Official Journal of the World Water Council
Water Policy

Water Policy Vol 24 No 4, 667 doi: 10.2166/wp.2022.306

Participatory water institutions and sustainable irrigation management: evidence and lessons from West Bengal, India

Soumyadip Chattopadhyay [a,*], Indranil De [b], Prabhat Mishra[c], Akhilesh Parey[d] and Subhasish Dutta[d]

[a] Department of Economics and Politics, Visva Bharati University, Santiniketan, West Bengal 731235, India
[b] Institute of Rural Management Anand, Anand, Gujarat 388001, India
[c] Water Resources Investigation and Development Department, Government of West Bengal, West Bengal Accelerated Development of Minor Irrigation Project (WBADMIP), Kolkata, India
[d] West Bengal Accelerated Development of Minor Irrigation Project (WBADMIP), Kolkata, India
*Corresponding author. E-mail: soumyadip.chattopadhyay@visva-bharati.ac.in, soumyadip.chattopadhyay@gmail.com

SC, 0000-0002-7373-1408; ID, 0000-0002-6174-2310

ABSTRACT

Based on a survey of selected Water Users' Associations (WUA) and their members in West Bengal, India, this paper examines the nature and determinants of member participation in irrigation management. WUA meetings were held on a regular basis with higher member participation under Tube Well, Check Dam and River Lift Irrigation schemes. Their physical characteristics (e.g., high sub-surface storage and flowing rivers with large catchment areas) and system features (e.g., centralized pump house and defined distribution infrastructure) contribute to better water availability, incentivizing the members to participate. Our regression analysis suggests that along with these factors, the socioeconomic attributes of members and their perception about the functioning and decision making of the WUA influence participation in the collective management of schemes. The more the members perceive the functioning of WUAs as democratic and transparent, the greater is their incentive to participate. Greater participatory involvement of the members in the form of donating land for irrigation construction and in training programs is also found to be crucial. So, this paper argues for making the decision-making processes within WUAs democratic and transparent, along with greater efforts toward capacity building of the members, including training for skill enhancement, management and provision of agricultural support practices.

Key words: collective action, India, participatory irrigation management, water users' association, West Bengal

HIGHLIGHTS

- Members participate frequently in association meetings in schemes with better water availability.
- Participation in crop plans and water mapping is limited.
- Democratic and transparent functioning of associations incentivizes members' participation.
- Skill development and improved agricultural practices positively influence participation.
- Members' involvement in maintenance works and land donation facilitates participation.

INTRODUCTION

Of late, the dramatic expansion of irrigation infrastructure has coincided with a policy shift in the role of governments from direct management of irrigation systems to transfer of the authority of governance to water users and

their capacity building (Narain, 2003; Chun, 2014). In India, poor maintenance of irrigation systems and the absence of proper mechanisms for distribution and efficient use of water has weakened government-operated irrigation systems developed during the 1970s (Reddy & Reddy, 2005; Bassi *et al.*, 2010). Subsequently, national policies on irrigation management have aimed at increasing the participation of water users in the management of their systems. Worldwide Participatory Irrigation Management (PIM) policies draw on the broader ideas of economic liberalization and the privatization of services along with an emphasis on the decentralization of irrigation management responsibilities to local governments and user-based associations. International donors like the World Bank and the United States Agency for International Development (USAID) have promoted these reforms since the 1980s and made the availability of funds conditional to the adoption of the PIM practices. Local NGOs have played a catalytic role in farmer mobilization and training and capacity building.

Water users' associations (WUAs) are formed to organize local farmers and facilitate their engagement in planning and managing water distribution and use. However, empirical evidence on the performance of WUAs is mixed. Some studies showcase the successes of WUAs in improving water delivery, increasing crop yield with greater crop diversification, increasing farmer income and improving the financial viability of irrigation systems (Reddy & Reddy, 2005; McCarthy & Essam, 2009; Bassi *et al.*, 2010; Huang *et al.*, 2010; Zhang *et al.*, 2013; Sudgen *et al.*, 2020). Other studies report about the underperformance of WUAs because these WUAs fail to organize and monitor water users and enforce the rules of collective water management (Bardhan, 2000; Meinzen-Dick *et al.*, 2002; Takayama *et al.*, 2018; Wang & Wu, 2018). Along with users' attributes, physical characteristics of the irrigation systems and outcome incentives, the success or failure of WUA-led irrigation schemes depends on users' participation in their management (Bastakoti & Shivakoti, 2012; Chun, 2014; Muchara *et al.*, 2014). The institutionalization of participatory decision-making processes with appropriate incentives and accountability arrangements motivates water users to act rationally in support of the system. In this context, this paper examines the nature and dynamics of members' participation in the management of irrigation systems and identifies the determinants of member participation in WUA activities to contribute to the formulation of sustainable local irrigation policies.

Policy rhetoric favoring WUAs draws on its strength from the theories of collective action, which argues that individuals choose collective action when their individual actions fail to fulfill their needs and when they find contribution to collective goods beneficial (Brewer *et al.*, 1999). However, given the rational self-seeking individuals' aim of maximizing their gains and non-excludability of public common pool resources, there is always the risk of overutilization of such resources (Ostrom & Gardner, 1993). Minimization of such risks calls for the establishment of an institution and attendant rules for resource management and appropriation that mobilize individuals to accomplish certain objectives (Ostrom, 1990, 1992). Theoretically, for such institutions, the relationship between group size, as well as their heterogeneity, and successful collective action is complex. Smaller and heterogeneous groups may help collective action, provided some members are more resourceful than the rest and they can cooperate with one another (Olson, 1965). However, a large group size increases the transaction and enforcement costs of group behavior, thus intensifying the problems involved in collective action (Meinzen-Dick, 1996; Gulati *et al.*, 1999). Ostrom (1992) further argued that the crafting of effective institutions crucially depends on peoples' involvement in setting and enforcing the operational and collective choice rules regulating decision making. Participatory processes and modalities – especially who participate in the institution and how well this reflects members' interests and the roles – shape the incentive structure and accountability mechanisms of WUAs (Subramanian *et al.*, 1997). Users' participation in the process of devising and continuously modifying collective rules is seen as more conducive for their enforcement and, therefore, tends to make the management of resources more sustainable.

