Beyond panaceas in water institutions

Ruth Meinzen-Dick*

Environment and Production Technology Division, International Food Policy Research Institute, 2033 K Street NW, Washington, DC 20006

Edited by Elinor Ostrom, Indiana University, Bloomington, IN, and approved June 29, 2007 (received for review March 12, 2007)

The past 50 years of water policy have seen alternating policies emphasize the state, user groups, or markets as essential for solving water-management problems. A closer look reveals that each of these solutions has worked in some places but failed in others, especially when policies attempted to spread them over too many countries and diverse situations. A study of the variable performances of user groups for canal irrigation in India illustrates the factors that affect institutional performance. Research that identifies the critical factors affecting irrigation institutions can lead to sustainable approaches that are adapted to specific contextual attributes.

irrigation | user organizations | water management | water markets | water policy

Managing water effectively is fundamental for human society. Yet evidence of the problems of water management is found throughout history. Over the past 50 years, a series of institutional arrangements has been presented as panaceas to improve water management: strong government agencies, user organizations, and water markets. Seemingly successful cases of state, user, or market governance of water were compared with problematic performances in other cases governed by other institutions, with the implication that if the institutions from the successful cases, whether a strong bureaucracy, a water users' association (WUA), or transferable water rights, were only replicated, they would solve the problems. Each of these approaches has failed to live up to expectations, largely because the variability of local situations and the difficulty of transplanting institutions from one context to another were not taken into account (1).

This article examines the experience of searching for panaceas in irrigation. It begins with an examination of the need for coordinating institutions and then reviews the evidence on policies promoting government agencies, user organizations, and water markets. A study of user groups in India shows how diagnostic analysis can help go beyond panaceas. The conclusions argue that effective irrigation management requires going beyond single-policy solutions to a more nuanced approach that builds on better diagnosis and adaptive learning to find solutions that fit local biophysical, social, and economic conditions.

The Need for Water Institutions

Because of the interconnected nature of the hydrologic cycle, one person's use of water generates externalities for others. As long as water is abundant relative to its use, these interaction effects may not be noticeable. But in dry climates, or as water use and pollution rise, the externalities become problematic without institutional arrangements to clarify rights and responsibilities. The spatial dimensions of water management create further needs for coordinating institutions (2). A well that supplies one farm can be built and operated by an individual. Small-scale irrigation systems supplying a group of farmers require coordination at the group or even up to the community level. Larger water systems cut across communities; some even cross international boundaries.

Coordination functions can be supplied by the state, collective action among users, market exchanges, or combinations of them. Many irrigation systems represent nested systems, with state agencies managing the main system, user groups at the secondary and tertiary levels, and individuals on the farms.

Empirical research has continued to examine the variability in institutional arrangements for irrigation systems. Initial research on case studies (3) was followed by metareviews to identify the factors that are likely to shape the effectiveness of institutions for irrigation management (4–10). Although the categories used by the different authors vary, the critical factors identified can be grouped under the headings identified by Ostrom (11) as indicated in Table 1.

The precise institutional arrangements that emerge are likely to depend on a number of factors, including the scale of the system, with greater advantage of private or collective-action institutions at smaller scales and more local levels because local users are likely to have greater local knowledge. State institutions have a greater comparative advantage at higher spatial scales because the state is more likely to have the resources and authority to coordinate across large areas and numbers of users (8). Storage facilitates market exchanges (7). The historic paths of local institutional change, cultural orientation, and political processes also play a critical role, with state, cooperative, or individual institutions valued differently in different societies, and over time (7, 10).

The Search for Water Panaceas

Research and policy on water management have followed three broad, overlapping trends in the past 50 years. The first focused on the central role of the state, the second focused on the scope for organized user management, and the third focused on a larger role for market institutions (12). Whereas the underlying research often identified a range of conditions needed for a particular institution to be effective, these nuances were often lost when translated into policies. As a result, outcomes often have not lived up to the frequently unrealistic expectations (1).

State Institutions. Wittfogel (13) in his influential book, *Oriental Despotism*, argued that a strong political and social structure was needed to mobilize the labor, financing, and other resources to construct and maintain large-scale hydraulic systems. Although Wittfogel's study was based on Asian experience, especially in India and China, the general pattern of a strong state role in developing water systems, which Reisner (14) refers to as the hydraulic mission, was also found in the western United States, Australia, and many developing countries, particularly from the 1950s on. Applying the framework presented in Table 1, these cases tended to be characterized by large size, canal infrastructure with large storage, arid or semiarid climates, and strong government organizations.

