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Participation level of water users in irrigated water management: A case study of Ban Vern Kham pumping irrigation project, Xaithani District, Vientiane capital, Lao PDR

Phonemany Sayyasettha and Kittiwet Kuntiyawichai*

Faculty of Engineering, Khon Kaen University, Khon Kaen 40002, Thailand

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Abstract

The objective of this research was to study the participation of a group of water users in irrigation water management in Ban Vern Kham Pumping Irrigation Project, Xaithani District, Vientiane, Lao PDR. This was done through analysis of variables and formulation of a participation equation. The study included 105 households for data collection based on their responses to the developed questionnaires. The collected data were analyzed using SPSS and expressed in the forms of frequency, percentage, mean, and standard deviation. The analysis of participation variables and stepwise multiple regression was done to obtain an equation to predict the participation level in an irrigation water management program. Based on the findings, the overall participation level was high, with a score of 3.62 (out of 5.00) with a standard deviation of 0.149. Specifically, the participation in planning for irrigation water allocation, as well as operation and maintenance of the irrigation system, had the same score (3.67). A lower score was for participation in allocating the benefits from use of irrigation water (3.53). Additionally, personal factors of water users were not found to affect their participation level. However, their educational levels played a role in their participation in irrigation water allocation planning with a statistical significance of 0.05. Other factors, such as ability to work and income obtained from the water user group were found to have a moderate relationship to participation level. The analysis revealed that the water user group was relatively well established due to strong cooperation and collaboration to find equitable ways to manage irrigation water. The participation level in irrigated water management was a function of users' ability to work, income obtained from the water user group, and one's position in water user group.

Keywords: Public participation, Irrigation water user group, Irrigation water allocation, Stepwise multiple regression analysis

1. Introduction

According to the development plan of Lao PDR, the country aims to leave the underdeveloped country list by relying on agricultural production. However, the country seems to lack a number of related inputs for irrigation system, which is urgently required for development and improvement of agricultural productivity [1]. Due to prolonged use and lack of maintenance, the irrigation machinery and its facilities in Lao PDR become deteriorated and affect the efficiency in water allocation and water supply for service areas, including the case of Ban Vern Kham Pumping Irrigation Project, Xaithani District, Vientiane Capital, Lao PDR (Figure 1). The Ban Vern Kham Pumping Irrigation Project relies on four pumping units installed on a floating house to pump the water from Ngum River to agriculture project areas covering a total area of approximately 2,500 rai. The project unit is nearby Ban Tha Ngon in the Southwest, Ban Sam Sa Aad in the Northeast, Ngum River in the East, and the forested area on the way to Salt Pond in the West.

In 2002, the project reported that its pumping system suffered from considerable damage, the water pipeline was found leakage, the irrigation canal was collapsed due to erosion, some irrigation canals were filled with sediment, which affecting the delivery of water to agricultural areas of the group members residing the far end of the canal. In addition, the project was likely to suffer from poor management and ineffective maintenance due to the lacking of understanding of water users in water allocation. The users tended to use water based on their own needs, leading to inequality in water use and resulting in competition for water. Such situation become worse particularly in summer, unless water management plans and water use planning were adopted.

Based on the aforementioned issues, this study was designed to investigate the participation of water user group members in the irrigated water management for agricultural activities in Ban Vern Kham Pumping Irrigation Project, Xaithani District, Vientiane Capital, Lao PDR.

2. Materials and methods

To achieve the objective set forth herein, the questionnaires were developed. The materials and methods used in this study were as follows.

