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Irrigation Management in East Asia: Institutions, Socio-Economic Transformation and Adaptations

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ABSTRACT: Irrigation management encapsulates human capacity for building and sustaining collective cooperation, which is directed at the allocation and utilisation of water as a common-pool resource. Although rooted in rural communities, irrigation management is also subject to macro socio-economic and ecological settings that mediate micro human-nature relations. In East Asia, the long-established tradition of irrigation management has been confronting a series of new challenges such as an ageing and decreasing rural populations, increasing regional and sectoral competition for water, the growing influence of neoliberalism, and shifting public policies that reshape state-society-market interactions. This Special Issue aims at revisiting irrigation management in East Asia against the backdrop of rapid socio-economic transformation. In this introductory article, we set the scene by illustrating why the understanding of irrigation management should be situated in a broader socio-economic and political context. We then briefly summarise the key findings of the collection of papers in this Special Issue. It is shown that external challenges do not necessarily lead to the failure of irrigation management. New features of irrigation practices (for example, institutional reinvention and restructuring) may emerge as public, communal and private actors who co-manage irrigation systems respond and adapt to societal and environmental changes.

KEYWORDS: Irrigation, institutions, socio-economic transformation, adaptation, East Asia

INTRODUCTION

The development of irrigation management requires institutions that are able to effectively allocate limited water resources, maintain public infrastructure, and reconcile conflicts among different actors with divergent pursuits of interests (Coward, 1980). This is an elusive task because, on the one hand, irrigation management concerns building and sustaining collective cooperation in a common-pool resource (CPR) system where short-term self-interested behaviour may jeopardise long-term group outcomes (Dawes, 1980; Buskens and Raub, 2013); on the other hand, however, irrigation management normally is situated in a changing context where evolving ecological, socio-economic and political conditions play an important role in shaping the way institutions emerge, evolve and operate.

Existing studies of irrigation management, inspired by Ostrom's seminal work (Ostrom, 1990, 2010; Ostrom et al., 1994), have mostly focused on the former, namely, institutional designs that may bring about better performance in overcoming social dilemmas (Lam, 1996; Tang, 1992; Cox et al., 2010; Yu et

al., 2016). A relatively understudied, but increasingly essential, subject of irrigation management relates to the relationship between institutions and the context in which they operate. In 2016, the *International Journal of the Commons* published a special issue on "the role of context, scale, and interdependencies in successful commons governance". In that issue, scholars engaged in methodological and theoretical reflections on the successes and failures of Ostrom's design principles across different types of CPR systems, including irrigation systems (Baggio et al., 2016; Anderies et al., 2016). That special issue signified an attempt to explore how the regularities of Ostrom's design principles relate to governance performance in diverse contexts (Schlager, 2016). The relationships between institutions and contexts, however, are multifarious and complex. Contextual variations are also not limited to a particular type of CPR system such as water, fisheries or forestry. Community-based irrigation systems in East Asia, for instance, may be substantially different from those in Latin America in terms of their nested biophysical, cultural and political settings; also, institutional principles for governing an irrigation system may not be applicable to large-scale water systems such as international rivers. In this sense, much contextual complexity remains to be unpacked, and the impact of context on institutional performance is far from fully understood.

In addition to the efforts to identify, compare and catalogue how different contextual variables affect institutional performance, a more critical question concerns the problem of endogeneity with regard to how institutions and diverse socio-ecological contexts interact (Araral, 2014). In other words, most existing studies of CPR institutions have treated institutions and contexts as two separate groups of variables, and the combinations of variables from each group are expected to formulate 'recipes' for successful collective action in different CPR systems. An alternative perspective, however, questions the presumption that institutional variables and contextual variables are mutually independent. Drawing from the tradition of critical social sciences, a group of critical institutionalists (including those working in the fields of sociology, anthropology, human geography and development studies) reject the assumption that institutions are an artificial product of human craft (Cleaver and Whaley, 2018); rather, they choose to view institutions as a result of 'bricolage', which is characterised by dynamic processes of constant modification, reinvention, evolution and legitimisation that are based on whatever resources are available (Cleaver, 2012; Cleaver and de Koning, 2015). They have paid increasing attention to close interconnections between institutions and contexts by associating the emergence and evolution of institutions with key contextually sensitive components such as power, social structure and meaning (Boelens, 2015; Blaikie, 2006; Johnson, 2004; Cleaver, 2002). From this point of view, institutions and contexts are integral to each other because institutions cannot work unless they are legitimised by accepted knowledge, culture and established mechanisms of authority in a specific context (Douglas, 1986; Cleaver, 2000).

