Water User Associations and Collective Action in Irrigation and Drainage

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This is a preprint of an article published by Oxford University Press in the Oxford Research Encyclopedia of Environmental Science.

Bruns, Bryan (2023, May 24). [Water user associations and collective action in irrigation and drainage](https://doi.org/10.1093/acrefore/9780199389414.013.791) https://doi.org/10.1093/acrefore/9780199389414.013.791

Summary

If there is too little or too much water, farmers may be able to work together to control water and grow more food. Even before the rise of cities and states, people living in ancient settlements cooperated to create better growing conditions for useful plants and animals by diverting, retaining, or draining water. Local collective action by farmers continued to play a major role in managing water for agriculture, including in later times and places when rulers sometimes also organized construction of dams, dikes, and canals.

Comparative research on long-lasting irrigation communities and local governance of natural resources has found immense diversity in management rules tailored to the variety of local conditions. Within this diversity, Elinor Ostrom identified shared principles of institutional design: clear social and physical boundaries; fit between rules and local conditions including proportionality in sharing costs and benefits; user participation in modifying rules; monitoring by users or those accountable to them; graduated sanctions to enforce rules; low-cost conflict resolution; government tolerance or support for self-governance; and nested organizations.

During the nineteenth and twentieth centuries, centralized bureaucracies constructed many large irrigation schemes. Farmers were typically expected to handle local operation and maintenance and comply with centralized management. Post-colonial international development finance for irrigation and drainage systems usually flowed through national bureaucracies, strengthening top-down control of infrastructure and water management.

Pilot projects in the 1970s in the Philippines and Sri Lanka inspired internationally-funded efforts to promote participatory irrigation management in many countries. More ambitious reforms for transfer of irrigation management to water user associations drew on examples in Colombia, Mexico, Turkey, and elsewhere. These reforms have shown the feasibility in some cases of changing policies and practices to involve irrigators more closely in decisions about design, construction, and some aspects of operation and maintenance, including cooperation in scheme-level co-management. However, water user associations and associated institutional reforms are clearly not panaceas and have diverse results depending on context and on contingencies of implementation. Areas of mixed or limited impact and for potential improvement include performance in delivering water, maintaining infrastructure, mobilizing local resources, sustaining organizations after project interventions; and enhancing social inclusion and equity in terms of multiple uses of water, gender, age, ethnicity, poverty, land tenure, and other social differences.

Cooperation in managing water for agriculture can contribute to coping with present and future challenges including growing more food to meet rising demand; competition for water between agriculture, industry, cities, and the environment; increasing drought, flood, and temperatures due to climate change; social and economic shifts in rural areas including outmigration and diversification of livelihoods; and the pursuit of environmental sustainability.

Keywords: Agricultural water control, collective action, cooperation, community-based natural resource management, hydraulic bureaucracy, irrigation and drainage management, irrigation management transfer, participatory irrigation management, water governance, water user association.

I. Introduction

Working together to manage irrigation and drainage can help farmers grow more crops, reduce risks, and earn more income. Such cooperation may help cope with present and future challenges. Growth in population and income is raising demand for food. Agriculture competes for water with industry, cities, and the environment. Climate change is increasing drought, flood, and temperatures for growing crops. Social and economic shifts such as outmigration, aging, and economic diversification are changing rural societies. Water is vital for environmental sustainability.

Improving the productivity of irrigated agriculture is a key to achieving global goals for sustainable development. These include ending poverty and hunger, better nutrition, equitable access to water, and environmental sustainability (UN, 2022). Globally, irrigation has been estimated to serve 20% of agricultural land, producing 40% of food (FAO, 2022; World Bank, 2020). Due to the constraints on expanding agricultural land, improved management of water for small and large farms is expected to play a central role in meeting future demand for food (De Wrachien et al., 2021). In many countries, crops relying on irrigation, drainage, and other forms of agricultural water control continue to be a crucial source of food and income for smallholder farmers cultivating a few hectares or less of land.

Farmers manage many irrigation systems through various forms of local collective action. Even where government agencies manage irrigation and drainage systems, or at least have primary responsibility for managing headworks and major canals, farmers usually play a leading role in management at smaller scales. They often participate to some extent in co-management of water and infrastructure in the larger system (Frey et al., 2016).

In this article, the term water user association (WUA) includes diverse forms of organization among farmers working together to manage water for agriculture. Small groups of neighboring farmers may share water and infrastructure such as weirs and canals. Large water user associations manage schemes that serve thousands or even hundreds of thousands of hectares. Irrigation WUAs take many forms, including irrigators' associations, irrigation districts, cooperatives, and land improvement districts. These may be autonomous, part of local government, or chartered by government agencies. Collective action to manage water for crops may also occur in contexts such as households irrigating with piped domestic water (Van Koppen & Smits, 2010) and larger scale watershed management. Legally WUAs may be based on general regulations for associations, cooperatives, or companies; specific legislation for WUAs, or supported by legal mechanisms that recognize forms of customary water governance (Hodgson, 2016; Salman, 1997). Or farmers may associate in ways that are informal or legally unrecognized. Organizations and collective action may be nested at multiple levels, within a single association or in federated structures.

Organizations managing water to grow crops may govern water flowing through surface canal networks or a variety of other water resources and infrastructure for agricultural water management (AWM) (Angelakus et al., 2020). This includes wells, springs, weirs, terraced fields, drainage canals, aqueducts, tunnels, and pipes, as well as levees (dikes and polders) that retain water or protect against floods. The scope of this article covers irrigation not only in narrow terms of delivering water to crops through canals or pipes but also collective action to manage water for agriculture more broadly, including drainage and flood protection.

Theories of collective action help understand why and how cooperation occurs. Analysis typically starts from the insight that simply having a shared interest in actions that would make things better is usually insufficient to ensure that cooperation happens (Olson, 1971). Instead, it is usually necessary to overcome problems of collective action, such as creating common understanding, coordinating on shared strategies or norms, building trust, and agreeing on enforceable rules (Ostrom, 1990; Holzinger, 2003). Much attention has concentrated on solutions for situations where individual motivations tempt people away from cooperation that would make everyone better off, for example contributing to maintenance of shared infrastructure or equitably sharing water. These situations are usually framed as social dilemmas (Dawes & Messick, 2000; Kollock, 1998). This is also discussed in terms of cooperation in prisoner's dilemma situations in game theory (Axelrod, 1984), tragedy of the commons (Hardin, 1998; Ostrom, 2008), and free-rider problems (Olson, 1971). Joint action to produce collective goods often involves conflict and contestation over how benefits and costs are distributed: who gains more, or less, or loses, for which a variety of game theory models may be relevant (Taylor & Ward, 1982). Collective action typically also faces second-order collective action problems (Heckathorn, 1989) of motivating people to lead, and the associated issues of trying to prevent leaders (principals and their agents, such as rulers and government officials) from abusing authority (Fargher, 2016). These are challenges that water users have faced and sometimes solved with some degree of success, through self-governance or in combination with governments (Ostrom, 1997; Sarker, 2013).