A lack of community participation and the absence of accountability mechanisms linking officials of government-managed irrigation systems to water users in China and Nepal resulted in poor performance of these systems (Ostrom, 1996; Hu *et al.*, 2014). Unsatisfactory awareness and a lack of involvement of the local community weakened the institutional structure of WUAs in a southern state of India and this, in turn, made the sustainability of benefits, e.g., improved quality of irrigation, uncertain (Reddy & Reddy, 2005). There is evidence of WUAs being captured by village elites or plagued by factionalism, often stymieing the process of collective action (Bardhan, 2000; Narain, 2003; Bassi *et al.*, 2010). Transparency is also key to building a strong community institution. Successful WUAs are found to be more transparent in the dissemination of information and provide clarity on procedures and the maintenance of physical and financial records. Such WUAs are also found to have strong grievance redressal mechanisms (Meinzen-Dick *et al.*, 2002). In spite of having an appropriate institutional framework, WUAs may not become effective if their members lack the necessary skills, knowledge and the capacity to work collectively (Howarth *et al.*, 2005). Further, the external environment in which the WUAs operate, e.g., physical scarcity of water and irrigation infrastructure, the systematic process of WUA formation involving local users, etc. also influence the scope of collective action (Meinzen-Dick, 1996; Narain, 2003). Extreme scarcity of water may make collective management difficult owing to severe conflicts arising out of scarcity, while abundant water may disincentivize the users in pursuing collective action (Uphoff *et al.*, 1990). Effective leadership can facilitate the mobilization of users and, thus, make the organization robust and sustainable (Gulati *et al.*, 1999; Narain, 2004). The dynamics of local power in terms of relationships between the users and the bureaucracy and also among the users shapes the autonomy and accountability of WUAs (Narain, 2004).

The existing literature on how the characteristics of irrigation systems and user groups shape collective action for irrigation management is rich. This paper complements the existing body of research with two-fold objectives: first to examine the participatory arrangements of WUAs and their implications for incentives and accountability and second to identify the factors shaping the nature of members' participation in WUA activities. This paper is structured as follows: The West Bengal Accelerated Development of Minor Irrigation Project (WBADMIP), the data and the methodological approach are described in the section 'The Data and Methodological Approach'. The section 'Members' Involvement in and Perception of Participatory Management Processes' assesses members' involvement in and perception about participatory management and governance processes. The section 'Regression Results' identifies the socio-economic-institutional factors affecting the members' participation in WUA meetings. The concluding section reflects on the main findings of this paper.

DATA AND METHODOLOGICAL APPROACH

This paper is based on a survey of 63 WUAs under the WBADMIP. The project aims to enhance the agricultural production of small and marginal farmers through multipronged strategies, including the strengthening of community-based irrigation management. WUAs are created to organize and involve the users in the operation and management of minor irrigation (MI) schemes with the provision for agricultural support services and improved technologies. Under this project, 2044 WUAs constituting 107,000 small and marginal farmers were formed (World Bank, 2019). Notably, the literature on water governance distinguishes between 'top-down' and 'bottom-up' participation practices (Buuren *et al.*, 2019). Under the 'top-down' approach, policymakers invite stakeholder participation to strengthen governance capacity, while stakeholders under the 'bottom-up' approach mobilize themselves to organize and manage water resources. The WBADMI project resembles the 'top-down' approach as farmers are mandated to participate in irrigation management through WUAs.

In this study, we selected WUAs through multistage stratified random sampling. First, we stratified the WUAs across the six agro-climatic regions of West Bengal. After stratifying the WUAs from each agro-climatic stratum by the type of scheme, 5% of the WUAs were randomly selected from each type of scheme. Although the scheme-

wise selected WUAs were proportional to their actual number, in a few cases, the number was adjusted to cover all types of WUAs in each agro-climatic region. Among the 63 WUAs, 52 WUAs were functioning fully or partially, whereas the rest were dysfunctional at the time of survey. Around 10% of members were surveyed, totaling 407 members. A structured questionnaire was used to collect information from them. Table 1 presents the distribution of the members in the survey. We have considered only functional WUAs and the responses of 345 members.

Acknowledging the possible interlinkages between the nature of the MI schemes and their performances, we have classified the WUAs under two categories – ground water (GW) irrigation (consisting of Deep Tube well (DPTW), DPTW (solar), Light-Duty Tube well (LDTW), Medium-Duty Tube well (MDTW), Shallow-Tube deep-well (STDW), Shallow-Tube well (STW), Tube well (TW), TW (solar) and PDW (Pump Dug Well) and surface water (SW) irrigation (consisting of Check Dam (CD), River Lift Irrigation (RLI), Surface Flow Minor Irrigation Scheme (SFMIS) and Water Detention Structure (WDS)).

We have employed regression models to identify the determinants of members' participation in irrigation management systems. Participation in WUA activities is influenced by the physical characteristics of the irrigation system, the institutional structure of WUAs and the socioeconomic attributes of the users. Our dependent variables include the frequency and mode of members' participation in WUA meetings. Multivariable regression is used to model the determinants of the frequency of members' participation in meetings. The application of the Breusch–Pegan test indicates the presence of heteroscedasticity – so, we have used a heteroscedasticity-consistent estimation method. Depending on members' responses on whether they raised any issue in the WUA meetings and took part in the subsequent discussions, binary modes of participation are considered and a probit model is employed.

The explanatory variables include the irrigation system, WUA and member-specific characteristics. We hypothesize that a higher number of group members and large command areas entail positive economies of scale in using resources and provide greater incentives to the members to participate. However, in larger groups, incentives to free-ride on other members' efforts may also be higher. Empirical evidence on the effect of the number of users on collective action is ambiguous (Takayama *et al.*, 2018). We have included both the number of group members and its square to examine the relationship between group size and participation in WUA activities. Members with larger land size are likely to participate more in WUA meetings as they can afford to spend more time and resources to initiate and maintain collective action (Nagendra, 2011). Members with more resources may accrue benefits from public goods' provision and collection action (Olson, 1965). The higher the distance between the MI structure and the member's agricultural land, the lower is their incentive to

Table 1 | Distribution of sample members by agro-climatic regions.

Agro-climatic region	No. of WUAs	No of members
Northern Hilly	1	8
Terai Teesta Floodplain	17	68
Vindhyan Old Floodplain	12	86
Gangetic Floodplain	9	90
Undulating Lateritic	19	97
Coastal Saline	5	58
Total	63	407

Source: Primary Survey, 2019.

participate. Age and education of the members – two proxies for human capital – are hypothesized to have a positive effect on their participation, because an aged person with higher educational attainments is likely to better comprehend the importance of participation in group activities. The positive influence of crop diversification is hypothesized because members undertaking crop diversification in three harvesting seasons are likely to participate more in WUA activities. Members who are more involved in the construction and maintenance of irrigation and contribute land for the construction of MI structures are more likely to participate in WUA activities (Subramanian *et al.*, 1997; Muchara *et al.*, 2014). Therefore, we expect a positive relationship between members' involvement in maintenance activities and contribution of land with their participation. If members have a better knowledge about the operational rules of WUAs, it is likely to facilitate their participation in WUA meetings in greater numbers. Based on their responses to the decisions taken by the Managing Committee (MC) via general meetings (involving more than half of the WUA members) or by the MC members/few members and the lack of any knowledge on their part, we have used two dummy variables, with the lack of any knowledge as the reference category. Members' perception about the transparent functioning of WUAs, captured through the disclosure and circulation of physical and financial information, including audited reports, influence the legitimacy of WUAs as institutions and, so, the expected impact of the associated dummy variable is positive. Members' perception about the ability of WUAs in managing water conflicts improves the credentials of the WUAs as institutions. So, if members are highly aware of conflict-solving approaches of WUAs, their willingness to participate in WUA meetings would be greater. Members who receive some training on skill development or improved practices of agriculture and related activities provided by WUAs would be more interested in participating in WUA meetings and activities. So, we expect that training dummy variables will have a positive impact. If members frequently participate in WUA meetings, their ability to actively take part in the decision-making process would be greater. So, the expected impact of meeting attendance frequency on the active mode of participation is positive. We have considered four different models to avoid multicollinearity from correlation among the independent variables.

