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# Farmers' participation in collective irrigation management in the Koga Irrigation Development Project, Ethiopia.

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**Abstract**

Irrigation technology played incommensurable role in agricultural practices as it reduces agricultural rainfall dependency and the adverse impacts of climate change. However, regardless of huge investments made in the establishment of irrigation schemes, some are collapsed soon after their operation. Among others, infirm management system and lack of beneficiaries' active participation in collective management activities remain the critical factors. The purpose of this study was thus to scrutinize beneficiaries' participation in collective irrigation management activities in the Koga Irrigation Development Project. Primary Data were collected from 220 randomly selected sample households. Principal Component Analysis and Censored Tobit Regression model were employed to analyze the data. The study found that households were mainly participated in regulation and controlling activities to manage the irrigation scheme. However, combinations of socio-economic and institutional factors such as annual income gains from irrigation agriculture, trainings, farmers' perceptions, access to credit and extension services have influenced their participations. As a result, the study recommends that so as to ensure long-term collective agricultural irrigation systems sustainability, farmers should be encouraged to participate actively in various collective irrigation management activities and hindering factors should be addressed as well.

**Keywords:** Irrigation, Farmer participation, Collective management activities

## Introduction

Irrigation projects contributed for rural food security and poverty reduction as well as production improvements in developing economies (Yigezu et al., 2014; Svubure et al., 2010; Abraham et al., 2003). One of the evidences is, for example, the positive growth rate record of cereal production in developing countries, particularly in sub-Saharan Africa (Chauvin et al., 2012). Similarly, India, China, and Pakistan have achieved food self-sufficiency in the 1960s and the 1970s through irrigation system which is recorded as achievement of the 20th century-unprecedented in the past (Bhattarai et al., 2002). In addition, irrigated agriculture has a significant contribution to enhance the value of livestock and poultry products since animal forage and feed can be produced using irrigation.

However, the contribution depends on enabling physical and socio-economic environments such as the presence of appropriate working structures, proper scheme management and beneficiaries' participatory approaches (Hassan, 2011; Ostrom, 2010). The contributions of the existing irrigation schemes in Ethiopia are highly variable. Some of them which have clearly defined boundaries and members with agreed collective management rules have providing increased income, higher productivity, significant job opportunity and considerable contribution to the economy, while others are not (Seleshi et al., 2008; Awulachew et al., 2008). Scholars noted a category of causes related to low contribution of irrigation schemes. These includes inadequate community involvement and consultation, (2) inadequate awareness of irrigation water management and maintenance of irrigation facilities, (3) inadequate knowledge on improved and diversified irrigation agronomic practices, (4) shortage of basic technical knowledge, (5) poor economic background of users to access irrigation technologies and agricultural inputs (Gebremedhin and Asfaw, 2015; Makombe et al., 2011; Hagos et al., 2009; Bruns and Helmi, 1996).

Among others, lack of active participations or unequal involvement of water users in collective management activities is a practical challenge that affects the KIDP to reach its desired goals. In the philosophy of collective action, beneficiary farmers sharing the irrigation resources are supposed to actively cooperate in managing the full components of the resource (Ostrom, 1990). The rationale is to improve the maintenance of irrigation facilities and irrigation service thereby maximizes the productivity of irrigated land and water, promote a culture of self-reliance among farmers and assure sustainability of the system. However, despite the huge government investments in the establishment and refurbishment, the irrigation scheme face difficulty of users' participation in management activities soon after its operation (Taffesse et al., 2012). Ostrom in her book of "governing the commons" argues that problems in managing common pool resources arise when an individual determines that he/she will still have access to the resource even if he/she does not fully contribute to its maintenance which fall the resource into ruin (Ostrom, 1990).

Some studies were done on irrigation scheme management activities and demonstrated how irrigations are managed in collective activities and what factors influence management activities (Muchara et al., 2014; Arun et al., 2012; Aheeyar et al., 2012; Amin, 2011; Khalkheili and Zamani, 2009; Lin, 2002). However, the studies on beneficiaries' participation concern found to be scanty in general and irrigation schemes in Ethiopia are not assessed in view of the issue raised under this research in particular. To the opposite, scheme wise knowledge concerning beneficiaries participation and hindering factors are vital to secure sustainable agricultural production. This study is, therefore, intended to investigate beneficiaries' participation in collective irrigation water management and associated factors in the Koga irrigation development project.

