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Enhancing production efficiency of public enterprises through stakeholder participation: the case of irrigation systems

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Abstract

This study investigates the impact of stakeholder participation on the production efficiency of irrigation systems in Laos through the implementation of Farmers Water User Committees (FWUCs). Utilising a difference-in-difference methodology, the research analyses data from 79 irrigation projects over a 13-year period. The findings reveal a statistically significant positive correlation between FWUC establishment and improved project effectiveness, even when controlling for variables such as project size, age, and socio-economic factors. Smaller, newer projects exhibited higher effectiveness, whilst remote locations faced greater challenges. The temporal analysis indicates that the benefits of participation accrue gradually, underscoring the importance of sustained implementation. These results carry significant implications for public enterprise reform, particularly in irrigation management. The study contributes to the growing body of evidence supporting the efficacy of stakeholder participation in public enterprise management, offering valuable insights for policymakers seeking to enhance the efficiency and sustainability of irrigation systems.

KEYWORDS: Stakeholder participation, longitudinal study, natural experiment, difference-in difference, irrigation efficiency

Introduction

The management and efficiency of public enterprises have long been subjects of intense scrutiny and debate within academic and policy circles. Amongst these, irrigation systems stand out as critical infrastructure that significantly impacts agricultural productivity, food security, and rural livelihoods. As governments worldwide grapple with the challenges of resource constraints and increasing demands for public services, the need to enhance the production efficiency of these enterprises has become more pressing than ever. This study delves into the intricate dynamics of stakeholder participation as a potential catalyst for improving the performance of public irrigation systems, exploring the nuanced interplay between governance structures, community engagement, and operational outcomes.

Irrigation systems, as quintessential public enterprises, serve as the lifeblood of agricultural communities, facilitating the cultivation of crops and the sustenance of rural economies. However, these systems often face a myriad of challenges, including inadequate maintenance, inefficient water distribution, and conflicts over resource allocation. Traditional top-down approaches to management have frequently fallen short in addressing these issues, leading to suboptimal utilisation of resources and diminished agricultural yields. In response to these shortcomings, there has been a growing recognition of the potential benefits of involving diverse stakeholders in the governance and operation of irrigation systems. This paradigm shift towards participatory management seeks to harness local knowledge, foster a sense of ownership, and align the interests of various actors involved in the irrigation ecosystem.

The concept of stakeholder participation in public enterprise management is not entirely novel, with its roots tracing back to broader discussions on democratic governance and community-driven development. However, its application to irrigation systems presents unique challenges and opportunities. The heterogeneous nature of stakeholders in irrigation projects, ranging from smallholder farmers and large agricultural enterprises to local government bodies and environmental agencies, necessitates a nuanced approach to engagement and decision-making processes. Furthermore, the technical complexities inherent in irrigation system management, coupled with the often-contentious nature of water resource allocation, add layers of intricacy to the implementation of participatory approaches.

This study aims to bridge the gap between theoretical frameworks of stakeholder participation and the practical realities of irrigation system management. By examining case studies from diverse geographical and socio-economic contexts, we seek to unravel the mechanisms through which stakeholder involvement can contribute to enhanced production efficiency. Our analysis encompasses various dimensions of efficiency, including water use optimisation, cost-effectiveness of operations, equitable distribution of resources, and long-term sustainability of irrigation infrastructure. Through this multifaceted exploration, we aim to develop a comprehensive understanding of the factors that facilitate or impede successful stakeholder engagement in irrigation management.

The relevance of this research extends beyond the immediate context of irrigation systems, offering insights into the broader discourse on public enterprise reform and participatory governance. As governments worldwide seek to revitalise their public sectors and improve service delivery, the lessons drawn from irrigation system management could inform policy approaches across various domains of public infrastructure and service provision. Moreover, in an era marked by increasing water scarcity and the looming threats of climate change, the efficient management of irrigation systems takes on added significance in ensuring food security and sustainable agricultural practices.

