize variability among numerous observed variables in terms of fewer unobserved variables called “factors”. Each variable is linearly related to each of the factors. The strength of the relationship is characterized by their factor loadings, which can be interpreted as standardized coefficients of regressing the factor on those variables.

In my survey, I had several questions regarding different aspects of social capital and the quality of local government. The responses to those questions were highly correlated. To characterize social capital and the quality of local government with fewer variables, factor analysis is conducted to generate common factors. The analysis can generate several common factors. When it happens, Kaiser Criterion is commonly used by researchers to keep a subset of them, i.e. keeping factors with eigenvalue greater than 1. The eigenvalue, which is also called characteristic root, for a given factor measures the variance in all the variables which is accounted for by that factor. If a factor has a low eigenvalue, it contributes little to the explanation of variances in the variables and may be ignored.

2.3.2 Cross-sectional regressions

After generating one factor for social capital and for the quality of local government, respectively, I performed cross-sectional regressions to examine the relationships between the dependent variables and independent variables.

I had two types of dependent variables. The first type was a dummy variable with only two values, 0 and 1. For example, I had a variable indicating whether the villager knew of the existence of WUAs. Specifically, 1 stood for “know” and 0 stood for “do not know”. The second was a continuous variable. Logistic regressions and Ordinary Least Squares (OLS) regressions were used for the two cases, respectively. More details on the methods can be found in Wooldridge (2002). In those regressions, robust and clustered errors were used to account for the unobserved intra-village correlations.

3.0 DATA DESCRIPTIONS

In the survey, there were 690 effective samples taken from 275 natural villages, which belonged to 61 administrative villages. A natural village or a hamlet, is a community that spontaneously and naturally exists. An administrative village, which consists of several natural villages, is the smallest bureaucratic entity in rural areas. The number of households randomly taken from each irrigation districts was roughly proportional with the agricultural population in WUAs.

3.1 Measures of Social Capital

Social capital was constructed from the respondents’ answers to the five statements regarding their perceived trust on villagers in the same natural village:

1) I can trust my neighbors to look after our house when we are away.

2) I can trust my neighbors to take care of my children when we are away.

3) In the future, I will still lend farming tools to villagers even though I had experienced having them not return the tools to me.

4) Most villagers can expect others to help them when they are in real difficult situations, such as when they are very sick or their houses are burned down.

5) Most villagers are trustworthy.

There were five levels of responses to the statements, in which 1 stood for “strongly disagree” while 5 stood for “strongly agree”. Table 1 documents the descriptive statistics of these five trust measures.

Table 1. Descriptive statistics of trust measures

Variable	Obs	Mean	Std. Dev.	Min	Max
Trusting neighbors to look after house	690	3.691	0.940	1	5
Trusting neighbors to take care of children	690	3.777	0.940	1	5
Lending farming tools to villagers	690	3.333	0.962	1	5
Expecting others to help in difficult situations	690	4.100	0.719	1	5
Most villagers are trustworthy	690	4.022	0.761	1	5

How did these trust measures vary within and across the two levels of communities: the natural villages and the administrative villages? Figure 3 illustrates the inter-natural-village shares of variance of the five trust measures. That four of the five variances were larger than 50% suggest that most of the variations were accounted by inter-community instead of within-community differences.

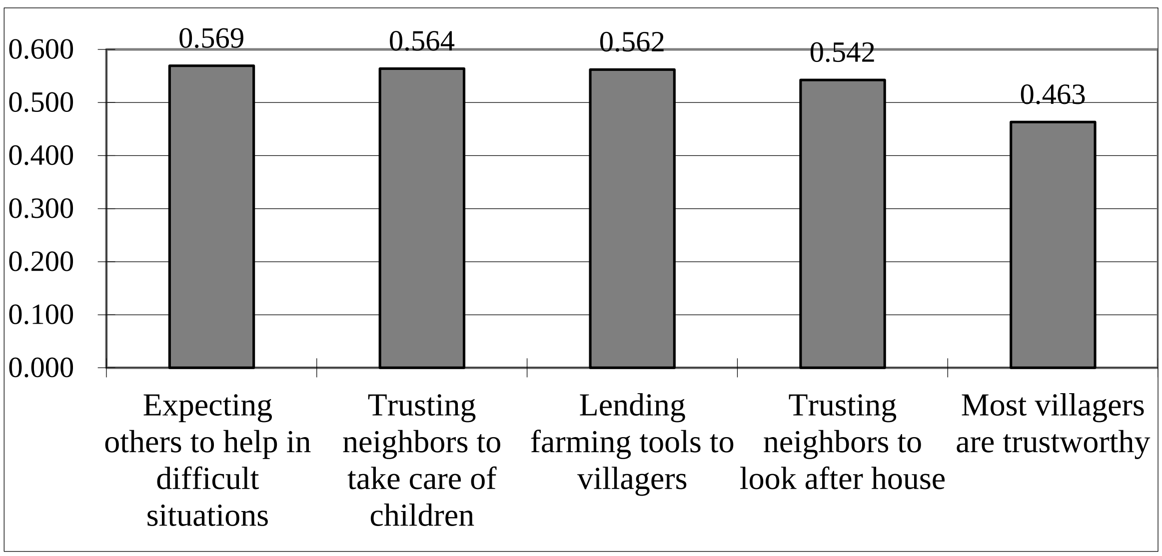

Figure 3. Inter-natural-village shares of variances

Figure 4 illustrates the inter-administrative-village shares of the total variance of the five trust measures. That all the shares were low suggest that there were no large variations coming from inter-administrative village differences.