During the 1970s and 1980s, there was evidence that many of the existing state systems were not performing up to expecta-

Author contributions: R.M.-D. designed research, performed research, contributed new reagents/analytic tools, analyzed data, and wrote the paper.

The author declares no conflict of interest.

This article is a PNAS Direct Submission.

Abbreviation: WUA, water users' association.

*E-mail: r.meinzen-dick@cgiar.org.

Table 1. Factors hypothesized to affect irrigation system management

Social, Economic, and Political Settings (S)

S1- Economic development S2- Demographic trends (density, settlement pattern)
S4- Government water policies and commitment to reform S5- Market incentives (distance to market)

Resource System (RS)

RS1- Sector: Water
RS2- Clarity of system boundaries
RS3- Size of irrigation system
RS4- Water infrastructure
- RS4-a Headworks
- RS4-b Channels
- RS4-c Control structures
- RS4-d Roads
- RS4-e Communications

RS5- Scarcity: relative water supply
RS6- Equilibrium properties
RS7- Predictability of supply
- RS7-a Seasonal
- RS7-b Interannual

RS8- Storage characteristics
RS9- Location

Governance System (GS)

GS1- Government organizations
GS2- Nongovernment organizations
GS3- Structure of user groups
GS4- Property rights
- GS4-a Property rights to infrastructure
- GS4-b Property rights to water

GS5- Operational rules
GS6- Collective-choice rules
GS7- Constitutional rules
GS8- Monitoring & sanctioning processes

Resource Units (RU)

RU1- Resource unit mobility
RU2- Water availability, by season
RU3- Hydrologic interaction among irrigation units
- RU3-a Interaction within a system
- RU3-b Interaction between systems

RU4- Economic value of output
RU7- Spatial & temporal distribution of water

Users (U)

U1- Number of users (total and in local units)
- U1-a Number of users in whole system
- U1-b Number of users in local units

U2- Socioeconomic attributes of users
- U2-a Wealth
- U2-b Heterogeneity
- U2-c Land tenure
- U2-d Stability of group

U3- History of irrigation
U4- Location (residence relative to canals)
U5- Leadership
U6- Shared norms/social capital
U7- Knowledge of irrigation
U8- Dependence on irrigation
U9- Technology used

Interactions (I) → Outcomes (O)

I1- Water use by diverse users
I2- Information sharing
- I2-a Information on resource use
- I2-b Information on conditions of resource

I3- Deliberation processes
I4- Conflicts among users
I5- Investment in maintenance
I6- Lobbying activities

O1- Socioeconomic performance
- O1-a Equity of water distribution
- O1-b Water use efficiency
- O1-c Cropping intensity
- O1-d Yields
- O1-e Value of output

O2- Ecological performance measures
- O2-a Waterlogging
- O2-b Salinity

O3- Externalities to other systems

Related Ecosystems (ECO)

ECO1- Climate patterns ECO2- Pollution patterns ECO3- Flows into and out of focal irrigation systems

Adapted from table 1 and figure 2 in ref. 11, drawing from refs. 7–10.

tions (10, 12, 14, 15). The area irrigated was often far less than designed, with shortages in some areas and waterlogging in others. There was greater recognition that technology was not sufficient to solve the performance problems of water systems. Initial institutional reforms focused on water bureaucracies, by providing training or increased budgets for operation and maintenance (12).

By the 1980s, Taiwan and the Philippines tried broader reforms for bureaucratic reorientation to improve service delivery (16). After examining experiences in Taiwan, Korea, Philippines, Indonesia, and India, Small and Carruthers (17) argued that the structure of irrigation fees could provide incentive for water agencies to improve their services to farmers if a substantial portion of their budgets, including salaries, depended on farmers' payments. The logic of this argument appeared to be substantiated by initial improvements in irrigation system performance in the Philippines' National Irrigation Agency after it became financially autonomous (18). But the effectiveness of state agencies for water management depends on more than just the financing mechanism. Similar financially autonomous agencies in Karnataka, India, were even less responsive than regular government agencies, because a range of other factors were not in place (19). Staff did not have a long-term identification with the autonomous unit, and farmers and outsiders assumed the state would step in to cover any shortfall.