*Corresponding author. Tel.: +6681 718 4330
Email address: kittiwet@gmail.com
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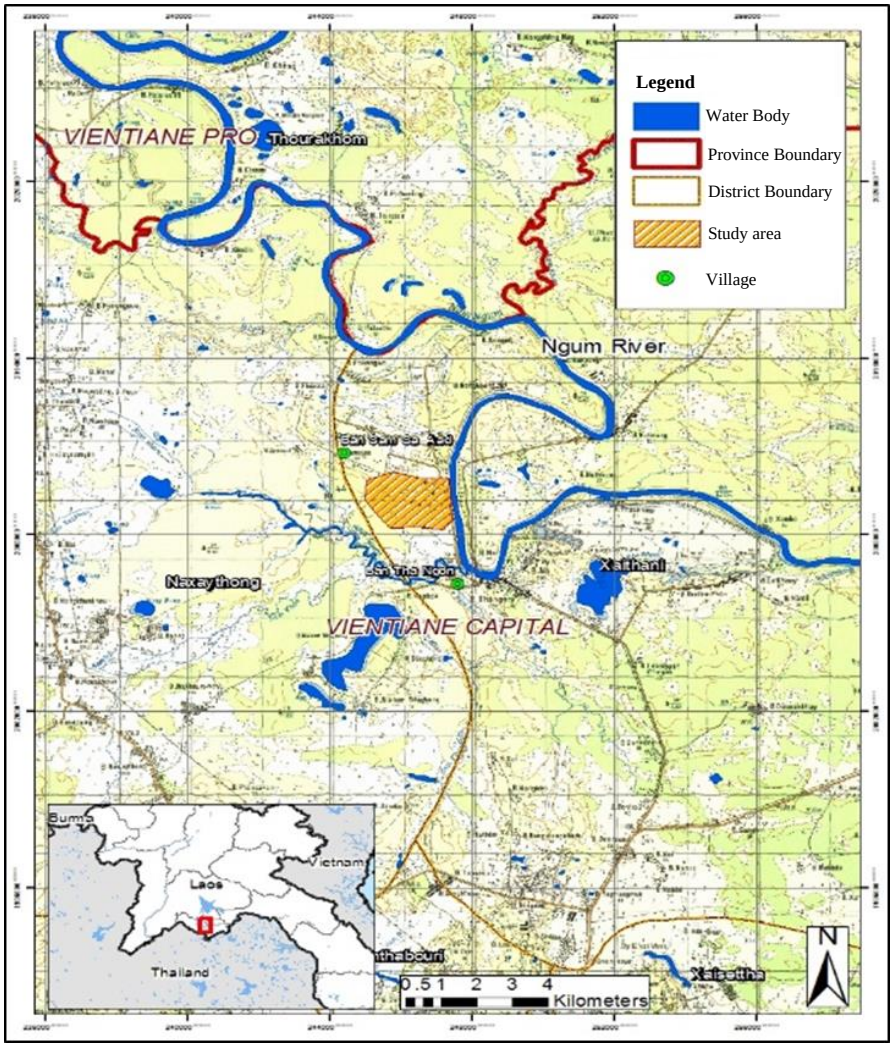

Figure 1 The study area "Ban Vern Kham Irrigation Project", Vientiane Capital, Lao PDR

2.1 Sample size

The sample size to be considered in this study was derived by [2] as shown below:

$$n = \frac{(t/e)^2 (P(1-P))}{1+(1/N)\left[(t/e)^2 (P(1-P))-1\right]} \quad (1)$$

where: n = sample size, P = family proportion (0.5), N = number of family (290), t = test statistic (1.28), e = sampling error (0.05).

Based on the calculation, it was found that the considered sample size in this study was 105 families out of 290 families. The tool to be used in this study was the developed questionnaire with close-ended and open-ended questions. The tool was approved by four experts from Department of Irrigation and Ministry of Agriculture and Forestry, Lao PDR, for content validity including personal, socio-economic, attitude, and water user participation factors.

2.2 Data analysis

The primary data were analyzed using Statistical Package for the Social Science (SPSS) and expressed as descriptive statistic and analytical statistic.

a) Descriptive statistic

This was carried out and expressed as frequency, percentage, means, and standard deviation in order to investigate the level of the participation of water users in the irrigation project.

b) Analytical statistic

The different level of water user participation based on the personal factors of water users, i.e. sex, age, level of education, position in water user group, period of working, background knowledge on water management prior to the given training, and the number of times attending the training, were investigated using Mann-Whitney U Test [3] which was a non-parametric statistical technique. It was used to compare the difference between the medians of two independent data sets. The Mann-Whitney U Test was also used to test the null hypothesis, subject to both samples coming from the same basic set or having the same median value. For the Kruskal-Wallis Test [4], it was a rank-based nonparametric test which was applied to consider the existence of statistical significant differences between three or more groups of an independent variable on a continuous or ordinal dependent variable. Meanwhile, in case of more than two independent groups, Mann-Whitney Test was alternatively used.

