

Determinants of participation in collective actions: empirical evidence from irrigation schemes in the Amhara Region, Ethiopia

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ABSTRACT

This study examines the institutional framework for water governance and identifies key factors influencing participation in collective action in irrigation schemes in Ethiopia. Although irrigation institutions, particularly in Raya Kobo schemes, have long existed as informal systems, there is no specific legal framework governing them. Instead, they operate under the broader structure of agricultural cooperatives, such as water users' associations and irrigation beneficiaries' cooperatives. Qualitative findings reveal major institutional challenges, including weak rule enforcement, lack of credit services, absence of committed leadership and membership, inadequate legal backing for sanctions, excessive political interference, and ineffective institutional arrangements. The study also identifies significant determinants of participation in collective irrigation activities. Results show that family size (adult equivalent), membership in water users' associations and agricultural cooperatives, age of the irrigation scheme, extension contact, access to training, total land size, land fragmentation, and social capital strongly influence participation decisions. The findings suggest the need for clearly defined roles and responsibilities of irrigation service providers in delivering rural public goods. Strengthening institutional arrangements and legal support is essential to improve water use, maintenance, and overall management of irrigation systems.

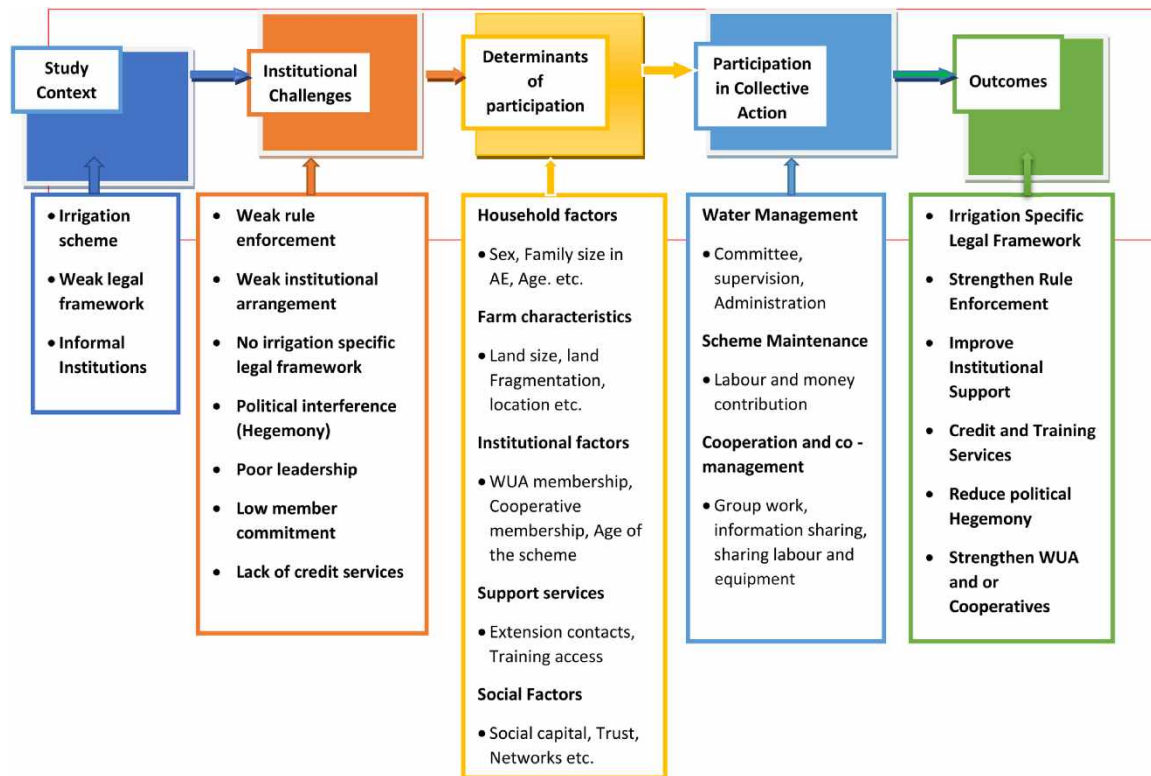
Key words: collective action, Ethiopia, institutional arrangement, multivariate probit, water users association

HIGHLIGHTS

- The institutions' defining characteristics were identified, such as low rule enforceability, lack of dedicated leaders and members, insufficient or inappropriate legal support for rule and sanction enforcement from government bodies.
- The key factors that influenced the decision to participate in irrigation collective action were identified, such as membership in water users' association and social capital.

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GRAPHICAL ABSTRACT



1. INTRODUCTION

Irrigation infrastructure, as a common pool resource, faces ‘the tragedy of commons’ problems such as free riding, inequitable distribution of irrigation water, higher conflict and competition among users for water resources, poor maintenance of irrigation systems, improper utilization of irrigation systems, and other related problems (Ostrom 1992). Hence, it is recommended that effective and efficient irrigation management is vital if the expansion of irrigation is to secure the sustainable use of the water resource, as well as increasing production and productivity (Narayanamoorthy & Deshpande 2004). Hence, irrigation management is crucial for the sustainable use of a scheme and to reduce the negative impacts on the environment due to improper use of a water resource and over-exploitation (Bromley *et al.* 1980).

Various theoretical as well as empirical studies have argued that institutions play a prominent role in the economic performance of a scheme through effective and efficient water resource utilization (Bekele *et al.* 2021; Zang *et al.* 2021). Collective action also has an important role in technology adoption, food security, poverty reduction, correcting market failures, genetic resource conservation, and watershed management (Eyzaguirre *et al.* 2004; Beyene & Hagedorn 2006; Meinzen-Dick 2009; Deneke 2014).

