12

KEY CONSTRAINTS AND COLLECTIVE ACTION CHALLENGES FOR GROUNDWATER GOVERNANCE IN THE EASTERN GANGETIC PLAINS

Ram C. Bastakoti, Fraser Sugden, Manita Raut and Surendra Shrestha

Introduction

Globally, irrigated agriculture is the main user of groundwater. An estimate has suggested that groundwater contributes about 38 per cent of total irrigation in the world (Siebert et al., 2010). Groundwater irrigation is increasing both in absolute terms and in percentage of total irrigation (Wada et al., 2014). In most parts of South Asia, groundwater irrigation expanded rapidly after the start of the Green Revolution in the 1970s (Scott and Sharma, 2009). Groundwater is the key irrigation source mainly for winter season crops, besides being used for supplemental irrigation of monsoon season crops. Groundwater is accessed through either shallow tubewells (STW) or deep tubewells (DTW). Particularly in the Indus–Ganges Basin (IGB), which feeds over a billion people and provides direct livelihoods for hundreds of millions of farmers with greater socio-economic heterogeneity (Sharma et al., 2010), groundwater represents the largest source of irrigation. The IGB includes some of the highest-yielding aquifers in the world (Mukherjee et al., 2015) and comprises 25 per cent of global groundwater withdrawals (MacDonald et al., 2016). The western and eastern parts of the IGB show a contrasting situation regarding the use of groundwater for irrigation. Groundwater is overexploited in the western IGB plains and underutilized in the east (Scott and Sharma, 2009; MacDonald et al., 2016).

This chapter focuses on the eastern lowlands of the IGB, commonly referred to as the Eastern Gangetic Plains (EGPs), covering Nepal, Bihar and West Bengal. In the EGPs, groundwater is the most critical common pool resource because the livelihoods of at least three-fourths of the rural population depend on groundwater as their main source of irrigation, particularly at a time of increasingly erratic monsoons. The EGPs are facing the challenge of increasing food production to cater to the demands of an ever-growing population (Aggarwal et al., 2004). In

most parts of the EGPs, the current extent of groundwater irrigation is far below full potential.

Against this background, this chapter attempts to unravel key constraints and opportunities for socially sustainable groundwater use, then looks at the ways in which farmers (both small and large) shape the informal groundwater market and the outcome of collective action among stakeholders. Both secondary and primary sources were consulted. National/state policy documents, published scientific literature and reports from relevant agencies constitute the secondary sources. Primary information was gathered through a survey of farmers conducted in the Saptari District of Nepal, the Madhubani District of Bihar and the Cooch Behar and Alipur Duar districts of West Bengal.

Policies and institutional framework for groundwater management

Understanding the issues surrounding groundwater governance is a precondition for developing policy recommendations for both national and transboundary groundwater governance. Theesfeld (2010) emphasizes that in order to conceptualize the institutional aspects of groundwater governance, the synthesis of resource system characteristics and the experience with policy instruments are critical. Three types of policy instruments could be relevant to groundwater governance: regulatory, economic and voluntary/advisory. These instruments are ideal types and no policy option relies purely on one type alone (Stone, 2002).

Groundwater is crucial to the economy of the EGPs region, given its major contribution to the local agriculture. As a result, governments in the EGPs region

TABLE 12.1 Groundwater policies and institutional framework at the state/national level

Features	*Nepal*	*Bihar*	*West Bengal*
Key policies	Groundwater Act, Irrigation Policy, Water Resources Strategy, National Water Plan, Nepal Agricultural Perspective Plan	India National Water Policy, Bihar State Water Policy, Bihar Irrigation Act, Bihar Irrigation Water Management Rules	India National Water Policy, West Bengal State Water Policy, West Bengal Groundwater Act, Minor Irrigation Policy
Main focus	Assessment and utilization of groundwater potential Subsidies in STW installation and pump – mainly in group Permission for STW installation	Assessment of groundwater potential Efficient management of groundwater and control depletion Subsidies for STW installation	Assessment of groundwater potential focusing on quality and economic viability Subsidies for STW/DTW installation to be provided in group
Organizational structure	National, regional and district levels	National, state and district levels	National, state and district levels

Source: Authors' compilation

(Nepal and India – mainly Bihar and West Bengal) have formulated a range of policies at the state/national level that address key issues of groundwater irrigation management by providing a guiding framework. Table 12.1 summarizes key policies that address issues related to groundwater, the focus of such policies and the type of organizational structure.