This study adopts a mixed-methods approach, combining quantitative analyses of irrigation system performance metrics with qualitative assessments of stakeholder experiences and perceptions. By triangulating data from diverse sources, including official records, field surveys, and in-depth interviews with key informants, we aim to present a holistic picture of the dynamics at play in participatory irrigation management. Our methodology also incorporates a comparative element, juxtaposing cases of successful stakeholder engagement with instances where participatory approaches have yielded suboptimal outcomes. Through this comparative lens, we seek to distil best practices and identify potential pitfalls in the implementation of stakeholder-driven management models.

The structure of this article unfolds as follows: After this introduction, we present a comprehensive review of the literature on stakeholder participation with a specific focus on irrigation systems. This is followed by a detailed exposition of our research methodology and data collection processes. We then delve into our findings, presenting a nuanced analysis of the relationship between stakeholder participation and production efficiency in irrigation systems. The subsequent discussion section synthesises these findings within the broader context of public enterprise reform and sustainable resource management. Finally, we conclude with policy implications and recommendations for future research directions.

As we embark on this exploration of stakeholder participation in irrigation system management, it is crucial to acknowledge the complexities and context-specific nature of the challenges at hand. While participatory approaches hold promise for enhancing production efficiency, their successful implementation requires careful consideration of local power dynamics, institutional capacities, and cultural norms. By critically examining both the potentials and pitfalls of stakeholder engagement in irrigation management, this study aims to contribute to a more nuanced understanding of how public enterprises can leverage community participation to improve their performance and better serve their constituencies.

Participation in Irrigation

Irrigation water is a common good with special characteristics. It features attributes of public and private goods and of common property resource, depending on the situation. Irrigation can be viewed as an insurance. It enables farmers to produce good, reliable crop yields, often two to three times those of rain-fed crops. Irrigation can reduce the impacts of frequent and even severe droughts though it does not eliminate all the risks of water shortages. Irrigation systems have an inbuilt technical externality due to an asymmetry: the activities of the farmers of the head reaches affect the farmers of the tail reaches but not vice versa. All farmers desire assured supply of water at the time of their choice. The factors that need to be considered are assurance, reciprocity and fairness.

In view of the need for both the regulatory as well as enabling functions it was presumed that only an active state apparatus can provide efficiency and equity. For ideological and practical reasons, irrigation projects are mostly in the public sector. They are difficult to fund on a commercial basis because they cannot deliver short-term predictable financial returns. Irrigation projects are self-contained investments that are dependent on local off-take, or the sustainability of the agricultural activities that use the water. Because water is one of the inputs into the production process, along with water resource management, credit, fertiliser, and market access, the ability and willingness to pay for water services must be weighed against total farmer capacities. There is no guarantee that investments will be recovered.

Most developing countries, especially those that emerged from conflict situations do not have a coherent bureaucracy. In many such countries, the state is viewed by the agrarian society as a predatory organisation. Even in presence of a democratic system with a well-established bureaucracy, the performance of government run irrigation projects has been poor. Robert Wade's (1982) analysis of irrigation in India revealed that an important reason for poor performance is the collection of vast amounts of illicit revenue by irrigation engineers in the field from the distribution of water and contracts, part of which is passed on to superior officers and politicians.

The recognition that a collaborative decision-making process must take into account a wide range of values, knowledge, and viewpoints has resulted in a slew of new approaches and processes being proposed to aid irrigation management, which include participatory forms of management (Von Korff et al., 2012). Empirical cross-disciplinary research in collaboration with practitioners in close cooperation with policy makers and other interested parties such as farmers can give useful results (Raya & Gupta, 2022).