## Materials and methods

### Study area description

The Koga irrigation and watershed management project (later renamed as "*koga* irrigation development project") is one of the large-scale modern irrigation schemes in Ethiopia (MacDonald, 2004). It is found in *Mecha Woreda*, Northern Ethiopia, 526 km far from Addis Ababa. It is located at the head of the Blue Nile basin within Lake Tana Watershed (Haileslassie et al., 2008) and it is under 'Woyina Dega' agro-climatic zone (Habtamu, 2012). The project area was first surveyed by the *Derg* regime in the 1980's to establish irrigation scheme. The current government has resumed the plan and started the construction in October 2004 and completed in 2012. In collaboration with the Ethiopian government, the cost of the project was covered by African development bank (Eriksson, 2012). The project was supposed to improve the formerly used rain fed agriculture by allowing two crop seasons thereby reducing poverty and enhance food security.

The *Koga* irrigation development project irrigates 7004 ha of land within a 22,000-ha catchment area. The Project has two dams, called main and saddle dam. The saddle dam is smaller with an embankment length of 1162 m and a maximum height above the riverbed of 9 m. The main dam has 1730m length and 21m height and its water impound capacity is 83.1 million $m^3$. The 11-night water storage reservoirs in the area are used to store water at night when the smaller canals discharge is down. In addition, 95 tertiary and 469 quaternary unlined canals are available in the scheme to serve areas larger than 80 ha and 8-16 ha, respectively. The command area has 12 blocks irrigated by tertiary canals which takes off from a secondary canal. The size of a block varies from 300-900 ha (Koga irrigation development project office, 2017). The main cultivated crops under the project are wheat, potato, shallot, pepper, garlic, onion, tomato and maize.

The project area encompassed 9 rural peasant associations/*kebeles* and 10,031 beneficiary households (Koga irrigation development project office, 2017). The urban population of *Merawi* and *Wetet Abbay*, with estimated population of 15,000 is also benefited directly and indirectly from increased economic activities. The majority of the households in and around the vicinity are dependent on farming for their livelihood (McCartney and Awulachew, 2006). The Koga Project is unique in Ethiopia because it integrates forestry, livestock, soil management, water and sanitation beyond basic irrigation development activities.

Sampling design and data sources

The sample households for this study were selected from among irrigation beneficiary households using stratified random sampling since it helps to select samples from strata. First, the nine-irrigation user *Kebeles* (small administrative unit of Ethiopia) were purposively divided in to three strata based on their location from the dam (i.e., upper, middle and lower catchment areas). Second, among the seven total *Kebeles,* four sample *kebeles* were selected using random sampling technique proportionately to each stratum. It was done by assuming that taking all is challenging but four is adequately representative. Finally, from a total of 7, 877 beneficiary households, 220 sample households were drawn from the sample *kebeles* by applying Yamane (1967) formula and they were taken through random sampling technique. At this stage, given the household size difference between *kebeles*, proportional sampling method was also used.

The study used both primary and secondary data sources. The interviewer administered household survey, key informant interview with Koga Irrigation Development Project office and field observations were the primary data sources. Basically, the primary data sources were targeted to gather information on irrigating households' demographic and socio-economic characteristics, water sharing mechanism, collective activities, size of farm and factors affecting participation in collective activities.

Prior to the actual survey, preliminary information based on informal discussions with community members and block controllers in the command area at the grass-root levels was gathered. To increase data validity and reliability, enumerators who are fluent in the local language (Amharic) were selected to administer the interviews with the selected sample farm households.