East Asia offers a valuable setting for further examination of the relationship between irrigation institutions and contexts. This is not only owing to the critical role that irrigation plays in East Asian societies; it is also because of rapid socio-economic changes that are substantially reshaping the context of irrigation management. In the past few decades, traditional East Asian societies characterised by the region's long history of agriculture and irrigation have been profoundly restructured by urbanisation, neoliberalisation and globalisation. Everyday practices of irrigation have been subject to many new challenges such as industrialised agricultural production, a growing demand for limited water resources, market-based rules and organisations, and large-scale rural-to-urban migration. Meanwhile, small landholdings and small-scale farming have persisted in East Asia despite these broader changes (Rigg et al., 2016; Hazell and Rahman, 2014). Farmers in general have chosen to hold on to their lands even though farming is no longer lucrative enough to provide them with a living. Rigg et al. (2018) have succinctly coined the phrase 'more farmers, less farming' to describe the phenomenon observed in Thailand and many places in Asia, where farming is no longer the major source of income for farmers yet remains a key livelihood activity for much of the rural population. The complexity pertains not only to the lifestyles of individual farmers but also to the overall socio-economic outlook of rural villages. In sharp contrast to

the conventional portrait of a rural village where farmers are closely tied to the land, heavily engaged in farming, and tightly associated with local communities, a rural village in Asia nowadays is hybrid in its identity, integrated with the economic and social activities of the neighbouring urban areas, and connected to the outside world both physically and virtually (Rigg et al., 2012). As a result, there is an integration of professional management and farmer engagement, modern technologies and traditional skills, and top-down development strategies and bottom-up livelihood choices; these have become increasingly connected in a rapidly transforming context which is shaping the trajectories and dynamics of irrigation management and the evolution of irrigation institutions.

Some scholars have made early attempts to investigate the interconnections between irrigation institutions and contextual changes in East Asia. Researchers at the China Institute for Rural Studies at Tsinghua University, for instance, have systematically examined how the Chinese context may affect performance of irrigation institutions; their investigation is based on large-scale survey data that covers over 1000 villages across mainland China (Wang et al., 2019). These systematic studies have examined how some key socio-economic factors such as migration (Wang et al., 2016b), land fragmentation (Wang et al., 2020c), and urban proximity (Wang et al., 2021) may affect irrigation performance. Studies in the Chinese context have also generated findings that challenge previously established understandings of irrigation institutions. A salient example is that of water users associations (WUAs), which are widely promoted by international agencies and are considered a key institution for successful irrigation management. In mainland China, WUAs have been shown to play only a peripheral role (Wang and Wu, 2018; Wang et al., 2016a); instead, domestic institutional innovations such as various types of informal water rights trading have emerged and proven effective (Wang et al., 2018). In-depth empirical studies of irrigation systems in Taiwan have likewise revealed various institutional responses to external changes. In a probe into the dynamics of institutional change in irrigation management, notable progress is made in understanding interactions between institutions and contexts. Scholars argue that these institutional responses are nested in a broader institutional setting that shapes farmers' adaptation strategies, thus resulting in both successes and failures in irrigation management (Lam, 2001; Lam and Chiu, 2016). These mixed findings suggest that external shocks do not necessarily lead to the decay of collective action in governing irrigation commons; at the same time, they also indicate that institutional prescriptions that have previously been proven successful are not necessarily effective when transplanted into a different context. In this sense, there remains much uncertainty and many unknowns with regard to the patterns and dynamics of institutional changes in diverse socio-ecological and political contexts.