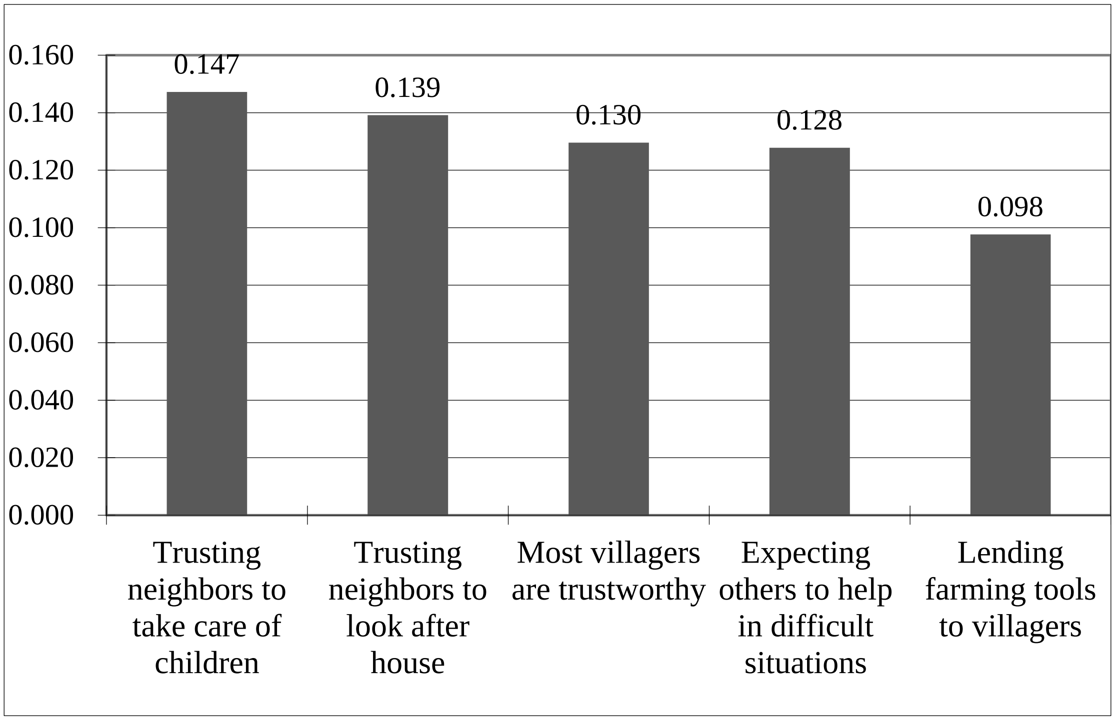

Figure 4. Inter-administrative-village shares of variances

The variance analysis illustrated in Figure 3 and 4 implies that trust measures were better aggregated at the natural village level to generate community-level social capital. Table 2 shows the descriptive statistics of average trust measures aggregated by "natural village" and "administrative village", respectively. Trust at the administrative village did not measure how respondents trusted people in other natural villages of the same administrative village. Instead, it was just the aggregate value of how people trusted villagers in the same natural village at a broader region.

It seems that the trust measures in Table 2 are higher for administrative villages, which were broader groupings, than for the local, natural groupings in which people lived close to each other day-to-day. The difference, however, was not statistically significant. Therefore, there was no difference between the two levels of trust. The smaller standard deviation of trust at the administrative level suggests that there was less variation across the administrative village than in the natural village.

Table 2. Descriptive statistics of average trust measures

Variable	Obs	Mean	Std. Dev.	Min	Max
Aggregated at natural village level					
Trusting neighbors to look after house	275	3.732	0.728	1.75	5
Trusting neighbors to take care of children	275	3.830	0.743	1.75	5
Lending farming tools to villagers	275	3.334	0.795	1.00	5
Expecting others to help in difficult situations	275	4.119	0.613	1.00	5
Most villagers are trustworthy	275	4.052	0.542	2.00	5
Aggregated at administrative village level					
Trusting neighbors to look after house	61	3.779	0.463	2.50	5
Trusting neighbors to take care of children	61	3.879	0.444	2.92	5
Lending farming tools to villagers	61	3.370	0.373	2.33	4.1
Expecting others to help in difficult situations	61	4.141	0.343	3.50	5
Most villagers are trustworthy	61	4.052	0.364	3.00	5

The five average trust measures at both the natural and administrative village levels were significantly and positively correlated with large coefficients as shown in Tables 3 and 4.

Table 3. Correlation matrix of trust measures at the natural village level

	Trusting neighbors to look after house	Trusting neighbors to take care of children	Lending farming tools to villagers	Expecting others to help in difficult situations	Most villagers are trustworthy
Trusting neighbors to look after house	1.000				
Trusting neighbors to take care of children	0.830*** (0.000)	1.000			
Lending farming tools to villagers	0.186*** (0.000)	0.261*** (0.000)	1.000		
Expecting others to help in difficult situations	0.334*** (0.000)	0.407*** (0.000)	0.245*** (0.000)	1.000	
Most villagers are trustworthy	0.371*** (0.000)	0.388*** (0.000)	0.281*** (0.000)	0.441*** (0.000)	1.000

Notes:
(1) Significant levels are in parentheses.
(2) * p<0.1, ** p<0.05, *** p<0.01.

Table 4. Correlation matrix of trust measures at administrative village level

	Trusting neighbors to look after house	Trusting neighbors to take care of children	Lending farming tools to villagers	Expecting others to help in difficult situations	Most villagers are trustworthy
Trusting neighbors to look after house	1.000				
Trusting neighbors to take care of children	0.736*** (0.000)	1.000			
Lending farming tools to villagers	0.145*** (0.000)	0.180*** (0.000)	1.000		
Expecting others to help in difficult situations	0.292*** (0.000)	0.441*** (0.000)	0.1303*** (0.001)	1.000	
Most villagers are trustworthy	0.431*** (0.000)	0.534*** (0.000)	0.0835** (0.028)	0.517*** (0.000)	1.000

Notes:
(1) Significant levels are in parentheses.
(2) * p<0.1, ** p<0.05, *** p<0.01.

Since the five measures of trust were highly correlated with positive coefficients, I used factor analysis to generate some factors of trust to reduce the dimension of trust measures. Factor analysis is a statistical method used to characterize the variability among observed variables in terms of fewer unobserved variables called factors. The observed variables are modeled as linear combinations of the factors, plus “error” terms. Table 5 shows the factor loadings and eigenvalues of the first factor of two levels of average trust. Since only the first eigenvalue was greater than 1 for both cases, I kept the first factor to stand for the social capital at the natural village and at the administrative village level, respectively.

Table 5: Factor loadings of the first principal factor

Trust measures	Aggregated at natural village level	Aggregated at administrative village level
Trusting neighbors to look after house	0.824	0.738
Trusting neighbors to take care of children	0.864	0.838
Lending farming tools to villagers	0.333	0.194
Expecting others to help in difficult situations	0.518	0.556
Most villagers are trustworthy	0.531	0.655
Eigenvalue	1.743	1.785

3.2 Measures of the Quality of Local Government

To evaluate the impact of local government on the performance of WUAs, I constructed a measure of the quality of local government since there were rarely other inputs than the efforts of government officials in building and managing WUAs. Three questions on the duties of government officials that were not about water affairs were asked in the questionnaire as follows:

1) Our village leaders will not prioritize their personal/family welfare when pursuing the welfare of the whole village.