In the EGPs region, policy and legal frameworks have progressed from a focus on water development (up to the 1970s) towards water management in recent decades in which water governance has become prominent (Sharma et al., 2010). India introduced a series of measures in the late 1990s and early 2000s that addressed the water sector. The federal structure of India has the provision that issues relating to water resources are addressed by the concerned state, even though the federal government provides guidance and model frameworks, such as the National Water Policy. At the federal level, there was gradual movement towards regulation of groundwater use after the formulation of the National Water Policy in 1987. Then the Groundwater Bill of 1992 introduced permits for and registration of new and existing wells, as well as the regulation of commercial well digging and the creation of a National Groundwater Authority. Subsequent revisions in 1996 and 2005 introduced additional criteria while evaluating applications for new wells and issuing permits to construct them. The 2005 bill placed more emphasis on enhancing the supply side through groundwater recharge systems. The federal government has also favoured a policy framework to stimulate groundwater utilization in the EGPs through public tubewell development (Sikka, 2002). Specifically, government programmes such as the Million Wells Scheme, which was launched in 1988/9, have sought to promote groundwater development, targeting poor and marginal farmers.

Nepal has realized the importance of groundwater irrigation from the very beginning of its periodic plans (1950s). The Eighth Development Plan (1992–1996) put increased emphasis on irrigation development. Guided by the objectives of the Eighth Plan, the government promulgated a new Irrigation Policy in 1992 (with subsequent revisions thereafter) that included provision of a subsidy for STW installation. This policy supported investment in irrigation infrastructure through capital subsidies, which for groundwater development ranged from 40 per cent for an individual, private STW to 85 per cent for a community DTW. Even though the ambitious target of the Agricultural Perspective Plan of 1995 to irrigate half of the total irrigable land with groundwater in the Terai region was not met because of insufficient budget allocation, the number of STWs increased rapidly (Kansakar, 2011). After 1999, the government of Nepal removed direct capital subsidies for STW installation. This triggered the private financing of tubewells. Rural power supply expansion and the wider availability of cheaper pumps, such as Chinese electric pumps, made STW usage more accessible and affordable for small farmers (Kansakar, 2011). Furthermore, since the 2000s, a number of STW programmes have been initiated by the government to provide 100 per cent subsidies for tubewells in areas of the Terai not served by canal irrigation. However, these are only provided to groups of farmers who form a water users' association for a

2.67-hectare command area (see Sugden, 2014). Nepal's subsequent development plans also put emphasis on harnessing the groundwater potential of rain-fed areas of the Terai region. Recently, the government drafted a Groundwater Bill which was at the final stage of parliamentary approval at the time of writing.

The focus of policies has been on a range of regulatory, economic and voluntary measures. Subsidies for STW installation and pumps have comprised the key policy instrument to facilitate groundwater expansion in the EGPs region. At the same time, given the significance of groundwater in the EGPs, one of the key policy focuses has been the assessment of groundwater potential.

Groundwater access and governance challenges

The literature reveals considerable variation in access to groundwater in different parts of South Asia. For example, Scott and Sharma (2009) reported that the EGPs present an energy–groundwater paradox as the region is rich in water sources, but inadequate electricity supply has led to increased reliance on diesel power. Such reliance on a single power source has been a major limiting factor in development of groundwater (Scott and Sharma, 2009). Other studies have documented land tenure characteristics, energy-related constraints and institutional barriers as major obstacles to groundwater development in the Terai region of Nepal and other parts of the EGPs (Bhandari and Pandey, 2006; Prathapar et al., 2014; Sugden, 2014; Sugden et al., 2014; Okwany et al., 2015).

Groundwater irrigation is primarily characterized by small, decentralized private irrigation involving a large group of smallholder farmers (de Fraiture and Giordano, 2014) who face several challenges. Groundwater requires capital investment to both dig the tubewell and purchase a pump, and it is dependent on the farmer owning the land where they plan to install the tubewell. Skewed land tenure, farmers' limited access to markets and inadequate power are key constraints that limit the expansion of groundwater irrigation in the EGPs (Bhandari and Pandey, 2006; Sugden, 2014). Other commentators have mentioned overreliance on diesel for groundwater pumping and the associated cost as major constraints (Pant, 2004; Mukherji, 2006; Shah et al., 2006, 2009). It is apparent from those studies that one of the governance challenges for groundwater irrigation is related to energy, implying that energy management plays a key role in groundwater governance.