This article discusses what water user associations can do, factors that affect various forms of local collective action in irrigation and drainage, and how water user associations (WUAs) might help respond to local and global challenges and opportunities. Major themes include co-management of irrigation by communities and states, the diversity of water governance institutions, and the resilience of local cooperation in managing water to grow food.

The article begins by looking at the long history of cooperation in irrigation, presents institutional design patterns in long-enduring local irrigation communities, points to the prevalence of co-production and co-management by states and communities, examines lessons from efforts to develop WUAs in the late twentieth and early twenty-first century, and highlights current challenges and opportunities for WUAs. The end of the article provides references and recommended readings.

II. Ancient Cooperation in Irrigation

Archeological research in recent decades has explored the diversity of ancient societies and the importance of cooperation, including collective action in managing water to grow food (Carballo et al., 2014; Scarborough & Lucero, 2010). For many thousands of years before crop domestication, people who still primarily relied on foraging (hunting and gathering) also used their knowledge, skills, and tools to create favorable conditions for plants and animals, constructing diverse ecological niches. In addition to small wandering bands this included permanent or seasonal settlements in ecologically rich areas such as coasts, estuaries, and rivers, and gatherings to hunt migrating herd animals and fish. This shows a long history of larger-scale collective action in groups of many hundreds or thousands of people. This required coping with the complexities of specialized social roles, disciplined cooperation, accumulation of property, inheritance, and various forms of social difference and inequality (Arnold et al., 2016; Boyd & Richerson, 2021; Graeber & Wengrow, 2021; Singh & Glowacki, 2021). There are still many questions and debates about how and why agricultural domestication and intensification occurred in different areas around the world. Early agriculture took place in diverse locations, including floodplains, wetlands, and terraced hillsides. Although households did much of the work, this often involved some degree of coordination among neighbors and larger groups of farmers. As an example, archeological evidence and historic records in Central America suggest that much cooperation for water control, for domestic or agricultural use, may have taken place among households and neighborhoods (Chase, 2019; Scarborough & Lucero, 2010).

Construction of larger dams for diversion and storage, and canals for irrigation and drainage also seems to have occurred in some early societies that appear to have had relatively egalitarian social organization, as well as in places where rulers were involved in construction and management. Rather than requiring a unified hierarchy, collective action may occur within contexts of heterarchy, meaning interaction and cooperation among individuals and groups who are unranked or who may be ranked in different ways by different criteria, for example in terms of religious influence, economic exchange, wealth, political power, or settlement size (Crumley, 1995; Cumming, 2016). Societies using irrigation have varied in the extent of social stratification, inequalities in wealth and power, and many other characteristics. There appear to have been multiple paths to social complexity, and substantial variation in the influence of religious activity, charismatic leadership, political hierarchy, social stratification, taxation, slavery, and other social institutions (Feinman & Nicholas, 2016).

Research on a set of thirty pre-modern societies (Blanton & Fargher, 2007; Blanton, 2016; Fargher & Blanton, 2021) analyzed variation in the extent to which they provided collective goods, including roads and water control for irrigation, urban water supply, and sanitation. These societies faced the challenges of how to effectively arrange large scale collective action,. This involves fundamental questions of governance, including how to mobilize resources (Levi, 1989) and how to control rulers (principals), such as chiefs and kings, and their officials (agents) (Fargher, 2016). The power of states to shape society (Mann, 2008) may be arranged and partially constrained through social institutions, such as moral codes, bureaucracies with salaried officials and open recruitment, land registries for taxation, accountable procedures, and appeal mechanisms (Blanton & Fargher, 2007). States that relied more on internal revenues, such as from farming and trade, tended to provide more collective goods, including water infrastructure. By contrast, states that relied primarily on other sources of revenue such as monopolistic control over long-distance trade or royal estates with unfree labor tended to provide less in the way of collective goods. To the extent that powerful bureaucracies or autocratic regimes sometimes may have built and tightly controlled large irrigation works (Wittfogel, 1957), these represent part of a diversity of possible institutional arrangements. Rather than only acting through unilateral top-down control, state roles in hydraulic infrastructure often seem to involve joint investment, co-production, combining contributions from governments and farmers (Blanton & Fargher, 2007).

Furthermore, households and local groups could usually build or maintain much of the infrastructure for water control on their own. This could occur even in societies that did also mobilize massive amounts of labor to build ceremonial centers, palaces, or large-scale hydraulic infrastructure such as dams, reservoirs, and long-distance canals (Scarborough & Lucero, 2010; Chase, 2019; Klassen & Evans, 2020). At the local level, rather than fragility or complete collapse, communities often seem to have been able to sustain agricultural systems, including water infrastructure, surviving the rise and fall of kings and dynasties. Large and extensive hydraulic systems, such as landscapes reshaped with canals and reservoirs (tanks) in Sri Lanka or earthen berms to redirect and retain floods in Angkor, could represent the cumulative product of generations of effort by rulers and farmers, without requiring continuous central control (Leach, 1959; Stargardt, 2019; Klassen & Evans, 2020).

Overall, archeology, history, anthropology, and other social science show substantial variety in how farmers and governments have organized irrigation and other collective action for agriculture and water control, with much scope for primarily local construction and management. Even where states did build ambitious works, much of the maintenance and operation seems likely to have relied on local organization, a mix of top-down and bottom-up institutions (Chase, 2019; Klassen & Evans, 2020). The extent to which governing elites used their power to engage in predatory exploitation or to provide public goods to benefit the populace varied, over time and between places (Blanton & Fargher, 2007; Fargher & Blanton, 2021). Ancient collective action in governing water for agriculture shows a mix including largely local autonomous efforts in some cases and other cases that often combined local and larger-scale organization in water governance.

III. Design Principles for Governing Irrigation Commons

At a local level, communities in Spain, Nepal, Southeast Asia, the Andes, East Africa and many other places have successfully managed irrigation systems, sometimes for centuries or millennia (Ostrom, 1992). The community-level water courts of Valencia in Spain have been settling disputes for over a thousand years. Irrigation in this area incorporates technologies, terms, and institutional arrangements derived from earlier Islamic society (Maass & Anderson, 1978; Glick, 2013; Nordman, 2021).

