Araral, E.K. 2011. The impact of decentralization on large scale irrigation? Evidence from the Philippines. Water Alternatives 4(2): 110-123

The Impact of Decentralization on Large Scale Irrigation: Evidence from the Philippines

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ABSTRACT: Decentralization has often been prescribed as an institutional panacea for a wide range of problems facing developing countries. This study investigates the impacts of decentralization on the ability of individuals to solve collective action problems in a large-scale common pool resource. Using econometric analyses of a data set from the largest (83,000 hectares [ha]) irrigation system in the Philippines, the study finds that decentralized subsystems are more likely to solve collective action problems such as free-riding, conflict resolution and rule enforcement. These findings are consistent with the theoretical and empirical literature but they highlight the importance of credible enforcement. These preliminary findings offer insights for the design of institutions for collective action in situations of large-scale collective action.

KEYWORDS: Decentralization, commons, large-scale irrigation, Philippines, collective action

INTRODUCTION

Decentralization has often been prescribed as an institutional panacea for a wide range of problems facing developing countries (Ostrom, 2001). From the 1980s to the mid-1990s, national governments in 63 out of 75 developing and transitional economies have embarked on some form of decentralization (Agrawal and Ribot, 1999). In natural resource management, donors often prescribe decentralization as a key feature of institutional reform. This has been the case in the management of forests, watersheds, coastal and marine resources, irrigation and protected areas (World Bank, 2008).

The key premise behind decentralization in natural resources management is that resource users will act collectively to advance their interests when given control of decisions and resources. As a result, proponents suggest, outcomes are likely to be more effective, efficient, sustainable and equitable compared with centralized arrangements (World Bank, 2008).

There appears to be a consensus in the literature that, in general, decentralization to communities of resource rights in forestry, irrigation and wildlife has positive effects on resource management. For instance, in a meta-analysis of the literature, Shyamsundar et al. (2005) find that increased local control motivates local interest in long-term investments, creates space for local decision-making and can increase accountability and management performance. They also conclude that devolution has ambiguous effects on poverty. On the one hand, it provides opportunities for better private incomes, access to public goods and control of resources but, on the other, devolution can also lead to higher costs. Furthermore, they find that devolution leads to a reduction in the fiscal burden on national governments particularly in the case of irrigation.

Other scholars, for example, Ostrom and Agrawal (2001), point to several key limitations of most efforts at decentralization of natural resources management: the limited scope of property rights, the uncertainty of those rights, and the nature of governance arrangements to protect those rights. They assert that many decentralization proposals are limited to the assignment of operational rights for authorised users to withdraw resource units and that significant operational rights continue to be held by government agencies including collective and constitutional choice rights. They argue that without these rights there is little incentive for sustainable management among resource users.

This paper investigates the effects of decentralization in large-scale irrigation using econometric analyses on a data set of 362 irrigation associations (IAs) from a large-scale system in the Philippines. Most of the field studies on irrigation decentralization focused on small-scale, farmer-managed irrigation systems. Studies on large-scale systems, however, are usually single case studies and thus have weak statistical power, for example Johnson (1995), Bagadion (1994), Eleazar et al. (2005), Wilder and Lankao (2006) and Uphoff (1992).

The next section is a review of the literature on decentralization in irrigation in general and in the Philippines in particular. This is followed by three sections the first, on the hypotheses, data and methodology, the second on findings and discussion, and the last on a conclusion.

DECENTRALIZATION IN IRRIGATION

The rationale for decentralization in irrigation – also referred to here as irrigation management transfer (IMT) – has been summed up by Vermillion (1997) as follows: first, government bureaucracies lack the incentives and responsiveness to optimize management performance while farmers have a direct interest in enhancing and sustaining the quality and cost efficiency of irrigation management. When farmers are given the authority and incentives to act collectively, they are more likely to improve irrigation operations because it is in their direct interest to do so. Second, when IMT occurs in a supportive socio-technical context, improved quality and cost efficiency of irrigation management will occur. Third, pressures to pursue IMT primarily stem from fiscal problems faced by national governments. IMT is one way to cut the recurring costs of irrigation operation and maintenance (O&M) for government.

In practice, the most common reasons given for adopting IMT programs are as follows (see Vermillion, 2005): 1) to empower water users to govern irrigation systems, 2) to reduce the cost of irrigation to the government, 3) to provide better water services, system maintenance and fewer water disputes, 4) to increase the productivity and profitability of water, and 5) to encourage other cooperative efforts in provision of agricultural inputs, agribusiness and marketing.