Another crucial aspect associated with groundwater use is the differential access to groundwater among different categories of farmers. Such differential access particularly could have a negative impact on the marginalization of small farmers (Amichi et al., 2012; Srinivasan and Kulkarni, 2014). Similarly, rental markets for tubewells and pump sets, which in many cases are the only way marginal farmers can access groundwater, are by no means governed by the invisible hand of the market (Bhandari and Pandey, 2006; Wilson 2002). In this context, inciting a debate about equity could be a first and fundamental step toward advancing more inclusive groundwater governance that crucially engages marginalized farmers (Hoogesteger and Wester, 2015).

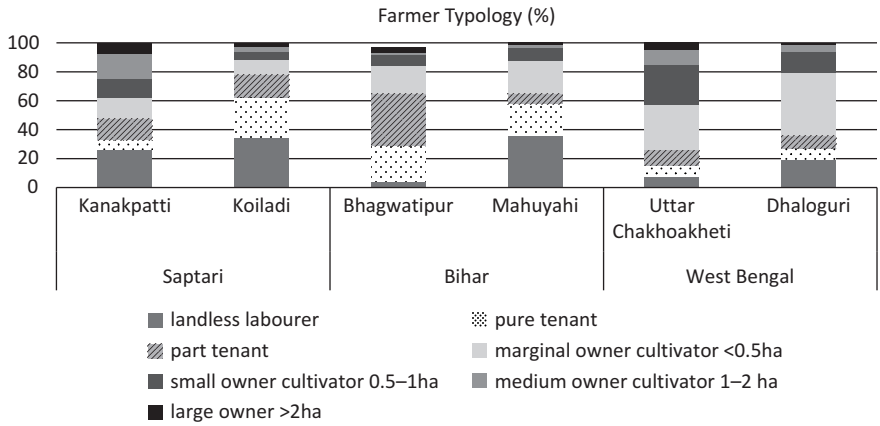

FIGURE 12.1 Farmers' categories based on landholding characteristics in the study districts of the EGPs

In order to understand the details of groundwater access and associated constraints at the local level we conducted a survey covering six villages in Nepal, Bihar and West Bengal. In Nepal, we visited the villages of Kanakpatti and Koiladi in the Saptari District; in Bihar the villages of Bhagwatipur and Mahuyahi in the Madhubani District; and in West Bengal the village of Dhaloguri in the Cooch Behar District and the village of Uttar Chakhoakheti in the Alipur Duar District. The socio-economic survey showed that a large gap exists in terms of access to land (see Figure 12.1). A large proportion of farmers are landless labourers, pure tenants or smallholder part tenants, with some variations across the locations. In Dhaloguri and Uttar Chakhoakheti in West Bengal, there are a greater proportion of small and marginal owner cultivators, and few tenants, due to the history of land reform in the state. By contrast, landlordism persists in the four villages in Nepal and Bihar, and these sites have a high proportion of landless tenants or part tenants who work primarily as sharecroppers. There is also a large pool of landless labourers, who move in and out of tenancy depending on the need of the household.

Focus group discussions (FGDs) conducted in all of the study villages revealed that groundwater was the main source of irrigation, although some villages reported the existence of canal irrigation, too. FGD participants reported installation of a number of STWs in their villages, mostly installed and managed privately and owned mainly by medium to large farmers. The survey also showed that STW and pump ownership were skewed toward large farmers (Figure 12.2). Pure tenants are rarely able to access their own tubewells. Only a tiny percentage of them owned tubewells, and these were likely to be next to their homesteads. Landlords are often not prepared to bear the costs of fixed investments on rented land. Furthermore, few tenants have formal documents, making any investment in a tubewell or other infrastructure risky. By contrast, ownership of tubewells among part tenants is relatively high, given that they have the security of some owned land. It is important to note,