CHANGING STATE-SOCIETY RELATIONS IN IRRIGATION MANAGEMENT IN EAST ASIA

In the dynamic context of transforming East Asia, state-society relations play a major role in irrigation management and underlie the evolution of irrigation institutions. Wittfogel (1957) attributes the historical domination of despotic governments to large-scale hydraulic bureaucracies that controlled irrigation and flood prevention in Oriental societies. He further argued that Maoist China bore a resemblance to the past and maintained a totalitarian system. Although the notion of Oriental despotism is open to critique if one probes into Chinese history and its complex central-local relations (Zhang, 2019), the close linkages between state power and water control are rightly highlighted. This pertains to a key subject of East Asia's irrigation management, namely, the balance and complementarity between the efforts of the state and of local communities. On one end of the complementarity spectrum are irrigation systems that emphasise government intervention in irrigation management; we have observed in these systems a tendency to supplement the hierarchical and managerial mode of irrigation management with different degrees of farmer engagement, and the movement to introduce WUAs in the last decades is a manifestation of such an approach. On the other end of the spectrum are irrigation systems that are managed by self-governing communities; for these systems, complementarity is often perceived to be a matter of appropriate government assistance. The core concern is to provide government assistance for

farmers' self-governing efforts without jeopardising the social, cultural and organisational tenacity of local communities.

The balance and complementarity in state-society relations in East Asia have forged parastatal systems that differ from either the bureaucratic or the self-governing mode of irrigation governance. Instead of trying to calibrate an effective mix of inputs from the state and communities, parastatal systems integrate the involvement of the two parties through institutions that not only provide incentives and opportunities for collective action and continuous learning at the local level, but, more importantly, embed autonomous local collective action into broader government jurisdictions so as to generate compatibility, flexibility and synergy.

The agrarian transition in the past few decades, however, has enabled parastatals in different East Asian jurisdictions to take diverse paths of adjustment and hence institutional change. The parastatals in Japan – the Land Improvement Districts (LIDs) – have largely been able to maintain their vibrancy. A federated structure prevails in which small local LIDs are tightly embedded in LIDs at higher jurisdictional levels; this structure has allowed local LIDs to be, on the one hand, aligned with the needs and situation of local communities and, on the other, to receive arm's-length support from higher-level jurisdictions (Sarker and Itoh, 2003; Sarker, 2014). In Korea, a government corporation called the Korea Agricultural and Rural Infrastructure Corporation (KARICO) was established in 2000 through a merger of the country's 103 irrigation parastatals, which had encompassed the Farmland Improvement Associations, the Federation of Farmland Improvement Associations and the Rural Development Corporation. The corporation was tasked with managing irrigation systems that had an irrigated area of larger than 50 hectares (ha), with the aim of tightening up administrative control of the country's decentralised irrigation agencies (Chung, 2002; Kim, 2004). In Taiwan, the irrigation parastatals – Irrigation Associations (IAs) – had always been highly politicised and had played an active role in local mobilisation for political parties. The bureaucratisation of the IAs in 2020 was the result of a mix of political and policy calculations. The political clout commanded by the IAs had been both a resource and a concern for the political parties, depending on whether or not a particular party was in power and hence in control of the resources channelled to the IAs. The development cycle of autonomy and control of the IAs over the past decades has been reflective of the changing political calculus of the ruling parties at different periods. In mainland China, although it is difficult to identify a single organisation as a parastatal, salient features of state-society coexistence and integration are prevalent in practices of irrigation management. Since the beginning of the reform and opening-up policies, the large-scale hydraulic bureaucracies have been increasingly integrated with an overarching authority. With the opening up of rural society, the acceleration of urbanisation, and the growth of intersectoral and cross-level negotiation, the goals of these hydraulic bureaucracies have become incorporated into an overall political agenda for economic development and social stability (Nickum, 2010). In the meantime, village committees as self-governing entities have gained more legitimacy, since their members are directly elected by the villagers (Guo and Bernstein, 2004; Sun et al., 2013). Villagers have likewise become increasingly empowered, not only by their right to elect village cadres and protect their interests, but also through being the beneficiaries of policies that aim to alleviate poverty, reduce inequality and provide social welfare in rural China (Liu and Wang, 2019; Li et al., 2012; Liu et al., 2017). With centralised power fragmented and strict control of social life relaxed, rural communities in China have taken on more responsibility for irrigation management than many expected (Wang et al., 2018). As a result, rural communities and state bodies often coexist in a parastatal-like symbiosis; this allows for various forms of self-governing efforts and local institutional innovation to evolve, while the state provides technical and financial assistance and relieves itself of multifarious local governance problems.