While irrigation management has long been practiced in Ethiopia by user institutions, these institutions have received due attention, and a policy framework to formalize the informal water user institutions has not been developed (Deneke 2014; Bekele 2021). Consequently, irrigation users have been organized as Irrigation Beneficiaries Cooperatives (IBCs) under the cooperative law in different parts of the country. The history of irrigation management institutions in the Amhara Region is similar to that of institutions in other parts of the country. Irrigation institutions have long been practiced as informal traditional institutions, such as ‘*Abahaga*’ (meaning traditional local water distributor) and ‘*Yewuha Abat*’ (meaning water fathers). Moreover, the formal irrigation institutions in the Amhara Region are organized as IBCs or Water User Associations (WUAs). Modern small-scale schemes are administered by WUAs established at the initiative of the district office of cooperatives. In the Amhara Region, WUAs are normally known as irrigation cooperatives and are established with the aim of not only the operation and maintenance of schemes but also the supply of agricultural inputs and marketing of outputs (Deneke 2014). Until now, public investment has emphasized the establishment of WUAs as the preferred approach to decentralized water management systems.

Although there are ample studies on irrigation institutions and collective action at an international level (Fujiie *et al.* 2005; Oates *et al.* 2015; Nakamaru *et al.* 2018; Takayama *et al.* 2018; Guido *et al.* 2019; Zang *et al.* 2021), institutional analysis in Ethiopia is lacking; there is a limited number of documented studies on irrigation institutions and collective action in irrigation in Ethiopia. Such studies include Beyene & Hagedorn (2006), Spielman & Kelemework (2008), Deneke *et al.* (2011), and Oates *et al.* (2020).

The success and effectiveness of collective action are based on the voluntary participation and cooperation of participants and the level of law enforcement by participants or by a third party. Hence, the modern irrigation beneficiaries' cooperatives, which manage irrigation projects under the Kobo Girana Valley Development Program (KGVPD) and Koga Irrigation and Watershed Management Project, manage not only the irrigation system but also the production activities and economic behavior of beneficiaries of the irrigation water with the aim of increasing production and productivity of irrigators through efficient resource utilization.

Despite the growing body of literature on collective action in irrigation and common-pool resource management, several important gaps remain. First, existing studies in Ethiopia and similar developing country contexts have largely focused on either socioeconomic or institutional factors in isolation, with limited integration of both dimensions in a unified analytical framework. Second, while informal irrigation institutions are widely recognized, there is insufficient empirical evidence examining how the absence of a dedicated legal framework affects their functionality and sustainability. Third, most prior empirical studies rely on single-equation econometric models, which fail to capture the potential interdependence among farmers' participation decisions in multiple collective activities. Finally, there is a lack of context-specific evidence linking institutional weaknesses such as governance inefficiencies, political interference, and limited enforcement capacity to actual participation behavior in irrigation schemes at the local level. Addressing these gaps is essential for improving both theoretical understanding and policy design in irrigation governance. In particular, there is a need for studies that integrate institutional analysis with rigorous econometric modeling to better explain participation behavior, while also providing context-specific insights into how governance structures shape collective action outcomes.

Hence, this study contributes to the literature by integrating institutional analysis with multivariate econometric modeling to identify the key determinants of collective action in irrigation systems, while revealing critical gaps in the legal and water governance framework in Ethiopia. Moreover, it is important to examine the type, characteristics, roles, and functions of existing irrigation institutions managing irrigation water to identify the determinants of participation in any collective actions which affect the provision and appropriation of irrigation water.

The next section explains the theoretical and analytical frameworks for the analysis of collective action. The third section deals with the research methods used and briefly describes the case study areas. The fourth section presents the results and discussion. Finally, conclusions and recommendations are drawn from the foregoing discussions.

2. THEORETICAL REVIEW, UNDERPINNING OR FRAMEWORK OF COLLECTIVE ACTION

2.1. Theoretical review, underpinning or framework

The description of the meaning, basis and attributes of collective action by authors including Wade (1987) and Marshall (1998) imply that the operational definition of collective action is the product of the interaction of three main elements, namely, the group, its action, and the common goal. According to Wade (1987) 'collective action is an action by more than one person intended to achieve a common goal or satisfy a common interest (that is, a goal or interest that cannot be obtained by an individual alone). Achievement means that a public or collective good has been provided'. Marshall (1998) defined collective action as 'the action taken by a group (either directly or on its behalf through an organization) in pursuit of members' perceived shared interests'. Collective action may be in the community context, taking voluntary action to attain a common goal (Meinzen-Dick *et al.* 2004). It includes setting a mutually acknowledged set of rules and regulations by the group. Rules and regulations enable the group to attain a common goal if strictly followed. Ostrom (2004) described collective action as an action that happens when more than one farmer contributes to a farmers' organization to achieve the desired outcome. The desired result of collective action includes smallholder farmers marketing their produce, planting, and harvesting together, buying agricultural input, and maintaining a local irrigation scheme.

Studies on collective action in common-pool resource management have drawn on the influential work of [Olson \(1965\)](#), *The Logic of Collective Action*. Most of the studies on collective action have focused on the determinants of collective action. However, theoretical puzzles or disagreements on the effect of some factors on collective action remain. This disagreement may emanate from the existence of different types of collective action on diverse types of common pool resources under diverse socio-economic, cultural and environmental conditions.

An immense number of contextual variables have been identified by different authors as determinants of collective action. Studies by [Wade \(1987\)](#), [Ostrom \(2000\)](#), [Meinzen-Dick \(2009\)](#), [Deneke \(2014\)](#) and [Zang *et al.* \(2021\)](#) have documented the factors that affect collective action either positively or negatively in a number of case studies. The factors can be classified as:

- (1) **Physical and technical characteristics of the resource:** the size and the boundaries of common pool resources, the predictability of resource flows, the relative scarcity of the good, technology (the cost of exclusion technology), relationship between resources and user group (agro-ecological conditions, proximity of users to their residence and to the resource locations, user demands, and user knowledge of resources).
- (2) **Social and economic characteristics of the resource user group** (size, boundaries, relative power of sub-groups, the heterogeneity of the group, the dependence of the group on the good, advantages of collective action, level of social capital among users, existing arrangements for discussion of common problems, having a choice of participating or not, exit options for users, the extent of the temptation to free ride, extent to which users are bound by mutual obligations, and punishment against rule breaking) and noticeability (ease of detection of rule-breaking free riders), and;
- (3) **Policy and governance factors** including rules applied in a local group (extent of formal and informal rules regarding boundary of and access to resources, monitoring and sanctioning; mechanisms for conflict resolution) as well as external forces (external arrangements that include property rights, delegation of decision making to a local level, right of recognition, and environmental and natural regulations), and the extent of linkages between formal and informal governance structures.