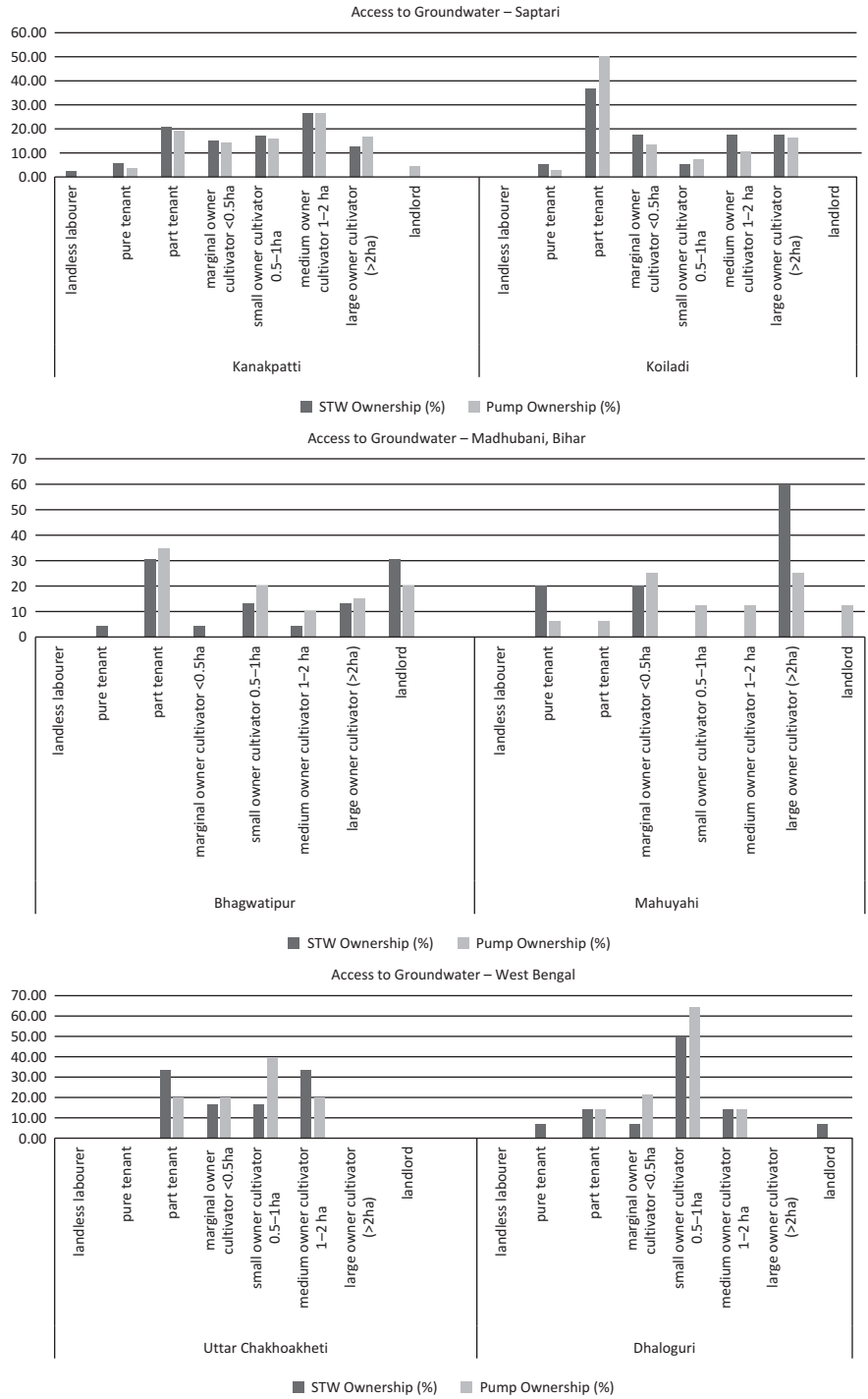

FIGURE 12.2 Access to groundwater: STW and pump ownership in the study districts of the EGPs

however, that ownership of pump sets is more important for irrigation than ownership of tubewells. Pump sets are expensive, and the survey revealed that ownership is negligible among tenants and mostly below 10 per cent among part tenants and marginal owner cultivators in Bhagwatipur, Mahuyahi and Koiladi. Only in Kanakpatti are there higher levels of ownership. In contrast, the majority of large owner cultivators and many medium owner cultivators own their own pumps. Some landlords rent out pumps, while others do not own any as they are not engaged in direct cultivation.