Since 1980's there is a growing recognition that farmers are highly entrepreneurial and small-scale farmers have for many centuries been developing a wide range of irrigation systems independent of development agencies or governments. Elinor Ostrom (1995) describes a World Bank financed irrigation scheme in Nepal for which the loan documents mentioned that the project is important because there was no irrigation in that valley. However, when the project was delayed, additional surveying revealed that there were in fact thirty-two existing and fully operational irrigation schemes in existence. Since these schemes were being-managed by farmers and not controlled by the government, they were invisible to the modernist engineers. Detailed studies of the operation and productivity of the irrigation schemes with modern head-works found that they were actually less productive in delivering water to system tail-enders than were farmer-managed irrigation schemes without modern infrastructure. Related work by Norman Uphoff (1992) on irrigation schemes in Sri Lanka reached a similar conclusion In the current study, the researchers saw a farmer-managed irrigation scheme in where a person had to climb a tree to reach a platform from where the gate is opened or closed; yet the irrigation scheme was working well.

During the last half century, there has been a divergence in the trajectory of agricultural development in Sub-Saharan Africa and Asia. In the former, the focus has largely been on expanding the irrigated area, whereas in the latter the emphasis has been on intensifying production on existing land by rehabilitating and modernising existing irrigation infrastructure (Makin, 2016, p. 2). In the eyes of the western aid agencies the supposed trade-off in modernisation of irrigation schemes in Asia was between the technical benefits of the modern infrastructure versus the erosion (or shift) in social capital needed to underpin the modern infrastructure; but when informal was not replaced with effective formal administration the new schemes could be "lose–lose": i.e. "worse at social capital and worse at irrigation" (Andrews et al., 2017, p.46).

The Setting

The Lao People's Democratic Republic, commonly known as Laos, is a landlocked country in Southeast Asia. Bordered by China, Vietnam, Cambodia, Thailand, and Myanmar, Laos is characterized by its mountainous terrain, the Mekong River valley, and tropical climate. The United Nations designates Laos as a least developed country, with agriculture forming a significant portion of its economy, making water management crucial.

The Mekong River, which forms a large part of the western border of Laos, is central to the country's geography, economy, and culture. Laos has been dubbed the "Battery of Southeast Asia" due to its hydroelectric potential, with numerous dams built or planned along the Mekong and its tributaries. This focus on hydropower development has led to both economic opportunities and environmental concerns.

Water resource management in Laos faces several challenges, the main being managing water for agriculture, particularly rice cultivation The Ministry of Natural Resources and Environment (MoNRE) is the primary agency responsible for water resource management in Laos. The country has implemented several policies and laws to improve water governance, including the Water and Water Resources Law (1996, amended in 2017) and the National Water Resources Strategy and Action Plan.

Given the importance of agriculture to Laos' economy, irrigation plays a crucial role. The government, often with support from international donors, has invested in irrigation infrastructure to increase agricultural productivity. However, many irrigation systems face challenges related to maintenance, efficiency, and sustainability.

Participatory irrigation management has been introduced in some areas, with the establishment of Water User Groups (WUGs) or Water User Associations (WUAs). These organizations aim to involve farmers in the operation and maintenance of irrigation systems, referred to FWUCs (Farmers Water User Committees) by scholars. Laos has made progress in recent years in improving its water resource management. The country continues to work with international partners and regional organizations like the Mekong River Commission to address these issues and promote sustainable water use.

