Social Capital, Local Government and Water User Associations

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Summary

This paper conducts an analysis of the underlying factors affecting the performance of water user associations (WUAs) in rural China. This paper first shows that there is a poor implementation of the standard structure of WUAs, using users' awareness of the existence of WUAs as an indicator. This paper then shows that a more responsible local government not only has direct positive contribution to the performance of WUAs but also affects performance through increasing the users' awareness about WUAs. Moreover, social capital has impact on some indicators of the performance of WUAs.

Keywords: Social Capital; Trust; Water User Associations; Local Government; Asia; China

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1. Introduction

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 invested a lot in infrastructure to develop new water resources and spent a lot of efforts in promoting water-saving technologies (Wang 2000). However, this huge investment has not proven to be as effective as expected and most of these sophisticated water-saving technologies have proven to be unsuccessful (Lohmar *et al*. 2003).

In response to these systemic failures, China's government began to implement water management reform based on this international experience since the 1990s. 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, Madrigal *et al*. 2011). Besides contracting canal networks to individuals, the formation of Water User Associations (WUAs) is one method of water management appreciated by irrigation ministries. 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 WUAs is that the latter's members can make decisions without being challenged by external government authorities. Ostrom (1990) present many cases where resource users have been able to manage the common pool resources well.

There are over 20, 000 WUAs having been formed in over thirty provincial-level administrative units in 2006 as documented by the Ministry of Water Resources of China. WUAs are generally organized at three levels in practice: 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 not been good as expected. An important factor that accounts for 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 of 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 existed. 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. More responsible local government officials are more likely to introduce WUAs. I test this prediction by regressing the awareness of WUAs by a measure of perceived quality of local government.

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 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). Isham and Kähkönen (1999) showed that in most cases, a set of eight social capital indicators is 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 is good for cooperation in small irrigation systems in Mexico. However, it is not clear that whether social capital has impact on the performance of these non-formal WUAs. Even though WUAs at

administrative village level are still managed by those former or current local government officials, WUAs at natural village level are managed by leaders elected by water users. Those users thus have some influence on water management, and social capital might have some impacts.

This paper shows that the quality of local government has a big effect on villagers' perceptions of WUAs, while social capital has no effect. The better the quality of the local government, the more aware local villagers are of WUAs and the greater their satisfaction with water distribution. Overall, it is the quality of local government is the main determinant of users' awareness of the existence of WUAs. Moreover, the quality of local government has a direct positive effect on the performance of WUAs. For example, the quality of local government has a strong impact on the amount of time spent monitoring water distribution. This is a relatively straightforward relationship, since the government directly organizes some monitoring activities in many villages. These combined findings suggest that a more responsible local government not only makes a direct, positive contribution to the performance of WUAs, but that it also affects performance by increasing awareness among community members. These combined facts suggest that responsible local government can make a significant positive contribution to the performance of WUAs.

The impact of social capital on the performance of WUA is less clear-cut. Social capital only has direct impact on some outcome indicators, such as monitoring efforts,

satisfaction with WUAs and satisfaction with water distribution. However, social capital is associated with lower proportion of villagers delaying the payment of fees only if villagers know of the existence of a WUA. Moreover, only the social capital that exists in densely-connected communities has a significant effect on community management. This result suggests that defining the boundary of common pool resources at the natural village level will be a very important step to maximize the impact of social capital.

The rest of paper is organized as follows. Section 2 provides the descriptive statistics of the data, and the method of constructing the indicator of social capital and the perceived quality of local government. Section 3 estimates the effect of social capital and perceived quality of local government on the performance of WUAs. Section 4 draws conclusions.

2. Data and Descriptive Statistics

2.1. Background

The field work for this research is conducted in the three river basins in Gansu province in Northwest China as shown in Figure 1 and 2. The three rivers are the Yellow, Shiyang, and Heihe; the latter two are inner continental rivers. In most regions, irrigation technology is still the traditional flood irrigation. Both surface water and underground water are used in a lot of areas. 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.