The WUAs have, on average, 66 registered members, with 10 of them being female[1]. A total of 66% of them are marginal farmers owning land of less than one acre. In terms of social group membership, the WUAs appear to be inclusive, because about two-fifths of the members belonged to the general caste category, one-third belonged to the Scheduled Caste (SC) and Scheduled Tribe (ST) categories[2] and one-fourth belonged to the other category (i.e., Muslim).

Nearly 35% of the members contributed land for the construction of irrigational infrastructure, with the same being higher in Tube well and PDW schemes. A total of 32% of the members reported that the MI structures were constructed on government land, while the rest reported land contribution by other WUA members. Inter-scheme variability in water availability is observed, with a comparatively higher proportion of members reporting better availability of water under the Tube well, PDW, CD and RLI schemes. An overwhelming majority of 94% of the members reported having made timely payment of water charges that are fixed either on the basis of area (per bigha per season) or on the basis of per hour. There has been a significant increase in the amount of average land cultivated and the number of crops, especially in the rabi and pre-kharif seasons. The average land cultivated

[1] The WUA membership under the WBADMIP is not based on ownership of land. All the water users within the command area can be a member of the WUAs. Households exercised their discretion in enlisting their male or female members as the WUA member. Importantly, the WBADMIP tried to involve the women in WUA activities through mandating that one-third of the Managing Committee member should be women and women should be the member of other sub-committees.

[2] Scheduled Caste and Scheduled Tribe are the Government of India classifications for certain caste groups that are historically subjected to discrimination, economic and social exclusion.

ranged from 2.04 bigha for SW schemes to 2.23 bigha for GW schemes in the rabi season – a significant portion of which remained unutilized before the introduction of the WBADMI program. In terms of cropping intensity,[3] the Tube well, PDW, CD and RLI schemes surpassed the program target value of 170 (World Bank, 2019). Moreover, a clear trend of crop diversification is observed as the members reported the cultivation of two to three crops a year, including cash crops, instead of the traditional one rain-fed subsistence crop.

MEMBERS' INVOLVEMENT IN AND PERCEPTION OF PARTICIPATORY MANAGEMENT PROCESSES

Members' participation in WUA meetings

WUAs are supposed to hold frequent MC and General Body Meetings (GBM) involving the members. These meetings provide a forum for the members to hold discussions on the management of irrigation systems, including the cropping pattern, the rules for water allocation and distribution, water charges and the identification of beneficiaries and conflicts therein. The scope of deliberations, between users and MC members of WUAs on irrigation issues, can make the decision-making process more democratic and improve accountability and transparency, which, in turn, can strengthen the institutional sustainability of WUAs. In reality, the more the members get the opportunity to participate and deliberate in public forums, the more chances they will get to enhance their skills and also get motivated, which are necessary to make such participation meaningful. Therefore, members' frequency of meeting attendance and their mode of participation are indicative of the effectiveness of participation in WUA meetings. A total of 85% of members are reported to have attended WUA meetings at least twice last year (Table 2). Among the GW schemes, members' participation in meetings is found to be the highest for the Tube well scheme, while such participation among the SW schemes is found to be the highest for the CD and RLI schemes. Notably, WUA meetings were held on a regular basis with more frequent participation of members under the Tube well, CD and RLI schemes. The tube well and RLI schemes consist of more activities, more maintenance-related work and carry more benefits due to the certainty of water supply under these schemes. These factors could have contributed to higher member participation.

Discussions in such meetings mostly centered on issues related to new agricultural/horticultural/fisheries techniques and practices. Only 12% of the members reported that some discussions took place on financial matters,

Table 2 | (Scheme/category wise) members' responses on their meeting attendance and mode of participation (in %).

		Irrigation scheme/category							
		TW	PDW	GW	CD	RLI	WDS	SW	Total
Meeting Attendance	Once	3.93	0.00	3.77	0.00	4.76	7.69	4.72	4.06
	Twice	12.66	40.00	13.81	0.00	4.76	15.38	6.60	11.59
	Three to four times	24.02	10.00	23.43	23.53	20.63	38.46	25.47	24.06
	Five to six times	19.21	10.00	18.83	29.41	19.05	30.77	23.58	20.29
	Seven to ten times	28.82	30.00	28.87	29.41	36.51	3.85	27.36	28.41
	More than ten times	11.35	10.00	11.30	17.65	14.29	3.85	12.26	11.59
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Raising of any issues in meetings	Yes	49.34	7.14	46.91	50.00	59.42	52.00	56.80	50.27
	No	50.66	92.86	53.09	50.00	40.58	48.00	43.20	49.73
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Primary Survey, 2019.

[3] Cropping intensity=(Gross Cropped Area/Net sown area)∗100.

for example, on water charges and audit reports. Very few discussions were held on important aspects like crop planning, seed distribution, water distribution, distribution of inputs in horticulture and fisheries, membership and registration of WUAs and overall functioning of WUAs, which are, nonetheless, essential for sustainable management of MI schemes. Moreover, roughly about half of the members preferred to simply sit and listen to the proceedings of the WUA meetings. It is worth noting that no significant differences were observed between the proportion of members belonging to the general category and the SC/ST category both in terms of frequency of meeting attendance and their mode of participation.

Members' participation in the crop development plan and water mapping

Preparation of crop development plans and water mapping are two important constituents of water management, especially if water is scarce. Adoption of appropriate allocation rules regarding the choice of crops, cropping sequence and the period and frequency of supply involving local users and their effective enforcement will help meet the demand and supply of water and reduce uncertainties and conflicts among users in accessing water. It was found that the members' awareness about the preparation and/or documentation of crop development plans was higher compared with their awareness on water mapping. The proportion of members reporting for the preparation and documentation of the crop development plan almost doubled during the kharif and rabi seasons as compared with the pre-kharif season. Among the different schemes, a comparatively great proportion of members under Tube well, RLI and CD reported for the preparation and/or documentation of crop development plans and water mapping in all three growing seasons, with the corresponding figures being the highest for the RLI scheme.