Even in the Philippines, improvements were not sustained: after 25 years, the majority of systems had poor maintenance, resulting in inadequate service delivery and low fee payment from farmers. Araral's (20) analysis of 2,048 systems in the Philippines attributes these problems to inadequate attention to the incentive structures for agency staff to maintain the systems and for farmers to pay for services. In particular, he found many of the factors in Table 1 to be important: water scarcity, cropping intensity, age (history), size, structure of user groups, socioeconomic attributes of poverty, land tenure security, and frequent face-to-face communication (social capital) all had a significant effect on the likelihood of farmers to pay for services. This finding suggests that reform of state institutions alone is unlikely to improve the performance of irrigation systems; attention is also needed to deal with the range of characteristics of the resource system, governance system, and user.

WUAs. As the limitations of state-run irrigation systems became apparent in the 1970s, a number of researchers studying farmer-managed irrigation systems in the Philippines, Indonesia, Sri Lanka, India, and Nepal challenged the notion that strong state authority was necessary or sufficient to construct and operate systems (10, 16, 21). Although the majority of farmer-managed systems were relatively small compared with major government-run systems, systems like Chhatis Mauja, covering 3,000 hectares in Nepal, and the zanjeras of the Philippines indicated that farmers could even manage medium-sized systems (10). Studies in India (3, 15) also indicated that many farmers had organized themselves at lower levels within state-run systems. Cases of effective farmer-managed systems were contrasted with state-run irrigation systems that were not serving their whole potential irrigated area because of numerous operation and maintenance problems.[†] With the fiscal crisis of the state in the 1990s, donors and many governments became more interested in increasing farmer involvement, as a means of both addressing performance problems and reducing the recurrent costs borne by the state, thus creating a new panacea (16, 23).

Attempts to scale up farmer involvement from sites where water management has been initiated and run by farmers at the local level to large areas under government programs illustrate the problems with institutional panaceas. Examining this development in terms of Table 1, the majority of systems with effective farmer management had long histories and farmers with strong property rights over the systems and decision-making authority on constitutional, collective-choice, and operational rules (7, 24). By contrast, the externally initiated programs seeking to develop farmer organizations in larger, state-run systems often involved the top-down imposition of a rigid structure of user groups and uniform rules that would allow state agencies to recognize and interact with WUAs. It was more difficult for farmers to become involved in the larger systems, and the rigid structure and imposed rules gave them less scope to adapt systems to meet their needs.

Some research has examined the performance of farmer organizations under externally initiated programs. Action research in the Gal Oya system in Sri Lanka highlighted the importance of a learning process and building trust between government and farmers as well as among farmers, rather than structural conditions alone (25). But as fiscal pressures on governments mounted, such intensive pilot activities for institution building were bypassed in favor of "big bang" approaches. Mexico adopted a policy of transferring property rights over even large irrigation systems from agency management to WUAs. Glowing reports of large decreases in government subsidies for irrigation and increases in irrigated area (26) generated a policy narrative that hailed this process in Mexico as a success. Such studies, plus tours that brought policy makers from other countries to visit privileged pilot sites in northern Mexico, generated an enthusiasm for adopting similar policies (27).

The policy responses ranged from participatory irrigation management programs that involved farmers as a supplement to government management, as in many states in India, to irrigation management transfer programs in which management, control, and even ownership of systems or subsystems were transferred to farmer management, as in Turkey. In 1994, a conference on irrigation management transfer, sponsored by the Food and Agriculture Organization of the United Nations, included case studies from 28 countries (28). A 2006 review of 46 cases, including some from the 1994 conference, on six continents found the outcome of transfer policies has been mixed (29). The cost of irrigation for the government fell in 33 cases, but rose for the farmers in 21 cases. Improvements were reported in timeliness of water delivery in 34 cases, equity of water delivery in 32 cases, quality of maintenance in 32 cases, collection of water charges in 30, amount of area irrigated in 29, yields in 23, and farm income in 24 cases.

The variable performance of management transfer programs between countries is also seen within countries and even within systems. Many analyses of factors affecting the success of transfers (29, 30) focus on the components of the programs, particularly the extent of implementation, accompanying reforms to irrigation agencies and the economic incentives for farmers. However, few programs have drawn on the studies of factors identified as affecting collective action among farmers. Perhaps not surprisingly, programs have failed to live up to expectations.