Farmer-managed vs. government-managed irrigation systems

Vermillion's hypothesis on the incentives faced by government bureaucracies is also empirically supported by Lam (1998) who unambiguously finds, in the case of Nepal, that farmer-managed systems consistently outperform government-managed systems. Lam argues that the basis for high levels of performance includes a high degree of mutual trust, active participation in the crafting and monitoring of rules, and a high level of rule conformance. More recent studies by Wilder and Lankao (2005) suggest that, in the case of two irrigation districts in Mexico, IMT promoted more participation but did not result in greater equity, efficiency or sustainability of water use.

Models of decentralization in irrigation and impacts

Just as there are various types of decentralization, e.g. political, administrative, and fiscal decentralization, so are there assorted models of decentralization in irrigation. These models vary in terms of their focus, scale, the responsible management units, and the scope of functions and property rights transferred to farmers.

Vermillion (2005) notes that the powers and functions that are increasingly devolved to IAs after IMT include, in varying degrees, the authorities to make decisions on: (1) rules and sanctions, with the maximum sanction of stopping water available to the IAs; (2) O&M plan and budgets; (3) water charges; (4) hiring or releasing management staff; (5) control over intake; (6) control over main canal system; (7)

control over subsidiary canal system; (8) responsibility for future rehabilitation; (9) canal rights-of-way; (10) right to contract and raise funds; and (11) right to make profits.

Vermillion further notes that the most significant and widespread issues for implementation of IMT were as follows: (1) deteriorated infrastructure needs to be rehabilitated or farmers may not be willing to take over responsibility for managing and financing the system after IMT; (2) training for both farmers and agency staff is frequently very inadequate; (3) shortage of funds for IMT (for training, organizing, rehabilitation, etc); (4) IMT is often resisted by irrigation agencies, but also sometimes by farmers; (5) given the many issues and different interests of stakeholders, more attention needs to be given to awareness and negotiation; and (6) farmers are concerned with IMT within their more basic need to improve the economic productivity of irrigated agriculture, so attention must be given to demand-driven agricultural extension, agribusiness and marketing.

Based on a meta-analysis of the literature, Araral (2005) summarizes the impacts of IMT as follows. First, IMT can contribute to poverty reduction if: (1) head-tail distribution improves; (2) the effects of any increases in water costs are overcome by improvements in efficiency or water availability; and (3) it leads to increased productivity as a result of expansion of cropping area, an increase in cropping intensities, and crop diversification. Second, IMT could contribute to improved irrigation operations, but maintenance remains a serious problem particularly for high-cost systems. Improved O&M are more likely when IMT is most progressive, i.e. when ownership is transferred to farmers and when the economic value of irrigated farming is high. Third, in larger systems, IMT is more likely to be successful when governing boards are farmer-elected, management consists of professional cadres, and legal systems can handle increasing scales of complexity. Finally, IMT can also contribute to conservation of water resources when (1) water rights and water service objectives are clear and secure; (2) water is priced as an economic good; (3) consumption is adequately monitored at the farm and basin level (e.g. use of volumetric pricing and water accounting); (4) water conserving technologies are practiced; and (5) IMT is most progressive.

However, Giordano et al. (2006) argue that straightforward IMT is unlikely to work in the case of smallholder developing countries even when the supposed preconditions for success are met including supportive legal-policy framework, secure property rights, local management, capacity building, and an enabling process to facilitate management transfer. They argue that success is more likely under large-scale and high-value crop farming than in small-scale agriculture involving thousands of impoverished farmers. Critics also point out that generally, governments have been pursuing decentralization to reduce the recurring costs of irrigation and to shift these costs to farmers (Vermillion, 1997, 2005).

Decentralization in irrigation in the Philippines

Since the 1970s, at least 25 developing countries have embarked on policy reforms to decentralize the O&M of large-scale public irrigation systems (Vermillion, 1997). The Philippines is one of the countries that pioneered in these efforts and its experience raises an interesting puzzle. In the mid-1970s, the National Irrigation Administration (NIA) of the Philippines – the government agency responsible for irrigation – launched a pioneering programme to gradually decentralize the construction and O&M of small and large-scale public irrigation systems. Numerous independent studies have earlier shown that NIA's model – known as the Participatory Irrigation Management (PIM) Program – has led to consistently positive results in irrigation as evaluated in the 1980s and early 1990s (Korten, 1984; Araral, 2009). Canals and structures built with farmer participation were more functional and the systems more productive with greater increases in rice yields and irrigated area in the dry season compared with those systems built without farmer participation. Participatory approaches also led to a more equitable water distribution and better financial management (Meinzen-Dick et al., 1995).