Overall, schemes like Tube well and RLI experienced a comparatively high participation in WUA meetings as well as in the preparation and/or documentation of crop plans and water mapping exercises. Some degree of water scarcity is presumed to incentivize users to manage and maintain irrigation systems compared with the situation when water scarcity is severe or when water is abundant (Takayama *et al.*, 2018). Tube well schemes are located in areas without any previous water arrangement. The check dams selected in our study belong to the western part of West Bengal, with a higher incidence of mono-cropping. Moreover, schemes like Tube well and RLI are characterized by a centralized pump house and a defined distribution infrastructure which ensure better availability of water, and, hence, the incentives for users to participate in WUA activities are higher. In contrast, in schemes like WDS, users use individual pumps that make access to water largely dependent on individual capacity and the distance of agricultural land from the water source. Also, poor maintenance of these schemes will lead to inadequate water supply. Thus, both the physical[4] and system features of different schemes provide differential incentives for the users, resulting in differential participatory practices. Further, almost half of the members present in WUA meetings preferred not to raise any issue. This could be due to the fact that the MC members and farmers who donated land for the schemes dominated the discussions. This could also be due to the general acceptability of MC's decisions to all WUA members. The limited participation seen for water mapping could jeopardize the WBADMI project's goal of equitable distribution of water and, also, could weaken the WUAs, thereby impairing the long-term sustainability of the project itself.

Members' perception on the governance of WUAs

Members' awareness regarding the selection of an MC is considered as an indicator for transparent and democratic functioning of WUAs. Here, about 60% of the members reported that the MC members are selected

[4] Water availability is better among the TW, PDW and RLIs as they tap high groundwater storage and flowing rivers with large catchment areas. In contrast, the lower storage capacity of schemes like WDS with the possibility of seepage and evaporation, especially during the dry seasons, reduces water availability.

through either GBM involving all members or GBM involving at least half of the members.[5] A total of 35% of the members were found to be unaware about the selection process. Only 6% of the members seemed to be unhappy, because they reported about the non-occurrence of any GBM or about the fact of only land donors becoming MC members.

A scheme-wise analysis of members' responses regarding the decision-making process indicates marginal inter-scheme variations. A large proportion, as high as 35%, of members were found to be unaware of the decision-making process (Table 3). This is concerning, because every member should participate in the decision-making process to devise rules that serve their best interests. Collective action would be successful and sustainable only if members themselves devise the rules and mechanisms with mutual agreement (Ostrom, 1990).

Moreover, transparency, reflected through the disclosure and circulation of physical and financial information, including audited reports, was less, as almost half of the members under CD, RLI and WDS pleaded ignorance about various matters related to physical and financial transparency, while the corresponding figures ranged from 61% for Tube well to 78% for PDW (Table 4). In terms of sharing the audit report with the Registrar of Societies or with the WUA members in the meeting, a relatively high proportion of members (20%) under the RLI scheme reported transparency.

So, the worrisome fact is that little more than one-third of the members were unaware of the selection process of the MC members and the decision-making process of the WUAs. Further, about three-fifths of the members exposed their ignorance about physical and financial information pertaining to irrigation schemes. This might be due to the users' adverse perception about the fruitfulness of acquiring such information, as they perceived that all financial, operational and maintenance activities were carried out only by a few select people. In fact, there is evidence that the MC members and farmers owning land near the schemes are more involved in the workings of the WUAs. In about 25% of the WUAs, farmers who contributed land for the schemes became the chairperson of the MC. Importantly, in 81% of the WUAs, the members of the MC remained the same since their inception (De *et al.*, 2022). Some members are treated no better than ordinary water buyers purchasing water from the schemes. Further, the project provided for the participation of tenant farmers and sharecroppers

Table 3 | (Scheme/category wise) members' perception regarding the decision-making process in WUAs (in %).

	Irrigation scheme/category							
Knowledge of the decision-making process in WUAs	**TW**	**PDW**	**GW**	**CD**	**RLI**	**WDS**	**SW**	**Total**
MC makes a decision on their own	7.47	0.00	7.06	8.33	2.35	3.70	3.50	5.78
MC through a general body meeting (involving more than 50% members)	58.92	50.00	58.43	66.67	60.00	59.26	60.14	59.05
Decision taken by a few members who control WUAs	0.41	0.00	0.39	0.00	1.18	0.00	0.70	0.50
Do not know	33.20	50.00	34.12	25.00	36.47	37.04	35.66	34.67
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Primary Survey, 2019.

[5] However, the WUAs hardly followed any specific criteria for member selection. Only in 13% WUAs, criteria like education, agricultural expertise or leadership qualities were considered for selecting Managing Committee members.

Table 4 | (Scheme/category wise) members' perception regarding the transparency of WUAs (in %).

	Irrigation scheme/category							
Transparency of WUAs	**TW**	**PDW**	**GW**	**CD**	**RLI**	**WDS**	**SW**	**Total**
Proactive disclosure in place	12.86	14.29	12.94	29.17	16.47	18.52	18.18	14.82
Non-members have on-demand access to physical and financial information	2.90	0.00	2.75	4.17	1.18	7.41	2.80	2.76
MC meeting minutes containing physical and financial matters circulated among members	4.15	0.00	3.92	4.17	4.71	0.00	3.50	3.77
Most MC members aware of the last meeting's discussion on physical and financial matters	3.32	0.00	3.14	0.00	2.35	7.41	3.50	3.27
The latest audit report shared with the Registrar of Societies	9.96	7.14	9.80	8.33	8.24	0.00	6.29	8.54
The latest audit report findings shared with all WUA members in the GBM	5.81	0.00	5.49	8.33	12.94	14.81	13.29	8.29
Do not know	61.00	78.57	61.96	45.83	54.12	51.85	52.45	58.54
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Primary Survey, 2019.

in the GBM, although without any voting rights. All these could undermine the democratic potential of the WUAs in the long run.

Members' involvement in maintenance activities

Regular maintenance of the irrigation infrastructure and members' involvement in the maintenance and construction phase of the schemes shape the long-term sustainability of the MI project. About 80–85% of the members rated the maintenance of the MI structure both 'before' and 'after' season as excellent or good, with the same being comparatively high for GW schemes (Table 5). Involvement of the WUAs in maintenance works was relatively more in the RLI and CD schemes, whereas the members themselves were more involved in maintenance works in the Tube well and PDW schemes.

In the event of a breakdown, Tube well schemes often require immediate technical assistance. This has prompted the members to hire technical experts to resolve such problems. However, the costs of maintenance

Table 5 | Members' perception and involvement in the maintenance of the MI structure (in %).

Perception regarding maintenance of the MI structure	**Before season**	**After season**	**Authority/persons responsible for maintenance of the MI structure**		**Type of involvement**	
Excellent/good	78.57	85.14	A	44.35	Passive	56.76
Average	20	13.43	B	47.74	Active	14.25
Poor/very poor	1.43	1.43	C	7.91	No Involvement	28.99
Total	100	100		100		100

Note: A: Only WUA; B: Beneficiaries and WUA; C: Landowners and WUA. Passive: Members were aware about maintenance activities; Active: Members participated in maintenance activities.
Source: Primary Survey, 2019.

activities in the RLI and CD schemes (e.g., replacement or purchase of pump sets, arrangement of inverters for addressing supply system breakdown, etc.) were higher. The MC of the WUAs was involved in addressing these maintenance-related issues. Effective leadership emerged as a crucial factor in one of the surveyed WUAs, as they quickly arranged for alternative pumps and managed to meet the water requirements of crops that could, otherwise, be damaged due to the non-availability of water for two consecutive days.