2) Our village leaders are among the first ones to approach government for help in the face of calamity (such as flood or fire) that will threaten the whole village.

3) Our village leaders can resolve the conflicts among village members in a fair manner.

The questions were asked this way: "In what degree do you agree with the following three statements on leaders' performance?" There were five levels of responses, in which 1 stood for "strongly disagree" and 5 stood for "strongly agree". Tables 6 and 7 show the descriptive statistics and their correlations.

Table 6. Descriptive statistics of quality of local government

Variable	Obs	Mean	Std. Dev.	Min	Max
Village leaders will not prioritize their personal/family welfare when pursuing the welfare of the whole village	689	2.911	1.062	1	5
Village leaders are among the first ones to approach government for help in the face of calamity	690	3.196	1.024	1	5
Village leaders can resolve the conflicts among village members in a fair manner	690	3.226	0.961	1	5

Factor analysis was conducted to create a comprehensive measure of the quality of local government. Table 8 documents the factor loadings of the three variables indicating leaders' performance. The first principle factor was used as the measure of the quality of local government since only its eigenvalue was greater than one.

Table 7. Correlation matrix of quality of local government

	Village leaders will not prioritize their personal/family welfare when pursuing the welfare of the whole village	Village leaders are among the first ones to approach government for help in the face of calamity	Village leaders can resolve the conflicts among village members in a fair manner
Village leaders will not prioritize their family welfare when pursuing the welfare of the whole village	1.000		
Village leaders are among the first ones to approach government for help in the face of calamity	0.538*** (0.000)	1.000	
Village leaders can resolve the conflicts among village members in a fair manner	0.490*** (0.000)	0.489*** (0.000)	1.000

Notes:

(1) Standard errors are in parentheses.

(2) * p<0.1, ** p<0.05, *** p<0.01.

Table 8. Factor loadings of quality of local government

Variable	The first factor
Village leaders will not prioritize their personal/family welfare when pursuing the welfare of the whole village	0.687
Village leaders are among the first ones to approach government for help in the face of calamity	0.684
Village leaders can resolve the conflicts among village members in a fair manner	0.642
Eigenvalue	1.352

3.3 Users' Awareness of the Existence of WUAs

The WUA in the research area operated basically as a small variation of the traditional management scheme. Majority (69%) of the villagers in the survey were not aware of the existence of the WUAs even though the WUAs were already nominally formed. Because a large proportion of the villagers did not know about the WUAs, the set of indicators proposed to measure their households' participation in the management of WUAs was not applicable.

Therefore, I used the households' awareness of their WUA as the indicator for the households' participation. If households were aware of the existence of WUAs, they were expected to influence the management of the WUAs through the election of the leaders of the natural village, who were also the heads of the WUAs. The dummy variable, awareness, has 690 observations with mean 0.312, and standard deviation 0.463.

3.4 Measures of WUAs' Performance

I used six indicators to measure the performance of the WUAs. These were four objective measures including the absolute difference between the actual and the reference amount (m^3/mu), time spent on monitoring water distribution in 2007 (*hours/labor*), time contributed to maintaining canals in 2007 (*hours/labor*), and proportion of villagers who were delayed in paying water fees in 2007.

In this research, I used the amount of water that users' bought as reported by the villagers. The reference amount of gross water use in Gansu province is about 700 m^3/mu for using surface water and 480 m^3/mu for using underground water. Since the households tended to contribute less on monitoring and maintenance efforts because of the free-riding incentive in the collective action, more contribution implies more cooperation among members.

There were two subjective measures including the villagers' satisfaction with the current water management organizations and the villagers' satisfaction with water distribution. If villagers knew of the existence of WUAs, satisfaction with the current water management organizations stood for villagers' satisfaction with WUAs; otherwise, it meant their satisfaction with the current water management organizations. Table 10 shows the descriptive statistics of those outcome variables.

Table 9. Descriptive statistics of outcomes

Variable	Obs	Mean	Std. Dev.	Min	Max
Absolute difference between actual and reference water use (*m3/mu*)	253	361.620	327.488	0	2976
Time spent on monitoring water distribution (*hours/labor*)	660	10.027	21.557	0	183
Time contributed to maintaining canals (*hours/labor*)	685	1.794	6.464	0	97.5
Proportion of villagers delayed in paying water fees	640	0.055	0.072	0	0.35
Satisfaction with the current water management organizations	498	3.179	1.114	1	5
Satisfaction with water distribution	689	3.224	1.123	1	5

3.5 Irrigation-Related Variables

A set of variables related with irrigation are important for the performance of WUAs, such as the frequency of weather shocks, the distance to irrigation water source, the proportion of surface water, the condition of the sublateral canals, and the villagers' knowledge on new irrigation technologies.

The frequency of weather shocks captured the number of droughts reported in the last five years. If the villagers only used surface water, the distance to irrigation water source meant the estimated length of canals carrying the water from its original source (e.g., river or reservoir) to the village. The distance was normalized to "0" if villagers only used groundwater. The distance to surface water source was used if the villagers used both surface and underground water for irrigation. The proportion of surface water was the ratio of surface water over total water used in 2007 as estimated by the respondents. The conditions of sublateral canals were measured by a dummy in which "1" stood for lined canals and "0" meant unlined canal or mixed types.

I only considered the condition of sublateral canals directly connected with farmers' lands because almost all the main or sub-branch canals were lined in the research areas. The villagers' knowledge on new irrigation technologies was measured by the number of listed new irrigation technologies that they have heard about. Table 9 shows the descriptive statistics of the explanatory variables including social capital and measures of government influences.