During the FGDs farmers reported land tenancy as one of the key obstacles to groundwater irrigation. Since a majority of farmers are tenants, this prevents them from planning any STW installation. Even if they were interested in installing an STW, most tenant farmers have insufficient capacity to invest in one. Additionally, a lack of land entitlement and land tenancy certificate prevents them from accessing government-run STW schemes, such as the Groundwater Resource Development Board and District Agriculture Office in Nepal (Kansakar, 2011). Indeed, most small and marginal farmers were unaware of such schemes, while those who knew about them found the application procedure difficult (ADB, 2012). They also reported that land fragmentation constrains STW installation. Further, the high operational cost of groundwater pumping – mainly the price of diesel – and the unreliable electricity supply limit access to groundwater.

For marginal farmers, a lack of access to credit for pump rental is another constraint. This can hamper both planting and irrigation. In some cases, male migration to neighbouring states and even abroad has brought women to the forefront of pump operation and negotiation with water lords – the large farmers who sell the water. While there has been a shift of women's roles towards traditionally male-oriented irrigation activities, accessing STWs when needed was highlighted as a challenge (Sugden et al., 2014). Moreover, repair and maintenance of pumps and having to irrigate fields at night are other constraints, particularly for women farmers.

Water markets are a key aspect of groundwater irrigation. They emerged in the 1990s when diesel pump operators were able to offer competitive services due to the relatively low cost of diesel, which allowed them to make a profit in areas where electricity was unavailable. Several studies have shown that local groundwater markets are beneficial for poor and marginal farmers, including sharecroppers in the EGPs region, as they enhance productivity by providing access to groundwater (Fujita and Hossain, 1995; Shah and Ballabh, 1997; Pant, 2005; Mukherji, 2007). However, other authors (e.g. Wilson, 2002) have argued that the markets are monopolistic and lead to greater inequality.

Our survey and FGDs conducted in the study villages reveal that marginal and tenant farmers mainly rely on groundwater markets to access groundwater irrigation. In such cases, they rent a pump set and tubewell from a wealthier farmer. In general, the price is based on hourly use of the pump and/or STW. The rate per hour varied across the villages as well as depending on the season. In addition, the pumping charge varied according to the capacity of the pump. Even though these informal groundwater markets increase access, the pump rental charge can vary.

However, the variation in pump rental charge is not related to each farmer's category. In addition, farmers may be unable to access water when they need it. The STW/pump owner dictates the price, so a kind of monopoly exists among a limited number of large farmers and landlords (Sugden, 2014).

Collective action for groundwater governance

The cases discussed in the previous section highlight that land tenancy is one of the key obstacles to groundwater irrigation. Marginal and tenant farmers have limited capacity to install STWs, while landlords are unwilling to spend money on fixed investments on rented land. Moreover, marginal farmers cannot afford to purchase pump sets. As a result, they have to rely on informal groundwater markets, which means they often have to pay high rental fees. Finally, the lack of access to credit for pump rental increases the farmers' difficulties.

These problems of accessing groundwater indicate that marginal and tenant farmers need to find better ways of working collectively. Past studies have highlighted the importance of collective action in groundwater management (Meinzen-Dick et al., 2016), which communities undertake through drafting a range of rules (Ostrom, 1990, 1992). Community-based groundwater management requires working through complex rural dynamics at various levels (Reddy et al., 2014; Shah, 2009).

In order to get organized for a common cause, previous experience of facilitating collective action can be crucial (Aarnoudse et al., 2012; Bouarfa and Kuper, 2012; Rica et al., 2012). Examples show that local communities have responded to issues relating to groundwater management by implementing local rules that have reduced conflict and provided more reliable and equitable access to water (Taher et al., 2012), where participation at different levels is key (Kulkarni et al., 2015).

The villages in our study revealed some experience of organizing their own groundwater management, such as an STW Management Committee, which facilitated groundwater use. Institutional development was inadequate to facilitate groundwater access: they had insufficient social capital, such as dedicated leadership, and a lack of explicit rules/norms to guide the groundwater access. However, involvement in local institutions had provided them with some exposure to various aspects of collective action that are required for good groundwater governance, such as water allocation mechanisms, operation and maintenance, and benefit sharing to ensure equity. Nevertheless, the hegemony of powerful farmers over access to the pumps could create conflict, resulting in group dissolution.