[Figure 1 and 2 about here]

Gansu province is one of the first provinces transforming the traditional management scheme to WUAs. The province began to implement the reform on water management since 2001 to combat the shortage of water. News or government reports show that the reform has achieved significant success. As of 2009, the province is one of the less developed provinces in the 31 provinces of China. With an annual GDP per capita in 2009 of 12,882 Chinese Yuan (approximately 1,886 US Dollars with an exchange rate of 6.83:1), it ranked 30th among the 31 province-level regions in mainland China.

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 towards WUAs are distributed along the main rivers in Gansu province. There are four major rivers in the province located from South-East to North-West, namely: Yellow, Shiyang, Heihe, and Shule. The Shule River Basin is not covered because the agricultural population is lower than the other sites. Further, the population density is only two people per square kilometer, which make sampling difficult.

In the rest three river basins, the following sampling procedures is employed: First, I randomly selected three counties along the Yellow and Heihe River and two counties along the Shiyang River. The counties are located from the upstream to the downstream of the three rivers, respectively. 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.

2.2. The data

In the survey, there are 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 is roughly proportional with the agricultural population in WUAs.

Social capital is 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 my children when we are away; 3) In the future, I will still lend farming tools to villagers even though I have 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 are five levels of responses to the statements, in which 1 stood for "strongly disagree" while 5 stood for "strongly agree".

Trust measures are aggregated by "natural village" and "administrative village" to generate two levels of community-level social capital. Note that trust at the administrative village does not measure how respondents trusted people in other natural villages of the same administrative village; instead, it is just the aggregate value of how people trusted villagers in the same natural village at a broader region. Since the five measures of trust at both the natural and administrative village levels are highly correlated with positive coefficients, I used factor analysis to generate some factors of trust to reduce the dimension of trust measures. Only the first eigenvalue is greater than 1 for both cases, I thus kept the first factor to stand for the social capital at the natural village and at the administrative village level, respectively.

To evaluate the impact of local government on the performance of WUAs, I constructed a measure of the quality of local government since there are rarely other inputs than the efforts of government officials in building and managing WUAs. Three questions on the duties of government officials that are not about water affairs are 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 are asked this way: “In what degree do you agree with the following three statements on leaders’ performance?” There are five levels of responses, in which 1 stood for “strongly disagree” and 5 stood for “strongly agree”. Factor analysis is conducted create a comprehensive measure of the quality of local government. The first principle factor is used as the measure of the quality of local government since only its eigenvalue is greater than one. Table 1 shows the descriptive statistics of trust and quality of local government.

[Table 1 about here]

The WUA in the research area operated basically as a small variation of the traditional management scheme. Majority (68.8%) of the villagers in the survey are not aware of the existence of the WUAs even though the WUAs are already nominally formed. Because of this large proportion of villagers who do not know about the WUAs, I use the households’ awareness of their WUA as the indicator for the households’ participation. If households are aware of the existence of WUAs, they are expected to influence the management of the WUAs through the election of the leaders of the natural village, who are also the heads of the WUAs.

I use four indicators to measure the performance of the WUAs. These are two objective measures including time spent on monitoring water distribution in 2007

(*hours/labor*) and the proportion of villagers who are delayed in paying water fees reported by respondents. Since the households tended to contribute less on monitoring efforts because of the free-riding incentive in the collective action, more contribution implies more cooperation among members. There are 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 2 shows the descriptive statistics of those outcome variables.

[Table 2 about here]

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 sublaterals, 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 is normalized to zero if villagers only used groundwater. The distance to surface water source is used if the villagers used both surface and underground water for irrigation. The

proportion of surface water is the ratio of surface water over total water used in 2007 as estimated by the respondents. The conditions of sublaterals are 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 sublaterals directly connected with farmers’ lands because almost all the main or sub-branch canals are lined in the research areas. The villagers’ knowledge on new irrigation technologies is measured by the number of listed new irrigation technologies that they have heard about.