Irrigation organization takes many forms for reasons that among other things reflect adaptation to local conditions and particular paths of local history. Variety in rules for sharing water, mobilizing labor, and other institutional arrangements shows that there are many different ways to manage irrigation. There is no single "best practice" or panacea solution for how to organize irrigation governance (Meinzen-Dick, 2007; Ostrom, 2007). Irrigation organization clearly relates to environmental conditions, physical aspects of infrastructure, and to social conditions. However, empirical evidence reveals substantial potential for development of diverse institutions, rather than being strictly determined by ecological factors or imperatives of scale or political power. Research on governance of irrigation systems and other common-pool resources such as fisheries, forests, and rangeland has found great diversity in the rules and other practices people use to manage shared natural resources, However, analysis has identified some general principles (or recurrent patterns) of institutional design in long-enduring commons (Ostrom, 1990; Cox et al., 2010). Many of these systems shared design principles including:

- clarity about social and physical boundaries,
- fit (congruence) between social institutions and environmental conditions, including proportionality between investments and benefits,
- involvement of users in making rules,
- monitoring by users or those accountable to users,
- graduated sanctions for enforcing rules,
- availability of low-cost institutions for resolving disputes,
- government tolerance or support for local self-governance, and
- nested or polycentric organization.

However, these principles by themselves are not sufficient to ensure success in terms of institutional endurance, resource condition, equity, efficiency, or other criteria. Furthermore, the importance of particular principles varies with local conditions. Other factors besides those listed in the design principles may be more important for successful resource governance (Frey, 2020). These patterns do offer some starting points for analyzing institutions, amidst a variety of other factors whose influences may be complex and sometimes highly contingent on specific local circumstances. The design principles suggest questions to consider for irrigators, local leaders, government officials and others involved in assessing or crafting irrigation institutions (Ostrom, 1992). The design principles also raise important questions about the political economy of such institutions.

- Who is included? Who is excluded?
- Who has power in making decisions?
- How are benefits and costs distributed?
- How to establish and control the power of those who monitor, enforce sanctions, resolve conflicts, and represent irrigators?
- How can local autonomy in self-governance co-exist with larger scale organization?

Research on local collective action in irrigation has highlighted a variety of socio-technical relationships. Farmers have found a many ways to organize themselves and carry out functions such as construction, operation, maintenance, resource mobilization, and conflict resolution (Coward, 1980; Maass & Anderson, 1978; Mabry, 1996; Ostrom, 1992; Uphoff, 1986). For canal irrigation, the greatest potential for cooperation may exist at intermediate levels of scarcity, in an "inverse-U" shaped curve between abundance and severe scarcity (Uphoff et al., 1990). Farmers at the upstream end of a canal may be able to take water away from those downstream. However, the advantages of being upstream may be counterbalanced by need for contributions from downstream farmers to build and maintain weirs and canals (Ostrom & Gardner, 1993; Janssen & Rollins, 2012). Other needs, such as coordinating fallow periods to control pests, may also help to balance interests between upstream and downstream farmers. Irrigators may be embedded in networks of social relationships, including religious rituals (Lansing, 1991, 2006). Understanding of community-managed (communal) irrigation systems has often been framed in relation to government policies and programs, including efforts to formalize governance (Aubriot, 2022). Much recent research on water governance emphasizes the need to understand the complexity of local institutions and contexts (Hassenforder & Barone, 2019).

Research and policy discussion has often focused on famous examples of well-organized canal irrigation based on reliable water flows, such as Valencia in Spain or Bali in Indonesia, and treated these as normal or ideal examples of irrigation management. However, there are a diversity of different institutional and technical responses to other opportunities and problems for agricultural water control, such as small reservoirs (ponds, tanks) with multiple uses (Sengupta, 1991; Mosse, 2006; M. Shah, 2004; Venot, 2014), irregular (flashy) spate flows in arid environments (Fadul et al., 2021; Mehari et al., 2011; Varisco, 1983), groundwater pumping (Llamas & Martínez-Santos, 2005; T. Shah, 2009), flood recession agriculture, and socio-ecological niches in wetland agriculture based on retaining, blocking, or draining floods along rivers and in deltas (O'Connor, 1995).

IV. Lessons from Promoting Participation

During the nineteenth and twentieth centuries, governments organized the construction of many large irrigation and drainage systems, including in the colonial empires of European countries. International development efforts after World War II contributed to a dramatic expansion of irrigation in many countries. Funding was usually channeled through irrigation bureaucracies, strengthening their control over and their benefits from irrigation investments (Repetto, 1986; Chambers, 1988; Araral, 2005). There was usually little involvement of farmers in planning, even when this irrigation expansion overlaid or destroyed existing farmer-built irrigation systems. This top-down control contrasts with the more prominent role of water user associations in irrigation planning and management in parts of Europe, Latin America, United States, Japan, Australia, and elsewhere. Project designs typically assumed that local communities would manage at the local level, for example "tertiary" canals serving a few hundred hectares or less. It should be noted that expansion of irrigation and drainage usually included not only construction of large-scale infrastructure such as dams, reservoirs, and canal networks, but also the immense amount of work farm households did to create, maintain, and improve irrigated fields.

Many government-built irrigation and drainage projects came under criticism for deficiencies in water delivery and infrastructure maintenance and for falling short of the planned outcomes in terms of area irrigated, crop production, and income. Increasing farmer participation was suggested as one way to improve irrigation systems, including as part of arguments for greater decentralization and democratization of development (Knox & Meinzen-Dick, 2001). In the 1970s, pioneering initiatives in the Philippines, Sri Lanka, and elsewhere employed community organizers to facilitate farmer organization and participatory irrigation management (PIM) in the design, construction, operation, maintenance, and improvement of irrigation systems (D. C. Korten, 1980; F. F. Korten & Siy, 1988; Uphoff, 1991). Mexico became a model for ambitious programs for irrigation management transfer (IMT), turning over governance authority to water user associations, for small and medium size irrigation systems or for secondary irrigation canals covering hundreds or thousands of hectares within larger irrigation systems (Johnson et al., 1995; Rap, 2006; Svendsen et al., 2000).

Many of these approaches to PIM and IMT were inspired by community-based management of irrigation and other natural resources. However, government-managed irrigation systems differ in important ways that make the applicability of principles based on community schemes questionable (Hunt & Hunt, 1976; Hunt, 1989). Within traditional irrigation communities, people typically connect with each other in complex networks of multiple social relationships. These reinforce trust and compliance with local norms and rules. Communities can more easily create and change institutions in response to local needs. Farmers who grow subsistence crops for their own consumption have different concerns and priorities from farmers growing crops primarily for sale. Where multiple communities receive water in large schemes in which government agencies manage major infrastructure this poses many more challenges for collective action.