Table 10. Descriptive statistics of explanatory variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Social capital at natural village level	275	0.067	0.964	-2.674	2.101
Social capital at administrative village level	61	0.248	1.161	-1.858	3.761
Quality of local government	689	0	0.820	-2.077	1.864
Frequency of weather shocks	690	1.974	2.010	0	10
Distance to irrigation water source (100 *km*)	687	0.355	0.450	0	1.850
Proportion of surface water	690	0.671	0.415	0	1
Dummy of canal type	690	0.249	0.433	0	1
Villagers' knowledge on new irrigation technologies	690	1.498	1.167	0	3

3.6 Demographic and Geographic Controls

Demographic and geographic variables including characteristics of the respondents, of households, and of villages, were controlled in the cross-sectional regressions.

Personal controls included age, year of education, dummy of marital status (*married*), dummy indicating whether respondent was a village leader, and dummy indicating whether the respondent engaged in non-farm work in 2007.

Household controls included dummy of telephone, land area per labor, expenditures on farming machinery, and reported value of houses indicating the household's long-term income. To control for the potential endogeniety of income arising from the fact that good WUA performance may lead to more income, I did not use the household's current income as one control variable. Instead, the value of houses which was less likely affected by the very recent WUA performance through income was controlled.

Village controls included the average reported distance to the farthest neighbor in the same natural village, average reported distance to the nearest neighbor in the same natural village, average distance to the nearest big road, and the village's distance to the nearest city. Table 11 shows the descriptive statistics of these control variables. The first two variables on distances indicated the size of the village and the density of the households; the subsequent variables could indicate households' connections with outside communities.

Table 11. Descriptive statistics of controls

Variable	Obs	Mean	Std. Dev.	Min	Max
Personal Controls					
Age	690	47.913	10.456	25	84
Year of education	690	6.862	3.451	0	15
Married	690	0.968	0.176	0	1
Village leader	690	0.110	0.313	0	1
Engaged in non-farm work	690	0.372	0.484	0	1
Household Controls					
Telephone	690	0.871	0.335	0	1
Land area per labor (*mu*)	690	3.564	2.845	0	23
Expenditure on farm machinery (*CNY*)	689	38.702	38.315	0	409.09
Estimated value of housing assets (10,000 *CNY*)	678	3.513	3.569	0	20
Village Controls					
Average distance to the farthest neighbor resided in the same natural village (*km*)	690	0.859	0.858	0.1	5
Average distance to the nearest neighbor resided in the same natural village (*km*)	690	0.017	0.077	0	1
Average distance to the nearest big road (*km*)	690	1.207	2.355	0	14
Village's distance to the nearest city (*km*)	690	29.510	24.754	1	90

4.0 ANALYTICAL FRAMEWORK

The performance of the WUA is expected to vary with the pre-existing stock of social capital in the communities. This idea is borrowed from the insights of community management of common pool resources based on social capital (McCarthy *et al.* 2001; Murty 1994; Knox and Meinzen-Dick 2001; Ostrom 1990). Since the seminal work of Coleman (1988) and Putnam (1993, 2000), there has been a rapidly growing interest in the role of community norms, networks, trust, and collective action on environmental management (McCarthy *et al.* 2001; Kähkönen 1999; Krishna and Uphoff 1999; Ostrom 1990; Pargal *et al.* 1999; Pretty and Ward 2001). Social capital is generally defined as the social connections among individuals and the norms of reciprocity and trustworthiness arising from them (Bowles and Gintis 2002; Putnam 2000).

Quantitative and qualitative results have shown that social capital plays an important role in facilitating the management of CPRs. For example, Krishna and Uphoff (1999) found that an index of social capital variables was related positively and consistently with better development outcomes not only in watershed conservation but also in cooperative development activities. This result was based on the field investigation conducted in 64 villages of Rajasthan, India. Isham and Kähkönen (1999) showed that in most cases, a set of eight social capital indicators was positively and significantly correlated with the participation in the design, construction, and operation and maintenance of community-based piped systems in Central Java, Indonesia. Dayton-Johnson (2000) also gave evidence that social capital was good for cooperation in small irrigation systems in Mexico.

This analytical framework considered not only the effect of social capital but also the effect of the quality of local government on the outcome of WUAs.

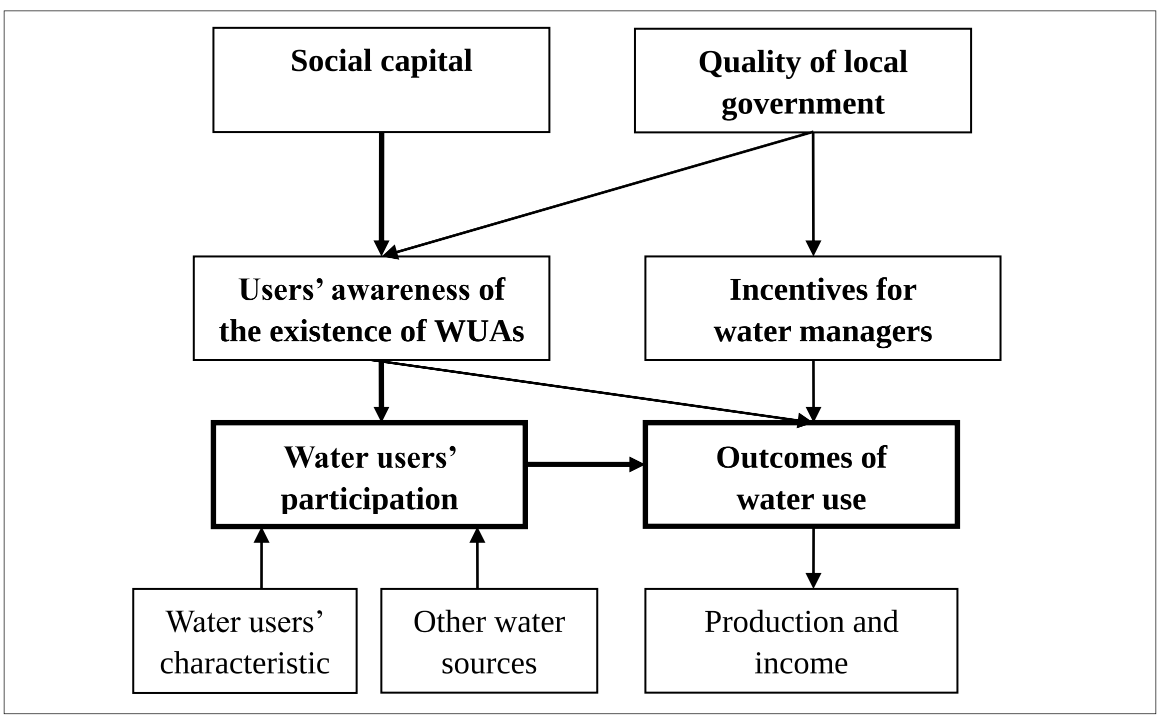

Figure 5. Analytical framework

5.0 EMPIRICAL RESULTS

5.1 Users' Awareness of the Existence of WUAs

In the research areas, villagers were not directly involved in the management of the WUAs. Awareness of the existence of WUAs was used as an indicator for the villagers' influence on WUA management. Awareness was important because if the villagers did not know about the WUAs, they would have no chance of influencing water management. Nevertheless, it must be admitted that knowing the existence of the WUAs may not always lead to participation. Rather, we can state that awareness would be associated with the villagers' chance of getting involved in the management of WUAs.