Demographic and geographic variables including characteristics of the respondents, of households, and of villages, are also controlled in the cross-sectional regressions. Personal controls included age, year of education, dummy of marital status (*married*), dummy indicating whether respondent is 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 do not use the household’s current income as one control variable. Instead, the value of houses which is less likely affected by the very recent WUA performance through income is 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. 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 3 shows the descriptive statistics of control variables.

[Table 3 about here]

3. Empirical Results

3.1 Users' Awareness of the Existence of WUAs

In the research areas many villagers does not know the existence of WUAs, thus their direct involvement in the management of the WUAs is limited. Awareness of the existence of WUAs is used as an indicator for the villagers' influence on WUA management. Awareness is important because if the villagers do not know of the WUAs, they would have few chance of influencing water management. Nevertheless, it must be admitted that knowing the existence of the WUAs might 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 is expected to have a significant impact on the villagers' awareness. This is because the first step in implementing the reform on water management is for them to introduce the WUAs to the villagers. If the local government officials are not responsible, or if they do not take villagers' interests seriously, they are expected to spend less effort 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:

$$y_{ij}^{*} = \beta_0 + \beta_1 G_j + \beta_2 SC_j + \beta_x' X_{ij} + \beta_p' P_{ij} + \beta_h' H_{ij} + \beta_v' V_j + \varepsilon_{ij},$$
$$Y_{ij} = \begin{cases} 1 & if \ y_{ij}^{*} > 0 \\ 0 & if \ y_{ij}^{*} \le 0, \end{cases} \quad (1)$$

in which i and j denote household and village, respectively, and Y_{ij}, G_j, SC_j, X_{ij}, P_{ij}, H_{ij}, and V_j denote the dummy variable indicating whether the household is 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. $Y_{ij} = 1$ means awareness. The error term $\varepsilon_{ij} \sim N\left[0, \sigma_1^2\right]$.

Table 4 reports the logistic estimation with different set of controls. I used social capital at the natural village level in column (1)-(3) and social capital at the administrative village level in column (4)-(6). I control personal characteristics in column (1) and (4), personal and household characteristics in column (2) and (5), as well as personal, household, and village characteristics in column (3) and (6). County dummies are included for all regressions to capture regional differences which are not covered by those independent variables. The standard errors reported in the regressions are all robust and clustered by the natural village in column (1)-(3), and clustered by the administrative village in column (4)-(6). I only report the quality of local government, social capital, and some water-related variables in Table 4 to save space.

The coefficients of the quality of local government are all positive and significant at 1% significance level. Moreover, the coefficients are fairly stable across models. These results confirmed the conjecture that local government played important roles in determining the households' awareness of WUAs. Better quality is associated with higher awareness. The coefficients of social capital are positive but not significant, which suggest that social capital has no significant effect on the household members' awareness of the existence of WUAs. Water users are not able to know of the existence without being introduced by local government, even with high social capital in the community. The results on the coefficients of quality of local government and social capital combined validate the effectiveness of the two measures.

[Table 4 about here]

The regression results also show that the ratio of surface water used has significantly positive effects on the awareness. One possible explanation is that broader cooperation and coordination is needed to resolve the conflicts during canal maintenance and water allocation when water users reply more heavily on surface water. Therefore the local government is more willing to transfer the power the water users to avoid the costs of management. Another significant variable is the frequency of weather shocks. More frequent weather shocks often leads to not enough water available for users, hence more difficulties in finding water for users and more conflicts in water allocation.