Notably, the WBADMIP schemes were predominantly introduced in areas with a near absence or a complete lack of any irrigational facilities and being used for single crop cultivation. Under Tube well, RLI and CD, 60–70% of the members reported receiving adequate water according to their requirements. These schemes also recorded comparatively high cropping intensities in the range of 184–190, which are higher than the program target value of 170. Better availability of irrigation water and its potential for increasing agricultural production and encouraging diversification of economic activities might have motivated the members to maintain these schemes. Better maintenance and higher availability of water created a virtuous circle. Moreover, a comparatively high proportion of members contributing land for GW schemes and their engagement as operators created a sense of ownership and increased their scope of involvement in maintenance activities.

Members' participation in capacity building and training programs

The WBADMI project encourages the adoption of improved production technologies and water management practices, augmentation of community-level productive capacities and diversification of economic activities focusing on horticulture and fisheries. Only half of the functional WUAs arranged such training and support services. About 15% of the surveyed members reported receipt of skill training for starting or developing economic activities (e.g., in areas of planning and operation; financial and technical management, etc.). Members' participation in training on issues related to agriculture including horticulture (e.g., seed treatment, seed preservation, System of Rice Intensification (SRI), pest management, organic farming, etc.) and fisheries (e.g., management of fish hatcheries, etc.) under WUAs was also quite low. Participation figures for training on issues related to agriculture, including horticulture and fisheries, were 14 and 9%, respectively. Perception of the effectiveness of the training programs was mixed, because some members reported the usefulness of such interventions in addressing technical and managerial issues, while some members, even after receiving training, did not adopt new technologies and practices. Here lies the importance of effective leadership, because in some of the surveyed WUAs, a few members took some bold and varied initiatives, including a sensitization of the WUA members toward the adoption of organic farming through the use and sale of vermicompost, the development of income-earning activities and motivating farmers and women to attend the training program to improve their livelihood opportunities. The World Environment Day was celebrated for general awareness building and presenting WUAs as important public institutions. These initiatives may help develop trust among the users and encourage them to participate in the General Body Meeting and other activities of the WUAs.

REGRESSION RESULTS

Determinants of the frequency of member participation

The definitions of the explanatory variables are summarized in Table 6. Table 7 presents the OLS estimates of the determinants of the frequency of member participation in the WUA meetings. The statistical significance of the estimated coefficients across the four models indicates their robustness. The overall significance of our estimated models is revealed by the statistical significance of the computed *F*-values. The results demonstrate that GROUP_MEM, NP, EDUCATION, INVLV_MI, L_DONATE, CONFLICT, DUM_TRNSP, MC_DV1, TRAINING and CD_KHARIF are positively and significantly associated with the frequency of WUA meetings attended by the members. The estimated coefficients of SQ_GROUP_MEM, CATEGORY and DISTANCE are

Table 6 | Explanatory variables.

Variable name	Description
GROUP_MEM	Number of members in the WUA
SQ_GROUP_MEM	Square of the number of members in the WUA
COM_AREA	Total command area of the WUA (in bigha)
CATEGORY	1 if the scheme is under GW; 0 otherwise
NP	1 if the scheme is located in the Northern Plateau region; 0 otherwise
CENTRAL	1 if the scheme is located in the central region; 0 otherwise
COASTAL	1 if the scheme is located in the coastal region; 0 otherwise
HILLY	1 if the scheme is located in the hilly region; 0 otherwise
AGE	Member's age in years
SEX	1 if the member is male; 0 otherwise
EDUCATION	Member's education in years
DISTANCE	Distance between the MI structure and the member's agricultural land
LAND	Land owned (in bigha) by the member
NO_OF_TIMES INVLV_MI	Frequency of meeting attendance by the member 1 if the member is involved in maintenance activities; 0 otherwise
L_DONATE	1 if the member donated land for MI construction; 0 otherwise
CONFLICT	1 if the member perceives that a WUA can solve water conflicts; 0 otherwise
DUM_TRNSP	1 if the member reported the availability of physical and financial information on WUA activities; 0 otherwise
MC_DV1	1 if the member reported that the Managing Committee of the WUA takes decisions involving more than half of the members; 0 otherwise
MC_DV2	1 if the member reported that the Managing Committee members or a few members of the WUA take decisions; 0 otherwise
TRAINING	1 if the member attended any skill training/agriculture/horticulture/fisheries training; 0 otherwise
CD_RABI	1 if the member undertakes crop diversification in Rabi season after the introduction of WBADMI; 0 otherwise
CD_KHARIF	1 if the member undertakes crop diversification in the kharif season after the introduction of WBADMI; 0 otherwise
CD_PREKHARIF	1 if the member undertakes crop diversification in the pre-kharif season after the introduction of WBADMI; 0 otherwise

Source: Primary Survey, 2019.

negative and statistically significant. The influences of other explanatory variables SEX, COM_AREA, AGE, LAND, CD_RABI, CD_PRE KHARIF and region dummy variables conform to our hypothesized relationship, although they are statistically insignificant.

Scheme characteristics

Positive and negative statistically significant coefficients of the number of group members and its squared term, respectively, indicate that the level of collective action as reflected in a higher meeting attendance increases with the increase in the number of group members but then decreases afterward. This is consistent with the theoretical

Table 7 | Determinants of the number of times the users attended WUA meetings.