The promotion of WUAs by governments and international development organizations can be seen as a large-scale "natural experiment" exploring this type of institutional intervention across a variety of conditions. PIM and IMT have offered an attractive and influential set of concepts, narratives (stories), and policy models. Such ideas provide a basis for analysis, planning project design, and for discussion about alternative approaches. However, "nirvana narratives" can also oversimplify and obscure power, politics, and the diversity of local contexts (Molle, 2008).

The rest of this section examines some issues and suggests lessons from international experience with promoting the development of WUAs. It draws on a variety of sources that also offer further analysis and additional references (Goldensohn, 1994; Baland & Platteau, 1996; D. Vermillion, 1997; Groenfeldt & Svendsen, 2000; T. Shah et al., 2002; Mollinga & Bolding, 2005; D. Vermillion, 2006; Garces-Restrepo et al., 2007; Ghazouani et al., 2012; Senanayake et al., 2015; Aarnoudse et al., 2018).

It should be noted that the literature on irrigation reform primarily takes the perspective of national governments, international development banks, and other "donors" (international development finance organizations). Policy-related research often pays less attention to how things look from the perspective of farmers (or agency field staff). It also often assumes the benefits of WUAs, rather than empirically examining whether and how cooperation in specific contexts can solve collective action problems and yield worthwhile benefits to farmers.

A. Participation can be improved

Many projects have shown that formal water user associations can be established. Farmer involvement in design, construction, and co-management can be increased, in policy and practice. This can reduce problems during project implementation and increase benefits for farmers. Practical examples include providing local knowledge about historic flood levels, aligning canals to fit farm boundaries and field conditions, coordination that reduces disruption to farming while allowing construction to proceed more smoothly, and more effective, equitable, and productive distribution of water. Policies to support participation have been formally issued, agency staff trained, and projects implemented working with farmers and WUAs.

Fielding of community organizers to facilitate participation has been a key intervention, intended to help people organize themselves and overcome obstacles to collective action (Bruns, 1993). This includes activities such as engaging farmers, local leaders, and irrigation staff in informal discussion, meetings, and canal walk-throughs to look at and discuss irrigation problems, solutions, and priorities. For facilitators, projects have recruited recent graduates, contracted with non-government organizations, retrained existing government staff, or hired community members. Some projects have placed more emphasis on intensifying cooperation with existing organizations and simplifying procedures for farmer self-organization. The prospective benefits from development projects can usually induce some level of participation. However, this may be differently organized and less sustainable than traditional locally-developed institutions (Mansuri & Rao, 2012).

"Big bang" approaches to rapid reform, such as in Mexico and Australia, were driven from the top down. They were part of broader reforms in government policies and built on the long irrigation experience of agencies and farmers. Many countries followed more gradual approaches, sometimes including prolonged pilot projects. Cases such as the Philippines and Andhra Pradesh were pointed to as demonstrating the potential for extensive transformations in how bureaucracies work with communities (F. F. Korten & Siy, 1988; Oblitas et al., 1999; Mollinga et al., 2004). However, these cases also show easily participatory reforms may be halted or reversed when high-level political support disappears, for example through the appointment of a new agency head or a different political party coming to power.

Comprehensive packages of reforms in irrigation institutions can be prescribed. Governments and agencies may agree to policies and projects, especially as a condition for receiving international financial assistance. However, ambitious reforms have often proved difficult or impossible to implement in practice. One response is to recommend better analysis, negotiation, and much stronger involvement of farmers and other stakeholders, as part of major structural reforms in irrigation policies and agency practices to ensure a better context for WUA development (Merrey et al., 2007; Lankford et al., 2016).

B. Farmers and governments want continued cooperation

Projects for irrigation management transfer often justified their investment as a means to reduce recurrent government expenditures on irrigation and increase contributions from farmers, typically framed in terms of "cost recovery." This was promoted as a way to escape a vicious circle of inadequate resources, neglected maintenance, poor service delivery, and inefficient rehabilitation.

The notion of "cost recovery" is often discussed without considering how the cumulative impact of investment reduces costs for consumers (by shifting the supply curve and lowering food prices) so that consumers rather than farmers receive most of the benefits of irrigation projects (Sampath, 1983). Furthermore, the value of increased farm production is often capitalized into land values, benefiting landowners rather than raising returns to labor (Ostrom, 1992). In terms of economic analysis, simply shifting costs from government to farmers does not yield net benefits to society. The potential for genuine economic gains depends on changes in the relationship between benefits, such as crop production, and costs, such as costs of maintenance, along with the question of how the benefits and costs are distributed.

To the extent that projects for irrigation management transfer were inspired by visions of stopping subsidies and shrinking government roles, in most cases this does not seem to have occurred over the longer term. Furthermore, that was usually not a change that farmers or irrigation bureaucrats were interested in pursuing, even if reduction in government roles was part of a 1990s era "Washington Consensus" orthodoxy in international development ideas. The prevalence and persistence of subsidies for irrigation in low-, middle-, and high-income countries around the world suggests the strength of political and economic factors favoring subsidies for farmers and for water infrastructure (Browne et al., 1992; Bauer, 2004). Rather than hoping to eliminate subsidies it may be more effective to reshape financial flows in ways that offer better incentives for efficiency and productive cooperation between governments and farmers, "smart subsidies." This could include mechanisms that enable WUAs to finance larger investments that they consider worthwhile.

There was much attention, effort, and debate about transferring formal legal ownership or management authority to WUAs (Johnson et al., 1995; D. L. Vermillion & Sagardoy, 1999). In principle, WUAs do need ways to ensure water users follow rules. However, governments have often treated WUAs like voluntary associations or cooperatives. As discussed in the reviews of PIM and IMT cited above, governments have often not followed through on reforming or implementing policies to strengthen WUA legal authority to control infrastructure, allocate water, enforce rules, or finance major investments. In practice, especially at the local level, farmers often find ways to assure cooperation, for example through informal social sanctions and through working with local authorities and agency officials. In retrospect strengthening the formal legal authority of WUAs and transferring ownership seem to be much less relevant than the potential for improving communication, coordination, and other forms of co-management between agency staff and farmers. In particular, improving linkages between government staff and WUAs may offer a key opportunity for improving irrigation performance (Suhardiman & Giordano, 2014). However, this may only work if farmers, and their organizations or social movements, have sufficient political influence and support.