The Pearson product moment correlation coefficient was used to analyze the relationship between the variables

covering personal, social, attitude, and socio-economic factors of the samples. The Pearson product-moment correlation coefficient was used to measure the correlation coefficient of the linear dependence between two variables which were interval or ratio scale. Its values usually range from +1 to -1, where 1 is considered to be a total positive correlation, 0 is no correlation, and -1 is a total negative correlation, respectively. In this study, the interpretation of the results was based on [5] for which the value falls between 0.70 – 1.00 means at high level, 0.30 – 0.69 means at moderate level, and 0.01 – 0.29 means at low level.

The multiple regression analysis based on the stepwise regression was used as refers to [6-8] by the following equation.

$$Y' = a + b_1X_1 + b_2X_2 + b_3X_3 + ... + b_nX_n \quad (2)$$

where: Y' is the score of participation in irrigation management, X_i is the study variable i, a is a constant value, b_1,…., b_n is the coefficient of correlation between the predicted and controlled variables (see Table 1).

Table 1 Variables used to determine the participation level of water users

Dependent variable	Code	Meaning
Personal factors	V_1	Gender
	V_2	Age
	V_3	Education level
	V_4	Position in water user group
	V_5	Working duration in water user group
	V_6	Basic knowledge of water users in water allocation
Social factors	F_{11}	Agricultural training
	F_{12}	Working ability
	F_{13}	Working endeavor
	F_{14}	Coordination among farmers
Attitude factors	F_{21}	Expectation to water users
	F_{22}	Feeling that the farmers can rely on the water user group
	F_{23}	Feeling that the farmers are important for water user group
Economic factors	F_{31}	Income obtained from water user group
	F_{32}	Compensation as an incentive for working

3. Results

According to the preliminary analysis, the majority of the water users were male (81%) with the mean age of the majority falls in between 36 – 45 years (59%). The average level of education was the secondary education (51.5%). The members who take a current position in the group was 86.7%. The period that the majority of the members working for the group was approximately 11.45 years. The members who have some basic knowledge on water allocation prior to attending the provided trainings was found to be at a moderate level (50%), whereas all members have attended the provided trainings more than five times (100%).

Referring to the analysis of participation level of members using means, standard deviation (rating scale), and Liker's Scale, it could be divided into five levels (see Table 2).

Table 2 Criteria to define the participation level of water users

Participation level	Score
Highest	5
High	4
Moderate	3
Low	2
Lowest	1

To find the average range of participation levels, the range was calculated based on the criteria established by [5] as shown in Equation 3, whereas the average range and participation level can be presented in Table 3.

$$\text{Range score} = \frac{\max \text{score} - \min \text{score}}{\text{number of intervals}} = \frac{5-1}{5} = 0.8 \quad (3)$$

Table 3 Average range and participation level

Range	Participation level
4.21 – 5.00	Highest
3.41 – 4.20	High
2.61 – 3.40	Moderate
1.81 – 2.60	Low
1.00 – 1.80	Lowest

According to the analysis of participation of all three respects (see Table 4), the level of overall participation was found to be 3.62 with the standard deviation of 0.149. In terms of separate aspects of participation, the highest level of participation was planning in irrigation water allocation and operation and maintenance of irrigation system, at the same average score of 3.67 and the standard deviations are 0.226 and 0.301, respectively. The lowest level of participation was the allocation of the benefit from irrigation water at the score of 3.53 and the standard deviation is 0.162. The average score from this analysis will be used as the criteria for the participation level in order to obtain the equation for predicting the level of further participation of water users.
The analysis of variables which affect the level of participation of water users including social, attitude, and economic factors, was presented in Table 5.