The local government was expected to have a significant impact on the villagers' awareness. This was because the first step in implementing the reform on water management was for them to introduce the WUAs to the villagers. If the local government officials were not responsible, or if they did not take villagers' interest seriously, they were expected to spend less efforts in introducing WUAs to the villagers.

In this section, I estimated the impact of social capital and the quality of local government on the awareness using a latent variable model:

$$y_{ij}^* = \beta_0 + \beta_1 G_j + \beta_2 SC_j + \beta_x' X_{ij} + \beta_p' P_{ij} + \beta_h' H_{ij} + \beta_v' V_j + \varepsilon_{ij},$$

$$Y_{ij} = \begin{cases} 1 & if \ y_{ij}^* > 0 \\ 0 & if \ y_{ij}^* \leq 0, \end{cases}$$

in which i and j denoted household and village, respectively, Y_{ij}, G_j, SC_j, X_{ij}, P_{ij}, H_{ij}, and V_j denoted the dummy variable indicating whether the household was aware of the WUAs, the quality of local government, a vector of water-related variables, as well as personal, household and village's characteristics, respectively. $Y_{ij} = 1$ meant awareness. The error term $\varepsilon_{ij} : \ N\left[0, \sigma_1^2\right]$.

Table 12 reports the cross-sectional logistic estimation with different model specifications. I used social capital at the natural village level in model (1)-(3) and social capital at the administrative village level in model (4)-(6) to do robustness checks. I controlled personal characteristics in model (1) and (4), personal and household characteristics in model (2) and (5), as well as personal, household, and village characteristics in model (3) and (6). County dummies were included for all regressions to capture regional differences which were not covered by those dependent variables. The standard errors reported in the regressions were all robust and clustered by the natural village in model (1)-(3), and clustered by the administrative village in model (4)-(6).

The coefficients of the quality of local government were positive and significant at 0.01. The results confirmed the conjecture that local government played important roles in determining the households' awareness of the existence of WUAs. Better quality led to higher awareness. The coefficients of social capital were positive but not significant, which suggest that social capital had no effect on the household members' awareness on the existence of WUAs.

Table 12. Logistic regressions of households' awareness

	(1)	(2)	(3)	(4)	(5)	(6)
Independent variable	Dependent variable: Awareness of the existence of WUA					
Quality of local government	0.491***	0.507***	0.493***	0.504***	0.525***	0.506***
	(0.137)	(0.138)	(0.137)	(0.167)	(0.164)	(0.163)
Social capital at natural village level	0.199	0.199	0.201			
	(0.150)	(0.153)	(0.153)			
Social capital at administrative village level				0.186	0.174	0.219
				(0.127)	(0.132)	(0.140)
Ratio of surface water	1.210***	1.131**	1.287***	1.178***	1.122***	1.290***
	(0.431)	(0.446)	(0.472)	(0.283)	(0.336)	(0.384)
Distance to water source	-0.349	-0.415	-0.114	-0.379	-0.448	-0.130
	(0.370)	(0.375)	(0.385)	(0.428)	(0.461)	(0.428)
Frequency of weather shocks	0.260***	0.253***	0.268***	0.252***	0.247***	0.261***
	(0.088)	(0.091)	(0.095)	(0.087)	(0.094)	(0.098)
Dummy of canal type	-0.340	-0.259	-0.276	-0.414*	-0.325	-0.354
	(0.306)	(0.303)	(0.301)	(0.229)	(0.234)	(0.224)
Personal controls	Yes	Yes	Yes	Yes	Yes	Yes
Household controls	No	Yes	Yes	No	Yes	Yes
Village controls	No	No	Yes	No	No	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	686	674	674	686	674	674
Adjusted r-squared	0.237	0.247	0.252	0.236	0.245	0.251
Number of clusters	274	272	272	60	60	60

Notes:
(1) Standard errors are in parentheses.
(2) * p<0.1, ** p<0.05, *** p<0.01.

5.2 Performance of WUAs

In this section, cross-sectional OLS regressions were conducted to estimate the effects of social capital on the performance of WUAs. Moreover, the villagers' awareness of WUAs was included as an explanatory variable. If the villagers were aware of the WUAs' existence, they tended to have more incentives to be involved in their management. The interaction term of awareness and social capital was also included to see if social capital was more effective when villagers were aware of the existence of WUAs. The OLS model had the following form:

$$Y_{ij}^{*} = \gamma_0 + \gamma_1 SC_j + \gamma_2 y_{ij}^{*} + \gamma_3 SC_j * y_{ij}^{*} + \gamma_x' X_{ij} + \gamma_p' P_{ij} + \gamma_h' H_{ij} + \gamma_v' V_j + \sigma_{ij},$$

in which i and j denoted household and village, respectively, Y_{ij}^{*}, SC_j, y_{ij}^{*}, X_{ij}, P_{ij}, H_{ij}, and V_j denoted the performance of WUAs, the quality of local government, a vector of water-related variables, as well as personal, household and village's characteristics, respectively. The error term $\sigma_{ij} : N\left[0, \sigma_2^2\right]$.

The determinants of each aspect of WUA's performance were analyzed by performing six OLS regressions. Social capital at the natural village level was included in model (1)-(3) and social capital at the administrative village level in model (4)-(6) to do robustness checks. Using different sets of controls, I examined whether social capital had different effects on different WUA outcomes, and whether the coefficients of key variables were stable.