There are, however, more radical forms of collective action which can bring farmers together to increase their access to irrigation. These involve addressing some of the root causes that impede access to groundwater: namely, inequitable distribution of land, lack of capital and tenure insecurity. In the study villages, some groups of tenants united to lease land collectively, while groups of small owner cultivators were encouraged to consolidate their plots voluntarily, which enabled them to cultivate and irrigate a contiguous area. This form of collective action has helped to address the constraints associated with land tenancy, as such farmers share

tubewells and pump sets. By cultivating a large, contiguous field, irrigation becomes more feasible and efficient, and costs can be shared across the group. Moreover, as all of the land is cultivated collectively, conflict over irrigation water ceases to be an issue due to joint installation of tubewells and shared ownership of pumps.

In an alternative model, farmers retain their own plots but draft rules and regulations relating to sharing a diesel/electric pump and an STW. These rules, which focus on water allocation, operation and maintenance of the STW and pump, facilitate equal contributions and benefit sharing. By creating balance in access to the water and capital contributions among all the members of the scheme, they eliminate exploitation and the farmers' reliance on informal groundwater markets. The members no longer have to pay high fees to rent an STW and a pump, and they can sell surplus water to neighbouring farmers, generating a fund which is used to maintain the system and for other agricultural inputs.

The increasing availability of electric, diesel and solar-powered pumps has ensured there are no delays in field irrigation among these groups. For example, in the event of a power cut, farmers can switch to a diesel pump. Furthermore, monthly savings allow for the creation of a group fund, which is used to advance small loans, purchase diesel, or pay an electricity bill when a member of the group does not have access to the necessary cash. Consequently, the chances of irrigation delays are greatly reduced.

Women from migrant households have perceived some benefits from these collective arrangements. In some groups, while the women are busy with internal household chores, fellow group members operate the pumps. The women then carry out other agricultural activities in return. Interestingly, though, the women in some groups have started operating the pumps themselves. For repair and maintenance of the system, they have established a mechanism to carry out such tasks. The group has assigned one specific member as pump operator, who takes care of the operation as well as the repair and maintenance of the pump. Some groups have drafted written rules whereas others have simply agreed them verbally.

Additionally, engagement in groups has increased access to and created linkages with regional agricultural and irrigation departments. For instance, farmers from the Saptari District of Nepal have formally registered as a group with the District Agricultural Development Office. This has helped them to access and share information on water and agricultural input-related schemes. Their collective efforts have resulted in uninterrupted access to groundwater at affordable prices, eliminating their dependence on the groundwater market. Each farmer is charged a modest rental fee which merely covers the operating costs and maintenance of the irrigation equipment. Furthermore, if they ever need to rent from large farmers, they do so collectively, which has increased their bargaining power. Overall, this has helped to address the imperfect informal groundwater markets that once prevailed in the village.

Conclusion and implications

Groundwater availability is not an issue in the Eastern Gangetic Plains, but its use for irrigation in an energy-efficient manner is critical. Findings show that governments in Nepal, Bihar and West Bengal have prioritized harnessing the groundwater potential of the EGPs, yet have enjoyed limited success mainly due to problems associated with groundwater pumping and the presence of informal groundwater markets.

One of the key features of groundwater governance is the presence of a pump rental market, an informal groundwater market. Due to a lack of land and investment capacity, small farmers depend on large farmers. The informal rental market provides smallholders with access to groundwater, but both the price and timely availability have been problematic. Poor social capital and low levels of collective action among farmers, especially in relation to landlords, still pose challenges.

Our research found that groundwater management improves when smallholders organize into collectives and install their own tubewells and pumps. Furthermore, once farmers organize into groups, their bargaining power increases, which leads to improvements in the functioning of the groundwater market and plays a role in changing the existing incentive structure. Overall, smallholders' access to groundwater would be enhanced by the introduction of a more formal pump rental market, for which reliable and cheap energy supply would be crucial. Policies that facilitate collective operation of marginal farmers could help to achieve this.