The early success of the model soon gained widespread international recognition and documentation. The World Bank cited NIA as "the finest irrigation agency in Asia and any developing country in the world" (NIA, 1990). The NIA model also attracted widespread documentation from experts and scholars, arguably one of the widest of its kind in the irrigation literature to date (see Araral, 2006). The NIA model not only caught the attention of researchers and donors alike but also of irrigation authorities in Asia who imported and adapted it to their countries. By the late 1980s, NIA had become the undisputed international leader in irrigation decentralization such that the World Bank acknowledged NIA's efforts as a "venerable tradition of reform" (Briscoe, 2000).

However, by the mid-1990s, NIA's process of decentralization in large-scale systems slowed down and stalled. NIA was reluctant to fully decentralize its large-scale systems because a sizable number of its personnel are employed in them and also because they serve as NIA's cash cow that keeps it afloat. NIA's token compliance with decentralization explains why in large-scale systems there are IAs with broad powers while others lack them.

Equally important, in the 1990s, international donors such as the World Bank, the Asian Development Bank, and the Japan International Cooperation Agency (JICA) significantly reduced their lending to NIA and so there was much less pressure for it to decentralize to irrigation associations (Araral, 2005). More recent studies, for example by Eleazar et al. (2005), suggest positive outcomes of measures to decentralize irrigation management in the Philippines. This study however is based on a single case study and thus cannot be generalized nationwide.

HYPOTHESIS, DATA AND METHODOLOGY

Proponents of decentralization, such as the World Bank (2005), suggest that in a decentralized context participants will act collectively to advance their interests due to motivational and informational factors. The motivational reason suggests that since these resources are usually salient to the livelihoods of users themselves, they are more likely than officials of a national government to have strong incentives to manage these resources efficiently and sustainably. The informational reason has to do with the cost of obtaining information to manage these resources. Resource users in developing countries are more likely to have lower costs of obtaining, assessing, and sharing information about the resource and resource users compared to agents of the national government. For these reasons, decentralization is often seen as an effective solution to local collective action problems in resource management.

This study tests the hypothesis that decentralization will facilitate collective action among individuals in a large-scale irrigation system. The hypothesis was tested using econometric analyses of a data set from the largest public irrigation system in the Philippines, the Magat River Integrated Irrigation System (MRIIS) with an irrigation service area of 83,458 ha.

MRIIS was chosen as a unit of study to control for relevant factors such as history, socio-economic conditions, crops planted, local weather, water source as well as irrigation governance and market conditions. No data were available for soil type and hydrologic conditions and thus these were not controlled for in the study.

Within MRIIS are 362 irrigation turnout service areas (TSA) which are served by tertiary canals, the smallest hydrologic unit in the irrigation system. An IA, composed of individual farmers, is responsible for the O&M of the tertiary canals in the TSA. At the time data were collected in 2002, MRIIS was classified as a national irrigation system under the responsibility of NIA. However, within MRIIS are a variety of contractual arrangements whereby some IAs, which operate the TSAs, were given more autonomy and authority compared with other IAs. For example, in some TSAs, farmers were merely involved in some form of management but effective control remains with NIA, referred to in this paper as a centralized irrigation subsystem.

In other TSAs, irrigation management was actually transferred to farmers such as rights to make and enforce rules including stopping water flow, the right to fire and hire personnel, and right of way to tertiary canals, among others. This modality is commonly known as irrigation management transfer (IMT) and referred to in this paper as a decentralized subsystem. The main reason why there are centralized and decentralized irrigation systems in MRIIS is that the decision to give the IAs more autonomy and decentralized property rights is made both by NIA and its donors based on a schedule of rehabilitation of different parts of MRIIS. Donors often require NIA to undertake IMT as a precondition to receiving more irrigation loans and therefore, regardless of the capacity of the IAs for collective action, they would have received more autonomy simply because they happen to be in that part of MRIIS requiring major rehabilitation.

A comparison of the differences between these two types of governance is reported in table 2 under the section on findings and discussion.

Within MRIIS are also communal irrigation systems (CIS) – farmer organized and managed associations – which paid amortization of NIA loans, but were designed to have some autonomy and not a sub-area of a national irrigation system. This study does not cover these CIS and is limited only to the national irrigation systems built by NIA, which employs either centralized management or IMT.

The cross section dataset used in this study came from a field survey in 2002-2003 by the Japan International Cooperation Agency (JICA) and NIA, the results of which were made available to the author. The survey covered all of the irrigation associations in the entire irrigation system of MRIIS. It describes the physical, hydrologic, engineering, organisational and social characteristics of the irrigation systems including a detailed dataset on the performance of each IA. The survey involved focus group discussions, key informant surveys among officers of the IA as well as walking about in the irrigation system. The survey, however, did not involve in-depth interviews to understand how farmers view group work and the sense of trust and reciprocity among the members of the IAs.