2.2. Concept and definition of collective action

In this sub-section, concepts and definitions of terms that are used in the subsequent section and econometric model are discussed thoroughly.

2.2.1. Institutions

Institutions are defined as normative and cognitive frames, formal or informal, which concern actors when they are engaged in collective action. Normative frames include rules, norms, and procedures. Cognitive frames include identity, culture, representations, and beliefs. These frames can be individual or collective. They survive and are replicated without particular effort, through social and political, self-maintained, and routinized mechanisms ([Ostrom 2005](#)).

2.2.2. Institutional arrangements

Institutional arrangements are sets of working rules that are used to determine who is eligible to make decisions in some situation and what actions are allowed or constrained ([Ostrom 1990](#)). Further, the rules describe what procedures must be followed, what information must or must not be provided, and what payoffs will be assigned to affect individuals ([Dorward & Omamo 2009](#)). Institutional arrangements refer to the formal and informal rules and norms that determine who has authority to make decisions over shared resources, such as water. They also shape how decisions are made regarding the use, management, monitoring, and enforcement of these resources ([Ostrom 2005](#)).

2.2.3. Water governance

Water governance refers to a range of political, social, economic and administrative systems that influence water use and management. It encompasses laws, regulations, and institutions, but it also relates to government policies and actions, to domestic activities, and to networks of influence, including international market forces, the private sector, and civil society ([Rogers & Hall 2003](#)).

2.2.4. Water Users Association

Water Users Association (WUA) refers to the grouping of water users, usually farmers, who are taking water from one or more sources (such as reservoirs, irrigation canals, and pumping stations) for the purpose of managing part of an irrigation and drainage system. A WUA is a participatory user-based organization established with the purpose of managing irrigation systems for its members, mainly on a nonprofit basis (Lemperiere *et al.* 2014; Takayama *et al.* 2018).

2.2.5. Collective action

Collective action can be defined as an action by more than one person directed towards the achievement of a common goal or the satisfaction of a common interest (that is, a goal or interest that cannot be obtained by an individual acting on his own) (Wade 1987). Collective action is mainly observed through the contributions of farmers' material and labor for activities such as canal clearing, repair of a diversion structure, and protection and maintenance of communal ponds and domestic water points.

2.2.6. Social capital

Social capital can be defined as the knowledge and skills that individuals bring to the process of solving problems (Ostrom 1990), and features of social organization, such as networks, norms, and trust, that facilitate coordination and cooperation for mutual benefit (Portes 1998).

2.2.7. Participation

Participation is a systematic involvement of local people in diverse activities to manage their own problems. It is a route to social progress in which people meet their collective needs. Therefore, the greater the participation of farmers in water management, the higher the level of agricultural benefits. Participatory practices involve community members in a process of empowered decision-making and policy implementation (Ruano *et al.* 2011).

3. RESEARCH METHODS

3.1. Case study areas

The study was carried out in four districts in the Amhara National Regional State (ANRS), Ethiopia. These districts have different levels of irrigation potential. The Amhara Region is located in the north-western part of Ethiopia between 8°45' and 13°45' north latitude and 36° 20' and 40° 20' east longitude. Its land area is estimated to be about 170,152 km². According to the Central Statistical Agency of Ethiopia (CSA), the projected total population in 2022 is around 27,618,552 of which 80% live in rural areas (CSA 2013). The study areas are located in North Wollo and West Gojjam administrative zones of the ANRS, Bahir Dar town being its capital.

The Raya Kobo and Habru districts of North Wollo represent low rainfall, moisture-limited areas of the region and are where the large irrigation schemes of KGVDP are located. The North Mecha and South Achefer districts of West Gojjam represent high rainfall and moisture-surplus areas of the region where the Koga River Dam and other small-scale irrigation schemes are located. This study was based on a survey of 544 irrigation households in 148 scheme groups from the four districts of ANRS in the period of 2019/20. However, during analysis due to inconsistency, outlier property and absence of important data, we also removed 17 observations, and so the total sample size used for analysis was 527. Moreover, the findings remain relevant for policy discussions, as many of the structural conditions and policy frameworks in place in 2019/20 persist today (Asfaw & Mekonen 2024). The study investigates structural relationships (e.g., determinants of household behavior, socioeconomic patterns) that are not expected to change substantially over short periods, making the 2019/20 dataset still informative. The study included three groups of communities from North Wollo, representing 108 schemes and two groups of communities in West Gojjam that represent 40 schemes. The schemes were categorized as either those having formal institutions (user or agency managed) or those led by traditional water committees or 'water fathers' in order to compare the different local institutional contexts in the management of irrigation infrastructure.

Focus group discussions and semi-structured interviews with key informants were the primary means of collecting data on local institutional arrangements, government interventions and management challenges. Interviews were conducted to collect primary data. Secondary data were obtained mainly from official documents. Informal discussions and formal semi-structured interviews were conducted with plot owners/farmers,

experts, heads of the projects and IBC and WUA committees in the area. In total, 32 semi-structured interviews, 24 key informant interviews and six focus group discussions were conducted. The data were collected during in-person interviews using a paper-based questionnaire. The household heads (male or female) were interviewed after they provided their oral approval to informed consent to participate in the survey. The interviews were conducted at farmers' residences, and no minors were involved in the survey.