CONTEXTUAL CHANGES AND THEIR IMPLICATIONS FOR IRRIGATION MANAGEMENT IN EAST ASIA

Changing state-society relations constitute an essential component of the rapidly transforming context in East Asia. They substantially influence local and regional irrigation management practices through institutional, economic, material and discursive mechanisms that not only characterise several important contextual changes but also create profound implications for irrigation management.

The first important contextual change is the increasing water scarcity that has posed great challenges to irrigation management. The most notable cause of the pressure on water availability is intersectoral and regional competition. Rapid economic development over the last few decades in China has brought about heavier water demand in the industrial, domestic and commercial sectors, resulting in more severe competition between agricultural and other water uses. The competition has escalated even further with the increased demand for irrigation water that has accompanied the need to maintain national food security (Qi et al., 2021). This has often led to top-down river-basin-water allocation plans which strictly limit each riparian actor's water use quota; this imposes an institutional constraint on water availability (Wang et al., 2017). With increasing water-use competition and a limited supply of surface water, many downstream farmers have turned to groundwater; this has resulted in groundwater overdraft and has threatened the sustainable development of irrigated agriculture in northern China (Wang et al., 2020a). Climate change is another important cause of the general trend towards water scarcity; for instance, it is expected that with extreme weather events becoming more frequent and intense, peasants engaged in irrigated agriculture on the North China Plain will be threatened by heatwaves (Kang and Eltahir, 2018).

Much remains unknown with regard to how water scarcity may affect irrigation management and the evolution of irrigation institutions. Will the diverse water users be able to cooperate with each other under more stringent conditions, or will they act in their own self-interest, leading to the decay of collective action (Nie et al., 2020)? Can new economic instruments be developed to cope with the challenge of scarcity? Can compensation mechanisms for agricultural water transfer offset adverse impacts on farmers (Dai et al., 2017; Wang et al., 2020b)? Will upstream and downstream water users be able to develop collaborative relationships which build in reciprocity, reconciliation of conflicts, and the sharing of limited water resources (Ng et al., 2013)?

The second critical contextual change for irrigation management is the emergence of neoliberalism and its prevalence in the water sector. Since the 1980s, a de-collectivising wave that commodifies and privatises water has been mainstreaming globally (Bakker, 2005; Swyngedouw, 2005). In this wave, water rights have been privatised and water markets have been established in some irrigation communities (Ahlers, 2010; Boelens, 2015). Agri-business companies have been grabbing water in traditional irrigation systems and have positioned themselves as co-suppliers of water services (Mehta et al., 2012; Birkenholtz, 2016). The 'magical' neoliberal prescriptions such as private property rights, scarcity pricing and economic resource allocation rarely succeed, however, when translated into local irrigation practices under heterogeneous economic, social, cultural, geopolitical and biophysical conditions. In Japan, corporate power and privatisation have clashed with traditional community-based collective management of natural resources; this has resulted in the emergence of overall social tension, local dissatisfaction, and political opposition (Sekine and Bonanno, 2016). The case of Taiwan, alternatively, seems to illustrate that instead of market mechanisms, political mechanisms – that is, hierarchies and bureaucratic allocations of water – combined with farmers' local self-governing efforts can generate incentives for effective and efficient water use (Lam et al., This Issue; Lam, 1996; Moore, 1989). Neoliberal reform in mainland China has moved beyond a dichotomous division between state and market (Jiang et al., 2019), with politically shaped markets embedded in a set of complex social rules (Jiang et al., 2021) and agricultural subsidies and market regulation instrumental to the function of the country's natural resources market (Weber, 2018). The empirical evidence suggests that neoliberalism does not have the same 'recipe' across the world, rather that localised variations in irrigation management are multifarious and warrant further investigation.