The survey covered three types of variables: (1) independent variables such as the extent of decentralization in each of the turn-out service areas and the extent of autonomy and powers vested in the IA; (2) the dependent variable, collective action, represented by proxy variables including the extent of group work, O&M performance and the ability of the IA to resolve conflicts and enforce rules; and (3) control variables such as cropping intensity, size of the service area, infrastructure condition, farm size and the size of the IA.

A number of variables were selected from this survey data for the regression model. Table 1 provides a description of the dependent, independent and control variables. The coding of variables in this study follows the default coding used in the JICA survey questionnaire.

Independent variable

The independent or predictor variable, DECENTRALISATION, refers to the extent of property rights and authorities which have been transferred to the IA and which have been postulated to affect the likelihood of collective action in an irrigation system. These include authorities related to: (1) rule making and enforcement, including the right of the IA to stop water; (2) O&M plan and budgets; (3) water charges; (4) hiring or releasing management staff; (5) control over intake; (6) control over main canal system; (7) control over lateral and tertiary canal system; (8) responsibility for future rehabilitation; (9) canal rights-of-way; (10) right to contract and raise funds; and (11) right to make profits.

Table 2 summarises the extent of property rights and authorities between centralized and decentralized irrigation systems. Given these distinguishing features, the independent variable has been coded as a binary variable.

Table 1. Description of independent and dependent variables.

Variable (Code)	Type	Description and coding
GROUPWORK	Dependent variable/ binary	Attendance in group works in the turnout service area; coded as 1 if attendance is greater than 50% of all farmers in the service area; 0 otherwise. Attendance records are kept by the IA secretary.
O&M	Dependent variable/ binary	Operation and maintenance. Coded as 1 if the IA is able to implement O&M plans 50% of the time during the cropping calendar, or else coded as 0. O&M refers to the preparation and implementation of cropping calendar, maintenance and repair of facilities, monitoring and reporting of irrigated and planted areas; collection of water service bills, coordination with NIA and formulation of IA policies.
CONFLICT RES	Dependent variable/ Binary	Conflict resolution. Refers to the ability of the IA to resolve conflicts among its members particularly in water allocation. Coded as 1 if the IA is able to resolve conflicts 50% of the time, or else coded as 0.
ENFORCEMENT	Dependent variable/ Binary	Rule enforcement. Coded as 1 if the IA is able to enforce rules 50% of the time, else coded as 0.
DECENTRALISATION	Independent variable /binary	Refers to the extent of property rights and authorities transferred to the IA. Please refer to text and table 2 for operational details.
CRPINT	Control variable/ Nominal	Crop intensity = Irrigated area (ha, wet +dry) x 100 Total Service Area (ha) Crop intensity is a proxy for water scarcity and cropping patterns. A score of 200 means that the entire irrigation unit received irrigation water in two cropping seasons while a cropping intensity of 100 means that it was only able to receive water in one cropping season.
SERVAREA	Control variable/ Nominal	Size of the irrigation service area (in hectares) under the responsibility of the IA. This also refers to the turnout service area.
INFRACON	Control variable/ Nominal	Infrastructure condition (in percentage) Infracon = No. of functional infrastructure x 100% Total infrastructure in a system Infrastructure includes head works, turnouts, canals and roads at all levels of the system. Functional was defined in terms of engineering standards in a 2002 survey by NIA irrigation engineers.
AGE of IA	Control variable/ Nominal	Age of IA reckoned from the date of its registration with the Securities Commission. Base year is 2002. An IA registered in 1990 would be 12 years old.
FARMSIZE	Control variable/ Nominal	The average size of farms (in hectares) in an irrigation unit/turnout service area.
GRPSIZE	Control variable/ Nominal	Group size; the number of farmers expropriating water from the irrigation unit or turnout service area served by a tertiary canal.

Table 2. Types of decision-making authorities by irrigation associations between centralized and decentralized TSAs within MRIIS.

Decision-making authorities by IAs	Centralized (Government-controlled TSAs of MRIIS)	Decentralized (Farmer-controlled TSAs of MRIIS)
1. Rules and sanctions including authority to stop water flow	Limited	Yes
2. O&M plan/budgets	Yes	Yes
3. Determine water charges	No	Yes
4. Personnel hiring and firing	No	Yes
5. Intake control	No	No
6. Control main canal	No	No
7. Control secondary canal	No	Yes
8. Canal rights-of-way	No	Yes
9. Authority to enter into contract/raise funds	Yes	Yes
10. Right to make profit	Yes	Yes

In centralized, government-controlled TSAs within MRIIS, IAs have limited authority to adopt certain rules, for example, voting rules, committee rules, rules on financial disclosure, attendance at meetings and group work, and other rules that govern the association. They do not have authority, however, to determine water charges, hire and fire personnel, control the water intake or the main and secondary canals; nor do they have canal rights of way. As corporate entities, these IAs have the authority to enter into contracts with NIA and other agencies as well as authority to raise funds.