3.2. Method of data analysis

In this research, both descriptive and econometric methods were employed. Hence, the quantitative data were analyzed using descriptive statistics such as percentages and arithmetic means. The econometric analysis was based on the Institutional Analysis and Development framework with selected relevant variables for collective action in irrigation institutions. The explanatory variables were divided into four types: rules-in-use, biophysical conditions, attributes of the community and attributes of the household. Moreover, the research objective was to investigate the determinants of participation in irrigation collective actions. Based on the data collected, the different collective actions were grouped into three categories, namely: (1) participation in labor-demanding activities, (2) participation in money-demanding activities, and (3) participation in scheme management activities. This led to the use of polychotomous (multiple category) responses or dependent variables to model the collective action choice behavior (Gujarati & Porter 2009). Econometric models used to estimate such unordered multinomial responses can be multinomial logit (MNL), multinomial probit (MNP), multivariate logit, and multivariate probit (MVP) models, among others. Both MNL and MNP models have one common limitation that they are the 'pick-one' type model that assumes individuals make just one choice at a time from the total choice set available to maximize utility (Walsh 1995; Dubé 2004). This assumption is not realistic as an individual can participate in more than one collective action that are interdependent on one another (Mehta & Ma 2012; Aurier & Mejía 2014).

In this study, irrigation user farmers could participate in more than one type of collective action (alternatives are not mutually exclusive) and the decision to participate in one collective action can be correlated with the decision to participate in other types of collective action (the error terms can be correlated), which means the unobserved factors affecting the choice of collective action can be correlated (Dubé 2004). Hence, the MVP model is more appropriate and was used to investigate factors affecting the decisions by irrigation user farmers regarding collective actions.

Given that a household, i , has access to a WUA, defined as those households living in a village, r , with at least one WUA member, a household is assumed to participate in collective action, $W_{ir} = 1$, if the utility they receive from joining in collective action, U_{ir1} , is greater than the utility received from not participating in collective action, U_{ir0} .

That is,

$$W = \begin{cases} 1 & \text{if } U_{ir1} \geq U_{ir0} \\ 0 & \text{if } U_{ir1} \leq U_{ir0} \end{cases} \quad (1)$$

We assume that the utility from engaging in collective action, W in $\{0, 1\}$, can be expressed as a factor of observable characteristics of the household, X_{irW} , the characteristics of other households in the area that affect collective action, A_{rW} , and a set of unobserved characteristics, ε_{irW} . That is,

$$U_{irW} = X_{irW}\beta + A_{rW}\delta + \varepsilon_{irW} \quad (2)$$

Hence, following Greene (2012), a system of simultaneous probit models was constructed for labor-demanding activities, money/financial-demanding activities, and participation in the scheme management committee as follows:

$$\begin{aligned} Y_m^* &= X_m' \beta_m + \epsilon_m, \quad Y_m = 1 \text{ if } Y_m^* > 0, \quad 0 \text{ otherwise}, \quad m = 1, \dots, M \\ E[\epsilon_m | X_1, \dots, X_M] &= 0 \\ \text{Var}[\epsilon_m | X_1, \dots, X_M] &= 1 \\ \text{Cov}[\epsilon_j, \epsilon_m | X_1, \dots, X_M] &= \rho_{jm} \\ (\epsilon_1, \dots, \epsilon_M) &\sim N_M[0, R] \end{aligned} \quad (3)$$

where Y_m^* and Y_m are the latent dependent variables and actual observations relating to the latent dependent variables, respectively, X_m' is a matrix of covariates, β_m is the matrix of unknown parameters to be estimated, ϵ_m are residual error terms distributed as multivariate normal, each with mean 0 and variance–covariance matrix R with the value of 1 on the leading diagonal and correlation $\rho_{jm} = \rho_{mj}$ as the off-diagonal elements that represent the unobserved correlation between the stochastic component of the j th and m th options.

The joint probabilities of the observed events $[y_{i1}, y_{i2}, \dots, y_{iM} | X_{i1}, X_{i2}, \dots, X_{iM}]$, $i = 1, \dots, n$, that form the basis for the likelihood function are the M -variate normal probabilities, given as (Greene (2012)):

$$L_i = \Phi_M(q_{i1}X'_{i1}\beta_1, \dots, q_{iM}X'_{iM}\beta_M, R^*), \quad (4)$$

where

$$q_{iM} = 2y_{iM} - 1$$

$$R^*_{jM} = q_{ij}q_{iM}\rho_{jm}$$

where ρ_{jm} is the correlation between ϵ_j and ϵ_m . The distributions are independent if and only if $\rho_{jm} = 0$. If that is the case, one can use a single probit model for each equation instead of MVP.

To estimate the above system of equations, the simulated maximum likelihood methods of the Geweke–Hajivassiliou–Keane simulator were used due to the numerical complexity of estimating integrals under the multivariate normal (Gates 2006). Moreover, the user-written Stata command named ‘mvprobit’ developed by Cappellari & Jenkins (2003) was used to run the estimation procedure.

4. RESULTS AND DISCUSSION

4.1. Description of activities that need collective action

As part of proper irrigation scheme management and reducing conflicts in water use, farmers in the study areas have been participating broadly in different collective irrigation scheme management activities. Table 1 identifies that the majority (87.48%) of the respondents participate in labor-demanding activities as part of collective actions, while 46.87% and 16.89% of respondents, respectively, participate in money-demanding activities and in scheme management committees. The analysis is based on a total sample of 527, since 17 observations were removed due to outliers in some important variables. Of the 527 households that responded, 9.87% do not participate in any of the three specified types of collective actions.

Table 1 | Types of collective action practiced in the study area

Collective action category	Number	Frequency
No participation	52	9.87%
Participating in labor-demanding activities	461	87.48%
Participating in money-demanding activities	247	46.87%
Participating in the scheme management committee	89	16.89%

Source: Own computation based on survey data, 2019.