Methods of data analysis

The objective of the study is intended to investigate farmers' participation in collective irrigation management activities and the determinant factors for their participation. According to Ostrom (2010), beneficiaries' collective action bind by rules and agreed norms have a significant role in effective irrigation water management. However, the levels of participation vary across members of the group accompanied by a combination of socio-economic, institutional and resource-related factors (Chauvin et al., 2012; Ostrom, 2010). As a result, a respondent might be participating in one activity but not in others. In such circumstances, it is logical to consider the multidimensional nature of activities and generate a composite index that captures the greatest number of possible collective activities in which farmers are expected to involve in. Hence, following Muchara et al. (2014) and Manyong et al. (2006), Principal Component Analysis (PCA) was used to generate a composite index of participation in this paper. PCA reduces the number of variables in an analysis by describing linear combinations of variables that contain most of their information. The variables representing collective action are not orthogonal, but PCA is used to reduce the dimensionality of variables and decompose variations in the variables into orthogonal components.

Respondents rated their participation level in a wide list of irrigation management activities. Following Muchara et al. (2014), a total of 8 activities were identified, which were grouped into three main themes, namely (i) labor-based participation (ii) participation in decision making and (iii) participation in regulation and control (Table 1). In addition, Muchara et al. (2014) has used financial-based activities, but it might not work for this case study. Because the participation level of irrigators in financial-based activities was equal with fixed amount of money paid in annual base for the service. So, this variable was dropped. Participation in collective activities were ranked using a 5-point Likert scale from 0 if a farmer is not involved in a given activity, to 4 if he/she is highly involved. The rankings then used to compute the participation index (PI) using PCA for individual farmers in water related activities.

Table 1. Description of variables for PCA model to generate participation index

| Themes of participation | Forms of collective participation | Level of participation | Sources |
|---|---|---|---|
| Labor-based participation | Participate in canal repair and maintenance | 0=not involved<br>1=low involvement<br>2=average involvement<br>3= high involvement<br>4=very-high involvement | Muchara et al., 2014; Ostrom, 2014; Ostrom, 2010; Fujiie et al., 2005; |
| Decision making | Attending meetings<br>Contributing ideas in water related issues<br>Attending trainings | | |
| Regulation and control | Reporting unlawful water use<br>Reporting and controlling theft of irrigation infrastructure<br>Reporting and controlling of water leakages /runoff<br>Reporting any infrastructure damages | | |

Explicitly, the participation in collective activities by farmers are assumed to have equal weights. This may be queried where smallholder farmers value the forms of contribution differently. The complexity of allocating specific values to the various forms of participation resulted in the current implicit assumption about equal weights. The PI was therefore used as a proxy to measure farmers' involvement in collective activities (Muchara et al., 2014).

Once having the index, it is worthy to assess why households differ in their PI. The study has extended the idea in to identifying the factors that affect farmers' participation in collective irrigation management activities. As a result, the derived PI indices from PCA for each of the sample households were used as the dependent variable in a Tobit model. We tried to fix the Seemingly Unrelated Regression model (SUR) to identify influencing factors, but we face inadequacies such as; 1) the model uses the dimensions separately as an outcome variable (proxy of participation) which does not adequately represent collective participation, 2) the model identifies influencing socio-economic and institutional factors in each dimension that could vary across the type of activities. However, first, it is not the focus of the study that it intends to identify factors for collective participation (represented by a composite PI); second, since dimensions are large, it could be very complicated for interpretation in this case, 3) the model couldn't censor a PCA-generated index and does not show the intensity of farmer's participation. The use of the PCA and Tobit model, therefore, overcomes the problems. As a result, following previous studies such as Muchara (2014) and Manyong (2006), a censored *Tobit* regression model was employed to estimate the determinant factors influencing farmers' participation in collective irrigation water management activities (Z), i.e., user attributes, physical or resource attributes, institutional attributes and the form and way of participation (participation index). The participation index (σ) is the dependent variable. Given the right- and left-censoring at minimum (σ min) and maximum (σ max ) score, respectively, the 2-limit *Tobit* model (Maddala, 1986) is specified as follows:

$$\sigma_i^* = \beta'(Z_i) + \varepsilon_i \qquad 1$$

Where: $\sigma_i^*$ is an unobservable latent response variable

$Z_i$ is an observable vector of explanatory variables

$\beta'$ is a vector of parameters to be estimated

$\varepsilon_i$ is a vector of independently and normally distributed residuals with a common variance θ.