On the other hand, IAs in decentralized or farmer-controlled parts of MRIIS have more effective and meaningful rights and authority to define and enforce rules, including authority to stop water flow. Unlike their counterparts in government-controlled parts of MRIIS, they can also determine water charges, hire and fire personnel and control secondary canals. As the econometric analysis will show, these variations in the authority between centralized and decentralized systems are highly likely to explain the ability of farmers in these two systems to solve collective action problems.

Dependent variable

The dependent variable, collective action, is represented by the proxy variables group work (GROUPWORK), O&M, conflict resolution (CONFLICTRES) and rule enforcement (ENFORCEMENT). It is hypothesised that collective action would be more likely if the irrigation system is decentralized. Group work refers to attendance in collective action activities, such as canal cleaning and maintenance of water facilities. O&M refers to the preparation and implementation of cropping calendar, maintenance and repair of facilities, monitoring and reporting of irrigated and planted areas, collection of water service bills, coordination with NIA and formulation of IA policies. Conflict resolution refers to the ability of the IA to resolve conflicts among its members, particularly in water allocation. Rule enforcement refers to the ability of the IA to enforce rules internally without the need for external authority.

Control variables

The control variables in the study – size of irrigation system, cropping intensity (a proxy for water scarcity), the number of farmers, infrastructural condition, age of the IA, and farm size, among others (see Araral, 2009) for a discussion of the relevance and testing of these control variables). Data for factors such as soil type and hydrologic conditions were not available and hence were not controlled for. Since both variables are not likely to affect collective action, the study would not suffer from omitted variable bias.

The potential problem of endogeneity, i.e. collective action affects the quality of infrastructure and cropping intensity, which in turn affects collective action, is often cited as concern in the literature that might affects the reliability of the results. This concern is valid for small-scale, farmer owned and managed irrigation systems where the quality of infrastructure and cropping intensity are solely dependent upon the quality of collective action by farmers. In contrast, in large-scale systems where water and infrastructure is owned and operated by the government irrigation agency largely independent of farmer's voluntary collective action, endogeneity is less of a concern. As defined in this study, infrastructure condition is defined in terms of the functionality of the infrastructure (water gates, canals, roads) in the irrigation system, which are operated and maintained by NIA, except for canals in the TSA. Likewise, cropping intensity is mainly a function of the availability of water coming from the MRIIS, which is owned and operated by NIA and independent of the quality of farmer's collective action.

In the econometric analyses, a logistic regression model was used, given that the dependent variables are binary variables. One advantage of the logistic regression model is that it provides an estimate of the odds ratio for each predictor in the model (Long and Freesse, 2001). The odds ratio is the ratio of two events where the odds of an event equals the probability the event occurs divided by the probability that it does not occur. The odds ratio can be any non-negative number and the odds ratio equal to one serves as the baseline for comparison. If the ratio is equal to one, this indicates that there is no association between the response and predictor variables. If the ratio is more than one, then the odds of success (i.e. observing free-riding) are higher for the reference level of the factor. If the ratio is less than one, the odds of success are less for the reference level. Robustness of the model was tested using a variety of goodness-of-fit tests such as Pearson, Deviance and Hosmer-Lemeshow.

FINDINGS AND DISCUSSION

Descriptive statistics

Of the 362 IAs (or farmer organisations whose members receive water from the TSAs), 44% have decentralized decision-making authorities and are autonomous from NIA. This means that the IAs in these service areas have full control over: (1) irrigation infrastructure (tertiary canals); (2) O&M and finances; (3) conflict resolution; (4) right to withdraw water; and (5) the right to stop water flow and exclude free-riders from the irrigation service. The irrigation decentralization model of the Philippines appears to be similar to those of other countries as described by Vermillion (1997, 2005).

In 184 out of 362 IAs, at least 50% of all farmers in those areas participate in group work activities. In 80% of the IAs, O&M plans are being implemented most of the time in the annual cropping calendar. This means that the preparation and implementation of cropping calendar, maintenance and repair of facilities, monitoring and reporting of irrigated and planted areas, collection of water service bills, coordination with NIA and formulation of IA policies are carried out by the IAs for most of the time in the cropping calendar.

Furthermore, 78% of IAs are able to solve conflicts among themselves most of the time, particularly in water allocation, while 80% are able to enforce rules most of the time without external assistance. The descriptive statistics for the rest of the variables are summarised in table 3.