C. Impacts of Institutional Changes on Irrigation Performance Have Been Modest

Projects have rehabilitated irrigation infrastructure and developed WUAs. However, it is not clear how much impact institutional reforms have had on performance in water service delivery, infrastructure maintenance, and resource mobilization. Some projects, involving changes in both institutions and infrastructure, do provide benefits such as increased supplies of water, less leakage from canals, delivery to larger areas, and better control over the timing and quantity of water delivery. These changes may raise production and income, and participation can contribute to better design, construction, and utilization. This could include more equitable sharing of water with downstream sections of irrigation systems, and better coordination and communication about plans for planting crops. PIM and IMT projects do seem to have achieved some changes in institutions without worsening performance in service delivery. However overall impacts on performance in delivering water seem to have been modest. Reviews of research on the impacts of projects for participatory irrigation management and irrigation management transfer show mixed results, positive, negative, and inconclusive. Reviewers point out major deficiencies in terms of methods, data, criteria, and representativeness, along with the need for better information on change processes, (Ghazouani et al., 2012; D. Vermillion, 1997; Senanayake et al., 2015). In many cases, project design and monitoring focuses on setting up an institutional apparatus without targeting or measuring performance indicators such as changes in water service delivery, functional condition of infrastructure, or the level of continuing investment in repairs and improvements.

One perspective on the generally limited impact of institutional reforms argues that institutional changes may have little effect on performance unless there are also major changes in irrigation operations and infrastructure, "modernization," to enable much more precise water measurement and control (Plusquellec, 2002; Renault et al., 2007, 2013). However, thorough modernization of operations, infrastructure, and institutional arrangements may depend on capacity to carry out a complex and highly customized design process, and on willingness and ability to change entrenched doctrines and procedures for irrigation operation, conditions which are often not present.

D. Villages and Local Governments also Govern Water

Projects have often rigidly insisted on organizing WUAs along the hydraulic boundaries associated with shared irrigation canals. This may be justified by an interpretation of research on some well-studied traditional irrigation communities. It may also conveniently match the views and interests of irrigation bureaucracies in having a separate local organization directly under their control or supervision. However, this can ignore and disrupt existing local institutions associated with village communities and local government where these had been present, such as, for example, in Turkey, Indonesia, and Vietnam (Bruns, 2013; Popkin, 1979; Svendsen & Nott, 2000). It also may miss an opportunity to build on the strengths of local governments (Ribot et al., 2008).

In practice, irrigators may find ways to comply with new organizational structures while maintaining traditional management patterns. They may combine available ideas and practices in a creative process of institutional bricolage, improvising and adapting new and old rules to fit their situation (Cleaver, 2012; Merrey & Cook, 2012; Bruns, 2013). This includes the question of whether and how existing local roles in irrigation management, such as "watermasters" and the people holding those positions are or are not incorporated into formalized institutions, along with customary practices such as for water allocation and resource mobilization. It should be noted that “traditional” irrigation leadership roles may themselves derive from or have been influenced by the way in which earlier government activities, including colonial governments, recognized or sought to control such roles within irrigation communities.

Rather than a single institutional model based on specialized user groups, as often promoted by government policies and projects, a variety of institutional mixes and hybrid arrangements seem to be possible. Part of this variation may be measured in terms of the roles of states and communities in co-management (Frey et al., 2016). These could involve farmer organizations, community institutions, and local and national government agencies, as well as roles for paid staff and private sector service providers. Developing a suitable set of institutional arrangements may in part depend on the history and capacity of different organizations, as well as the benefits and costs of collective action for different tasks.

As one example of institutional diversity, drainage and flood protection may require major mobilization of resources for initial construction, and occasional maintenance and repair, but not require the routine cooperation and control needed for water distribution in canal systems. Thus, for leadership, and for authority to enforce rules and mobilize resources, drawing on the capacity of local governments may offer advantages in cases that require more episodic rather than routine collective action.

Organization based on entire communities of water users, not just irrigation user groups, provides a way to include a broader range of stakeholders such as domestic water users, fishers, and owners of large or small livestock (e.g. sheep and goats) and to promote more inclusive processes and more equitable outcomes (FES, 2010, 2021). Rather than insistence on single-purpose WUAs focused only on irrigation, there may be synergies that could profitably link farmers with suppliers and buyers, as well as sources of agricultural knowledge and finance (T. Shah et al., 2002).

While there are many different ways to organize WUAs, those involved need to consider not just owners of irrigated land but also questions such as:

- What is the relationship to hydrological boundaries while also ensuring authority to govern and work effectively with local governments and other administrative jurisdictions and agencies?
- For various water users in the local context, what are the most important needs and opportunities for collective action in irrigation and drainage management?
- How to involve not just landowners but all those who cultivate irrigated crops including household members of all ages and genders, sharecroppers, renters, and agricultural laborers?
- How to engage with multiple uses and users of water including domestic water, home gardens, livestock, aquaculture, fisheries, and more?
- How can farmers work together to better deal with buyers and suppliers of goods and services for irrigated agriculture (value chains), including sources of information and finance?

E. WUAs are Less Active Post-project

The potential benefits of construction and expanded irrigation are often sufficient to induce WUA establishment and cooperation with project activities (Garces-Restrepo et al., 2007; Mansuri & Rao, 2012). However, in many cases WUAs become much less active post-project

(Molle et al., 2002; Ghazouani et al., 2012). In part this is because the formal aspects of establishing WUAs, such as holding meetings, choosing leaders, and registering documents are much easier to accomplish and monitor than more substantive results, such as equity in water distribution and adequacy of maintenance. Measuring project performance in terms of organizational paperwork rather than delivery of water and maintenance services risks creating the form but not the substance of institutions, "isomorphic mimicry" (Andrews, 2013). Nevertheless, even where formal WUA activities fade, farmers often continue to mobilize for urgent needs, such as cleaning and repairing canals at the beginning of the irrigation season, water distribution during periods of shortage, and emergency repairs. They may use WUAs as a forum for communication with government, such as in requesting financial support or resisting unwanted interventions (Verzijl & Dominguez, 2015). There could also be pseudo-WUAs that look like WUAs on paper, but are actually under the control of individuals or small groups (Theesfeld, 2019). Larger WUAs with specialized paid staff, including for management and accounting, are more likely to continue functioning through formal procedures. However, this may also depend on receiving continuing support from government staff and having sufficient capacity to deliver effective services.