Key collective action activities engaged in by farmers were to contribute labor for canal cleaning and maintenance activities (87.5%), collective nursery preparation, disease and pest control (70.4%), group sales of outputs (67%), contributing funds (money) for operation and maintenance of the scheme (46.9%), participating in group meetings (35%), group input purchases like seed and fertilizer (27.9%), participating in water controlling and distribution activities (20.1%), participating as scheme management committee members (16.9%) and participating in conflict resolution committees (14.8%) (see Table 2). Participation in labor-demanding activities and group sales was very high. Group sales involved farmers aggregating their products in order to be able to sell in bulk to dedicated buyers/brokers. This enabled them to enjoy economies of scale and also reduced the number of transactions since buyers did not have to move from house to house to buy smaller quantities. Participation in labor-demanding activities involved farmers safely accessing irrigation water by cleaning the silt

Table 2 | Key collective action activities practiced in the study area

Collective action activities	Number	Frequency
Contribute labor for canal cleaning, canal, and pump repair	461	87.48%
Collective nursery preparation, disease and pest control	371	70.39%
Group input purchases like seed and fertilizer	147	27.89%
Contribute money for the operation and maintenance of the scheme	247	46.87%
Participate in water control and distribution activities (reporting unlawful diversion of water, reporting theft of irrigation infrastructure, and reporting damages and water leakages along the major irrigation infrastructure)	106	20.11%
Participate in the conflict resolution committee	78	14.80%
Participate in group meetings (attending meetings, lobbying, and contributing ideas on water-related issues)	185	35.10%
Group sales of output	353	66.98%
Participating in the scheme management committee (regulation and control)	89	16.89%

Source: Own computation based on survey data, 2019.

traps and grass in canals on time before planting. Farmers were also involved in group input purchases such as seeds, fertilizers, pesticides, and other agricultural inputs.

4.2. Determinants of farmer' participation in collective action

Collective action was found to be an important policy for the sustainable management of common-pool resources. In line with their arguments, respondents were asked about whether they would participate in collective irrigation activities if a community-managed irrigation scheme existed in their localities. Those who supported participation in irrigation scheme management were then asked to choose the nature of participation approaches, which these generated three different outcome variables: (1) households' participation decision in labor-demanding activities, (2) participation decision in money contribution, and (3) participation decision in the scheme management committee.

The effects of socioeconomic and institutional variables on the three outcome variables were analyzed. We employed an MVP model to analyze the factors that affect participation in any collective action. A household is considered as a participant in a collective action if she/he undertook at least one of the aforementioned activities (see Table 2). Combinations of socioeconomic, institutional and resource-related variables can influence farmer participation in collective activities.

The overall fit of the equations indicated that in the MVP model, the log likelihood ratio is -729.02 and the Wald statistic is 130.68, with significance at 1% level, suggesting that the explanatory variables taken together influence participation decisions in collective action. Hence, it was concluded that the model has a good fit. The decision to participate in labor contribution activities (such as disease and pest management, cleaning of canals and maintenance of irrigation infrastructures) was found to be significantly affected by family size in adult equivalents, membership in WUA and access to training (see Table 3).

Similarly, the decision to participate in money (funds) contribution activities was found to be significantly affected by a number of variables, including family size, membership in WUA, the land fragmentation index and social capital. Moreover, the decision to participate as committee members was found to be significantly affected by the variables: age of the scheme (number of years since the scheme was established), total land size, membership in WUA, credit service utilization, membership in agricultural cooperatives, extension contact, and social capital.

As family size in adult equivalents increases by one unit, the predicted probability of participating in labor contribution activities and contributing funds for irrigation activities increases by 14.2% and 11.7%, respectively. It is plausible that the size of a household is often a proxy for household labor endowment. Households with a small household size are unable to participate due to workloads, especially during planting and harvesting times. Thus, households with a large family size have more labor available to participate in collective actions than households with only a few family members. Moreover, the larger the family, the higher the earning

Table 3 | Multivariate probit model result of participation in any type of collective action

Explanatory variables	Labour contribution Coef. (Se)	Scheme committee Coef. (Se)	Financial contribution Coef. (Se)
Age	0.001 (0.007)	0.005 (0.007)	0.005 (0.006)
Sex	0.027 (0.200)	–	0.164 (0.160)
Group size	0.000 (0.001)	–0.001 (0.001)	0.000 (0.000)
Year of scheme establishment	–0.002 (0.025)	0.046** (0.022)	–0.003 (0.018)
Type of institutional arrangement	–1.184 (0.831)	–0.481 (1.122)	0.696 (0.817)
Command area in ha	–0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
Proportion of females in the group	0.001 (0.017)	0.006 (0.014)	0.004 (0.012)
Total land size in ha	0.020 (0.115)	0.204** (0.104)	0.142 (0.088)
Land fragmentation	–0.121 (0.491)	–0.363 (0.553)	1.302*** (0.402)
WUA member	0.711*** (0.180)	0.431** (0.175)	0.476*** (0.138)
Credit use	0.246 (0.172)	–0.382** (0.162)	0.026 (0.123)
Member of the government team	–0.234 (0.200)	–0.108 (0.197)	0.103 (0.150)
Member of agri. cooperative	0.197 (0.280)	0.608*** (0.220)	0.176 (0.205)
Family size in adult equivalents	0.142*** (0.054)	0.011 (0.051)	0.117*** (0.041)
Agro-ecology	–0.053 (0.298)	0.211 (0.279)	0.297 (0.220)
Social capital	–0.132 (0.169)	0.349** (0.170)	0.478*** (0.137)
Training access	0.120*** (0.023)	0.011 (0.017)	0.017 (0.016)
Water distribution method	–0.922 (0.927)	0.181 (1.199)	0.829 (0.878)
Surface irrigation source	0.365 (0.449)	–0.428 (0.440)	0.416 (0.338)
Extension contacts	–0.166 (0.318)	0.936** (0.451)	0.267 (0.221)
Formal education level	–	0.030 (0.022)	–
Local administration member	–	0.093 (0.153)	–
_cons	7.124 (50.843)	–96.030** (43.62)	3.532 (35.64)
ρ_{21}	0.551*** (0.080)		
ρ_{31}	0.239* (0.123)		
ρ_{32}	0.065 (0.087)		
Predicted probability	87.9%	47.4%	17%
Joint probability (success)	9.4%		
Joint probability (failure)	9.8%		
Number of observations	544		

Likelihood ratio test of $\rho_{21} = \rho_{31} = \rho_{32} = 0$: $\chi^2(3) = 37.447$, $\text{prob} > \chi^2 = 0.0000$.Wald $\chi^2(61) = 130.68$; log likelihood = –729.02; number of simulations = 100.Note: Standard errors in parentheses; statistical significance at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

capacity of the household. This result is in line with the findings of Engida & Mengistu (2013) and Muchara *et al.* (2014).