3.2 Performance of WUAs

In this section, OLS regressions are conducted to estimate the effects of social capital and quality of local government on the performance of WUAs. The villagers' awareness of WUAs is also included as an explanatory variable. If the villagers are aware of the WUAs' existence, they tend to have more incentives to involve in the management of WUAs. Moreover, the interaction term of awareness and social capital is also included to examine if social capital is more effective when villagers are aware of the existence of WUAs. The OLS model has the following form:

$$Y_{ij}^{*} = \gamma_0 + \gamma_1 SC_j + \gamma_2 y_{ij}^{*} + \gamma_3 SC_j * y_{ij}^{*} + \gamma_x' X_{ij} + \gamma_p' P_{ij} + \gamma_h' H_{ij} + \gamma_v' V_j + \sigma_{ij}, \quad (2)$$

in which i and j denoted household and village, respectively, and Y_{ij}^{*}, SC_j, y_{ij}^{*}, X_{ij}, P_{ij}, H_{ij}, and V_j denote 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 $\sigma_{ij} \sim N\left[0, \sigma_2^2\right]$.

Four indicators of WUA's performance, monitoring hours per household labor, perceived proportion of villagers delayed payment of water fees, the satisfaction with WUAs and the satisfaction with water distribution, are analyzed in models with all the independent variables. Table 5 reports the regression results for objective measures including monitoring hours per household labor and perceived proportion of villagers delayed payment of water fees. Social capital at the natural village level is included in column (1) and (3) and social capital at the administrative village level in column (2) and (4). County dummies are included in all the models to capture regional differences which

are not covered by those independent variables. The standard errors reported in the regressions are all robust, and clustered by the natural village in column (1) and (3) and by the administrative village in column (2) and (4).

[Table 5 about here]

Column (1) and (2) presents the results for monitoring hours per household labor. The measure of social capital at the natural village level has a positive effect, however, the social capital at the administrative village level is not significant with a much smaller coefficient. The results are consistent with the fact that monitoring activities are generally organized at the natural-village level. The quality of government and awareness of the existence of WUAs both have positive impacts on the monitoring efforts. These results are straightforward since some monitoring activities are organized by the local government officials, and more responsible government tended to contribute more efforts to organizing the activities. Water users are also more likely to contribute to monitoring when they know the WUAs.

Column (3) and (4) report the results for the perceived proportion of villagers delayed payment of water fees. The regressions show that social capital has no direct impact on the perceived proportion of villagers delaying payment of water fees. If the villagers know of the existence of WUA, higher social capital is associated with lower proportion of villagers delaying payment of water fees. The awareness of the existence of WUAs also has direct effect on reducing the proportion of villagers with delayed

payment. However, the evidences are weak since the coefficients are not significant at 5% significance level in model (3) and (4) although their signs are just as expected.

Table 6 reports the regression results for objective measures including the satisfaction with WUAs and on the satisfaction with water distribution. Column (1) and (2) presents the results for the satisfaction with water distribution and column (3) and (4) the results for the satisfaction with water distribution. Social capital at the natural village level is included in model (1) and (3) and social capital at the administrative village level in model (2) and (4). County dummies are included in all the models to capture regional differences which are not covered by those independent variables. The standard errors reported in the regressions are all robust, and clustered by the natural village in model (1) and (3) and by the administrative village in model (2) and (4).

[Table 6 about here]

Table 6 shows that both the awareness of the existence of WUA and the quality of local government has significant and positive effects on the degree of satisfaction with WUAs and water distribution. The coefficients of social capital at the natural village level are also significant and positive. However, the coefficients of social capital at the administrative village level are not significant though the signs are as expected. The interaction between social capital and awareness is not significant in all models. The regression results suggest that the quality of local government and users' awareness play important roles in determining users' satisfaction, while social capital has little impacts.

The results in Table 5 and 6 combined show that social capital at the natural village level has impact on the performance of WUAs and on the satisfaction of water users in some cases. However, social capital at the administrative village level is not significant in all the models. These results might suggest that only social capital in the densely-connected community can be useful for community management.