Then the actual model can be represented as follows:

$$\begin{aligned} \sigma_i &= \sigma_{min}\ if\ \sigma_i^* \le \sigma_{max} \\ &= \beta'(Z_i) + \varepsilon_i\ if\ \sigma_{min} \le \sigma_i^* \le \sigma_{max} \\ &= \sigma_{max}\ if\ \sigma_i^* \ge \sigma_{max} \qquad (2) \end{aligned}$$

With this specification of participation variable parameters, the model is estimated by maximizing the following corresponding log-likelihood function [31]:

$$L(\beta,\theta) = \prod_{\delta i=\delta min} \Phi\left(\frac{\delta_{min} - \beta' Z_i}{\theta}\right) \prod_{\delta i=\delta i^*} \frac{1}{\theta} \emptyset \left(\frac{\delta_i - \beta' Z_i}{\theta}\right):$$

$$\times \prod_{\delta_i - \delta_{min}} \left[1 - \Phi\left(\frac{\delta_{max} - \beta' Z_i}{\theta}\right)\right] \quad (3)$$

Where: Φ and Ø are the standard normal density and distribution functions, respectively.

Table 2. Description of explanatory variables for Tobit model and expected signs

| Explanatory variable | Description and expected effects | |
|---|---|---|
| Age of household head | Continuous (in year) | - |
| Family size | Continuous (in number) | + |
| Education | Continuous (years spent in formal school) | - |
| Average annual income in irrigation agriculture | Continuous (in birr) | + |
| Proportion of irrigated land over total land holding | Continuous (in ha) | + |
| Average amount farmers pay for irrigation management | Continuous (in ETB) | - |
| Gender of the household head | Dummy (1 if HH head is male; 0 otherwise) | + |
| Position of farm plot from the main canal | Categorical (1 =Upper, 2 = Middle,3 = Tail-end) | ± |
| Frequency of water-related meeting calls | Dummy (1 if it is regular; 0 less regular) | - |
| Satisfaction with the work of committee | Dummy (1 if HH is satisfied; 0 otherwise) | + |
| Perception of water sharing equality | Dummy (1 if HH perceive equal; 0 otherwise) | + |
| Training in irrigation water management | Dummy (1 if there is training; 0 otherwise) | + |
| household has been involved in water-related conflict in the past year | Dummy (1 if HH involved; 0 otherwise) | - |
| Perception on participatory approach application in the system | Dummy (1 if HH perceived as the system follows participatory approach; 0 otherwise) | + |
| Perceived rigidity of rule and regulations in the system | Dummy (1 if HH perceives; 0 otherwise) | - |
| Access to credit service | Categorical (0=no access, 1=small, 2=medium, 3=high) | + |
| Access to extension service | Dummy (1 if HH could access; 0 otherwise) | + |
| Membership of individual irrigators to a water user association | Dummy (1 if HH is a member; 0 otherwise) | + |

Source: adapted from Muchara et al. (2014); Ostrom (2014); Ostrom (2010); Fujiie et al. (2005)

## Results and discussion

Descriptive results

The demographic profile of sample households in Table (3) showed that majority (68.6%) of the respondents were males. It is also indicated that the average age of sample households was 42.5 years which means they were on average adults. These households have lived on average for 37 years in their current respective residential *kebele* and they had 23 years of average farming experience. This implies that they are more familiar and adaptive to the agro-ecology and livelihood strategies in the area. The average family size was 6, while the average years of attending formal education was 2 years. In the surveyed kebeles, the average landholding was 1.3 ha. This indicates the landholding of the sample population is smaller than the average household land holding of Ethiopia. Since 1975 national land reform, there have been frequent redistributions and adjustments to accommodate newly forming households that led to the subdivision of farm lands into smaller plots in Ethiopia (Woldeamlak, 2003). Table (3) presents the mean of continuous variables and the percentage of dummy variables of respondents' socio-economic characteristics.