References

Aarnoudse, E., Bluemling, B., Wester, P., Qu, W. (2012). The role of collective groundwater institutions in the implementation of direct groundwater regulation measures in Minqin County, China. *Hydrogeology Journal* 20: 1213–1221

ADB. (2012). *Shallow Tubewell Irrigation in Nepal: Impacts of the Community Groundwater Irrigation Sector Project*. Kathmandu: ADB

Aggarwal, P.K., Joshi, P.K., Ingram, J.S.I., Gupta, R.K. (2004). Adapting food systems of the Indo-Gangetic plains to global environmental change: Key information needs to improve policy formulation. *Environmental Science and Policy* 7: 487–498

Amichi, H., Bouarfa, S., Kuper, M., Ducourtieux, O., Imache, A., Fusillier, J.L., Bazin, G., Hartani, T., Chehat, F. (2012). How does unequal access to groundwater contribute to marginalization of small farmers? The case of public lands in Algeria. *Irrigation and Drainage* 61: 34–44

Bhandari, H., Pandey, S. (2006). Economics of groundwater irrigation in Nepal: Some farm-level evidences. *Journal of Agricultural and Applied Economics* 38: 185–199

Bouarfa, S., Kuper, M. (2012). Groundwater in irrigation systems: From menace to mainstay. *Irrigation and Drainage* 61: 1–13

de Fraiture, C., Giordano, M. (2014). Small private irrigation: A thriving but overlooked sector. *Agricultural Water Management* 131(1): 167–174

Fujita, K., Hossain, K. (1995). Role of groundwater market in agricultural development and income distribution: A case study in a northwest Bangladesh village. *Developing Economies* 33(4): 442–463

Hoogesteger, J., Wester, P. (2015). Intensive groundwater use and (in)equity: Processes and governance challenges. *Environmental Science & Policy* 51: 117–124

Kansakar, D.R. (2011). *Regulating Common Pool Groundwater under Fugitive Surface Water Laws and Regulations in Nepal*. Jalsrot Vikas Sanstha/Global Water Partnership Nepal. www.jvs-nwp.org.np/sites/default/files/Water%20Laws%20and%20Regulations%20in%20Nepal.pdf(accessed 19 May 2017)

Kulkarni, H., Shah, M., Shankar, P.S. (2015). Shaping the contours of groundwater governance in India. *Journal of Hydrology: Regional Studies* 4: 172–192

MacDonald, A.M., Bonsor, H.C., Ahmed, K.M., Burgess, W.G., Basharat, M., Calow, R.C., Dixit, A., Foster, S.S.D., Gopal, K., Lapworth, D.J., Lark, R.M., Moench, M., Mukherjee, A., Rao, M.S., Shamsudduha, M., Smith, L., Taylor, R.G., Tucker, J., van Steenbergen, F., Yadav, S.K. (2016). Groundwater quality and depletion in the Indo-Gangetic Basin mapped from in situ observations. *Nature Geoscience* 9: 762–766

Meinzen-Dick, R., Chaturvedi, R., Domènech, L., Ghate, R., Janssen, M.A., Rollins, N.D., Sandeep, K. (2016). Games for groundwater governance: Field experiments in Andhra Pradesh, India. *Ecology and Society* 21(3): 38

Mukherjee, A., Saha, D., Harvey, C.F., Taylor, R.G., Ahmed, K.M., Bhanja, S.N. (2015). Groundwater systems of the Indian Sub-continent. *Journal of Hydrology: Regional Studies* 4: 1–14

Mukherji, A. (2006). Political ecology of groundwater: The contrasting case of water-abundant West Bengal and water-scarce Gujarat, India. *Hydrogeology Journal* 14: 392–406

Mukherji, A. (2007). Political economy of groundwater markets in West Bengal, India: Evolution, extent and impacts. Ph.D. thesis, Cambridge University

Okwany, R., Prathapar, S.A., Siddiqui, S., Bastakoti, R., Rajmohan, N. (2015). *Assessment of Water Resources and Demand for Irrigation in Nine Districts within the Eastern Gangetic Plains*. Final project report. Colombo: International Water Management Institute

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. New York: Cambridge University Press

Ostrom, E. (1992). *Crafting Institutions for Self-Governing Irrigation Systems*. San Francisco: Institute for Contemporary Studies

Pant, N. (2004). Trends in groundwater irrigation in Eastern and Western UP. *Economic and Political Weekly* 31: 3463–3468