Table 4 Statistical results of overall and separate aspects of water user participation

Type of participation	Score	S.D.
Planning in irrigation water allocation	3.67	0.226
Allocation of benefit from irrigation water	3.53	0.162
Operation and maintenance of irrigation system	3.67	0.301
Overall participation	**3.62**	**0.149**

Table 5 Factors affecting the level of participation of the water users

Factor	Score	S.D.
Social	3.74	0.250
Attitude	3.65	0.213
Economic	3.66	0.312
Average score	**3.70**	**0.181**

Based on the result in Table 5, by considering all three aspects, the most significant variable affecting the level of participation was the social factor with highest score of 3.74 (high participation level). The analysis results also reveal that the economic factor was considered to be at a high participation level with the average score of 3.66, whereas the attitude factor also appeared to be at a high participation level with the score of 3.65. Above all, the average score of overall participation was found to be at a high participation level with the average score of 3.70 and the standard deviation was 0.181.

In terms of the comparison between the participation levels of water user members, the results of different comparison considering both separate and overall aspects were as follows: sex (P = 0.933), age (P = 0.098), position in water user group (P = 0.269), basic knowledge in water allocation before attending the trainings (P = 0.659). Based on the results of different comparison, it was found that the level of participation shows no different level of participation as can be seen that the P-value in the bracket is greater than 0.05, which was irrelevant to the hypothesis (note: the results will be designated as "statistically significant" if the P-value is less than 0.05). By considering the separate aspects, the water users with a different level of education have no different level of participation (P-value is greater than 0.05), in view of allocation of benefit from irrigation water (P = 0.902), and operation and maintenance of irrigation system (P = 0.089). However, in terms of the participation in planning irrigation water allocation, it was found that the water users with a different level of education have a different level of participation in irrigation water allocation with statistical significance (P = 0.002), which was relevant to the hypothesis. As suggested by [9], the multiple comparison test called "Bonferroni simultaneous confidence intervals was used to test the differences among water users in view of different level of education as shown in Table 6.

According to Table 6, the water users who hold the primary educational degree or lower have the level of participation different from those with the upper secondary or higher (as indicated in column "P-value" with the P values of less than 0.05). In short, it can be emphasized that the gap in education between the water users is significant for participation.

Analysis of the correlation between personal factors and level of participation of water users of Ban Vern Kham Pumping Irrigation Project was also carried out as presented in Table 7. Based on the results of the analysis of the correlation between personal, social, attitude of water users, and economic factors, and the overall level of participation of water users (Y') in view of the participation in planning irrigation water allocation, allocation of benefit from irrigation water, and operation and maintenance of the irrigation system, it can be summarized that the correlation coefficients range between -0.048 and 0.385. The education level (V_3), working ability (F_{12}), and income obtained from water user group (F_{31}) showed a positive correlation with a medium level. However, the age factor (V_2), working endeavor (F_{13}), and coordination among farmers (F_{14}) showed a positive correlation with a low level, in comparison to the overall participation (Y') with statistical significance at 0.05.

To develop the equation for predicting the level of participation of water users, the stepwise multiple regression analysis was employed in this study. This process was used in every step until there was no variable eliminated from the equation and no variable put into the equation. Thus, the prediction equation with high coefficient was obtained. By considering the coefficient determination (R^2), if the considered variable decreases the value of R^2, the considered variable would be eliminated, whereas if the considered variable increases the value of R^2, the considered variable would be kept (See Table 8). The analysis results of personal,

Table 6 Multiple comparison test for testing different level of participation of water users with different level of education

Education level (I)	Education level (J)	Mean difference (I - J)	Standard Error	P-value
Primary or lower	Lower secondary	-0.06167	0.03143	0.158
	Upper secondary or higher	-0.14667*	0.04337	**0.003**
Lower secondary	Primary or lower	0.06167	0.03143	0.158
	Upper secondary or higher	-0.08500	0.04081	0.119
Upper secondary	Primary or lower	0.14667*	0.04337	**0.003**
or higher	Lower secondary	0.08500	0.04081	0.119

Note: I and J are the symbols for comparing water users
* The mean difference is significant at the 0.05 level (P-value is less than 0.05)

Table 7 Correlation coefficient between the variables affecting the overall participation (Y')