F. Governing Groundwater Is Complex

Beginning in the latter decades of the twentieth century, individual farmers have dramatically expanded irrigation using small privately-owned mechanized pumps and tubewells, particularly for groundwater. This "silent revolution" hugely increased access to water and income for farmers in India, China, and elsewhere, while often drawing down aquifer water levels (Foster & Chilton, 2020; Llamas & Martínez-Santos, 2005; Molle et al., 2003). Farmers in Africa and elsewhere are continuing to expand irrigation using small privately-owned pumps, in a process of farmer-led irrigation development (FLID) (Woodhouse et al., 2017). Africa in particular has relatively little irrigation at present and opportunities for tapping large and renewable aquifers (Pavelic et al., 2013; Wijnen et al., 2018; Cobbing & Hiller, 2019). Solar-powered pumping has potential to benefit smallholders, while also posing questions about detecting and limiting negative impacts on local and downstream water availability and ecosystems (T. Shah et al., 2018; Otoo et al., 2018; Gebregziabher et al., 2019).

Groundwater is harder to observe and understand and is usually extracted from individual wells, and so does not require the kind of collective action typical of canal irrigation systems (T. Shah, 2009). There are cases where communities have limited well installation and restricted crop choices and where farmers and local groups cooperate to replenish groundwater (Aslekar et al., 2022; Zwarteveen et al., 2021; Steenbergen & Shah, 2003). Government efforts to require measuring or controlling groundwater withdrawals, including as part of efforts to develop water user associations, often meet resistance and tend to fail. Examples of successful groundwater governance in practice are still scarce (Molle & Closas, 2020).

There are well-developed recommendations for systematic and integrated approaches to groundwater governance including WUAs and other stakeholders (Villholth et al., 2018). These typically assume substantial government capacity and political support. Rather than trying to directly measure and control groundwater withdrawal, a more feasible option in some cases may be to focus on collective action to coordinate more easily-monitored choices about crop selection and timing (Das & Burke, 2013). Educational "games" offer a practical way to help people understand groundwater and options for improving management (Meinzen-Dick et al., 2016). California's Sustainable Groundwater Management Act (SGMA) offers an interesting example of a regulatory strategy intended to gradually develop local self-governance of groundwater, with substantial facilitation, technical, legal, and financial support (Lubell et al., 2020).

G. Interventions Tend to Reproduce Social Differences

Project interventions may reduce but mostly tend to reproduce and sometimes worsen existing social differences, such as inequalities related to landholding, age, gender, type of water use, and social marginalization. From critical perspectives that center issues of equity and justice, there is a need and opportunity to do much more to improve social inclusion and achieve more equitable processes and results from irrigation and other development projects (Lefore et al., 2019; Mdee & Harrison, 2019). Recent guidelines illustrate approaches designed to facilitate inclusive local decision-making in developing WUA governance (Merrey & Lefore, 2018) and to assess and identify ways to improve gender equity in irrigation (Lefore et al., 2017).

In many places, irrigation governance has typically been assumed to be a male activity. This occurs even where women may be highly involved in irrigated agriculture including managing water in fields and canals. In many parts of Africa and elsewhere, women manage farms, as well as using water for domestic use and home gardens. Many projects have tried to overcome the tendency for WUA leadership and membership to be exclusively or primarily male and tried to improve the inclusion of women in WUAs. This could include specific measures such as gender analysis of local irrigation practices, requiring gender quotas for leadership positions, facilitating women's preparation for and representation at meetings, and holding meetings at convenient times and places. It is not clear how much impact such efforts have had beyond attendance at meetings and selection of some women for roles such as secretary or treasurer. In some cases, such seemingly token participation might initiate significant and locally acceptable changes that open the door to longer-term shifts in norms and practices. Recent analysis of gender-related changes in irrigation governance in Nepal does reveal gendered ways communities have adapted constructively to changes including male outmigration, mechanization, improved transport, and commercialization of agriculture (Meinzen-Dick et al., 2021).

A prominent issue and topic of debate about efforts to increase community involvement in the governance of natural resources concerns who controls decisions and who benefits. This is typically discussed in terms of the risk of "elite capture." It can be important to distinguish between how elites are involved in decisions and questions about who benefits. In some cases, elites may control decisionmaking without disproportionately capturing benefits. This may be due to factors including electoral accountability, contestation between elite groups, and community norms, effectively "capturing elites" (Dasgupta & Beard, 2007; Warren & Visser, 2016). Requirements for elections and other good governance practices intended to promote more inclusive and democratic decisionmaking may work in some cases, may be ineffective, or may have an impact only over longer time scales (Lund & Saito-Jensen, 2013). Considering power, distribution of benefits, and the role of elites also raises key questions about what reforms may be feasible in specific situations and whose criteria to use in assessing reforms. This may be a challenge even when projects are implemented with strong attention to political economy, concern about voice and equity, and "working with the grain" of local institutions (Whaley et al., 2021). A key underlying question of political economy concerns the extent to which rural people organize and can get politicians and government agencies to respond to their concerns.

H. Lessons

A recent review of international experience with developing WUAs suggests that conventional approaches, typically emphasizing policies, regulations, contracts, and training, have not been sufficient to reach intended goals, including participation in irrigation management and collection of sufficient fees for operation and maintenance to create a virtuous circle of improvement (Aarnoudse, Closas, and Lefore 2018; see also Bizikova et al. 2020). The authors conclude that at this point, it appears questionable whether further efforts to organize formal WUAs will have much impact unless strategies shift. They suggest alternative strategies including:

- a more specific focus on participatory design of investments,
- multi-stakeholder platforms for innovation in irrigated agriculture (Van Rooyen et al., 2017; Schut et al., 2019) and for representation in basin water allocation,
- joint management of water delivery by agency field staff and WUAs as a key activity,
- multi-functional WUAs engaged in agricultural value chains,
- WUA partnership in contracts with private operators, and
- combining WUA management of surface and groundwater.

More generally, future opportunities for improving collective action in irrigation may be more likely to lie in approaches where farmers and other stakeholders take a leading role in working together to solve specific problems in ways that fit meaningfully with their political situation and their economic and ecological context (Cleaver, 2012; Waalewijn et al., 2019). Rather than the array of systemic and relatively standardized reforms that have characterized PIM and IMT policy recommendations, with projects focused on a single organizational model or process, this may involve more diverse, flexible, and customized approaches: contentious, messy, pragmatic, and incremental, that follow pathways dependent on local history, strategic alliances, and political possibility.