Table 3. Descriptive summary of household characteristics

| Variable | Mean/ percentage |
|---|---|
| Age (years) | 42.52 |
| Total family size (in number) | 6.004 |
| Education level (in years) | 2.027 |
| Gender (1=male) | 68.64 |
| Total land holding size(ha) | 1.304 |
| Marital status(2=married) | 87.73 |
| Length of residence(years) | 38.47 |
| Farming experience | 22.95 |

Source: Own survey

The process of targeting irrigation beneficiaries in the KIDP

In a community that faces the effects of drought, poverty and food insecurity, irrigation agriculture is critically important. However, for various reasons, all households in and around the vicinity of irrigation projects could not be equally targeted. According to the KIDP administrative office, irrigator households in the KIDP were selected on the basis of how they were affected by the project. Groups of households who have been displaced and relocated because of the construction of reservoir, inhabiting adjacent and/or in to the irrigation scheme and communities hosting relocates were the identified affected groups by the project. These household groups were therefore considered in the process of beneficiary selection. The project administrator said that villagers in the command area were exclusively selected beneficiaries.

Table 4. Irrigation beneficiary household selection criteria - frequency and % of respondents

| Criteria of selecting irrigators | Frequency | Percent |
|---|---|---|
| Geographically located in the command area | 185 | 84.09 |
| Replaced land in place of land taken for construction | 33 | 15.00 |
| Voluntary resettlement | 1 | 0.45 |
| Investor | 1 | 0.45 |
| Total | 220 | 100.00 |

Source: own calculation

The descriptive result in Table 4 indicated that about 84.1 percent of beneficiary respondents were directly targeted because they were geographically located in the command area even before the establishment of the project. Therefore, they are voluntary users so that their level of participation in management activities is directly related. The remaining 15 percent were relocated beneficiaries from the adjacent areas. This group of households is either being compensated in place of their land taken for construction or totally displaced from their residence to other *kebeles*.

The result suites to the findings of Ayalew et al. (2008), who have argued that in most cases households reside in command areas are the direct targets, whereas in some cases based on the design and purpose of schemes, irrigation projects will apply different criteria to select beneficiary households. For example, according to the design of the scheme, all farmers that helped with scheme construction were allocated land within Bwanje valley irrigation scheme in Malawi (Nkhata, 2014).

Measuring household participation in irrigation management collective activities

Researchers (Ostrom, 2014; Fujiie et al., 2005; Abraham et al., 2003) have underlined that beneficiaries' participation in collective irrigation management activities should not be overlooked since it is important for sustainable and efficient utilization of irrigation resources. As a result, this study has assessed how the KIDP irrigation users were participating in irrigation management activities. It was done by employing PCA. The descriptive statistics in PCA shows that eight cases with no missing value were actually used in the principal components. Almost all variables have closely similar mean values. The least and largest value of each activity is also the same that indicates farmers participation in each collective action vary from no involvement up to higher involvement (0-4) in the KIDP.

Eight principal components were extracted using Pearson correlations. Then, by applying Kaiser Criterion, two components with eigenvalues greater than 1 were retained. That is the information in 7 variables is represented by the two components. The initial number of factors used in the factor analysis was eight. Post-estimation test was conducted to ensure the proportion of variation in a variable explained by the other factors. It helps to assess how well this model explains most of the variation in those variables. As a result, seven variables with commonality value P>0.5 were retained and one variable (attending training, i.e., ATRNG) was removed. The PCA results are presented in Table (2) below.

The first principal component (PC hereafter) explains 56% of the total variation of farmers' participation in collective activities, with the second principal component explaining 16%. The two PCs together explained 72% of the variation in the data. Unlike PC2, all PC vectors in the first component are positive. This can be taken as evidence that PC1 represents the aggregate variations of farmers' participation in collective management activities. As a result, PC1 was retained and then used to generate the participation index (PI). The idea is consistent with Muchara et al. (2014) and Manyong et al. (2006) that the first retained component which accounts for a large percentage of the variance in the variables can be used alone without much loss of information. Following Fujiie et al. (2005), the PI is calculated as the sum of seven variables weighted by coefficients in the PC vector, after normalizing each variable by subtracting its average from individual observations and dividing these differences by standard deviation.