County dummies were included for all regressions to capture regional differences, which were not covered by those independent variables. The standard errors reported in the regressions were all robust, and these clustered by the natural village in model (1)-(3) and by the administrative village in model (4)-(6).

5.2.1 The effects on water use

In this section, the determinants of the absolute value of the difference between reported and reference water use were analyzed by OLS regressions. The observations of water use were only about 1/3 of the total observations because most of the villagers did not know exactly how much irrigation water they consumed. The amount of water refers to the quantity running out of the water source before any leakages, evaporation, or conveyance losses. Three dummies indicating whether the household planted wheat, corn, and cash crops were also included.

In model (1)-(3), the coefficient of social capital and awareness were not significant, but the interaction term was negative and significant. This result implies that social capital contributes to less difference between actual and reference water use if the households are aware of the existence of WUAs. However, in (4)-(6), the coefficient of social capital was negative and significant in two of the three models. The results in Table 13 also suggest that the quality of local government did not have direct effect on the water difference between actual and reference water use.

Table 13. OLS regressions of water use

	(1)	(2)	(3)	(4)	(5)	(6)
Independent variable	Dependent variable: Absolute difference between actual and reference water use (m^3/mu)					
Awareness on the existence of WUA	-17.216 (34.695)	-4.803 (35.937)	-18.499 (38.445)	-27.484 (30.318)	-14.702 (31.035)	-27.312 (31.296)
Social capital at the natural village level	14.363 (22.193)	13.782 (22.530)	22.834 (20.869)			
Awareness*social capital at the natural village level	-59.087** (29.452)	-61.741** (29.847)	-70.216** (29.468)			
Social capital at the administrative village level				-38.764** (17.862)	-37.404** (17.898)	-18.797 (23.785)
Awareness*social capital at the administrative village level				-22.367 (28.436)	-28.543 (29.359)	-42.739 (31.666)
Quality of local government	7.390 (18.174)	6.841 (19.094)	3.095 (18.384)	6.359 (21.019)	3.823 (21.337)	-0.007 (20.828)
Ratio of surface water	21.524 (56.597)	24.597 (54.837)	59.364 (60.450)	13.383 (56.328)	11.460 (51.967)	52.094 (60.088)
Distance to water source	-17.347 (69.949)	5.101 (72.047)	61.668 (72.931)	-15.412 (75.492)	5.625 (81.798)	56.100 (83.491)
Frequency of weather shocks	2.873 (13.158)	3.187 (13.112)	5.549 (13.791)	9.502 (10.930)	10.31 (10.818)	10.96 (11.072)
Dummy of canal type	72.112* (42.343)	59.494 (43.532)	50.803 (43.400)	70.711 (43.124)	57.218 (43.408)	47.878 (41.707)
Personal controls	Yes	Yes	Yes	Yes	Yes	Yes
Household controls	No	Yes	Yes	No	Yes	Yes
Village controls	No	No	Yes	No	No	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes
Crop dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	244	238	238	244	238	238
Adjusted r-squared	0.175	0.144	0.165	0.178	0.146	0.156
Number of clusters	122	120	120	49	49	49

Notes:

(1) Standard errors are in parentheses.

(2) * p<0.1, ** p<0.05, *** p<0.01.

5.2.2 The effects on monitoring

In this section, the determinants of average labor contribution to maintenance were analyzed by OLS regressions. Table 14 shows that all the models were significant at 0.01, with adjusted R-squared ranging from 0.066 to 0.086. The measure of social capital at the natural village level had a significant positive effect with stable coefficients in the different models. However, the social capital at the administrative village level was not significant with small coefficients. Results of regressions also show that the quality of government had a strong impact on the monitoring. It was straightforward since some monitoring activities were organized by the government. A more responsible government tended to contribute more efforts to organizing various activities.

5.2.3 The effects on maintenance

In this section, the determinants of average maintenance efforts were analyzed by OLS regressions. The results in Table 15 show that the awareness about the WUA and the quality of local government had no significant effects on average maintenance efforts. The coefficients of social capital at the natural village level were significant in the first two models, but these were not significant in the models with the full set of controls.

Table 14. OLS regressions of monitoring

	(1)	(2)	(3)	(4)	(5)	(6)
Independent variable	Dependent Variable: Average Monitoring (*hours/labor*)					
Awareness on the existence of WUA	4.659*	4.879*	4.807*	5.049**	5.203**	5.143**
	(2.530)	(2.618)	(2.638)	(2.367)	(2.441)	(2.486)
Social capital at the natural village level	3.798***	3.652**	3.667**			
	(1.462)	(1.476)	(1.506)			
Awareness*social capital at the natural village level	-1.893	-2.130	-2.056			
	(2.375)	(2.390)	(2.408)			
Social capital at the administrative village level				0.440	0.295	0.349
				(1.148)	(1.100)	(1.091)
Awareness*social capital at the administrative village level				0.140	0.155	0.317
				(3.126)	(3.172)	(3.476)
Quality of local government	4.897***	4.902***	4.875***	4.913***	4.907***	4.863***
	(1.231)	(1.214)	(1.229)	(1.186)	(1.181)	(1.187)
Ratio of surface water	0.738	-0.798	-0.506	1.183	-0.233	0.040
	(3.111)	(3.423)	(3.531)	(2.324)	(2.446)	(2.686)
Distance to water source	-0.0756	-1.585	-1.039	-0.0333	-1.639	-1.244
	(2.878)	(2.880)	(3.064)	(2.649)	(2.697)	(3.005)
Frequency of weather shocks	1.134	1.147	1.220*	1.256	1.265	1.320
	(0.728)	(0.735)	(0.736)	(0.779)	(0.790)	(0.800)
Dummy of canal type	2.061	2.524	2.450	1.848	2.478	2.412
	(2.618)	(2.753)	(2.791)	(2.784)	(2.998)	(3.023)
Personal controls	Yes	Yes	Yes	Yes	Yes	Yes
Household controls	No	Yes	Yes	No	Yes	Yes
Village controls	No	No	Yes	No	No	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	656	644	644	656	644	644
Adjusted r-squared	0.081	0.086	0.080	0.066	0.072	0.067
Number of clusters	266	264	264	60	60	60

Notes:

(1) Standard errors are in parentheses.

(2) * p<0.1, ** p<0.05, *** p<0.01.