4. 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 the irrigation water. Better management would reduce the agricultural use of water and allocate more water to protect the environment. This is especially in arid and semi-arid areas where the ecological environment is very fragile.

Therefore, it is important to know how WUAs are actually organized and whether they have contributions to water management. If the policy proved to be of no use, the government needed to find out the reasons, and then to fix those problems or change to some other 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 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 paper have three contributions.

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

Second, this paper shows that the quality of local government is the main determinant of users' awareness of the existence of WUAs. This result implies that a more responsible government is needed to contribute more efforts in implementing the reform or/and to transfer power to users. Moreover, the awareness of users on the WUAs and the quality of government both have positive effects on the performance of WUAs. These two facts together suggest that a more responsible local government not only has direct positive contribution to the performance of WUAs but that it also affects performance through the users' awareness about WUAs. This brings an important policy-relevant question, i.e., how do we increase the awareness?

Actually, assembling villagers together and introducing them to the WUAs is a simple task for village leaders without incurring large costs. However, government officials are not doing it. The problem, it seemed, came 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 are significant in some 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 in some cases. Combining with the results that the coefficients of social capital at the administrative village level are not significant in all the models, we might conclude that only social capital in the densely-connected community could be useful for community management. Therefore, defining the boundary of water user associations at the natural village level is very important for social capital to be effective.

Despite the research's contributions, there are still inadequacies. 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 believing that WUAs are not useful. Third, the potential endogeneity of social capital and quality of local government is not handled.

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Figure 1: Gansu Province in China

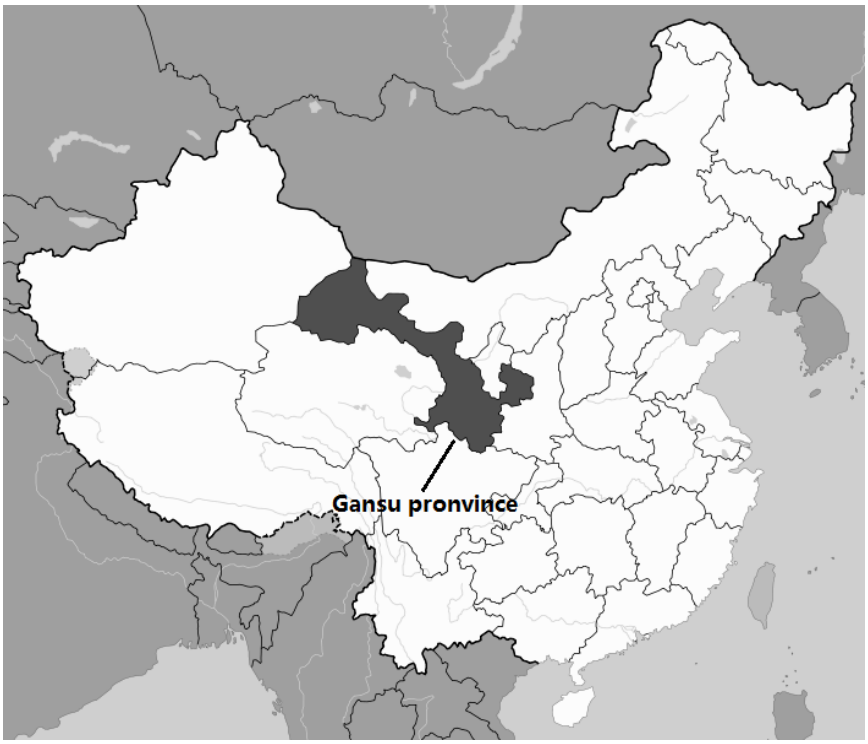

Figure 2. The map of research areas in Gansu province

Table 1. Descriptive statistics of trust and quality of local government

Variable	Obs	Mean	Std. Dev.	Min	Max
Trust at Individual level					
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
Perceived quality of local government					
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