The ways that neoliberalism is animated in irrigation practices is thus an issue of critical concern. Monetary incentives are important yet limited. People pursue personal interests but are also bounded by moral values and social conventions that are deeply embedded in a specific context. It is therefore interesting to explore how market or quasi-market mechanisms have succeeded or failed in motivating different actors to engage in collaborative activities. The long-term socio-ecological impacts of neoliberal reform are also subject to debate. Although market instruments have been hailed by many international agencies and donors, critical scholars have called for extra attention to the marginalisation of vulnerable groups and the expanding inequality that can accompany the process of neoliberalisation (Budds, 2004, 2013; Bakker, 2007; Harris et al., 2020). In this sense, the scope of neoliberalism analysis in irrigation management should be broader than an examination of its efficiency and effectiveness; it is equally important to consider how the penetration of neoliberalism into rural communities has reshaped knowledge, livelihoods and identities.

The third salient contextual change – and one that may reshape irrigation management in East Asia – is agricultural modernisation, which is characterised by the increasing use of new agricultural technologies. The Chinese government, for instance, in order to replace traditional 'inefficient' irrigation, has been providing financial support for water-saving technologies such as piped water delivery systems and pressurised systems for sprinkler and drip irrigation (Blanke et al., 2007). The "effective utilisation coefficient of irrigation water" measures the extent to which water diverted from sources such as a river or well has actually contributed to crop growth in the farmer's field (Perry, 2011). This has been chosen by the government as an important indicator for the development of agricultural water use, which has witnessed the expansion of wells, growing reliance on groundwater, and increasing use of water-saving facilities.¹ In addition to water-saving technologies, greenhouses have been promoted on the basis of energy efficiency, quality control and product uniformity. Although promising a more stable food supply and higher economic returns for farmers (Ge et al., 2019; Zhong et al., 2020), higher demands for irrigation management are also imposed on local stakeholders. Irrigation management is thus not only subject to the production, distribution and utilisation of technology; it is also a site for complex interactions between agricultural technological development and rural societal change.

The impacts of agricultural modernisation are profound. The spread of modern irrigation technology is expected to improve the reliability of water delivery and the efficiency of agricultural water use; however, it is also associated with unintended consequences such as overdraft of groundwater and land subsidence, which are among the long-term ecological concerns that accompany the transition from canal irrigation to groundwater irrigation systems (Wang and Cao, This Issue). In addition, the market can amplify the effects of agricultural technologies because investments are more likely to flow towards modern technologies which ensure that agricultural products are tailored to specific demands. As technology and the market penetrate rural communities, the transition towards agricultural modernisation has been restructuring the ways that irrigation is organised. New features of irrigation management have resulted in subtle societal changes such as the diminishing of collective action, the decay of social capital within rural communities, and the marginalisation of vulnerable groups who cannot afford to participate in the technically demanding and capital-intensive ways of production. This poses questions as to whether modern water infrastructure such as lined concrete water channels, drip and sprinkler irrigation, and greenhouses are the dominant and ultimate solutions to sustainable rural development (Muller et al., 2015; Palmer et al., 2015; Wu et al., 2010).

The fourth and final contextual factor which could substantially reshape the agricultural sector is policy change; in the process, new questions are being raised about the sustainability and robustness of irrigation management. In East Asia, the changes in sociopolitical contours are often associated with

¹ In northern China, groundwater irrigation was almost non-existent before the 1950s, but by 2004 it accounted for nearly 60% of irrigation (Wang et al., 2020a). By 2019, the area covered by water-saving irrigation technology in China had reached 37 million ha and accounted for half of the country's total irrigated area (Ministry of Water Resources, 2020).

rural-to-urban migration and reforms in land use policy. China's household responsibility system (HRS), as a pioneering political reform, transferred responsibility for agricultural production from the commune to the household; in the process, it set free a huge amount of rural surplus labour which migrated to urban areas and became an important driving force for urbanisation (Lin, 1988). Accordingly, the strict control of agricultural land has been gradually relaxed, resulting in diverse land tenure arrangements which allow the exchange of land use rights, the consolidation of fragmented farmland, and the commodification of land development (Lin and Ho, 2005). These sociopolitical changes resulted in the decline of agriculture's economic significance as large numbers of people migrated to cities for higher-income jobs; it also restructured the governance of collective affairs, owing to the demographic and livelihood transformations that took place in rural communities. Against this backdrop, irrigation management – as a typically collective rural affair – can no longer maintain its traditional ways; in response to sociopolitical change, it is inevitably beginning to demonstrate new features.