Table 3. Descriptive statistics of control variables.

Variable	Count	Mean	SE Mean	StDev	Minimum	Maximum
CRPINT	362	166.37	1.86	35.13	20.00	200.00
SERVAREA	362	230.55	6.06	115.23	19.00	882.00
INFRACON	362	55.40	1.56	29.62	18.00	91.00
AGE of IA (Age of IA)	362	14.83	0.26	4.88	2.00	28.00
GRPSIZE (Group size)	362	166.58	4.20	79.50	30.00	515.00
FARMSIZE (Farm size)	362	1.45	0.03	0.50	0.50	3.70

SE = Standard Error; StDev = standard deviation

Cropping intensity (CRPINT) within MRIIS averaged 166 with a minimum of 20 to a high of 200. A score of 200 means that the entire irrigation unit received irrigation water in two cropping seasons while a cropping intensity of 100 means that it was only able to receive water in one cropping season. The average turnout service area (SERVAREA) within MRIIS under the responsibility of the IA is 230 ha with a minimum of 18 ha and a maximum of 882 ha. The proportion of the total number of infrastructures in MRIIS (head works, turnouts, canals and roads at all levels of the system) that are still functional by engineering standards is 56% with a standard deviation of 29%. The average age of IAs (AGE of IA) is 14.8 years reckoned from the date the IA was registered with the Securities Commission, the base year being 2002. The average size of farms (FARMSIZE) in an irrigation unit/turnout service area is 1.45 ha with a standard deviation of 0.5 ha. Finally, the average membership size (GRPSIZE) in each IA is 166 individuals with a standard deviation of 79, a minimum of 30 and a maximum of 515.

Correlation analysis

Table 4 provides a summary of the correlation matrix among the dependent and independent variables. Decentralization, the independent variable, was positively and moderately correlated to the dependent variables and the results are all statistically significant at alpha 0.001. For instance, enforcement rights are strongly correlated with the implementation of O&M activities and the ability of IAs to internally resolve conflicts with both results being statistically significant.

Table 4. Correlation matrix.

	GROUPWORK	O&M	CONFLICTRES	ENFORCEMENT
O&M	0.068			
	(0.207)			
CONFLICTRESOLUTION	0.134	0.663		
	(0.013)	(0.000)		
ENFORCEMENT	0.121	0.541	0.662	
	(0.024)	(0.000)	(0.000)	
DECENTRALISATION	0.338	0.339	0.420	0.372
	(0.000)	(0.000)	(0.000)	(0.000)

Cell Contents: Pearson correlation coefficients (figures in parentheses are p-values).

Surprisingly, however, the right to enforce rules is weakly correlated with attendance in group work (GROUPWORK). This might suggest that coercive enforcement mechanisms such as stopping of water service is not as strong as positive incentives such as the salience of rice farming to the livelihoods of farmers. It could also suggest that other incentives for cooperation could be at work such as reputational pressures. In government-owned, centralized irrigation subsystems, free-riding is seen by farmers as an offence committed against fellow farmers.

In contrast, farmers in decentralized, autonomous and farmer-governed subsystems are more likely to be consistently sensitive to issues of legitimacy and fairness. Free-riding is often seen as an offence to the collective. Group work as a social activity could also bring about benefits to individual farmers as it affords them an opportunity to socialise with one another. In this sense, coercive mechanisms such as stopping of water service take a back seat to more positive inducements.

Binary logistic regression

While useful, correlation analysis is inadequate to provide a nuanced understanding of the relationships between decentralization and its effects on collective action. Binary logistic regression was therefore used to model the effects of decentralization on several proxy indicators of collective action: attendance in group work, implementation of O&M plans, enforcement of rules and resolution of water allocation conflicts while also controlling for the effects of physical, historical, organisational and social factors. The results of the models are presented in tables 5 to 8.

Table 5 suggests that, controlling for theoretically relevant variables, it is 4.19 times more likely to find greater group work participation (i.e. at least 50% of farmers participate) in irrigation subsystems that are decentralized and autonomous compared with centralized irrigation subsystems. The result is statistically significant at alpha 0.001 and is highly consistent with expectations and robust to measures of association.

Table 5. Logistic regression: GROUPWORK versus DECENTRALISATION.