	Y'	V_1	V_2	V_3	V_4	V_5	V_6	F_{11}	F_{12}	F_{13}	F_{14}	F_{21}	F_{22}	F_{23}	F_{31}	F_{32}
Y'	1	-0.008	0.207*	0.322*	0.080	-0.001	-0.017	-0.048	0.359*	0.226*	0.243*	0.070	0.129	0.177	0.385*	-0.010
V_1		1	-0.178	-0.164	0.048	-0.149	0.176	-0.038	-0.079	0.116	-0.091	-0.299*	-0.107	-0.009	0.102	0.033
V_2			1	-0.055	0.125	0.354*	-0.069	-0.236*	-0.016	-0.102	-0.005	0.184	-0.227*	-0.014	-0.062	-0.216*
V_3				1	-0.099	-0.119	-0.183	-0.170	0.347*	0.226*	0.180	0.141	0.324*	0.207*	0.257*	-0.120
V_4					1	0.026	0.100	-0.025	-0.049	-0.247*	0.105	-0.119	-0.041	0.022	-0.028	0.033
V_5						1	-0.209*	0.103	-0.078	0.093	0.151	-0.042	-0.076	-0.007	0.006	0.040
V_6							1	-0.035	-0.112	-0.102	-0.024	-0.127	0.119	0.076	-0.071	-0.099
F_{11}								1	-0.034	0.079	0.314*	-0.251*	0.112	-0.088	0.112	0.172
F_{12}									1	0.143	0.279*	0.074	0.219*	0.348*	0.142	0.220*
F_{13}										1	0.199*	0.043	0.215*	0.079	0.267*	0.139
F_{14}											1	-0.037	0.037	0.110	0.128	0.282*
F_{21}												1	-0.091	-0.166	-0.050	-0.115
F_{22}													1	0.282*	0.101	0.036
F_{23}														1	0.042	0.013
F_{31}															1	0.215*
F_{32}																1

Note: * The mean difference is significant at the 0.05 level (P < 0.05)

Table 8 The analysis results of personal, social, attitude, and economy factors by stepwise multiple regression analysis

Prediction	Unstandardized coefficient		Standardized coefficient	t-test	P-value
	b	Standard Error	Beta		
Working ability (F_{12})	0.130	0.036	0.327	3.645*	0.000
Income obtained from water user group (F_{31})	0.118	0.037	0.284	3.147*	0.002
Position in water user group (V_4)	0.201	0.068	0.266	2.960*	0.004

Note: a = constant value = 2.310; F-statistic (F) = 12.948
R = coefficient of correlation = 0.556; b = Unstandardized coefficient
R^2 = coefficient of determination = 0.309; P-value = probability to reject the null hypothesis
SE_{est} = Standard Error of the estimator = 0.11637; * The mean difference is significant at the 0.05 level (P < 0.05)

social, the attitude, and economy factors by stepwise multiple regression analysis was presented in Table 8, in which the weighting factors for the prediction of level of participation of water users were also given.

Referring to Table 8, the optimal predictor selected to derive the prediction equation is working ability (F_{12}), income obtained from water user group (F_{31}), and position in water user group (V_4), as it has a linear correlation with the variables with the statistical significance at 0.05 ($P < 0.05$). That is to say, when the other variables were added, there were no statistically significant correlations between those variables ($P < 0.05$). Therefore, the adding variables were not considered to be the predictor and not appeared in the prediction equation. After obtaining all correlated variables, it was found that the factors related to working ability (F_{12}), Income obtained from water user group (F_{31}), and position in water user group (V_4) showed a positive correlation with the participation of water users as can be seen from the standardized coefficients of 0.327, 0.284, and 0.266, respectively. The value of coefficient correlation (R) of the level of overall participation of the water user members with working ability (F_{12}), income obtained from water user group (F_{31}), and position in water user group (V_4) was 0.556, where the obtained equation could predict the level of overall participation at 30.9% with an error of 0.11637. Thus, the prediction equation for the level of participation in irrigation water allocation can be derived and presented below.

By considering Equation 4, it can be noticed that when working ability (F_{12}), income obtained from water user group (F_{31}), and position in water user group (V_4) are found to be increased, the level of overall participation of the water users will also increase (and vice versa).

4. Discussion

Based on the investigation of water user group participation in irrigated water management of Ban Vern Kham Pumping Irrigation Project, Xaithani District, Vientiane Capital, Lao PDR, the overall participation level was reported to be high. According to the main findings of this study, the factors that drive the water user group participation can be summarized and explained below.