Water Markets. The presence of large externalities and other sources of market failure in the water sector has limited the reliance on market institutions in this sector. But continued inefficiencies of water use, combined with neoliberal reforms in many donor agencies, led to greater interest in market institutions to improve the performance of the water sector. In an influential article, Rosegrant and Binswanger (31) laid out the case for tradable water rights to create incentives for water-use efficiency. Their article notes that water markets depend on several factors listed in Table 1: infrastructure to allow transfer of water from one user to another; effective government organizations, especially to regulate impacts on third parties; and effective user groups to provide information and allow small farmers to take part. They point out that the costs and benefits of alternative institutional arrangements are likely to vary, depending on climate, water scarcity, agricultural intensification, and water use by diverse users, especially from different sectors.

Examples of water transfers from agriculture to municipal and industrial uses in the western United States indicated that markets for water were feasible, but Chile's example generated the strongest policy narrative in support of water markets. The country had a long history of private irrigation systems, water rights allotted by shares, and fairly flexible infrastructure to transfer water. National policies allowed private transferable property rights for water use, and both the government organization regulating water and the user groups were relatively strong. The documentation of substantial gains from trade as high-value grape farmers bought water from farmers producing lower-value crops in the Elqui Valley (32) generated considerable interest.

Australia's water reforms stimulated further interest in water markets as overallocation of water, especially in the Murray-Darling basin, and increasing salinity and ecological externalities prompted the adoption of tradable water rights. The history of water licenses, norms of commercial farming, along with professional river operators and active user groups that own irrigation systems, facilitated market allocation, but even with these relatively favorable conditions, there was initial public reluctance until experience with water shortages and serious environmental consequences strengthened norms that water was a finite good that needs to be carefully managed; the experiences with an active water market further allayed many concerns (33).

The question remains whether market allocation can be applied to water systems in developing countries, particularly where infrastructure is not as well developed to transfer water and government organizations have less regulatory capacity. Active groundwater markets exist in South Asia at the local level, but they are informal and not recognized by the state (34). Attempts to introduce formalized water markets are often met with objections to the privatization and commercialization of water, because of norms that water is a free good or a gift from god. As with public and collective institutions for water gover-

[†]Lam's (22) study in Nepal provides one of the most comprehensive comparisons of performance of agency-managed and farmer-managed irrigation systems.

nance, the path dependence of institutional change implies that water markets cannot be transplanted without due consideration for their fit with the physical, institutional, and cultural environment.

Evidence from Canal Irrigation in India

Each type of institutional panacea can point to some places in which it works well, but these results are far from automatic. Merely transplanting structures that have worked in one context to another site is more likely to create paper tigers, organizations that exist on paper only, than real institutional change. A closer look at the performance of user groups illustrates how critical study of irrigation institutions can improve diagnosis of the characteristics of water systems that work or are missing in each context and craft appropriate responses.

Although there are several metaanalyses of existing case studies for identifying critical factors affecting water user organizations (4, 5, 7–10), case studies suffer from three major limitations. The first is selection bias: case studies are almost always of effective user organizations. Where irrigators have failed to develop effective governance of local and regional resources, either they stop delivering the water or their systems are absorbed into government-managed systems, and the user groups are not studied. Second, the case studies identify the factors that seem to affect their cases, but because of the variety of conditions found and the range of theoretical approaches of the researchers, they do not all address the same issues. Hence, it is difficult to say whether a factor was not important in one site, or the author just did not note it. Third, systems developed by farmers may be quite different from systems developed by external programs.

A few studies have attempted to test the range of factors hypothesized to affect user organization through quantitative analysis of a large number of sites (35, 36). Unfortunately, because most of the factors vary at the community or irrigation unit level rather than the household or individual level, it is very difficult to obtain data on sufficient sites to quantitatively test all of the factors identified as potentially important in affecting the functioning of user groups. Thus, a subset of the key factors must be selected, and consistent data must be collected on them from each site.