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% CI Lower	95% CI Upper
Constant	-0.3707	1.0755	-0.34	0.730			
DECENTRALISATION	1.43212	0.2464	5.81	0.000	4.19	2.58	6.79
CRPINT	0.00070	0.0034	0.20	0.840	1.00	0.99	1.01
SERVAREA	0.00328	0.0032	1.00	0.318	1.00	1.00	1.01
INFRACON	0.00773	0.0039	1.96	0.051	1.01	1.00	1.02
AGE of IA	-0.03407	0.0243	-1.40	0.162	0.97	0.92	1.01
GRPSIZE	-0.00375	0.0044	-0.84	0.399	1.00	0.99	1.00
FARMSIZE	-0.22125	0.4929	-0.45	0.654	0.80	0.30	2.11
Goodness-of-fit tests							
Method	Chi-Square	DF	P				
Pearson	354.366	344	0.338				
Deviance	437.815	344	0.000				
Hosmer-Lemeshow	12.339	8	0.137				

Note: SECoef = Standard error of coefficient; Z = z-score; P = probability; CI = confidence interval

Table 6 summarises the regression results between O&M and decentralization. The results suggest that, *ceteris paribus*, decentralized systems are 9.29 times more likely than centralized systems to be observed to implement O&M plans most of the time during the cropping calendar. The results are statistically significant at alpha 0.01 and are robust to measures of association and are consistent with expectations (i.e. that irrigation management transfer leads to better O&M).

Table 6. Logistic regression: O&M versus DECENTRALIZATON.

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% CI Lower	Upper
Constant	1.27880	1.42357	0.90	0.369			
DECENTRALISATION	2.22930	0.459637	4.85	0.000	9.29	3.78	22.88
CRPINT	0.0077371	0.0041904	1.85	0.065	1.01	1.00	1.02
SERVAREA	0.0065657	0.0048184	1.36	0.173	1.01	1.00	1.02
INFRACON	0.0081902	0.0048706	1.68	0.093	1.01	1.00	1.02
AGE of IA	-0.0751379	0.0332769	-2.26	0.024	0.93	0.87	0.99
GRPSIZE	-0.0069847	0.0065956	-1.06	0.290	0.99	0.98	1.01
FARMSIZE	-0.882563	0.654432	-1.35	0.177	0.41	0.11	1.49
Goodness-of-fit tests							
Method	Chi-Square	DF	P				
Pearson	312.649	331	0.758				
Deviance	270.812	331	0.993				
Hosmer-Lemeshow	7.374	8	0.497				

The results suggest that it is more likely to observe better performance in settings where individuals have the authority to make their own rules. This result is also consistent with findings from Araral's (2005) meta-analysis of the problems of public infrastructure. Araral (2005) suggests that improved O&M is more likely when decentralization is most progressive, i.e. when farmers are given significant amounts of authority such as making and enforcing rules.

Table 7 summarizes the regression results between conflict resolution (CONFLICTRES) and decentralization. The results suggest that, *ceteris paribus,* decentralized irrigation subsystems IAs are 10.40 times more likely to be observed as resolving conflicts internally without resorting to external assistance compared to IAs in centralized irrigation subsystems. The results are statistically significant at alpha 0.001 and are robust to measures of association.

Table 7. Logistic regression: CONFLICTRES versus DECENTRALISATION.

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% CI Lower	Upper
Constant	-0.190057	1.30173	-0.15	0.884			
DECENTRALISATION	2.34145	0.383703	6.10	0.000	10.40	4.90	22.05
CRPINT	0.0065334	0.0039254	1.66	0.096	1.01	1.00	1.01
SERVAREA	0.0026422	0.0043414	0.61	0.543	1.00	0.99	1.01
INFRACON	0.0017555	0.0043890	0.40	0.689	1.00	0.99	1.01
AGE of IA	-0.0266564	0.0287102	-0.93	0.353	0.97	0.92	1.03
GRPSIZE	-0.0021779	0.0060509	-0.36	0.719	1.00	0.99	1.01
FARMSIZE	-0.334627	0.602916	-0.56	0.579	0.72	0.22	2.33
Goodness-of-fit tests							
Method	Chi-Square	DF	P				
Pearson	323.706	331	0.602				
Deviance	322.239	331	0.625				
Hosmer-Lemeshow	6.336	8	0.610				

Table 8 summarises the regression results between enforcement and decentralization. The results suggest that decentralized irrigation subsystems IAs are 6.34 times more likely to be observed to consistently enforce rules. The results are statistically significant at alpha 0.001 and are also robust to measures of association. The result is also consistent with the empirical literature, for example Gibson et al. (2005).

Table 8. Logistic regression: ENFORCEMENT versus DECENTRALISATION.