Dependent variable: No of times the users attended WUA meetings

	Estimated coefficients			
Explanatory variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
GROUP_MEM	0.021*** (3.1252)	0.021*** (3.0384)	0.020*** (2.8590)	0.020*** (3.0162)
SQ_GROUP_MEM	−0.0004*** (−2.8185)	−0.000*** (−2.7838)	−0.000** (−2.4974)	−0.000*** (−2.7389)
COM_AREA	0.0007 (0.4294)	0.0013 (0.6758)	0.0012 (0.6229)	0.0013 (0.7153)
CATEGORY	−1.342*** (−3.1420)	−1.423*** (−3.3002)	−1.468*** (−3.555)	−1.402*** (−3.404)
NP	2.513*** (4.5714)	2.913*** (5.6465)	2.628*** (4.9122)	2.516*** (4.6287)
CENTRAL	0.0215 (0.043037)	0.0407 (0.0808)	0.0470 (0.0895)	−0.0213 (−0.0424)
COASTAL	−0.9823 (−1.6372)	−1.007* (−1.7023)	−1.1180** (−1.8343)	−1.1314** (−1.8530)
HILLY	−0.914 (−1.213610)	−1.369* (−1.8114)	−1.365 (−1.5735)	−1.339 (−1.5364)
AGE	0.015 (1.0304)	0.017 (1.1044)	0.016 (1.0660)	0.016 (1.0562)
SEX	0.158 (0.240526)	0.051 (0.0777)	0.180 (0.2746)	0.254 (0.3992)
EDUCATION	0.1812** (2.3446)	0.2051** (2.5858)	0.1914** (2.4573)	0.2002*** (2.5976)
DISTANCE	−0.001* (−1.844403)	−0.001* (−1.8939)	−0.0008* (−1.6552)	−0.001** (−1.8835)
LAND	0.513 (1.1365)	0.514 (1.0795)	0.571 (1.2542)	0.514 (1.1327)
INVLV_MI	1.135*** (3.1113)	1.228*** (3.2202)	1.070*** (2.7799)	1.016*** (2.6718)
L_DONATE	0.781* (1.878)	0.804** (1.9367)	0.837** (1.9645)	0.803** (1.9442)
CONFLICT	0.987*** (2.6909)			
DUM_TRNSP		0.564* (1.7364)		
MC_DV1			0.912** (2.2914)	
MC_DV2			1.151 (1.6275)	
TRAINING				1.030*** (2.6207)
CD_RABI	0.452 (1.2058)		0.492 (1.3277)	
CD_KHARIF				0.595* (1.6647)
CD_PREKHARIF		0.107 (0.2040)		
Const	1.662 (1.2460)	1.876 (1.3413)	1.524 (1.0842)	1.286 (0.9504)
Loglikelihood	−842.8362	−846.6621	−843.5173	−842.2940
F-statistics	9.751***	9.115***	9.073***	9.842***
Adjusted R^2	0.302	0.286	0.297	0.304
No of observation	345	345	345	345

Figures in the first brackets are computed *t*-statistics.
*, ** and *** imply significance at 10, 5 and 1%, respectively.

proposition of the medium-sized group being more successful in facilitating collective action for common pool resources and with the empirical findings of irrigation management in Japan (Takayama *et al.*, 2018). The frequency of meeting attendance increases for the SW schemes. The better availability of water in the CD and RLI schemes indicates efficient functioning of the WUAs, and this, in turn, motivated members to more frequently attend the WUA meetings.

This is consistent with the Bardhan (2000) findings of a positive relationship between cooperative behavior in irrigation management and access to water in India. The distance of cultivated land from the MI structure has a significant negative effect, which is consistent with the findings of previous studies (Muchara *et al.*, 2014; Wang & Wu, 2018). Water may become scarcer with an increase in distance, and this, in turn, will demotivate members to participate in WUA meetings. There were significant coefficients of the region variables – Northern Plateau (NP) suggest that as compared with the Western region, the members of NP attended the WUA meetings more frequently. The impacts for the coastal and hilly regions are negative, although insignificant. This could be due to locational differences in the operation and management of irrigation schemes in terms of design, training, etc., leading to better availability of water in better-managed locations (IWMI, 2019). A positive and significant coefficient of CD_KHARIF and the positive coefficients of CD_RABI, CD_PRE KHARIF suggest that members who undertake crop diversification after the introduction of the MI structure participate more frequently in WUA meetings, because such diversification entails better income-earning opportunities.

Users' characteristics

The positive estimated coefficients of education indicate that more educated members understand the importance of participation in WUA activities. This result is consistent with that of previous studies (Muchara *et al.*, 2014). The coefficients related to members' involvement in maintenance works and donation of land for the construction of the MI structure positively influence their willingness to participate in WUA meetings. Participation in maintenance works and land donation activities could be useful for infusing accountability into irrigation management and is in line with the results of existing studies (Muchara *et al.*, 2014).

Transparency and democratic functioning

Three independent variables – DUM_TRNSP, MC_DV1 and MC_DV2 – control the effects of transparent and democratic functioning of WUAs on members' participation. Our results show that transparent functioning of the WUAs as reflected by members' perception about the disclosure of physical and financial information, including audit report, is positively and significantly associated with the frequency of meetings attended by them. Members' awareness about the decision-making process involving more than half of the members is significantly and positively associated with their participation, whereas if members perceive the decisions taken by a few members or only by the MC members, the association is positive but insignificant. Similar empirical results are reported by Muchara *et al.* (2014) for South Africa and Takayama *et al.* (2018) for Japan. They state that transparent and democratic practices improve the level of collective action for irrigation management. The significant and positive coefficients of CONFLICT indicate that some members believed that WUAs can resolve water conflicts and participated more frequently in WUA meetings. These are also consistent with the findings of Chun (2014) for India. The significant and positive coefficient of TRAINING indicates that some members attended a few training sessions and participated more frequently in WUA meetings, and these are consistent with the findings of Muchara *et al.* (2014) for South Africa.

Determinants of the mode of member participation

We have considered members' two modes of participation – *active* if a member raised an issue and took part in discussions in the meeting and *passive* if a member simply sat and followed the meeting proceedings. Among the determinants, NO_OF_TIMES, DUM_TRNSP, MC_DV1, MC_DV2, CONFLICT, TRAINING, CD_RABI and CD_KHARIF are positively and significantly associated with members' mode of participation (Table 8). The impacts of EDUCATION turn out to be negative and statistically significant in two of the models. The significant and positive coefficients of CD_RABI and CD_KHARIF make economic sense, because members who diversified their agricultural production are more willing to actively participate in WUA meetings. More frequent meeting

Table 8 | Determinants of the members' mode of participation in WUA meetings.

Dependent variable: Mode of participation (1=Active; 0=otherwise)