Table 15. OLS regressions of maintenance

Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Average maintenance contribution (*hours/labor*)					
Awareness on the existence of WUA	0.108	0.161	0.216	0.109	0.156	0.216
	(0.315)	(0.309)	(0.295)	(0.316)	(0.305)	(0.279)
Social capital at natural the village level	0.286*	0.271*	0.255			
	(0.156)	(0.159)	(0.158)			
Awareness*social capital at natural village level	-0.307	-0.322	-0.299			
	(0.208)	(0.206)	(0.204)			
Social capital at the administrative village level				-0.059	-0.046	-0.098
				(0.203)	(0.223)	(0.224)
Awareness*social capital at the administrative village level				0.116	0.107	0.129
				(0.232)	(0.234)	(0.239)
Quality of local government	-0.066	-0.075	-0.065	-0.090	-0.101	-0.088
	(0.182)	(0.190)	(0.187)	(0.209)	(0.218)	(0.210)
Ratio of surface water	0.723	0.493	0.305	0.784	0.554	0.368
	(0.563)	(0.562)	(0.609)	(0.502)	(0.552)	(0.602)
Distance to water source	1.281**	1.086*	0.671	1.264***	1.059**	0.618
	(0.590)	(0.605)	(0.507)	(0.434)	(0.459)	(0.392)
Frequency of weather shocks	0.144	0.145	0.121	0.154	0.153	0.132
	(0.173)	(0.175)	(0.192)	(0.158)	(0.160)	(0.168)
The dummy of canal type	0.566	0.594	0.604	0.563	0.602	0.618
	(0.449)	(0.486)	(0.485)	(0.453)	(0.506)	(0.495)
Personal controls	Yes	Yes	Yes	Yes	Yes	Yes
Household controls	No	Yes	Yes	No	Yes	Yes
Village controls	No	No	Yes	No	No	Yes
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	656	644	644	656	644	644
Adjusted r-squared	0.077	0.082	0.076	0.061	0.067	0.061
Number of clusters	266	264	264	60	60	60
F statistics	2.662	2.723	2.395	5.632	9.782	9.003
p-value	0.000	0.000	0.000	0.000	0.000	0.000

Notes:

(1) Standard errors are in parentheses.

(2) * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

5.2.4 The effects on paying water fees

In this section, the determinants of the proportion of villagers who have experienced delay in paying water fee were analyzed by OLS regressions.

The results in Table 16 show that all the models were significant at 0.01, with adjusted R-squared ranging from 0.108 to 0.130. If the villagers knew of the existence of WUA, higher social capital led to lower proportion of villagers having delayed payment of fees. The awareness on the existence of WUAs might have direct effect on reducing the proportion of villagers with delayed payment. However, the evidences are weak since the coefficients were not significant in model (3) and (6) although their signs were just as expected.

5.2.5 Effects on users' satisfaction

Tables 17 and 18 show that all the models on the satisfaction with water management organization and on the satisfaction with water distribution were significant at 0.01, with adjusted R-squared ranging from 0.215 to 0.228 and 0.132 to 0.148.

Both the awareness on the existence of WUA and quality of local government had significant effects on the degree of satisfaction. The coefficients of awareness on the existence of WUA and the quality of local government were positive and consistent in the six models. The coefficients of social capital at the natural village level were significant, positive and stable. However, the coefficients of social capital at the administrative village level were not significant though the signs were as expected.

Table 16. OLS regressions of payment of water fee

	(1)	(2)	(3)	(4)	(5)	(6)
Independent variable	Dependent variable: Percent of villagers delayed in paying water fee					
Awareness on the existence of WUA	-0.015**	-0.014*	-0.012	-0.016**	-0.014*	-0.013*
	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
Social capital at the natural village level	0.003	0.003	0.002			
	(0.006)	(0.006)	(0.006)			
Awareness*social capital at the natural village level	-0.015*	-0.016**	-0.016**			
	(0.008)	(0.008)	(0.008)			
Social capital at the administrative village level				-0.000	-0.000	-0.003
				(0.005)	(0.005)	(0.005)
Awareness*social capital at the administrative village level				-0.014**	-0.014**	-0.014*
				(0.007)	(0.007)	(0.007)
Quality of local government	0.004	0.004	0.005	0.004	0.003	0.005
	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)
Ratio of surface water	0.014	0.008	0.002	0.014	0.008	0.002
	(0.014)	(0.014)	(0.016)	(0.018)	(0.018)	(0.020)
Distance to water source	0.031***	0.029**	0.013	0.032***	0.030**	0.014
	(0.011)	(0.011)	(0.011)	(0.012)	(0.011)	(0.010)
Frequency of weather shocks	0.002	0.002	0.002	0.003	0.003	0.002
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.006)
Dummy of canal type	-0.001	-0.001	-0.000	0.000	0.001	0.001
	(0.010)	(0.011)	(0.010)	(0.013)	(0.013)	(0.013)
Personal controls	Yes	Yes	Yes	Yes	Yes	Yes
Household controls	No	Yes	Yes	No	Yes	Yes
Village controls	No	No	Yes	No	No	Yes
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	637	625	625	637	625	625
Adjusted r-squared	0.109	0.110	0.132	0.108	0.108	0.130
Number of clusters	267	265	265	60	60	60

Notes:

(1) Standard errors are in parentheses.

(2) * p<0.1, ** p<0.05, *** p<0.01.