Table 5. Household's irrigation management participation index generation using PCA

| | Extracted Principal component (PC) | |
|---|---|---|
| | 1 | 2 |
| Eigenvalues | 3.92 | 1.11 |
| % of explained proportion of Variance | 55.95 | 15.71 |
| % of explained Cumulative variance | 55.95 | 71.66 |
| Variables | Factor loading | |
| Participate in canal maintenance (PCNLM) | 0.1584 | 0.6689 |
| Attending meetings (AMETING) | 0.3605 | 0.4529 |
| Contributing ideas in water related issues (IDEACONT) | 0.3744 | 0.3269 |
| Reporting unlawful water use (REPULWUSE) | 0.4193 | -0.2438 |
| Reporting theft of irrigation infrastructure (REPTHFT) | 0.408 | -0.3345 |
| Reporting water leakages /runoff (REPROFF) | 0.4392 | -0.233 |
| Reporting any infrastructure damages (REPDSTRN) | 0.4118 | -0.123 |

Rotation Method: Varimax with Kaiser Normalization; Note: Five-point Likert scale values are: 0 = not involved; 1 = low involvement; 2 = average; 3 = high; 4 = very high

Source: Own survey

The positive coefficient of a variable highly indicates farmer's participation in other activities. Hence, all variables in PC1 indicated that households were involved in various collective actions. On the contrary, the negative coefficient of a vector indicates a farmer (household) is likely to participate in few other collective activates. The higher and lower coefficients mean that participating in an activity conveys more or less information about the other activity.

The first PC is dominated by farmers' participation in regulation and control activities. This indicates that households who participate in irrigation resource management are more involved in reporting resource wastage such as water leakages/runoff and infrastructural damages, and controlling illegal activities like infrastructure theft and unlawful water use. Since most of the activities in communal irrigation management schemes are complementary in nature (Fujiie et al., 2005), these farmers are also involved in other activities. The second PC is dominated by participation in labor-based activities (canal maintenance) followed by decision making activities (attending meetings and contributing ideas).

In the PCA results, the high factor loading of water leakages/runoff further indicated water leakage and run off out of tertiary canals is a common problem. It is occurred either when diversion gates are not properly closed and damaged or when water is introduced into furrows. According to Schwankl et al. (2007), runoff begins when water reaches the lowest part, or end of the orchard, unless the end of the orchard is blocked with berms to keep the water in the orchard.

In general, the result indicates that farmers should be encouraged to participate equally in various collective activities because failure or success of a particular activity affects the performance of the others. Moreover, participatory approach is expected to deliver a number of positive outcomes and impacts like empowering farmers, better system maintenance and service, reducing cost of irrigation to the government, higher water productivity and profitable agriculture, and sustainable management of communal irrigation schemes (Kulkarni and Tyagi, 2012; Lin, 2002). Possible solutions to prevent water leakage/runoff include recruit stand by controller at the water gets and aware farmers about efficient irrigation water utilization.

Determinants of farmer’s participation in collective irrigation management activities

Despite the huge government investments made in the establishment of irrigation schemes, some are collapsed soon after their operation (Muchara et al., 2014). Among others, lack of beneficiaries’ active participation in collective system management activities remains an important factor (Ostrom, 2014; Fujiie et al., 2005; Abraham et al., 2003). However, various types of constraints will determine beneficiaries’ active participation in collective management activities. As a result, the study expanded the idea of farmers’ participation in collective activities into identifying the determinant factors that affect their participation. To do so, a 2-limit Tobit regression model was employed because the response variable generated from PCA is right and left censored (Manyong et al., 2006). Farmer participation index (PARTN_INDX) in collective irrigation management activities was, therefore, the dependent variable in the model.