Table 2. Descriptive statistics of outcomes

Variable	Obs	Mean	Std. Dev.	Min	Max
Awareness of the existence of WUAs	690	0.312	0.463	0	1
Time spent on monitoring water distribution (*hours/labor*)	660	10.027	21.557	0	183
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

Table 3. Descriptive statistics of independent 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
Lined sublaterals	690	0.249	0.433	0	1
Villagers' knowledge on new irrigation technologies	690	1.498	1.167	0	3
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	409.1
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	.1	5
Average distance to the nearest neighbor resided in the same natural village (*km*)	690	0.017	0.077	0	1
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

Table 4. Logistic regressions of households' awareness of the existence of WUA

	(1)	(2)	(3)	(4)	(5)	(6)
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 the natural village level	0.199	0.199	0.201			
	(0.150)	(0.153)	(0.153)			
Social capital at the 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)
Lined sublaterals	-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 obs.	686	674	674	686	674	674
Pseudo 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.

Table 5. OLS regression results for objective outcome measures

	(1)	(2)	(3)	(4)
	Monitoring		Delay of paying fees	
Awareness of the existence of WUA	4.807*	5.143**	-0.012	-0.013*
	(2.638)	(2.486)	(0.008)	(0.007)
Social capital at the natural village level	3.667**		0.002	
	(1.506)		(0.006)	
Awareness*social capital at the natural village level	-2.056		-0.016**	
	(2.408)		(0.008)	
Social capital at the administrative village level		0.349		-0.003
		(1.091)		(0.005)
Awareness*social capital at the administrative village level		0.317		-0.014**
		(3.476)		(0.007)
Quality of local government	4.875***	4.863***	0.005	0.005
	(1.229)	(1.187)	(0.005)	(0.004)
Ratio of surface water	-0.506	0.040	0.002	0.002
	(3.531)	(2.686)	(0.016)	(0.020)
Distance to water source	-1.039	-1.244	0.013	0.014
	(3.064)	(3.005)	(0.011)	(0.010)
Frequency of weather shocks	1.220*	1.320	0.002	0.002
	(0.736)	(0.800)	(0.005)	(0.006)
Lined sublaterals	2.450	2.412	-0.000	0.001
	(2.791)	(3.023)	(0.010)	(0.013)
Personal controls	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes
Village controls	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Number of obs.	644	644	625	625
Adjusted r-squared	0.080	0.067	0.132	0.130
Number of clusters	264	60	265	60

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

Table 6. OLS regression results for subjective outcome measures

	(1)	(2)	(3)	(4)
	Satisfaction with WUAs		Satisfaction with water distribution	
Awareness of the existence of WUA	0.332***	0.313**	0.223**	0.232**
	(0.118)	(0.137)	(0.102)	(0.116)
Social capital at the natural village level	0.192*		0.137*	
	(0.098)		(0.070)	
Awareness*social capital at the natural village level	0.021		0.103	
	(0.122)		(0.103)	
Social capital at the administrative village level		0.102		0.121
		(0.119)		(0.073)
Awareness*social capital at the administrative village level		0.113		0.147
		(0.148)		(0.112)
Quality of local government	0.353***	0.374***	0.199***	0.203***
	(0.071)	(0.071)	(0.063)	(0.059)
Ratio of surface water	-0.156	-0.114	-0.357**	-0.344**
	(0.176)	(0.164)	(0.178)	(0.160)
Distance to water source	-0.334*	-0.333**	-0.561***	-0.563***
	(0.170)	(0.165)	(0.181)	(0.122)
Frequency of weather shocks	-0.013	-0.015	-0.026	-0.031
	(0.039)	(0.043)	(0.038)	(0.037)
Lined sublaterals	0.315**	0.270*	0.244**	0.203*
	(0.145)	(0.153)	(0.118)	(0.117)
Personal controls	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes
Village controls	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Number of obs.	486	486	673	673
Adjusted R-squared	0.228	0.215	0.138	0.132
Number of clusters	216	57	271	60

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