	Estimated coefficients			
Explanatory variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
GROUP_MEM	0.001 (1.1307)	0.001 (1.3592)	0.001 (1.1883)	0.001 (1.2436)
CATEGORY	−0.210 (−1.1899)	−0.207 (−1.1732)	−0.258 (−1.4463)	−0.239 (−1.3614)
NP	0.265 (1.1829)	0.244 (1.1009)	0.174 (0.7627)	0.203 (0.9067)
CENTRAL	−0.242 (−1.1705)	−0.221 (−1.0669)	−0.248 (−1.1764)	−0.233 (−1.1306)
COASTAL	−0.267 (−0.9786)	−0.247 (−0.9104)	−0.280 (−1.0159)	−0.293 (−1.0718)
HILLY	0.161 (0.3203)	0.154 (0.3069)	0.205 (0.4115)	0.090 (0.1823)
AGE	0.005 (0.8327)	0.004 (0.6484)	0.006 (0.9765)	0.004 (0.6615)
SEX	−0.243 (−0.7741)	−0.269 (−0.8646)	−0.154 (−0.4848)	−0.213 (−0.6797)
EDUCATION	−0.051 (−1.4010)	−0.069* (−1.8939)	−0.053 (−1.4524)	−0.062* (−1.7002)
DISTANCE	0.000 (0.5710)	0.000 (0.5176)	0.000 (0.5756)	0.000 (0.5852)
NO_OF_TIMES	0.063** (2.5460)	0.062*** (2.5114)	0.055*** (2.2002)	0.061*** (2.4475)
LAND	0.274 (1.389)	0.244 (1.2556)	0.294 (1.4701)	0.268 (1.3718)
INVLV_MI_REV	0.229 (1.1730)	0.178 (0.9074)	0.182 (0.9085)	0.159 (0.8015)
L_DONATE_REV	0.148 (0.7502)	0.218 (1.1130)	0.202 (1.0150)	0.173 (0.8778)
CONF_REV		0.315** (2.004)		
DUM_TRNSP	0.340** (2.2888)			
MC_DV1			0.363** (2.1612)	
MC_DV2			0.683** (2.0695)	
TRAINING				0.310* (1.8050)
CD_RABI	0.309** (1.9189)			0.347** (2.1741)
CD_KHARIF			0.525*** (3.3765)	
CD_PREKHARIF		0.284 (1.2010)		
Const	−0.758 (−1.2160)	−0.580 (−0.9390)	−1.040 (−1.6354)	−0.708 (−1.1359)
Loglikelihood	−212.7402	−214.8217	−208.3031	−213.7327
LR Chi	52.76510	48.60212	61.63921	50.78004
McFadden Pseudo R^2	0.110	0.102	0.129	0.106
No of observation	345	345	345	345

Figures in the first brackets are computed *z*-statistics.
*, ** and *** imply significance at 10, 5 and 1%, respectively.

attendance also increases the probability of members being active in such meetings. A similar positive impact was also noted by Takayama *et al.* (2018) for Japan. The more the members attend meetings, the better is their knowledge on the operational rules of WUAs and greater is the possibility of social interactions. Such active participation is likely to induce other members to participate in WUA activities. The significant and positive coefficients of DUM_TRNSP, MC_DV1, MC_DV2, CONFLICT and TRAINING indicate a transparent and democratic decision-making process, the WUAs' ability to manage conflicts and the provision of training

improved the perceived effectiveness of the WUAs in irrigation management and, thus, motivated the members to actively participate in WUA meetings and activities. This is consistent with the findings of Muchara *et al.* (2014).

Overall, the econometric results largely conform to the empirical findings on the theory of collective action in the context of irrigation management in West Bengal. In particular, they underscore the importance of Ostrom's (1990, 1992) core argument that the development of irrigation infrastructure is unsustainable unless water users play a larger role in its governance and management.

CONCLUSION

The existing empirical literature on irrigation management in India acknowledges that, apart from the problem of growing water stress due to shortage of water, the absence of appropriate institutional arrangements for collective action hinders the process of sustainable water resource management (Reddy & Reddy, 2005; Bassi *et al.*, 2010; Sudgen *et al.*, 2020). Successful as well as sustainable collective efforts are marked by the effective participation of water users in the governance, financing and management of irrigation systems, but it is hard to prescribe any standard model (Subramanian *et al.*, 1997; Narain, 2003; Chun, 2014). The combination of the physical characteristics of the irrigation system, the institutional structure of WUAs and the socioeconomic attributes of the users determines user participation in the collective activities of the WUAs.

Based on the members' responses under the WBADMI project, this study found that WUA meetings were held on a regular basis with higher as well as more frequent participation of members under the TW, CD and RLI schemes. The WBADMI project constructed these schemes in areas lacking in irrigational facilities and those that are being used for mono-cropping. So, apart from physical scarcity, the access to and availability of water appears to be crucial. The physical characteristics (e.g., high sub-surface storage and flowing rivers with large catchment areas under Tube well, PDW and RLI) and system features (e.g., a centralized pump house and a defined distribution infrastructure) of these schemes contribute to better availability of water, which, in turn, incentivize the members to participate. This calls for technical interventions, e.g., in the form of improvement in storage capacity or distribution systems in schemes where water supply is inadequate to meet the members' water demands. Moreover, the members' passive mode of participation in such meetings and limited participation in the preparation and/or documentation of crop plans, as well as water mapping exercises, could weaken the formal institutional structures of the WUAs.

Meaningful participation under the 'top-down' approach, as mandated under the WBADMIP, requires transparent participatory practices and empowering stakeholders through capacity development (Meinzen-Dick *et al.*, 2002; Howarth *et al.*, 2005; Buuren *et al.*, 2019). In conformity with the empirical literature on collective irrigation management, our regression analysis suggests that along with the institutional and socio-economic attributes of WUAs and members, the latter's perception about the functioning of the WUAs influences their participation in the collective management of schemes. Furthermore, the more the members perceive the functioning of WUAs as democratic and transparent, the greater is their incentive to participate. When the members are engaged in planning and managing their own irrigation services, the most difficult task is to craft rules and procedures creating enough incentives for the members to effectively participate in collective management (Subramanian *et al.*, 1997; Ostrom, 2000). Under the WBADMI project, the WUA members have options to discuss their problems in the GBM and to assess the progress and prospects of ongoing irrigational projects. The MC members are also expected to appraise the WUA members about the different initiatives for improving agricultural productivity as well as diversification of economic activities. Members' participation can be effective when they grasp the details of WUA activities and the decision-making process and, thus, can hold the MC members accountable and feel motivated to participate in WUA activities with greater vigor. Arbitration and dispute

resolution are one of the major imperatives for forging collective action (Ostrom, 1990). Proper institutionalization of such arrangement, coupled with greater transparency, is likely to increase the legitimacy of WUAs and create a sense of ownership of water resources among members, thus making the irrigation management sustainable. Necessary steps should also be taken to ensure greater active participation by the participating members with special focus on including disinterested members through a sustained awareness program for arousing their interest in WUA activities and in the necessity of devising crop plans and water mapping. Supporting organizations should arrange awareness campaigns to acquaint all water users with the functioning of WUAs and the rights and responsibilities of members and WUA committees.

WUA members' receipt of training on skill development or improved practices of agriculture positively influence their participation in WUA meetings and activities. However, in this study, institutional support in providing training and capacity building was inadequate, creating disincentives at two levels – the members were disinterested in adopting any new method of production and also in attending any training program. Planned interventions from state- and district-level project management units through the WUAs in appraising the users about the appropriateness of new technologies and formulating locally relevant plans backed up by continuous monitoring and support at the intermediate stages could incentivize the members to participate in WUA activities. Knowledge exchange and experience sharing among the members of better performing and underperforming WUAs could ensure greater replication of best practices. So, greater efforts should be made toward capacity building of the members, including training for skill enhancement, management and policy making, agriculture or horticulture or fisheries practices.

Greater participatory involvement of the members in the form of donating land for MI construction is also crucial because members would be more interested in pursuing collective action to match the benefits accrued with their contributions under the project. Given the interconnectedness of governance, financing and management aspects of the irrigation system (e.g., participation in WUA meetings, involvement in maintenance activities, payment of water charges, etc.), the members must be encouraged to participate in all activities of WUAs. This may strengthen cooperative behavior and enhance the effectiveness and sustainability of both irrigation infrastructure and the WUA as an institution.