The scores were scaled from -5.08 to 3.22 and cannot fall outside of this range. Before interpreting the results, to ensure whether Tobit regression is correctly specified, post-estimation tests were done. Having a strong F-value (P=0.000), the model has a good fit to the data. Multicollinearity of the explanatory variables was tested using variance inflation factors (VIF), which were all below 10 with an average of 1.27. As a rule of thumb, if the VIF of a variable exceeds 10, there is a serious multicollinearity problem (Amare, 2005). To correct for heteroskedasticity, the robust standard errors were also estimated. Furthermore, normality was assessed by applying the Jarque-Bera test. As a result, the null hypothesis cannot be rejected that the model without predictors is as good as the model with the predictors; therefore, it is defendable to use the model. The result of Tobit regression model is presented in Table (6).

Table 6. Determinants of farmer participation in collective irrigation management activities

| Variables | Tobit regression | |
|---|---|---|
| | Coefficients | Robust std. error |
| Gender of household head (GENDER) | 0.176 | 0.253 |
| Age of household head (AGE) | -0.006 | 0.011 |
| Family size (FAMSIZ) | 0.065 | 0.066 |
| Irrigable land size owned by hh (IRRLAND) | -0.207 | 0.278 |
| Average annual income from irrigation agriculture (INCMIRR) | 0.002* | 0.001 |
| Payment for irrigation management (PAYMNT) | 0.290 | 0.509 |
| Location of farm plot from the main canal (LOCDAM) | -0.075 | 0.158 |
| Frequency of water-related meetings (MTNGPAR) | 1.781*** | 0.350 |
| Training in irrigation water management (TRNGPAR) | 0.764*** | 0.279 |
| Perception of water distribution equality (WDEQLTY) | 0.216 | 0.276 |
| Satisfaction with the work of committee (SONCMTT) | -0.341 | 0.299 |
| Perceived rigid rule and regulations in the system (RGDRUL) | 0.361* | 0.228 |
| Perceived participatory approach in the system (PARTAPP) | -0.102 | 0.308 |
| Conflict on water sharing (CFLCT) | 0.058 | 0.260 |
| Education level (EDUYRS) | 0.055 | 0.038 |
| Access to credit (CREDIT) | 0.334*** | 0.101 |
| Access to extension (EXTENSION) | 0.514** | 0.258 |
| Member of water user association (WUAM) | 0.504* | 0.354 |
| _cons | -3.059*** | 0.899 |
| /sigma | 1.520 | 0.070 |

| | | | |
|---|---|---|---|
| F(18,201) | 9.600 | Uncensored observations | 216 |
| Prob>F | 0.000*** | Left censored observations | 1(Minimum ≤ -5.08) |
| Pseudo R2 | 0.131 | Right censored observations | 3(Maximum ≥3.22) |

Note: *, ** & *** denote significance at the 10%, 5% and 1% levels, respectively.

Source: own survey

The regression result indicates that combinations of economic, institutional and social factors influence farmers' participation in irrigation resources management activities in the KIDP. Annual income gains from irrigation agriculture (INCMIRR), frequency of attending water-related meetings (MTNGPAR), trainings related to irrigation water management (TRNGPAR), farmer perception of rigid rule and regulations of the system (RGDRUL), access to credit (CREDIT) and extension (EXTENSION) services available for irrigators, and membership of water user's association (WUAM) were found to be statistically significant determinant factors of farmers' participation in collective activities.

As it is indicated from the above table participation of beneficiaries is influenced by the average annual income gain from irrigation agriculture. Indeed, this is meaningful because a farmer who gains more income from irrigation agriculture is more eager to participate in management activities than those whose gain is low. Since the main purpose of irrigation is profit maximization, beneficiaries' willingness to manage irrigation resources will be decreased if it does not increase their income. This is consistent with the study of Muchara et al. (2014) whose finding revealed that income generated in irrigation farming can be one of the incentives for farmers to participate in irrigation activities. Another economic factor which significantly and positively affects farmer participation was the availability of credit service for irrigators. It indicates that farmers who have easy access to credit service were more willing to participate in collective management activities. According to Venot et al. (2012), one of the main constraints preventing smallholder farmers from cultivating more land and adopting irrigation technologies and affect the willingness of participation in management activities is the cost of inputs. Hence, to cover the costs, irrigator households are more likely to apply to loan services than non-irrigator households (Hagos et al., 2009). Unexpectedly, the data of this study indicated that equivalent to non-irrigators (66.9%), about 66.4% of irrigators in the KIDP had no access to credit loans. This suggests the importance of strengthening local microfinance institutions to address the demand for credit services, which might improve farmers' technology adoption habits, which requires farmer's participation in irrigation activities.

