Journal of Hydrology 537 (2016) 171–186

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Assisting community management of groundwater: Irrigator attitudes in two watersheds in Rajasthan and Gujarat, India

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ARTICLE INFO

Article history:
Received 4 November 2015
Received in revised form 13 January 2016
Accepted 4 February 2016
Available online 12 March 2016
This manuscript was handled by Geoff Syme, Editor-in-Chief

Keywords:
Livelihood
Managed aquifer recharge
Community management
Irrigator attitudes

SUMMARY

The absence of either state regulations or markets to coordinate the operation of individual wells has focussed attention on community level institutions as the primary loci for sustainable groundwater management in Rajasthan and Gujarat, India. The reported research relied on theoretical propositions that livelihood strategies, groundwater management and the propensity to cooperate are associated with the attitudinal orientations of well owners in the Meghraj and Dharta watersheds, located in Gujarat and Rajasthan respectively. The research tested the hypothesis that attitudes to groundwater management and farming practices, household income and trust levels of assisting agencies were not consistent across the watersheds, implying that a targeted approach, in contrast to default uniform programs, would assist communities craft rules to manage groundwater across multiple hydro-geological settings. Hierarchical cluster analysis of attitudes held by survey respondents revealed four statistically significant discrete clusters, supporting acceptance of the hypothesis. Further analyses revealed significant differences in farming practices, household wealth and willingness to adapt across the four groundwater management clusters. In conclusion, the need to account for attitudinal diversity is highlighted and a framework to guide the specific design of processes to assist communities craft coordinating instruments to sustainably manage local aquifers described.

1. Introduction

Indian policies concerned with agricultural development have evolved from an initial focus on increasing food production to contemporary concerns for the environment, poverty and diversified livelihood options. Correspondingly, Gosh et al. (2012) and Baker et al. (2012) contend that irrigation development continues as a primary factor in rural poverty alleviation by ensuring agricultural development, expanding livelihood opportunities and employment both on and off farm. The agricultural application of extracted groundwater has contributed to Indian rural poverty alleviation by enabling farmers to better manage episodic deficiencies in monsoonal rainfall, avoid drought related crop losses and engage in dry-season irrigation.

Groundwater in India accounts for about 80% of domestic water requirements and more than 45% of total agricultural water, irrigating 39 million hectares (Kumar et al., 2005; Siebert et al., 2010). Groundwater is also the primary source of water supply for many industrial uses and the single largest and most productive source of water for irrigation (Gangwar, 2013; Kinzelbach et al., 2003). Margat and van der Gun (2013) assess total annual Indian groundwater withdrawals at 251 km^3 or 26% of estimated global withdrawals. Famiglietti (2014) estimates withdrawals from Indian and Pakistan aquifers exceed recharge by 17.7 km^3/year. The annual net depletion rate of 7% highlights the lack of hydrological observation and monitoring networks (Famiglietti and Rodell, 2013), crucial information for estimating groundwater scarcity and negotiating sustainable aquifer management.

The notion of groundwater as a privately managed resource, with informal rights vested with the individual and associated with land rights, coupled with the absence of instruments to coordinate, constrain and enforce individual well operation has led to an exploitative extraction regime that exceeds recharge potential in Rajasthan and Gujarat, India (Shah, 2008, 2009; Maheshwari et al., 2014). Informal rights to extract groundwater are conferred

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http://dx.doi.org/10.1016/j.jhydrol.2016.02.003
0022-1694/

by well construction (costs are incurred by individuals) and land ownership (land ownership confers default rights to the aquifer below). The nexus between land and water rights has remained intact in the two watersheds, albeit the Indian Government has introduced statutory legislation whereby the sovereign rights to water are vested with the State (Cullet and Gupta, 2009). Rajasthan and Gujarat are currently debating local statutory variants.

Limited hydrological data to establish sustainable aquifer limits and the absence of state regulations or markets to coordinate the operation of autonomously operated individual wells has focussed attention on devolved administration and community level institutions (Steenbergen, 2006) as the primary loci for sustainable groundwater management in the Meghraj (Gujarat) and Dharta (Rajasthan) watersheds.

Ostrom (1992) developed design principles of robust, self-organised irrigation systems, emphasising clearly-defined boundaries; proportional equivalence between benefits and costs; the ability of irrigators to set and modify rules; monitoring; graduated sanctions; conflict resolution mechanisms; external recognition of rights to organise and nested enterprises. That is multiple, interdependent social and biophysical scales interacting at prescribed levels.