A study of collective action among WUAs within two Indian states with participatory irrigation management policies illustrates the strengths and limitations of such quantitative studies and gives further insights on the conditions under which programs building on WUAs are likely to succeed (37). A stratified sample of 12 hydrologic units, defined as minors (tertiary distribution canals) or watercourses, was selected in each of four major canal irrigation systems, one old and one new system each in Karnataka and Rajasthan states, for a total sample size of 48. Whereas this sample was not large enough to test statistically for the effect of all factors hypothesized to affect user organization and activity, it did provide a more complete picture than is available from individual case studies. A review of the literature highlighted the importance of several factors presented in Table 1, including water scarcity, size of WUAs, socioeconomic heterogeneity of users, leadership, social capital from other local organizations, distance to market, and government policies, all of which were hypothesized to affect farmer participation. Operationalizing these concepts required identifying indicators of these factors and farmer participation that could apply across culturally and ecologically diverse sites. Defining the dependent variable required addressing whether organizations are seen as an end in themselves or as an instrument to increase farmers' contributions to system management. The government programs sought to increase farmers' involvement in maintenance of the minors, but in many cases farmers organized themselves for collective lobbying and appeals to get better service from the agency, so both collective maintenance and collective lobbying were included as indicators of collective action.

Table 2. Factors affecting farmer organization in canal irrigation in India

Explanatory variables	Farmers' organization	Collective maintenance	Collective lobbying
Located at head	1.46	0.72	−4.24*
Located at tail	1.94	1.12	2.41
Command area, hectare	0.0031*		
Villages		−0.39†	0.55
Market distance, km	−0.092*	−0.04	−0.07
Cooperatives	3.21		
Temples	0.60*		
Wells		−4.22	23.91
Tractors			26.98†
Graduates	0.17†	0.05	
Influential people	4.83*		3.01
Castes		−0.15	1.73
Predicted WUA		2.28†	2.70
Model χ^2	40.59*	18.72†	42.70*
% correct	92.00	77.00	85.00

Dummy variables for irrigation system have been omitted. Adapted from tables 2–4 in ref. 35.

*Significant at 0.05 probability level.

†Significant at 0.10 probability level.

The presence of an organization does not necessarily lead to greater farmer participation in irrigation management. Not all cases with formal or informal WUAs undertook collective maintenance of the irrigation structures; 53% of the sites with no organizations did collective maintenance and 69% with no WUAs engaged in collective lobbying. A two-stage logistic regression analysis was used to first identify the physical and socioeconomic variables that affected the likelihood of farmer organization, and then to examine collective action for maintenance and lobbying as a function of predicted organization and other factors characteristic of the resource base and user groups. In the first stage, head, middle, and tail of the system provided a proxy for scarcity. Area irrigated by an outlet was an indicator of size of hydrologic units. Distance to markets indicated market access. Cooperatives and temples were selected as the other key organizations that might shape social capital, because the irrigation department targeted areas with cooperatives, but ethnographic studies indicate that, in these predominantly Hindu areas, temples provide a nucleus for social interaction. College graduates and influential persons living in the community provided indicators of leadership potential. Dummy variables for an irrigation system controlled for differences in climate, age of system, legal recognition of organizations, and agency responsiveness.

Results are presented in Table 2. What factors affect the likelihood that farmers will organize? Location on a canal and, by extension, ease of water availability did not have an effect, but larger command areas were more likely to have an organization. Farmers farther from the market centers were less likely to have organizations. Somewhat surprisingly, the presence of other types of cooperatives in the command of a minor does not have a significant effect, but the number of temples increases the likelihood of organization for irrigation. The social capital generated by religion seems to have a stronger influence on organization for natural resource management than social capital created by cooperatives, despite the fact that organizing WUAs has been largely entrusted to the cooperatives. The presence of college graduates and influential persons have significant, positive effects on the establishment of an irrigation organization. Graduates offer innovation and have the skills required for setting up and managing a formal organization. Influential people from the local area have networks of contacts both within and outside the local area that could draw officials' attention to the area and be useful in starting an organization for irrigation. Overall, this model correctly predicts the organizational status of 92% of the cases.

The second-stage analysis included variables for system, head/tail location, and distance to markets, as well as predicted likelihood of a formal or informal WUA. Instead of command area, the number of villages served by a minor provides an indicator of size of units and social proximity. Additional variables in the second stage include the number of wells indicating an alternate water supply, tractors as an indicator of wealth, and castes indicating social heterogeneity. The model for collective maintenance used the number of college graduates as an indicator of the relevant leadership; collective lobbying used the number of influential people. Results indicate that the presence of organizations did increase the likelihood that farmers would undertake collective maintenance, but if the group spanned more than one village, the farmers were less likely to do collective repairs on the canal because of the lower level of social contact and greater difficulty and costs of organizing. No other factors were significant, but the model correctly predicted 77% of the cases.