V. Contemporary Challenges and Opportunities for WUAs

This section discusses some of the ways in which WUAs may be able to play an important role in coping with contemporary challenges including increasing food production, improving the lives of smallholder farmers, sustaining irrigated landscapes, adapting to climate change, and sharing water among competing uses and users. Responding to these challenges may benefit from appreciating and building on the strengths of existing collective action by water users, and understanding how government policies and programs may support changes that serve both local and broader goals. In the context of changing conditions, this poses questions of institutional choice about how water user associations are organized internally, and about the roles and relationships between WUAs, government agencies, businesses, NGOs, and other actors and organizations.

A. Water for Food

Population growth, rising incomes, and shifting diets will continue to increase demand for food, including higher-value fruits and vegetables as well as grains for humans and livestock (De Wrachien et al., 2021; Molden, 2007). Globally, the potential for further conversion of land to agriculture is limited and such conversion would also reduce carbon storage and biodiversity. Future increases in food production are expected to come from intensification, more yield from existing land, for which water control can make a crucial difference. In many cases, growing more food will depend on collective action both among neighboring farmers and at larger scales to better manage irrigation and drainage systems and river basins.

B. Farm Livelihoods

Irrigation and drainage, including collective action to govern shared water and infrastructure, continue to play an essential role in the livelihoods of many smallholders, defined as farmers growing crops on two hectares or less. In low- and middle-income countries, most rural households still rely on farming as a major part of their livelihood. Smallholder agriculture has also proved remarkably persistent in middle- and high-income countries. This includes mixed livelihood strategies where farmers combine growing crops with other activities, sometimes called "part-time farming" or "pluriactivity."

Globally, farmers with two hectares or less of land grow an estimated 35% of food, using about 12% of cropland (Lowder et al., 2021; Ricciardi et al., 2018). Small farms make up about 84% of all farms globally. Improving the productivity and profitability of small farms is crucial for achieving global goals to eliminate hunger and poverty. On the other hand, the largest 1% of farms, over fifty hectares, operate more than 70% of farmland. So for food production the involvement of large scale farm operators is also necessary for irrigation governance. Globally there are over six hundred million farms. Family farms, large and small, run by an individual or family and relying on family labor, still make up 90% of farms, operate about 80% of agricultural land, and produce about 80% of food by value.

Irrigation is conventionally estimated to serve only about 20% of farmland, while producing about 40% of food (World Bank, 2020). However, statistics on irrigated area in many countries leave out substantial areas of small-scale locally-constructed irrigation and drainage, and informal or unauthorized pumping from formal irrigation systems as well as pumping from lakes, streams, wetlands, and aquifers. Improved water management is likely to also be crucial on much of the land that is currently rainfed. This includes expanded use of shared groundwater and surface resources, as well as on-farm activities such as reshaping land for better rainfall retention and infiltration, and construction of storage ponds. Cooperation, including through water user associations, may help manage and reduce impacts on neighboring farms, underlying aquifers, and those further downstream.

Shared interests in irrigation and irrigation organizations are part of the social fabric of many rural communities. As irrigation becomes a less important part of their portfolio of livelihood activities, farmers may be less inclined to invest time and effort in collective action to manage water. However, they may also adapt institutional arrangements. WUAs may shift to contributions of money rather than labor, increase mechanization and automation, and rely more on paid staff for system operation and maintenance. The mix of activities may also shift between WUAs, government agencies, and other service providers (Frey et al., 2016).

Demographic, social, and economic changes strongly affect rural communities, especially as people move to cities and those who stay in farming grow older. In some areas, such as much of Africa, jobs for youth are an urgent priority. Politically, concerns about farmers and food often continue to be very influential in elections and political discourse. Governments are likely to continue to be concerned about and subsidize irrigated agriculture and water infrastructure. Government policies and actions are influenced by and influence water user associations and other rural groups. Policies aimed at rural economic development are likely to continue to seek ways to protect farm incomes, including in combination with stewardship of rural landscapes and ecosystems.

WUAs in East Asia illustrate divergent paths for WUAs and government roles in irrigation (R. Y. Wang et al., 2021). China has many irrigation systems for which WUAs are responsible at the local level. While there are examples of well-performing WUAs, a large-scale cross-sectional survey indicated WUAs did not on average perform better than villages or district committees in terms of infrastructure condition, maintenance expenditure, disputes, and farmer satisfaction with water delivery (Y. Wang & Wu, 2018). In Taiwan, a 2018 law converted irrigation associations into bureaucratic agencies (Lam et al., 2021). This occurred in a context where farming had become a minor part of the national economy. Government had taken over payment for irrigation services, so farmers no longer had to pay fees. Technological changes such as automation, canal lining, and groundwater pumping had made local cooperation among farmers less necessary. Irrigators associations were seen as an obstacle to intersectoral water reallocation and to efforts to promote more sustainable farming and environmental management (Lam and Tang 2021). In the 1990s, the Korean government incorporated irrigation associations into government-owned corporations that offer a range of agricultural services. In Japan, despite aging and shrinking farm populations, Land Improvement Districts continue to play a key role in irrigation, including activities for water and land conservation.

Similar issues about WUA roles arise for policies affecting rural areas with irrigation in Europe, the Americas, Africa, and elsewhere. Even where operation and maintenance are increasingly done by specialized employees, WUAs may still provide an important forum for communications and decisions, as well as representation in wider-scale governance. There are important options and choices for governments in designing and implementing policies that affect rural livelihoods, and opportunities for governments to work together with farmers through formal WUAs or other forms of cooperation.

C. Sustaining Waterscapes

Many rural landscapes have been shaped to control water, including networks of irrigation and drainage canals, bunded fields, terraces, and levees. Even apparently “wild” habitats may depend on return flows from irrigated fields, overland and subsurface flows that supply wetlands, aquifers, and streams. Broader approaches to environmental management may cover a mosaic of diverse landuses, within which farmers using irrigation are again important stakeholders. This is yet another area where WUAs may represent farmers as important participants in environmental governance. Irrigated landscapes may also be valued as part of cultural heritage, for example terraced rice fields in Bali (Lansing, 2006; Lansing & Kremer, 1993) and the Philippines (Araral, 2013). Farmers and their organizations may act as stewards in conserving and enhancing the ecological and cultural value of such waterscapes.