This calls for more analysis of diverse local responses to policy changes. Scholars have, for instance, examined how Chinese farmers react to pricing policies that aim to create incentives for water savings (Wang et al., 2006, 2009, 2014; Chen et al., 2020). The land use policy that facilitates the gradual consolidation of fragmented farmland has received both support and resistance as it simultaneously involves land accumulation for development, and dispossession (Zhan, 2019; Kan, 2019, 2020). The formal and informal institutions that maintain irrigation management also require more in-depth investigation. For example, as the influence of irrigation management transfer (IMT) and participatory irrigation management (PIM) grew, how did these imported institutions interact with domestic institutions (Suhardiman, 2013; Cambaza et al., 2020)? What are the relationships between different state, market and community stakeholders in terms of co-managing irrigation systems and ensuring accountability? To what extent, and in what ways, do newly designed institutions such as IMT and PIM succeed, or fail, in improving irrigation efficiency, equity and sustainability? To answer these questions, much more detailed discussions are needed in order to uncover the political, economic and social structures that shape local institutional responses to broader changes.

INSTITUTIONAL ADAPTATION, DYNAMICS AND DEVELOPMENT

The collection of papers in this Special Issue attempts to understand irrigation management in the context of a rapidly transforming East Asia. It considers the question from three angles. First, it captures the decline of gravity canal irrigation systems as a salient physical response to broader contextual transformations (Wang and Cao, This Issue). Second, it probes the subtle evolution of institutional arrangements for managing irrigation systems, examining the changes in irrigation institutions that occur in response to the shifting political-economic settings in which they are embedded (Lam et al., This Issue; Satoh and Ishii, This Issue; Wang et al., This Issue). Last, adaptation strategies – both government-led and spontaneous – have been put forward in order to demonstrate how different actors develop coping strategies to address external challenges (Chai and Zeng, This Issue; Deng et al., This Issue).

Wang and Cao's article (This Issue) provides an overview of the decline of gravity canal irrigation systems in China. The decline is characterised by three main aspects, namely, the increasing neglect of gravity canals infrastructure, the rising dependence on groundwater, and the spread of new water-saving irrigation technologies. These authors attribute the decline of canal irrigation in China to a series of broader contextual transformations including industrialisation, urbanisation, marketisation, policy changes, and technological change in irrigation. These contextual transformations have resulted in the adoption of new irrigation technologies, the decay of rural leadership and the ability to self-govern, and the privatisation of water use rights, all of which are directly associated with a decreasing community input in local canal systems. Although the transition towards groundwater and new irrigation technologies has maintained stable water supply for agricultural production, the decline of canal irrigation systems is having profound socio-economic and ecological impacts. For local farmers, the

transition has brought about an increased financial burden, a decline in the sense of agency that was traditionally rooted in collective action, and a decrease of social capital within the rural community. Ecological impacts such as land subsidence, seawater intrusion and degraded water quality can also not be overlooked as the use of groundwater grows. These socio-economic and ecological impacts call for more in-depth investigation into groundwater conservation. In rural communities that are experiencing a decline in the traditional institutional structures of canal irrigation, institutions need to be reconceptualised and reinvented.

Institutional arrangements, and their evolution in changing contextual settings, is another focus of this Special Issue. Satoh and Ishii (This Issue) present the formation and function of PIM in Japan, implying that the success of the Japanese co-management model cannot be separated from the indirect intervention of the government and from the traditional village structure. Although the responsibility for management of irrigation systems has been ascribed to farmers' irrigation associations, the government still regularly supervises and provides guidance to these associations. The common interest and strong internal cohesion among members of the traditional village administration unit are also key to the success of PIM in Japan; however, a notable challenge to the traditional Japanese irrigation model is the decrease of small-scale farmers and their gradual replacement by a limited number of large-scale farmers.