By contrast, there was no significant effect of organization on collective lobbying, indicating that it requires less ongoing organization than maintenance. The only factors that were statistically significant were head-end location, indicating that users with better water supply had less need for lobbying, and tractors, because farmer groups with more tractors are both wealthier and more mobile in an area where tractors are used to transport groups of farmers to government offices to make collective demands for water or system repairs.

Rigorous analyses of the factors affecting irrigation institutions can contribute to improved diagnostic capabilities, to go beyond blanket prescriptions. But they, too, have limits in explaining the underlying mechanisms for coordination and how it can be stimulated. For example, the two leadership variables (graduates and influential people) measured the external characteristics of potential leaders, but not their internal motivation. Much hinged on having a dynamic leader, especially for getting started. Although not reported in the studies presenting the quantitative analysis, in my field research I also examined the motivations of different types of leaders and identified three broad types: leaders guided by a sense of noblesse oblige or seeking prestige, idealists guided by a desire to improve local conditions, and leaders who organize people to obtain contracts for labor-intensive work and make financial profits. Reducing such motivations to quantitative indicators is likely to lose information or even be misleading. Careful qualitative research is needed, linked with quantitative analysis, such as by examining how leaders' characteristics, especially their motivations, affect the likelihood of organizations and interactions and outcomes such as effectiveness of maintenance, lobbying, and equity of resource distribution. Although the latter activity has been overlooked in much of the literature on irrigation management, it plays a vital role in building networks, passing information regarding system conditions from farmers to the irrigation agency, and creating some accountability of the agency to farmers.

These results indicate that identifying and building from existing bases of cooperation, such as temples and villages in India, instead of government-instituted cooperatives and hydrologic units, and making provision for group learning are more likely to lead to active farmer participation in the systems. Active engagement with the state is also needed. If state agencies do not provide support, farmers may spend more effort in trying to get the attention of officials than in directly managing the systems. Programs that promote user organizations as the institutional panacea for the water sector, and do not recognize the variability in user involvement and need for external support, are likely to be perceived as failures when they do not deliver on all expectations of increased performance, leading to the search for the next purported solution to water problems. Instead, both state and user organizations need to learn to work together.

Discussion

The search for panaceas in water governance has put forward first public, then collective, then market institutions as the one answer to problems of water mismanagement. Existing poor performance of a water system is contrasted with an image of optimal performance under the new system being promoted. Although each approach has drawn on research, the policy narratives that are generated to promote a particular institutional approach have too often ignored the evidence on shortcomings of the proposed approach and the conditions under which that type of institution is likely to function poorly or well. Donor agencies and policy makers are attracted to the simplicity of an apparently successful model that offers a recipe for application elsewhere (38). Something that may have functioned well in one part of the Philippines, Mexico, or Chile is promoted in sweeping reforms applied to large areas that have very different resource systems, governance systems, resource units, and users. As a result, the new program fails to deliver the expected results and is declared a failure, and policy makers seek the next solution. Instead of setting up unrealistic expectations of success, it is more productive to recognize that any type of institution will vary between sites and over time. Rather than setting up rigid institutional models and then declaring each to be a failure, it is better to make explicit provision for institutional learning and change.