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% CI Lower	Upper
Constant	-1.54003	1.26436	-1.22	0.223			
DECENTRALISATION	1.84656	0.345629	5.34	0.000	6.34	3.22	12.48
CRPINT	0.0095536	0.0038835	2.46	0.014	1.01	1.00	1.02
SERVAREA	0.0020922	0.0041543	0.50	0.615	1.00	0.99	1.01
INFRACON	0.0039977	0.0043732	0.91	0.361	1.00	1.00	1.01
AGE of IA	0.0164464	0.0281549	0.58	0.559	1.02	0.96	1.07
GRPSIZE	-0.0019933	0.0057492	-0.35	0.729	1.00	0.99	1.01
FARMSIZE	-0.103209	0.580468	-0.18	0.859	0.90	0.29	2.81

Goodness-of-fit tests

Method	Chi-Square	DF	P
Pearson	315.253	331	0.724
Deviance	330.858	331	0.492
Hosmer-Lemeshow	7.150	8	0.521

CONCLUSION

This study investigated the impacts of decentralized property rights on the ability of individuals to solve collective action problems in a large-scale common pool resource. Using econometric analyses of a data set from the largest (83,000 ha) irrigation system in the Philippines, the study finds that decentralized irrigation subsystems are more likely to solve collective action problems such as free-riding, conflict resolution and rule enforcement.

Specifically, IAs which were granted the right to make rules and sanctions including authority to stop water, determine water charges, hire and fire personnel, control secondary canals, among others, were more likely to: (1) have greater farmer participation in group work; (2) solve conflicts among themselves without resorting to external assistance; (3) implement O&M; and (4) enforce rules compared with centralized irrigation systems. These findings are all statistically significant, not surprising, and consistent with empirical literature such as by Ostrom (1990), Tang (1991), Vermillion (1997, 2005), Lam (1998), Weissing, F. and Ostrom, E. (1990), Bardhan (2002), Andersson (2003), Gibson et al. (2005), and Huang et al. (2009), among others.

Several insights can be drawn from these preliminary findings. First, collective action in a large-scale common pool setting requires purposive cooperative behaviour among individual actors. As Lam (1998) suggests, successful collective action requires a high degree of mutual trust, active participation in the crafting and monitoring of rules, and a high level of conformance with rules, all of which are more likely in self-managed and decentralized systems.

Second, the results also suggest that the motivational and informational reasons, while necessary, are not sufficient conditions to ensure the success of collective action in a common pool setting. It cannot be supposed that farmers in centralized irrigation subsystems are less motivated and informed compared with their counterparts in decentralized subsystems. The conditions in both centralized and decentralized subsystems are similar having controlled for theoretically relevant variables such as group size, age of the IA, size of the irrigation system, water source and infrastructural condition.

It is argued instead, using the MRIIS case in the Philippines, that variation in collective action between centralized and decentralized irrigation subsystems can be explained by variations in property rights and decision-making authorities. For instance, the econometric analyses have shown that individual farmers are more likely to solve collective action problems if they are endowed with the following rights and decision-making authority: (1) making rules and sanctions, including stopping water; (2) determining water charges; (3) hiring and firing of personnel; and (4) control of secondary canals and rights-of-way.

Third, the right to ultimately stop water service to free-riders is what makes enforcement of sanctions credible in decentralized subsystems. It is argued that this is what mainly differentiates the collective action performance of decentralized versus centralized irrigation subsystems. Specifically, credible sanctions provide strong incentives along with motivational and informational reasons in solving a variety of collective action problems in common pool resources, for example, free-riding in group work, O&M contribution, conflict resolution and rule enforcement. This finding is consistent with the broader literature, e.g. Gibson et al., 2005.

Finally, in government owned and controlled centralized irrigation subsystems, enforcement of sanctions are not credible compared to those in decentralized subsystems. One main reason is the perception of rule fairness and legitimacy. In government controlled subsystems, free-riding is seen by farmers as an offence committed against the irrigation bureaucracy and not against fellow farmers. In contrast, farmers in decentralized, autonomous and farmer-governed subsystems are more likely to be consistently sensitive to issues of legitimacy and fairness. Free-riding is an offence against fellow farmers. Reputational pressures in centralized irrigation subsystems, therefore, may not be as strong as those in farmer-controlled systems. Strategic interdependence and vulnerability among farmers in decentralized systems increases the role played by social norms and networks in solving collective action problems. In centralized irrigation subsystems, interdependence between NIA and IAs also creates strong moral hazard problems when farmers view the public irrigation agency as their patron (Araral, 2006).

Overall, these findings are consistent with the theoretical and empirical literature but they highlight the significance of credible enforcement. This conclusion has important implications in the design of institutions for collective action in irrigation in particular and in the management of large-scale common pool resources more generally.

ACKNOWLEDGEMENTS

The support by the International Water Management Institute and the Comprehensive Assessment of Water Management in Agriculture is gratefully acknowledged. The usual caveats apply.

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