ACKNOWLEDGMENT

This work is based on the WBADMIP – a project supported by the World Bank. The authors are grateful to the reviewers for their constructive comments and to the SRG Consultancy, Kolkata, for conducting the survey work. The usual disclaimers apply.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

REFERENCES

Bardhan, P. (2000). Irrigation and cooperation: an empirical analysis of 48 irrigation communities in South India. *Economic Development and Cultural Change 48*(4), 847–865.

Bassi, N., Rishi, P. & Choudhury, N. (2010). Institutional organizers and collective action: the case of water users' associations in Gujarat, India. *Water International 35*(1), 18–33. doi:10.1080/02508060903515275.

Bastakoti, R. C. & Shivakoti, G. P. (2012). Rules and collective action: an institutional analysis of the performance of irrigation systems in Nepal. *Journal of Institutional Economics 8*, 225–246. doi:10.1017/S1744137411000452.

Brewer, J., Kolavalli, S., Kalro, A. H., Naik, G., Ramnarayan, S., Raju, K. V. & Sakthivadivel, R. (1999). *Irrigation Management Transfer in India: Policies, Processes and Performance*. Oxford & IBH Publishing Company, New Delhi & Calcutta.

Buuren, A., Meerkerk, I. & Tortajada, C. (2019). Understanding emergent participation practices in water governance. *International Journal of Water Resources Development 35*(3), 367–382. doi:10.1080/07900627.2019.1585764.

Chun, N. (2014). The challenge of collective action for irrigation management in India. *Asian Economic Papers 13*(2), 88–111.

De, I., Chattopadhyay, S., Nathan, H. S. K., Mishra, P., Parey, A. & Dutta, S. (2022). Structural and institutional arrangements impacting collective actions in WUAs of West Bengal, India. *International Journal of Water Resources Development*. doi:10.1080/07900627.2022.2041407.

Gulati, A., Meinzen-Dick, R. & Raju, K. V. (1999). *From Top-Down to Bottoms Up: Institutional Reform in Indian Canal Irrigation. National Workshop*. Mimeo. Institute of Economic Growth, Delhi.

Howarth, S. E., Parajuli, U. N., Baral, J. R., Nott, G. A., Adhikari, B. R., Gautam, D. R. & Menuka, K. C. (2005). *Promoting Good Governance of Water Users' Associations in Nepal*. Available at: https://assets.publishing.service.gov.uk/media/57a08ccf40f0b6497400146e/R80233.pdf

Hu, X. J., Xiong, Y. C., Li, Y. J., Wang, J. X., Li, F. M., Wang, H. Y. & Li, L. L. (2014). Integrated water resources management and water users' associations in the arid region of northwest China: a case study of farmers' perceptions. *Journal of Environmental Management 145*, 162–169.

Huang, Q., Wang, J., Easter, K. W. & Rozelle, S. (2010). Empirical assessment of water management institutions in northern China. *Agricultural Water Management 98*, 361–369.

International Water Management Institute (IWMI) (2019). *WBADMI Project Rapid Impact Assessment Report*. Available at: http://www.wbadmip.org/publications-external.php

McCarthy, N. & Essam, T. (2009). Impact of water user associations on agricultural productivity in Chile, *IFPRI Discussion Paper 00892*, August.

Meinzen-Dick, R. (1996). Policy trends in farmer participation. *Workshop on Institutional Reform in Indian Irrigation.* National Council of Applied Economic Research, New Delhi, November 6, 1986. NCAER-IFPRI Collaborative Project.

Meinzen-Dick, R., Raju, K. V. & Gulati, A. (2002). What affects organization and collective action for managing resources? Evidence from canal irrigation systems in India. *World Development 30*(4), 649–666.

Muchara, B., Ortmann, G., Wale, E. & Mudhara, M. (2014). Collective action and participation in irrigation water management: a case study of Mooi River Irrigation Scheme in KwaZulu-Natal province, South Africa. *Water SA 40*(4), 699–708.

Nagendra, H. (2011). Heterogeneity and collective action for forest management. Human Development Research Paper 2011/2. UNDP, New York.

Narain, V. (2003). *Institutions, Technology and Water Control Water User Association and Irrigation Management Reforms in Two Large Scale Systems in India*. Wegningen University, Weningen.

Narain, V. (2004). Brackets and black boxes: research on water users' associations. *Water Policy 6*, 185–196.

Olson, M. (1965). *Logic of Collective Action: Public Goods and the Theory of Groups*. Harvard University Press, Boston.

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

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

Ostrom, E. (1996). Incentives, rules of the game and development. *Annual World Bank Conference on Development Economics, 1995*. The World Bank, New York, pp 207–233.

Ostrom, E. (2000). Collective action and the evolution of social norms. *Journal of Economic Perspectives 14*(3), 137–158.

Ostrom, E. & Gardner, R. (1993). Coping with asymmetries in the commons: self-governing irrigation systems can work. *Journal of Economic Perspectives 7* (4), 93–112.

Reddy, V. R. & Reddy, P. R. (2005). How participatory is participatory irrigation management? Water user associations in Andhra Pradesh. *Economic and Political Weekly 40*(53), 5587–5595.

Subramanian, A., Jagannathan, N. V. & Meinzen-Dick, R. (1997). User organizations for sustainable water services. World Bank Technical Paper No. 354, April, Washington, DC.

Sudgen, F., Agarwal, B., Leder, S., Saikia, P., Raut, M., Kumar, A. & Ray, D. (2020). Experiments in farmers' collectives in Eastern India and Nepal: process, benefits, and challenges. *Journal of Agrarian Change*, 1–32. https://doi.org/10.1111/joac.12369.

Takayama, T., Matsuda, H. & Nakatani, T. (2018). The determinants of collective action in irrigation management systems: evidence from rural communities in Japan. *Agricultural Water Management 206*, 113–123.

Uphoff, N., Wickram Singhe, M. L. & Wijayratna, C. M. (1990). Optimum participation in irrigation management: issues and evidence from Sri Lanka. *Human Organisation 49*(1), 26–40.

Wang, Y. & Wu, J. (2018). An empirical examination on the role of water user associations for irrigation management in rural China. *Water Resources Research 54*, 9791–9811. https://doi.org/10.1029/2017WR021837.

World Bank (2019). *West Bengal Accelerated Development of Minor Irrigation Project Implementation Support and Review Mission Aide Memoire*, September 4–13. Available at: http://www.wbadmip.org/publications-external.php

Zhang, L., Heerink, N., Dries, L. & Shi, X. (2013). Water users associations and irrigation water productivity in northern China. *Ecological Economics*. http://dx.doi.org/10.1016/j.ecolecon.2013.08.014.

First received 20 December 2021; accepted in revised form 15 April 2022. Available online 22 April 2022