If a household is a member of a WUA, the predicted probability of participating in labor contributing activities, in contributing funds and participating as committee members increases, respectively, by 71.1%, 47.6% and 43.1%. This result is as expected since the objectives of WUA are the coordination of collective actions like canal cleaning, removing grass and silt, and nursery bed preparation that demand labor contributions from members as well as the collection of funds and fees from users. This result is in agreement with the findings of Muchara *et al.* (2014), who found that WUA membership affects participation in irrigation water management in South Africa, Wang *et al.* (2021) in China and Chattopadhyay *et al.* (2022) in India, who also identified a mediating effect of membership in a WUA on irrigation collective action.

If a household has access to training, the predicted probability of participation in labor contributing activities increases by 12%. Farmers with some form of training in water/irrigation scheme management participate more in scheme management activities. This highlights the importance of farmer training as a key to improving

collective irrigation scheme management. This result is consistent with studies conducted by Muchara *et al.* (2014) in South Africa and Chattopadhyay *et al.* (2022) in India. As the age of the scheme increases by one year, the predicted probability of participating as committee members increases by 4.6%. The age of the scheme shows the strength and the development of irrigation scheme beneficiaries, as the years go by, encouraging committee membership positively. Membership in agricultural cooperatives also has a positive effect on participation as a committee member. Being a member of an agricultural cooperative significantly increases the predicted probability of participation as a committee member by 60.8%, as a result of social ties imposing indirect repetition and the opportunity to be a better household in the community.

Total cultivated land size has a positive and statistically significant effect on participation as a committee member. The result implies that as the size of a farm increases by one hectare, the predicted probability that a farmer will participate in committee activities increases by 20.4%. This may be explained by the fact that larger farms tend to gain more from improved access to irrigation water, markets, agricultural inputs, and extension services. Consequently, households with larger landholdings may have stronger incentives to engage in collective action among water users. This result is consistent with the findings of Muchara *et al.* (2014).

Land fragmentation has a positive and statistically significant effect on participation in financial contributions. The result implies that as the land fragmentation increases or as the number of plots increases by one unit, the predicted probability of the farmer contributing funds for collective action activities increases by 130%. This could be due to the fact that land fragmentation increases land circulation because it reduces agricultural production efficiency. Whether the property right is transferred out or transferred in, the purpose of land circulation is to improve efficiency and realize economies of scale in agricultural production. This implies a greater demand for irrigation facilities. Thus, land fragmentation leads to land circulation, which leads to cooperation in irrigation collective actions. The result is consistent with the findings of Wang *et al.* (2020) but disagrees with the findings of Zang *et al.* (2019) in their study on the effects of land fragmentation on the governance of commons in China.

Credit service utilization has a negative and statistically significant effect on participation as a committee member. The result implies that as the household receives credit service, the predicted probability of the farmer participating in committee activities decreases by 38.2%. Extension contacts have a positive and statistically significant effect on participation as a committee member. The result implies that as the household receives extension services, the predicted probability of the farmer participating in committee activities increases by 93.6%.

Social capital has a positive and significant effect on collective actions. For households having good social ties and networks, the predicted probability of participating in fund-contributing activities and as committee members increases, respectively, by 47.8% and 34.9%.

The predicted probabilities of participating in labor-demanding activities, contributing funds and participating as committee members were 87.9%, 47.4%, and 17%, respectively. The joint probability of participating in all types of collective action was 9.4%, whereas the probability of not participating in any of the collective action activities was 9.8%.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The study has identified factors that affect participation in three types of irrigation collective actions. The study found that participation in labor-demanding collective actions was significantly influenced by family size in adult equivalents, membership of a WUA and access to training. The MVP model results also show that the decision to contribute funds for collective actions was found to be significantly affected by the family size, membership of a WUA, the land fragmentation index and social capital. The model results also demonstrate that the decision to participate as a committee member was significantly affected by the age of the scheme (number of years since the scheme was established), total land size, membership in a WUA, credit service utilization, membership in an agricultural cooperative, extension contact, and social capital.

The study also provides empirical evidence that irrigation institutions in Ethiopia lack a dedicated legal framework, despite their long informal history. Therefore, this empirical finding shows that irrigation governance is misaligned with existing cooperative laws. It highlights a policy blind-spot in water governance.

5.2. Recommendations

A farmer's reason for participating in an irrigation scheme is an interest in growing more crops. They are willing to try new crops if irrigation water is available. A WUA should capitalize on this to encourage more farmers to participate within a scheme. In the opinion of farmers and the discussions with the different groups during the field study, it was observed that farmers/users give priority to WUA members in river irrigation systems because it is richer in nutrients, whereas the groundwater is devoid of them. In order to attract farmers to participate in a WUA scheme, management should encourage farmers/users to diversify their crops by giving different incentives, such as allowing the use of water for crops other than cereals in the study areas, the distribution of improved seeds, and small-farming consultancy, which would teach farmers improved agricultural practices. The increasing trend of payment of cash fines is not favorable to the user management system. The majority of the farmers are in favor of labor contributions. If cash contributions are encouraged, then the user management system may suffer the same fate as agency or state-managed schemes, which are neither able to collect water charges nor to involve farmers in the collective actions of operations and maintenance activities.

Irrigators who joined a local WUA revealed higher participation in any collective activities compared with nonmembers. This suggests a need to increase farmer participation in formalized institutions that also expose them to water management training, through capacity-building programs run by the government and through other nongovernment stakeholder initiatives. Knowledge exchange and experience sharing among the members of better-performing and underperforming WUAs could ensure greater replication of best practices. Hence, provision of training for irrigation farmers, their executive committees and irrigation experts at each level will improve the efficiency and sustainable use of irrigation water. Finally, the study recommends the creation of irrigation-specific legal frameworks that lead to strengthening enforcement and institutional support for actionable governance reforms.