Research on system performance is needed, but it should present the strengths and weaknesses of each, based on a sound sampling of sites, instead of pilot projects that are seen to be performing well. Sufficient research exists to help identify factors that improve the effectiveness of state, user, or private interests. The variables summarized in Table 1 provide a starting point for thinking broadly of the contextual factors, and past research can help to specify the next tier of variables to consider. For example, water markets require infrastructure that will allow water to be transferred from one user to another and strong government regulatory capacity (a subtier of GS1 in Table 1), whereas government systems require strong implementing agencies (another subtier of GS1). In general, we often find that user groups have an advantage in community-level system management, but higher levels involve some state coordination. There are cases of large farmer-managed systems with federated structures, particularly where farm sizes are large and farmers own transport and communication equipment like cell phones or computers. In such cases, the state role is often limited to issuing water licenses and coordinating water sharing among systems in a river basin. Water scarcity, because of either agroclimatic conditions or increasing water use, is generally associated with higher management intensity, but excessive scarcity can exacerbate conflicts and cause coordination to break down. Groups with a long cultural tradition of irrigation are likely to be more involved than users who have recently started irrigating. But the activity of market and collective user institutions in water management also depends on the economic returns. Declining terms of trade for agriculture are reducing incentives for farmers to participate, particularly when reforms call for higher payments or labor contributions. Unfortunately, a common element of administrative reforms, farmer participation programs, and market allocation is that they have generally created higher farmer costs. Such reforms often meet resistance or noncompliance unless broader economic issues are addressed, which may be beyond the scope of water projects. Farmers are often offered initial subsidies for rehabilitation in exchange for assuming greater costs in the future. However, this type of support is, at best, an unstable bargain when not accompanied by the changes in farmer and government capacity, including access to financing that would be needed to sustain performance.

Further work is required to translate the nuanced findings of research into diagnostic capabilities for program development and implementation. Handbooks such as the United Nations' Food and Agriculture Organization's guidelines for irrigation management transfer (23) are important steps in this regard. But more is needed for program developers and implementers to be able to recognize existing conditions and how they vary within a country, state, or even a single project, instead of "seeing like a state" (39) and expecting uniformity across all sites. A particular challenge is for state agencies to identify the existing degrees of organization among users and the institutional bases for cooperation. Too often, only registered organizations are visible to the state agencies. Yet as the India study shows, formal organizations may not be active, whereas other social institutions provide important coordination functions.

There is no single solution for all water problems. A strong focus on a single institutional pillar, whether public, collective, or private, has too often ignored the need for a polycentric combination of each of these types of institutions (1). In analyzing the performance of irrigation bureaucracies, Uphoff *et al.* (40) highlight the importance of effective WUAs as partners for state agencies and creators of pressure for reforms and accountability. Garcés-Restrepo *et al.*'s study (29) of irrigation management transfer points out the many ways in which WUAs need supporting services from state agencies and market service providers. In both the Chilean and Australian cases of water markets, strong state regulatory agencies and farmers' organizations played critical roles.

Instead of a single pillar, a more appropriate image is a tripod or stool, in which state, collective, and market institutions each play a role. Instead of trying to import new institutions, policies should then seek to identify the strengths of the existing institutions and build from them. The next step is to look for the connections between different types of institutions so they can strengthen each other, for example, by agencies providing financial training to water users groups or user groups creating accountability for government agencies (41). But such polycentric governance patterns require a commitment to working together. However, there is a need for more research on combinations of institutions, rather than the performance of single institutions in presumed isolation. And to have a real impact on water management, the results of research must be built into adaptive learning that strengthens the capacity of the state and water users to address evolving challenges: a process that requires going beyond panaceas.

This article draws on collaborative research with many colleagues over the years. Special thanks go to Bryan Bruns, Ashok Gulati, Doug Merrey, Peter Mollinga, Ujjwal Pradhan, K. V. Raju, Claudia Ringler, Mark Rosegrant, Mark Svendsen, Douglas Vermillion, and Walter Huppert. I also thank participants in the Beyond Panaceas Project and three anonymous reviewers for helpful comments and Joanna Broderick for editing.