Table 17. OLS regressions of satisfaction with water management organization

	(1)	(2)	(3)	(4)	(5)	(6)
Independent variable	Dependent variable: Satisfaction with water management organization					
Awareness on the existence of WUA	0.298**	0.322***	0.332***	0.284**	0.310**	0.313**
	(0.116)	(0.119)	(0.118)	(0.130)	(0.137)	(0.137)
Social capital at the natural village level	0.177*	0.177*	0.192*			
	(0.096)	(0.097)	(0.098)			
Awareness*social capital at the natural village level	0.048	0.044	0.021			
	(0.117)	(0.121)	(0.122)			
Social capital at the administrative village level				0.086	0.088	0.102
				(0.109)	(0.109)	(0.119)
Awareness*social capital at the administrative village level				0.139	0.137	0.113
				(0.137)	(0.143)	(0.148)
Quality of local government	0.351***	0.344***	0.353***	0.372***	0.366***	0.374***
	(0.071)	(0.072)	(0.071)	(0.071)	(0.072)	(0.071)
Ratio of surface water	-0.105	-0.101	-0.156	-0.094	-0.074	-0.114
	(0.160)	(0.168)	(0.176)	(0.167)	(0.162)	(0.164)
Distance to water source	-0.284*	-0.261	-0.334*	-0.303*	-0.287*	-0.333**
	(0.157)	(0.161)	(0.170)	(0.167)	(0.170)	(0.165)
Frequency of weather shocks	-0.001	-0.001	-0.013	-0.007	-0.008	-0.015
	(0.036)	(0.036)	(0.039)	(0.041)	(0.042)	(0.043)
Dummy of canal type	0.374***	0.310**	0.315**	0.334**	0.270*	0.270*
	(0.142)	(0.142)	(0.145)	(0.147)	(0.147)	(0.153)
Personal controls	Yes	Yes	Yes	Yes	Yes	Yes
Household controls	No	Yes	Yes	No	Yes	Yes
Village controls	No	No	Yes	No	No	Yes
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	497	486	486	497	486	486
Adjusted r-squared	0.229	0.227	0.228	0.218	0.216	0.215
Number of clusters	218	216	216	57	57	57

Notes:

(1) Standard errors are in parentheses.

(2) * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Table 18. OLS regressions of satisfaction with water distribution

	(1)	(2)	(3)	(4)	(5)	(6)
Independent variable	Dependent Variable: Satisfaction with water distribution					
Awareness on the existence of WUA	0.208** (0.0994)	0.225** (0.101)	0.223** (0.102)	0.217* (0.115)	0.236** (0.114)	0.232** (0.116)
Social capital at the natural village level	0.129* (0.0700)	0.139* (0.0708)	0.137* (0.0700)			
Awareness * social capital at the natural village level	0.108 (0.106)	0.108 (0.104)	0.103 (0.103)			
Social capital at the administrative village level				0.112 (0.0679)	0.124* (0.0711)	0.121 (0.0725)
Awareness * social capital at the administrative village level				0.169 (0.109)	0.152 (0.109)	0.147 (0.112)
Quality of local government	0.196*** (0.0619)	0.201*** (0.0628)	0.199*** (0.0628)	0.197*** (0.0576)	0.205*** (0.0581)	0.203*** (0.0587)
Ratio of surface water	-0.377** (0.162)	-0.359** (0.173)	-0.357** (0.178)	-0.381** (0.151)	-0.358** (0.151)	-0.344** (0.160)
The distance to water source	-0.642*** (0.156)	-0.560*** (0.160)	-0.561*** (0.181)	-0.657*** (0.121)	-0.582*** (0.132)	-0.563*** (0.122)
The frequency of weather shocks	-0.0254 (0.0369)	-0.0231 (0.0366)	-0.0255 (0.0379)	-0.0346 (0.0362)	-0.0324 (0.0367)	-0.0310 (0.0365)
The dummy of canal type	0.268** (0.114)	0.235** (0.117)	0.244** (0.118)	0.229** (0.110)	0.198* (0.114)	0.203* (0.117)
Personal controls	Yes	Yes	Yes	Yes	Yes	Yes
Household controls	No	Yes	Yes	No	Yes	Yes
Village controls	No	No	Yes	No	No	Yes
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	685	673	673	685	673	673
Adjusted r-squared	0.137	0.141	0.138	0.133	0.135	0.132
Number of clusters	273	271	271	60	60	60

Notes:

(1) Standard errors are in parentheses.

(2) * p<0.1, ** p<0.05, *** p<0.01.

6.0 CONCLUSION

Why is it important to examine the performance of WUAs in China? Shortage in irrigation water is becoming more serious in rural China. Governments are trying to build more WUAs to better manage irrigation water. Better management would reduce the agricultural use of water so more could be allocated to protect the environment. This is important, especially in arid and semi-arid areas where the ecological environment is very fragile.

Therefore, it is important to know how WUAs have been organized and whether they have had contributions to water management. If the policy proves to be of no use, the government needs to find out the reasons why, and find solutions to these problems or resort to other more effective policies. Any delay would result to more serious implications. For example, the Minqin Oasis in the downstream of Shiyang River, which is almost surrounded by two deserts, is going to become a desert soon without increased water supply. However, there is not enough water to allocate to it because of the large demand for water in the river's upstream. In short, improvement in the management of irrigation water is not only important for water users, but also for the environment under risk. Specifically, this report had three contributions.

First, the report shows that there was poor implementation of WUA reform in China as indicated by many villagers who did not even know about the existence of WUAs. It appears that water users were not directly involved in managing the water resources. Ostrom (1990) had shown that entitling users the rights to manage the resources is vital to the success of community governance of common pool resources.

Second, the report shows that the quality of local government was the main determinant of users' awareness on the existence of WUAs. This implies that a more responsible government is needed to contribute more efforts in implementing the reform or/and in transferring power to users. Moreover, the awareness of users on the WUAs and the quality of government both had positive effects on the performance of WUAs. These combined facts suggest that a more responsible local government not only has a direct positive contribution to the performance of WUAs but that it also affects the WUAs' performance through enhanced awareness of users. This brings an important policy-relevant question: how do we increase the awareness of water users?

Assembling villagers together and introducing them to the WUAs seems to be a simple task for village leaders without incurring large costs. However, government officials have not been doing it. The problem seems to boil down to how to give them incentives, or how to select more responsible government officials. Some literature on the grassroots democracy in China, such that of Shen and Yao (2008), shows empirical evidence that election leads to better local government performance.

Third, the coefficients of social capital and/or that of the interaction terms of social capital and the awareness were significant in many models on the performance of

WUAs and on the satisfaction of water users. The results suggest that social capital could affect the performance of WUAs. Considering also that the coefficients of trust aggregated at the administrative village level were not significant in all the models, we can conclude that only the trust in the densely-connected community could be useful for community management. This result suggests that defining the boundary of common pool resources at the natural village level is very important for social capital to be effective.

The research faced some challenges. First, the unavailability of the exact amount of households' water use because of the lack of meters made the estimation of efficient water use impossible. Second, the reasons why the local government did not introduce WUAs to villagers need to be carefully studied. The possibilities include officials having no incentives to transfer the power of water management to users, or they believing that WUAs were not useful. Third, the identification of social capital remains a challenge, particularly in finding good measures for social capital.

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