Gibson et al. (2000) distinguish the concepts of scale and level. Scale describes the nature of what is being measured, defining the spatial, temporal, quantitative, or analytical dimensions used to measure and study phenomena, in this case hydrology, land use, livelihoods, institutions and equitable access to groundwater. Levels refer to the units of analysis that are located at different positions on a scale. Kaczan and Ward (2011) report level mismatch between poverty and water scales in Africa. Syme et al. (2012) argue that poorly aligned levels of hydrological, social and economic scales have comprised efforts to achieve sustainable watershed development in India. Meinzen-Dick et al. (2002) argue that a careful examination of scale and level specific factors that create incentives for irrigator's to cooperate and influence willingness to participate in community level groundwater management is critical for developing effective institutions to devolve groundwater management. Ludwig et al. (1993) and Ward and Kaczan (2014) argue that scale 'misfit' of water management occurs when organisations, such as national governments and catchment management authorities undertake uniform management action at a level that does not match either the biophysical or socio-economic differentiation of the system. Ludwig et al. (1993), Meinzen-Dick et al. (2002) and Syme et al. (2012) highlight the selection of the hydrological level coupled with social and individual heterogeneity as central challenges which influence how irrigators might organise for community based groundwater management.

Ostrom (1998, 2003), Bowles and Gintis (2005) and Ward et al. (2008) contend that community crafted groundwater institutions appeal to, and mobilise individually held attitudes and motivations that reinforce collective action. Empirically tested theoretical frameworks from cognitive and social psychology indicate that behaviour, decision making and actions are shaped partially on individually held attitudes expressed as social norms (Ajzen, 1991; Schwartz and Bilsky, 1990; Schwartz, 1992; Stern et al., 1998, 1999). However the underpinning attitudes that potentially shape Indian irrigator's willingness to participate and cooperate in community based groundwater management has received limited attention.

Attitudes towards groundwater management held by irrigators located in the Meghraj and Dharta watersheds are introduced as an additional scale with the potential to better understand irrigator motivations and flag possible attitudinal tensions when assisting communities to coordinate groundwater management. Quantifying the diversity of individual groundwater attitudes represents a scale intended to contribute to two research objectives (i) improve the correspondence of institutional levels capable of self-organisation with hydrological levels likely to meet sustainability criteria; and (ii) provide an empirical basis to design participatory processes that will assist groundwater dependent communities craft institutions to sustainably manage local aquifers.

The attitudes of individual well owners were derived from a social and economic survey conducted as part of the Managed Aquifer Recharge through Village-level Intervention (MARVI) research program (Maheshwari et al., 2014). The survey explored a wide range of issues and challenges related to groundwater management, including attitudinal questions on groundwater use strategies, adoption of farming practices such as the use of moisture conservation techniques (e.g., mulching), selection of crop varieties that save water and the use of irrigation technologies that are more efficient (e.g., drip system). The analysis of survey data enabled testing of the general hypothesis H_a: attitudes towards groundwater management and farming practices, household income and trust levels are significantly different across the watershed and village levels. These three variables, tested independently, have substantial influence on groundwater management strategies, institutional settings and future policy needs. Relatively homogenous attitudes would suggest that a uniform participatory approach could assist the two watershed communities craft consistent rules to manage groundwater such as well placement, well operation, monitoring and standardised sanctions and negotiations within and between management levels. In contrast, heterogeneity would suggest locale specific institutions may evolve and participatory approaches that address attitudinal diversity would improve the efficacy of community assistance programs.

The analysis followed a sequence of four steps. First, a hierarchical cluster analysis of attitudes towards groundwater management and farming practices was estimated to determine attitudinal diversity across the watersheds. The hypothesis was rejected if a two or less ($\leqslant 2$) cluster solution was derived. Second, a typology of Meghraj and Dharta groundwater users was constructed to ascertain the management preferences and willingness to cooperate of members of the different cluster segments. Third, significant differences ($\alpha = 0.05$) in household income and assets across attitudinal clusters; and significant differences in the trust levels of assisting agencies across attitudinal clusters were estimated using ANOVA. In conclusion, a framework of cluster specific factors is described to address objective (ii): that is to provide an empirical basis to design participatory processes that assist groundwater dependent communities craft institutions to sustainably manage local aquifers.

2. Literature review

The Managed Aquifer Recharge through Village level Intervention (MARVI) research project focussed on developing a transdisciplinary participatory approach to assist communities craft institutions to balance the extraction and managed recharge of groundwater in the Dharta (Rajasthan) and Meghraj (Gujarat) watersheds (Maheshwari et al., 2014). The project investigated the spatial extent, water quality characteristics and hydrological dynamics of the Meghraj and Dharta hard rock aquifers, conducted school education programmes, elicited traditional knowledge, trained villagers in well monitoring and facilitated community consultation to ascertain the potential of MAR for recharge augmentation.

Meinzen-Dick et al. (2002) argue that a careful examination of scales and levels that create incentives for irrigator's to cooperate and influence willingness to participate is critical for developing effective institutions and policy implementation of devolved