1) By considering the participation in irrigation water allocation planning, allocation of benefit from irrigation water, and operation and maintenance of the irrigation system, it was found that the level of participation in planning irrigation water allocation and operation and maintenance of the irrigation system was found to be relatively high. This may be because before starting any agricultural production activity, the water users usually arrange meetings as soon as the issues arise and they are willing to strictly follow the agreed regulations. Regarding the allocation of benefit from irrigation water, the participation level was found to be moderate, i.e. some water users suffered from inadequacy of water supply due to the delay of delivery and the readiness of water users. This was relevant to the study of [10-11] who revealed that the water users received the information, suggestions, and trainings from the authorities and they were found to participate in water use planning policy and water management with a different level of participation in both overall and separate aspects.

2) In view of different personal factors such as sex, age, education level, position in water user group, basic knowledge in water allocation, and the number of opportunities to attend the provided trainings that affect the participation level can be suggested as follows.

- In terms of the difference in gender of water users, the level of participation in irrigation water management for both separate and overall aspects was found to be no different as both male and female were allowed to participate in water management based on their knowledge obtaining from the given trainings;
- The water users with different ages had no different level of participation for both separate and overall aspects since most water users have extensive experience and well understanding. On average, the minimum age at which the water users will be part of water user group management is 26.7 years old as either chairman or working committee of water user group;
- The water users with a different level of education were found to be no different in level of participation in allocating the benefit from irrigation water and operation and maintenance of irrigation system. On the contrary, the different education level influenced the participation level in planning irrigation water allocation since the higher educated water users have higher ability and knowledge so that they understood in working and ready to adapt themselves to the environment;
- The water user group members with a different position in water user group were found to have no different in level of participation for irrigation water allocation in both separate and overall aspects. It was indicated that 96.2% of the water users were the water user group members and some of them were selected to be the chairman or working committee;
- The water user group members with a different basic knowledge in irrigation water allocation before attending the trainings were found to be no different in participation level in both separate and overall aspects as the water users were willing to help each

other and willing to provide the useful advice to the water users who had no basic knowledge.

5. Conclusions

The overall participation in irrigated water management of Ban Vern Kham Pumping Irrigation Project, Xaithani District, Vientiane Capital, Lao PDR, was generally found to be in a high level. However, only the participation in planning irrigation water allocation was found to be relevant to a different education level of water users with the statistical significance of 0.05, which corresponded to the hypothesis. Conversely, the water users with different education level have no different level of participation in allocating the benefit from irrigation water and operation and maintenance of irrigation system.

Finally, from the variable correlation analysis of personal, social, attitude, and economic factors of the water user group members and the overall participation level (Y') which covers the participation in irrigation water allocation planning, allocation of benefit from irrigation water, and operation and maintenance of irrigation system, the education level (V_3), working ability (F_{12}), and income obtained from water user group (F_{31}) had a moderate correlation. The factors related to age (V_2), working endeavor (F_{13}), and coordination among farmer (F_{14}) had a low correlation compared to the overall participation (Y') of the water user group members with the statistical significance at 0.05. From the analysis of stepwise multiple regression, the prediction equation of overall water user group participation in irrigated water management was $Y' = 2.310 + 0.130(F_{12}) + 0.118(F_{31}) + 0.201(V_4)$. Based on all correlations mentioned above, the Ban Vern Kham Pumping Irrigation Project, Xaithani District, Vientiane Capital, Lao PDR, will be sustainable and effective if the public participation is taken into consideration in all relevant processes. The project will probably be successful since the water user group members have the age of over 25 years old and have extensive experience in working in the field of water management in Ban Vern Kham.

6. Recommendations

The required issue to be addressed is to arrange more meetings to further enhance the level of participation. In detail, the meetings are required to be organized regularly for information dissemination of the water user group activities, water user responsibilities, water user group regulations, opinion sharing, and collaboration for problem solving among water user group. The arrangement of several meetings may help prevent misunderstanding related to the ownership of the irrigation project which should not belong to the government and it is the responsibility of water users to fully take care as well as to maintain the entire irrigation system.

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