Pant, N. (2005). Control and access to groundwater in UP. *Economic and Political Weekly* 40 (26): 2672–2680

Prathapar, S.A., Rajmohan, N., Bastakoti, R., Okwany, R. (2014). *Water Management Interventions to Cope with Climate Variability in Indo-Gangetic Plains*. Final project report. Colombo: International Water Management Institute

Reddy, V.R., Reddy, M.S., Rout, S.K. (2014). Groundwater governance: A tale of three participatory models in Andhra Pradesh, India. *Water Alternatives* 7(2): 275–297

Rica, M., López-Gunn, E., Llamas, R. (2012). Analysis of the emergence and evolution of collective action: An empirical case of Spanish groundwater user associations. *Irrigation and Drainage* 61: 115–125

Scott, C.A., Sharma, B. (2009). Energy supply and the expansion of groundwater irrigation in the Indus–Ganges Basin. *International Journal of River Basin Management* 7(1): 1–6

Shah, T. (2009). *Taming the Anarchy: Groundwater Governance in South Asia*. Washington, DC: Resources for the Future Press

Shah, T., Ballabh, V. (1997). Water markets in North Bihar: Six village studies in Muzaffarpur district. *Economic and Political Weekly* 32(52): 183–190

Shah, T., Singh, O.P., Mukherji, A. (2006). Some aspects of South Asia's groundwater irrigation economy: Analyses from a survey in India, Pakistan, Nepal Terai and Bangladesh. *Hydrogeology Journal* 14(3): 286–309

Shah, T., Ul Hassan, M., Khattak, M.Z., Banerjee, P.S., Singh, O.P., Ur Rehman, S. (2009). Is irrigation water free? A reality check in the Indo-Gangetic Basin. *World Development* 37(2): 422–434

Sharma, B., Amarasinghe, U., Xueliang, C., de Condappa, D., Shah, T., Mukherji, A., Bharati, L., Ambili, G., Qureshi, A., Pant, D., Xenarios, S., Singh, R., Smakhtin, V. (2010). The Indus and the Ganges: River basins under extreme pressure. *Water International* 35(5): 493–521

Siebert, S., Burke, J., Faures, J.M., Frenken, K., Hoogeveen, J., Döll, P., Portmann, F.T. (2010). Groundwater use for irrigation – a global inventory. *Hydrology and Earth System Sciences* 14: 1863–1880

Sikka, A.K. (2002). Augmentation and management of groundwater resources: Participatory watershed management as a policy and strategy. In *Proceedings of the International Groundwater Conference on Sustainable Development and Management of Groundwater Resources in Semi-Arid Region with Special Reference to Hard Rocks, Dindigul, Tamil Nadu, India, 20–22 February, 2002*. Rotterdam: A.A. Balkema Publishers

Srinivasan, V., Kulkarni, S. (2014). Examining the emerging role of groundwater in water inequity in India. *Water International* 39(2): 172–186

Stone, D. (2002). *Policy Paradox: The Art of Political Decision Making*. New York and London: W.W. Norton & Company

Sugden, F. (2014). *Landlordism, Tenants and the Groundwater Sector: Lessons from Tarai-Madhesh, Nepal*. Colombo: International Water Management Institute

Sugden, F., Maskey, N., Clement, F., Ramesh, V., Philip, A., Rai, A. (2014). Agrarian stress and climate change in the Eastern Gangetic Plains: Gendered vulnerability in a stratified social formation. *Global Environmental Change* 29: 258–269

Taher, T., Bruns, B., Bamaga, O., Al-Weshali, A., van Steenbergen, F. (2012). Local groundwater governance in Yemen: Building on traditions and enabling communities to craft new rules. *Hydrogeology Journal* 20(6): 1177–1188

Theesfeld, I. (2010). Institutional challenges for national groundwater governance: Policies and issues. *Groundwater* 48(1): 131–1142

Wada, Y., Wisser, D., Bierkens, M.F.P. (2014). Global modeling of withdrawal, allocation and consumptive use of surface water and groundwater resources. *Earth System Dynamics* 5: 15–40.

Wilson, K. (2002). Small cultivators in Bihar and 'new' technology. *Economic and Political Weekly* 37(13): 1229–1238