Lam et al. (This Issue) demonstrate how Taiwan's parastatal IAs were bureaucratised in order to cope with macro political-economic changes, including the demise of agriculture and the rapid ageing of the rural population. Although Taiwan's IAs have been considered exemplars of co-production and state-community synergy by the international water research community, their institutional set-ups were designed solely to facilitate agricultural production. While these institutional set-ups could maximise the systems' robustness to water shortages and fluctuating water supplies, their sole focus on water efficiency made them less adaptive and robust to new challenges as the task environment changed. Although the sophisticated rules of water rotation could presumably maximise water efficiency, they built a rigidity into the systems that was not conducive to the promotion of eco-friendly agriculture. Effective parastatals also required that farmers be able to serve as committed, effective co-producers; thus, when farmers lost the capacity and incentive to engage in irrigation management, the *modus operandi* of co-production needed to be adjusted. The adjustments mainly focused on substituting farmers' input with better technology and heavier government involvement; however, as farmers became increasingly irrelevant to irrigation management, the viability and utility of the parastatals were seriously questioned by the government and policy actors. In 2020, the government seized an opportunity of power transition to bureaucratised the IAs. From the government's perspective, the reform served the policy purposes of tightening water source control, reallocating water resources across sectors, and enhancing the government's ability to cope with policy challenges that straddle policy domains.

Against the backdrop of broader contextual changes, the dynamics of institutional evolution are extremely complex. Wang et al. (This Issue) report a high degree of diversity in institutional responses to the economic and governance structural reform in rural China. The concept of institutional bricolage is used to explain why diverse institutional modalities emerge and persist. Based on an empirical investigation in the upstream Yellow River region, the paper identifies four institutional modalities – a pumping station, a WUA, a village committee, and an individual villager – any of which could be the dominant entity of irrigation governance in a village. It reports the different sources of legitimacy that are resorted to by local bricoleurs and what sustained each institutional modality. As institutions initiate, operate and evolve, various sources of institutional legitimacy emerge; these include, for example, due process of decision-making, neoliberal discourse, established authority of hierarchical governance, satisfactory outcomes, and social recognition. Moreover, these different sources of institutional legitimacy may interact, contradicting or combining with each other to result in different institutional dynamics during the process of institutional bricolage. The heterogeneous, dynamic and context-specific processes of legitimisation not only offer a more in-depth explanation of the persistence of diverse irrigation institutions in rural China; they also contribute to thinking about institutional bricolage.

In addition to institutional evolution, practical adaptation measures developed by the government and local communities are also of great concern. Chai and Zeng (This Issue) show that the local government and communities used rotation irrigation as a strategy for adapting to the stringent quantitative water regulation imposed in southern China. By cultivating different crops with different water-demanding cycles, a mosaic cropping pattern has structured an adjusted spatial-temporal characteristic of the rotation system, one that has avoided peak water demands and reduced the transaction costs of coordination for water allocation among villages. This adaptation measure indicates that new agricultural knowledge developed by the local agricultural department and rural communities could alleviate the water management problems that have been exacerbated by the quantitative water regulations.

Deng et al. (This Issue) examine the seasonal land fallowing policy (SLFP), which is a large-scale attempt to address groundwater overdraft in the North China Plain region. The SLFP provides economic incentives to farmers for not growing winter wheat between October and May. It is therefore considered to be a programme of payments for ecosystem services (PES) rather than another water-demand management adaptation measure such as water pricing, water rights reforms, and water-saving technologies. In the case of the SLFP, it is found that the PES programme can significantly reduce the amount of groundwater used for irrigation by adjusting the cropping pattern and limiting the irrigated area for winter wheat, however the effect on the groundwater level is unclear. There still exist major challenges from inadequate participation, unstable and unqualified participants, low utilisation of off-farm labour, stiff subsidies, doubtful policy sustainability, and underused fallow land. More government effort should be expended on achieving full participation of households, policy promulgation, and the flexibility of compensations standard.

The six papers in this Special Issue shed light on the complexity of irrigation management in a rapidly transforming East Asia. They show that external challenges do not necessarily lead to the failure of irrigation management. Diverse new features of irrigation practices (for example, institutional reinvention and policy restructuring) may occur as public, communal and private actors who co-manage irrigation systems respond and adapt to societal and environmental changes. Although much remains to be learned about how irrigation systems evolve and maintain resilience to broader changes, the diverse findings in empirical settings indicate that a deeper understanding of irrigation management needs to move beyond 'best practices' or 'good governance' that imply a one-size-fits-all solution. More detailed investigations of diversity, change, evolution and adaptation may provide a more comprehensive and nuanced understanding of irrigation management in rapidly transforming societies.



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