D. Coping with Climate Change

Climate change illustrates the importance of governance institutions that can adapt to changing conditions. In many places, climate change is increasing the variability of rainfall, producing greater extremes of flooding and drought. Sea level rise and increasingly severe storms affect coastal areas. Higher temperatures require more water for crop transpiration, making an adequate and reliable supply of water more crucial. However, the ways these changes may play out at the local level is uncertain and hard to predict in detail (De Wrachien et al., 2021). Adapting to such changes may require expanding irrigation, improving collective action in agricultural water management, and cooperation to revise rules for sharing water among irrigators and within river basins. Better maintenance and improved infrastructure and operations may also be needed, such as in canal systems. Adaptation may also require or benefit from more systematic transformations in agricultural practices, such as regenerative agriculture that does more to retain water in fields. Transformations in land and water management, such as approaches to "living with floods," can help communities improve preparedness, reduce vulnerability, and increase resilience. Effective adaption in water governance will depend on the knowledge and action of local communities. The need to respond to climate change is likely to stimulate increased investment and effort in irrigation. This includes collective infrastructure such as canals as well as individual pumps that rely on shared water resources such as streams and aquifers. Farmers and WUAs may contribute to this through their direct efforts. They may also monitor and improve accountability for service delivery and resource management.

Methane emissions due to anaerobic conditions in flooded rice fields are a significant source of greenhouse gas. Changes in cultivation techniques, such as alternate-wet-dry irrigation (AWD) and system of rice irrigation (SRI) can reduce methane emissions (Chapagain et al., 2011). However, these irrigation techniques require precise, reliable, and well-coordinated control of water levels and irrigation timing. Therefore, these form another area where collective action for effective local level water management could be crucial. Such shifts in irrigation and crop cultivation are much more likely to succeed if they include participatory planning and deliver benefits that encourage farmers to make changes voluntarily. Co-management with WUAs may offer a fruitful pathway for planning and implementing such changes.

Overall, climate change increases the need for collective action to manage water for crops, efficiently, productively, and equitably. This could build on the many ways in which farmers already formally and informally collaborate to manage water.

E. Sharing Water

In most river basins, there is increasing competition for water, with rising demand for water for agriculture, cities, industries, and environmental needs (Molle & Berkoff, 2006). While each individual farmer uses a tiny amount compared to the water in a river basin, cumulatively farmers usually withdraw and consume by far the biggest share of water. This makes them crucial stakeholders. Water user associations can enable farmers to have a voice in decisions about water allocation and reallocation. This can include preparing plans in advance for dealing with droughts and flooding, as well as more urgent decisions during crises, as illustrated by drought conciliation procedures in Japan (Omachi, 1997).

Higher level federations of water user organizations can help represent farmers' interests and concerns, for example in communicating with legislators and government officials, as well as multi-stakeholder forums in river basins. Farmers usually have valuable local knowledge about the feasibility and social acceptability of various potential solutions. For example, this could include negotiating acceptable arrangements to compensate farmers willing to stop irrigating during a drought. Another example of a change where WUAs may help to coordinate activities is for farmers shifting to use treated wastewater for irrigation. Deliberate storage of water in aquifers may be much cheaper and easier than building new reservoirs. However, this may require coordination to manage withdrawal, consumptive use, and replenishment of aquifers (Blomquist, 1992).

In some cases, WUAs hold formal rights to water, as an organization or on behalf of their members. Social rules related to access and use of water (water tenure) are usually part of local practices and customs. These may be explicitly recognized in legislation regarding land or water, or be implicit in agency practices (Hodgson, 2016). Better understanding of existing water tenure arrangements can help find more workable and fairer options for enhancing equity, productivity, and sustainability in water management.

Achieving genuine increases in water productivity, as a response to increasing scarcity, requires a good understanding of how much water crops consume through evapotranspiration and how changes in irrigation practices affect return flows that are used downstream (Grafton et al., 2018; Perry, 2007). Without this, changes such as drip irrigation that may appear profitable and "efficient" for individual farmers can actually increase overall water consumption. Intensified or expanded crop production may take water away from other users downstream, so that there is little or no net gain at the basin scale. Remote sensing of crop evapotranspiration can help inform the management of crop water consumption, including information provided to WUAs and individual farmers through smartphone apps (Bastiaanssen et al., 2009). WUAs can offer a framework for improving understanding and collective management of shared resources such as surface water and groundwater (FES, 2021). They may be able to help coordinate changes, such as in planting dates, crop choices, and irrigation practices, that avoid wasteful or counterproductive efforts and instead contribute to genuine improvements in water productivity ("real water savings").

Proposals for temporary or permanent transfer of water away from irrigators may meet with opposition. This includes concerns about the implications for the farmers who share the remaining water and irrigation infrastructure (Garrick et al., 2020). WUAs can offer a forum for organizing to protect local interests from harm. They may help negotiate about potential transfers of water away from irrigation in ways that consider community impacts, share benefits from water transfers, and facilitate equitable transitions to more sustainable water governance.

VI. Conclusions

The history of cooperation to control water for growing food offers important lessons about design principles that contribute to successful local governance of irrigation, drainage, and other common-pool resources. Larger irrigation systems have often been built and managed through co-management that combines the efforts of governments and communities. Experience in recent decades shows the feasibility, in some cases, of increasing participation in design, construction, and management of irrigation. However, WUAs are clearly not any kind of panacea. Assessment shows the need for customized approaches to pursue improved impacts in terms of water service delivery, local resource mobilization, infrastructure maintenance, and social inclusion. Going forward, water user associations could play a key role in communication and cooperation to manage shared water resources more productively, equitably, and resiliently. Key questions concern how WUAs may be able to help respond to the challenges of growing more food, coping with changing climates; competition for water within river basins; socioeconomic transformations in rural communities, and sustaining waterscapes.

Efforts to promote the development of WUAs have shown limits to ambitious efforts to transplant institutional models or implement sweeping reforms in the structures and practices of irrigation agencies. In some cases, there may be political conjunctures that open opportunities for major reforms, in which case recommendations based on experience with PIM, IMT, agency reform, and irrigation modernization are available (Merrey et al., 2007; Renault et al., 2007; Lankford et al., 2016). However, in most cases practical opportunities may lie in much more carefully targeted efforts to improve cooperation between communities and government in operating, maintaining, and improving irrigation and drainage systems (Zwarteveen et al., 2017; Aarnoudse et al., 2018; Waalewijn et al., 2019). Prospects seem more favorable if this is done together with other stakeholders, particularly actors in value chains that can make irrigated agriculture more profitable, and where farmers have some political power to get governments to respond to their needs. Rather than being able to rely on a single institutional model or a standardized process, efforts to support and improve collective action in irrigation and drainage face the challenges of understanding and working with institutional diversity. This involves finding ways to pragmatically learn together to craft institutions that fit with local experience, needs, and opportunities, so farmers and other stakeholders can solve problems and make meaningful improvements in their lives.

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VIII. Suggested Readings

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