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DECLARATIONS

Ethics approval and consent to participate: this research involves human subjects and has received ethical approval from Haramaya University with letter HUSP_2018_9582 and Amhara Agricultural Research Institute (ARARI).

ETHICAL CLEARANCE

We have obtained formal ethical clearance from Haramaya University and Amhara Agricultural Research Institute (ARARI) Institutional Review Board before commencing fieldwork, ensuring compliance with both national regulations and international research ethics guidelines. There are no significant physical, psychological, or legal risks anticipated from participation in the study. However, since some questions may touch on household livelihoods, income, or community dynamics, care will be taken to design questions sensitively and to avoid any form of discomfort, judgment, or misinterpretation. Data collectors will be trained to conduct interviews in a respectful, nonintrusive manner. A robust informed consent process was implemented using forms translated into local languages (*Amharic*), clearly explaining the study's purpose, procedures, and participant rights. For nonliterate community members, we will obtain documented verbal consent witnessed by a neutral party. Participant selection had followed nondiscriminatory methods to ensure fair representation across different social groups, with special protections for vulnerable populations, including female-headed households and marginalized community members.

DATA AVAILABILITY STATEMENT

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

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

- Asfaw Eshetu, A. & Mekonen, A. A. (2024) Determinants of small-scale irrigation adoption in drought-prone areas of northcentral Ethiopia in the context of climate change, *Frontiers in Climate*, **6**, 1410527. doi:10.3389/fclim.2024.1410527.
- Aurier, P. & Mejía, V. (2014) Multivariate logit and probit models for simultaneous purchases: presentation, uses, appeal and limitations, *Recherche et Applications en Marketing (Marketing Research and Applications)*, **29** (2), 75–94.
- Bekele, R. D. (2021) *The Economics of Irrigation Systems in Ethiopia: Technological and Institutional Analysis*. PhD thesis. Rheinischen Friedrich-Wilhelms-Universität Bonn.
- Bekele, R. D., Mirzabaev, A. & Mekonnen, D. (2021) Adoption of multiple sustainable land management practices among irrigator rural farm households of Ethiopia, *Land Degradation & Development*, **32** (17), 5052–5068.
- Beyene, F. & Hagedorn, K. (2006) Examining collective action among Mieso agropastoralists of Eastern Ethiopia'. In: *Poster Paper Prepared for Presentation at the International Association of Agricultural Economists Conference*, 12–18 August, Gold Coast, Australia.
- Bromley, D. W., Taylor, D. C. & Parker, D. E. (1980) Water reform and economic development: institutional aspects of water management in the developing countries, *Economic Development and Cultural Change*, **28** (2), 365–387.
- Cappellari, L. & Jenkins, S. P. (2003) Multivariate probit regression using simulated maximum likelihood, *The Stata Journal*, **3** (3), 278–294.
- Chattopadhyay, S., De, I., Mishra, P., Parey, A. & Dutta, S. (2022) Participatory water institutions and sustainable irrigation management: evidence and lessons from West Bengal, India, *Water Policy*, **24** (4), 667–684. https://doi.org/10.2166/wp.2022.306.
- CSA (Central Statistical Agency) (2013) Federal Democratic Republic of Ethiopia Population Projection of Ethiopia for All Regions at Woreda Level from 2007–2037. Addis Ababa, Ethiopia: Central Statistical Agency.
- Deneke, T. T. (2014) Processes of institutional change and factors influencing collective action in local water resources governance in the Blue Nile Basin of Ethiopia. In: Melesse, A. M., Abtew, W. & Setegn, S. G. (eds) *Nile River Basin: Ecohydrological Challenges, Climate Change and Hydropolitics*. Cham, Switzerland: Springer.
- Deneke, T. T., Mapedza, E. & Amede, T. (2011) Institutional implications of governance of local common pool resources on livestock water productivity in Ethiopia, *Experimental Agriculture*, **47** (S1), 99–111. doi:10.1017/S0014479710000864.
- Dorward, A. R. & Omamo, S. W. (2009) A framework for analyzing institutions. In: Kirsten, J. F., Dorward, A. R., Poulton, C. & Vink, N. (eds) *Institutional Economics Perspectives on African Agricultural Development*. Washington, DC, USA: International Food Policy Research Institute (IFPRI), pp. 75–110.
- Dubé, J.-P. (2004) Multiple discreteness and product differentiation: demand for carbonated soft drinks, *Marketing Science*, **23** (1), 66–81.
- Engida, T. & Mengistu, A. T. (2013) Explaining the determinants of community-based forest management: evidence from Alamata, Ethiopia, *International Journal of Community Development*, **1** (2), 63–70. doi:10.11634/233028791301431.
- Eyzaguirre, P., McCarthy, N., Di Gregorio, M. & Dennis, E., (2004) Property rights, collective action, and plant genetic resources. In: Meinzen-Dick, R. & Di Gregorio, M. (eds) *Collective Action and Property Rights for Sustainable Development, 2020 Vision Focus 11*. Washington, DC, USA: International Food Policy Research Institute (IFPRI), Brief 10 of 16.
- Fujiie, M., Hayami, Y. & Kikuchi, M. (2005) The conditions of collective action for local commons management: the case of irrigation in the Philippines, *Agricultural Economics*, **33**, 179–189.
- Gates, R. (2006) A Mata Geweke-Hajivassiliou-Keane multivariate normal simulator, *The Stata Journal*, **6** (2), 190–213.
- Greene, W. H. (2012) *Econometric Analysis*, 7th edn. Boston, MA, USA: Prentice Hall.
- Guido, A., Robbett, A. & Romaniuc, R. (2019) Group formation and cooperation in social dilemmas: a survey and meta-analytic evidence, *Journal of Economic Behavior and Organization*, **159**, 192–209.
- Gujarati, D. N. & Porter, D. C. (2009) *Basic Econometrics*, 5th edn. New York, NY, USA: McGraw-Hill.
- Lemperiere, P., van der Schans, M. L. & Bavanirajan, V. J. G. (2014) *Research for Development Using Participatory Rapid Diagnosis and Action Planning for Irrigated Agricultural Systems: A Manual for Development Researchers and Practitioners. Updated Edition*. Colombo, Sri Lanka: IWMI and Rome, Italy: Food and Agriculture Organization of the United Nations. doi:10.5337/2014.225.
- Marshall, G. (1998) *A Dictionary of Sociology*. New York, NY, USA: Oxford University Press.
- Mehta, N. & Ma, Y. (2012) A multicategory model of consumers' purchase incidence, quantity, and brand choice decisions: methodological issues and implications on promotional decisions, *Journal of Marketing Research*, **49**, 435–451.
- Meinzen-Dick, R. S. (2009) Coordination in natural resource management. In: Kirsten, J. F., Dorward, A. R., Poulton, C. & Vink, N. (eds) *Institutional Economics Perspectives on African Agricultural Development*. Washington, DC, USA: International Food Policy Research Institute, pp. 319–342.
- Meinzen-Dick, R., Di Gregorio, M. & McCarthy, N. (2004) *Methods for Studying Collective Action in Rural Development*. CAPRI Working Paper No. 33, Washington, DC, USA: International Food Policy Research Institute.