As can be seen from regression results, most determinants of participation in collective activities in the KIDP were institutional related variables. One of them is the frequency of attending water related meetings. It indicates since meeting is a channel through which farmers could get updated information about what a system requires to be done, irrigators more likely to participate in collective actions if the system has regular meetings. In addition, training related to irrigation water management has influenced farmers' participation. Beneficiaries having a piece of irrigation management training were more likely to actively participate in management activities. This makes economic sense, as farmers could get more capacity building training, their demand to adopt technologies for maximizing their production increases and hence they will invest more effort to manage their resources for this achievement. Moreover, meeting and training are keys to disseminate knowledge and information which might result cooperation among members. This fits to the finding of Muchara et al. (2014) and Nakano and Kajisa (2011) who noted that the adoption of modern varieties and resource management are highly associated with training in both rain-fed and irrigated plots. Furthermore, beneficiaries' perception of rules and regulations of the system determines their participation in collective actions. Water users who perceive the abide rules and regulations are not rigid were probably more participants than those who perceive the system use rigid rules and regulations. This could occur when either beneficiary have no detail awareness of rule and regulations or when rules are set without people's participation and agreement. These findings highlight the importance of regular meetings and training to improve farmer participation in collective irrigation system management. It is also indicated that since rules and regulations benefit irrigators themselves, it should be explicitly agreed upon and practiced. Because social norm and rule, especially in a setting where there is communication between the parties, can work as well at generating cooperative behavior than externally imposed set of rules (Ostrom, 2014).

The estimated coefficient for access of extension service positively affects farmers' participation in collective irrigation management. As farmers could get good access of professional advice and consultation (agricultural extension service) about how to advance their resource management skill, then more effort is required by the farmer. This is the reason farmers accessed to extension service were more likely to take part in irrigation management activities in the KIDP. Consistently, Ammani et al. (2011) confirmed that achieving the goal of increasing agricultural production through harnessing of national irrigation potentials mostly depend on agricultural extension services. However, about 32.7% sample irrigators in the KIDP had no access to extension services. This indicates farmers are still practicing their former traditional knowledge which might not guarantee them to efficiently utilize this modern irrigation technology.

The result indicated membership of water users' association significantly affects farmer participation in management activities. It indicates active members of WUA were more likely to participate in collective actions than non-members. This implies that membership of farmers' association or cooperative society is preferable to manage resources rendered to them. On the other hand, unlike Muchara et al. (2014), average irrigated land size, education level and position of the plot from the main canal were not found to be statistically significant influencing factors of collective participation in the KIDP.

**Conclusions and policy implications**

Understanding farmers' participation in collective irrigation management and the associated determinant factors that affect their participation is important for formulating sustainable large scheme irrigation policies. The study, therefore, investigated households' participation in collective scheme management activities by employing Ostrom's collective action theory and PCA and Censored Tobit models. The result of the study depicts that irrigation users in the KIDP priority participated in regulation and control activities than decision making and labor based collective management activities. Their participation was under the influence of many factors such as annual income gain from irrigation agriculture, water-related meetings and pieces of training, being a member of the water users association and access to credit and extension services.

As a result, the study concluded that the sustainability and performance of large-scale irrigation schemes depend on the beneficiaries' commitment to use and manage the system collectively governed by the abide rules and agreed norms. However, interplay of socio-economic and institutional-based attributes greatly influenced users' participation in collective management of irrigation schemes.

Therefore, to achieve the objectives of the project, in collaboration with the water committees and the regional water authority, community based organizations and concerned NGOs, the KIDP office should encourage farmers to participate equally in various collective activities as the failure or success of a particular activity affects the performance of the scheme. To enhance the users' participation, the scheme's administrative body should intervene by focusing on the identified determinants of participation such as infrastructure refurbishments, awareness creation through meetings and training, and supplying credit and regular extension services.

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