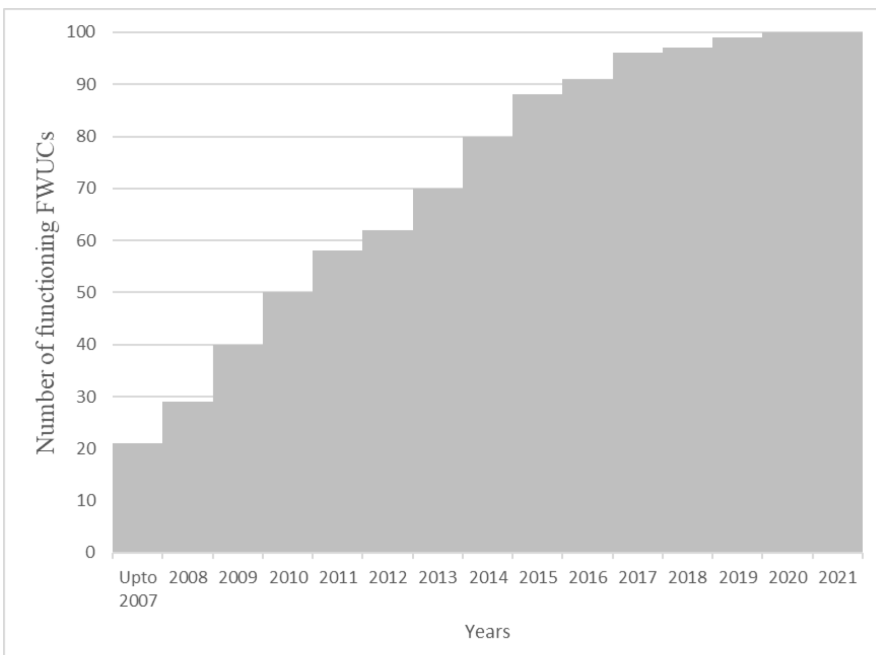
Methodology and data

We use difference in difference method that goes back to the work of John Snow (1855) in the water sector. To prove that cholera is caused by bad water rather than bad air (dominant theory at the time), Snow compared the changes in cholera mortality rates in the districts served by two water utilities which in 1849 obtained their water supply from the river Thames in central London. In 1852, one of the utilities moved its water works upriver to an area relatively free of sewage. Cholera mortality fell in both cases but more so in the districts supplied by the company whose water works moved upriver. Natural experiments and the difference in difference (also called D-in-D or DD method did not attract much attention in the social sciences literature for several decades. Since the 1990s, DD methods have moved into mainstream social science research. The methodology has been more or less standardised and is being used frequently in water sector. Empirical econometricians Guido Imbens, David Card and Joshua Angrist who have shown what conclusions about cause and effect can be drawn from natural experiments were awarded Nobel Prize for Economics in 2021.

This study is based on analyses of medium and minor irrigation projects, which were selected on a random basis for a study by Japanese Bank of International Cooperation through consultants M/s Mott MacDonald for another broader research project. Of the 50 projects in the study area, 21 projects had functioning FWUCs in the year 2010. Another 50 irrigation schemes were added to the research project and FWUCs were operating in all the projects by 2022. Our sample covers 79 projects where FWUCs were established between 2010 and 2021. The study required contacting the officials of MoNRE as also international support agencies and their consultants. Since the focus of the study was on physical implementation of the projects, the data was verified and updated for each project on the basis of several field visits. The number of projects in which the FWUCs were functioning is given in Figure 1.

Figure1

Year wise growth of Farmers Water Users Committees



As a determinant of Project efficiency, independent variable Participation is a dummy variable, taking a value of 1 for where FWUC was established project and of 0 otherwise. In the choice of independent variables, we have followed a system wherein the independent variables have been chosen on the basis of economic logic rather than through computer programmes which facilitate choosing of variables which give the highest Adjusted R square.

One obvious variable that can affect project effectiveness is the size of the project. When we regress the project effectiveness ratio against the size of the project (designed command area), we find a significant negative relationship ($t > 2.0$). Similar results are obtained when the project effectiveness ratio is regressed against the natural logarithm of the size of the project. We use the MWD test, and find that the log of size will be more appropriate as an explanatory variable. On the basis of similar analysis, the log of age and, as a variable for remoteness, the log of distance was included as the explanatory variables. Other variable included are age of project, rainfall, literacy level and per capita income.