1. Merrey DJ, Meinzen-Dick RS, Mollinga PP, Karar E (2007) in *Water for Food, Water for Life*, ed Molden D (Earthscan, London), pp 193–232.
2. Knox A, Meinzen-Dick RS, Hazell P (2002) in *Innovation in Natural Resource Management*, eds Meinzen-Dick RS, Knox A, Place F, Swallow B (Johns Hopkins Univ Press, Baltimore), pp 12–44.
3. Wade R (1979) *J Dev Stud* 16:3–6.
4. Agrawal A (2001) *World Dev* 29:1649–1672.
5. Baland J-M, Platteau J-P (1996) *Halting Degradation of Natural Resources* (Food and Agriculture Organization of the United Nations, Rome).
6. Bardhan PK (1993) *World Dev* 21:633–639.
7. Ostrom E (1992) *Crafting Institutions for Self-Governing Irrigation Systems* (Institute for Contemporary Studies, Oakland, CA).
8. Subramanian A, Vijay Jagannathan N, Meinzen-Dick RS, eds (1997) *User Organizations for Sustainable Water Services* (World Bank, Washington, DC).
9. Tang SY (1992) *Institutions and Collective Action* (Institute for Contemporary Studies, Oakland, CA).
10. Uphoff NT (1986) *Improving International Irrigation Management with Farmer Participation* (Westview, Boulder, CO).
11. Ostrom E (2007) *Proc Natl Acad Sci USA* 104:15181–15187.
12. Svendsen M, Meinzen-Dick RS (1997) *Irrigat Drain Syst* 11:139–156.
13. Wittfogel K (1957) *Oriental Despotism* (Yale Univ Press, New Haven, CT).
14. Reisner M (1993) *Cadillac Desert* (Penguin, New York).
15. Chambers R (1988) *Managing Canal Irrigation* (Oxford, New Delhi).
16. Korten FF, Siy RY, eds (1989) *Transforming a Bureaucracy* (Kumarian, West Hartford, CT).
17. Small LE, Carruthers I (1991) *Farmer-Financed Irrigation* (Cambridge Univ Press, Cambridge, UK).
18. Svendsen M (1992) *Assessing Effects of Policy Change on Philippine Irrigation Performance* (International Food Policy Research Institute, Washington, DC).
19. Gulati A, Meinzen-Dick RS, Raju KV (2004) *Institutional Reforms in Indian Irrigation* (Sage, New Delhi).
20. Araral EK, Jr (2005) *Policy Sci* 38:131–157.
21. Coward EW, ed (1980) *Irrigation and Agricultural Development in Asia* (Cornell Univ Press, Ithaca, NY).
22. Lam WF (1998) *Governing Irrigation Systems in Nepal* (Institute for Contemporary Studies, Oakland, CA).
23. Vermillion DL, Sagardoy J (1999) *Transfer of Irrigation Management Services* (Food and Agriculture Organization of the United Nations, Rome).
24. Coward EW (2002) in *Irrigation Investment, Technology, and Management Strategies for Development*, ed Easter WK (Westview, Boulder, CO), pp 225–244.
25. Uphoff NT (1992) *Learning from Gal Oya* (Cornell Univ Press, Ithaca, NY).
26. Gorriz CM, Subramanian A, Simas J (1995) *Irrigation Management Transfer in Mexico* (World Bank, Washington, DC).
27. Rap E (2006) *J Dev Stud* 42:1301–1324.
28. Johnson SH, Vermillion DL, Sagardoy JA, eds (1995) *Irrigation Management Transfer* (Food and Agriculture Organization of the United Nations, Rome).
29. Garcés-Restrepo C, Vermillion D, Muñoz G (2007) *Irrigation Management Transfer* (International Water Management Institute and Food and Agriculture Organization of the United Nations, Rome), in press.
30. Brewer JD, Kolavalli S, Kalro AH, Naik G, Ramnarayan S, Raju KV, Sakthivadivel R (1997) *Irrigation Management Transfer in India* (Sage, New Delhi).
31. Rosegrant MW, Binswanger HP (1994) *World Dev* 22:1613–1625.
32. Hearne RR, Easter KW (1997) *Agr Econ* 15:187–199.
33. Haisman B (2005) in *Water Rights Reform*, eds Bruns BR, Ringler C, Meinzen-Dick R (International Food Policy Research Institute, Washington, DC), pp 113–150.
34. Easter KW, Rosegrant MW, Dinar A (1998) *Markets for Water* (Kluwer, Boston).
35. Bardhan PK (2000) *Econ Dev Cult Change* 48:847–865.
36. Fujiie M, Hayami Y, Kikuchi M (2005) *Agr Econ* 33:179–189.
37. Meinzen-Dick RS, Raju KV, Gulati A (2002) *World Dev* 30:649–666.
38. Mollinga P, Bolding A, eds (2004) *The Politics of Irrigation Reform* (Ashgate, London).
39. Scott JC (1998) *Seeing Like A State* (Yale Univ Press, New Haven, CT).
40. Uphoff NT, Ramamurthy P, Steiner R (1991) *Managing Irrigation* (Sage, New Delhi).
41. Huppert W, Urban K (1998) *Analysing Service Provision* (Deutsche Gesellschaft für Technische Zusammenarbeit, Eschborn, Germany).