- 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 South Africa*, **40** (4), 699–708. <https://doi.org/10.4314/wsa.v40i4.15>.
- Nakamaru, M., Shimura, H., Kitakaji, Y. & Ohnuma, S. (2018) *The effect of sanctions on the evolution of cooperation in linear division of labour*, *Journal of Theoretical Biology*, **437**, 79–91.
- Narayanamoorthy, A. & Deshpande, R. S. (2004) Irrigation institutions in India with special reference to Maharashtra State. In: *18th European Conference on Modern South Asian Studies (SASNET)*, 6–9 July, Lund, Sweden.
- Oates, N., Jobbins, G., Mosello, B. & Arnold, J. (2015) *Pathways for Irrigation Development in Africa – Insights from Ethiopia, Morocco and Mozambique*. FAC Working Paper 119, Brighton, UK: Future Agricultures Consortium.
- Oates, N., Hisberg, A., Rodríguez Ros, J., Solomon, H., Ludi, E., Marlet, S. & Jamin, J. Y. (2020) *The implications of state intervention for self-governed irrigation schemes: insights from Tigray, Ethiopia*, *Irrigation and Drainage*, **69** (S1), 88–99. <https://doi.org/10.1002/ird.212>.
- Olson, M. (1965) *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge, MA, USA: Harvard University Press.
- Ostrom, E. (1990) *Governing the Commons: The Evolution of Institutions for Collective Action*. New York, NY, USA: Cambridge University Press.
- Ostrom, E. (1992) *Crafting Institutions for Self-Governing Irrigation Systems*. San Francisco, CA, USA: International Center for Self-Governance.
- Ostrom, E. (2000) *Collective action and the evolution of social norms*, *Journal of Economic Perspectives*, **14** (3), 137–158.
- Ostrom, E. (2004) Understanding collective action. In: Meinzen-Dick, R. & Di Gregorio, M. (eds) *Collective Action and Property Rights for Sustainable Development, 2020 Vision Focus 11*. Washington, DC, USA: International Food Policy Research Institute (IFPRI), Brief 2 of 16.
- Ostrom, E. (2005) *Understanding Institutional Diversity*. Princeton, NJ, USA: Princeton University Press.
- Portes, A. (1998) *Social capital: its origins and applications in modern sociology*, *Annual Review of Sociology*, **24**, 1–24.
- Rogers, P. & Hall, A. W. (2003) *Effective Water Governance*. Technical Committee Background Papers No.7, Stockholm, Sweden: Global Water Partnership (GWP).
- Ruano, A. L., Dahlblom, K., Hurtig, A.-K. & Sebastián, M. S. (2011) *‘If no one else stands up, you have to’: a story of community participation and water in rural Guatemala*, *Global Health Action*, **4**, 6412.
- Spielman, D. J. & Kelemework, D. (2008) *Mobilizing Rural Institutions for Sustainable Livelihoods and Equitable Development: A Case Study of Irrigation, Water Management and Smallholder Cooperatives in Ethiopia*. Addis Ababa, Ethiopia: International Food Policy Research Institute.
- 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. <https://doi.org/10.1016/j.agwat.2018.04.031>.
- Wade, R. (1987) *The management of common property resources: collective action as an alternative to privatisation or state regulation*, *Cambridge Journal of Economics*, **11**, 95–106.
- Walsh, J. W. (1995) *Flexibility in consumer purchasing for uncertain future tastes*, *Marketing Science*, **14** (2), 148–165.
- Wang, Y., Zang, L. & Araral, E. (2020) *The impacts of land fragmentation on irrigation collective action: empirical test of the social-ecological system framework in China*, *Journal of Rural Studies*, **78**, 234–244. <https://doi.org/10.1016/j.jrurstud.2020.06.005>.
- Wang, Y., Chen, S. & Araral, E. (2021) *The mediated effects of urban proximity on collective action in the commons: theory and evidence from China*, *World Development*, **142**, 105444. <https://doi.org/10.1016/j.worlddev.2021.105444>.
- Zang, L., Araral, E. & Wang, Y. (2019) *Effects of land fragmentation on the governance of the commons: theory and evidence from 284 villages and 17 provinces in China*, *Land Use Policy*, **82**, 518–527. <https://doi.org/10.1016/j.landusepol.2018.12.042>.
- Zang, L., Wang, Y. & Su, Y. (2021) *Does farmland scale management promote rural collective action? An empirical study of canal irrigation systems in China*, *Land*, **10**, 1263. <https://doi.org/10.3390/land10111263>.

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