Is it possible that, just as participation influences effectiveness, effectiveness influences participation? When the project is effective for extraneous reasons, do farmers join the FWUC? It is important to test for endogeneity because having endogenous regressors in a model will cause ordinary least squares (OLS) estimators to fail, as one of OLS's assumptions is that the predictor variable and the error term have no correlation. We apply Hausman specification test to detects endogenous regressors (predictor variables) and do not find any endogeneity. In absence of endogeneity give OLS estimates are unbiased (even for small samples) and have minimum variance. In such a case, OLS estimators will be BLUE (best linear unbiased estimators). Participation is generally regarded as a good thing. However, because the project effectiveness is a cardinal variable and not a subjectively measured ordinal variable we do not expect any systematic measurement error caused by halo effect

This paper uses the cross-irrigation project and cross-time variation in the participation to determine its effect. The data covers all years from 2009 to 2020. It was felt that the period of thirteen years is long enough to make meaningful assessment of the trend. Moreover, this panel data allows us to exploit only the variation in time of introduction of participation, holding the decision to introduce participation fixed for all irrigation projects in the sample. The identification strategy is valid as long as the changes in outcome variable, that is, project effectiveness would be similar across irrigation projects in the absence of FWUCs. The required assumption for the estimations to be valid is that the changes in the outcome variable would not have differed systematically between the treatment irrigation projects and the control irrigation projects if participation had not occurred. While this assumption is essentially untestable, it is likely to hold if there are no initial systematic differences. We employed three methods for checking for any endogeneity. First, we interviewed the organisers who stated that the programme of participation had nothing to do with the changes in effectiveness of a particular irrigation project in the past or the expectation thereof in the future. To check whether the irrigation projects are indeed comparable from this point of view, we split our data into two parts – projects with early participation, that is, the irrigation projects in which FWUC were started operating earlier and the irrigation projects where FWUC came into operation later. The comparison in Table 1 shows that the difference between the two groups is statistically insignificant. To further examine the pattern of timing of participation, we regressed each of the variable on the year of participation. The coefficients on the year of implementation were not found significant at even 10% level.

Table 1

Project characteristics

	Early participation average	Late participation average	Difference in averages	Coefficient on year of participation
(1)	(2)	(3)	(4)	(5)
Changes in Outcome variable between 2016 and 2021				
Project effectiveness ratio	0.121	0.117	0.004	0.001
Background variable as in 2021				
Total command area (in ha)	1101	1079	22	21
Age of project (years since construction/rehabilitation)	19.1	17.9	1.2	0.18
Remoteness (distance from capital in km)	189	207	-18	3.3
Rainfall (in cm per year)	167.5	168.5	-1.0	3.2
Literacy (in % for 15+ age group in project area)	83.2	82.6	0.4	1.7
Per capita income (in US$ in the project area)	1293	1269	24	25
N	39	39		

Note: None of the differences in column 4 and none of the coefficients in column 5 are significant even at 10% significance level.

We can safely conclude that there is no statistically significant trend for changes in any of these variables. The fact that the irrigation projects were not randomly selected for implementation of participation does not invalidate identification strategy as the timing of participation in various projects was not related to the lagged values or expected future values of outcome variables of interest. The identification strategy relies on the changes over time being similar across irrigation projects; the checks described above validate the strategy.

Results and Discussion

According to the identification strategy described previously, we obtain the main results by running the following regression with OLS:

$$y_{it} = \alpha + \beta_i + \gamma_t + \pi P_{it} + \varepsilon_{it} \quad (1)$$

where the subscript i denotes the project and t denotes years. This regression includes project fixed effects β_i and annual fixed effects γ_t. The variable P_{it} is the Participation dummy and, for each project, it is equal to one for the year in which the FWUC became operational and for all following years. We run the regression without and with the background variables. The standard errors of the regressions are clustered at the project level. As explained in Bertrand et al. (2004), clustering at this level helps to prevent the problem of serial correlation in difference-in-difference estimates which use a large number of time periods. Table 2 shows the main results of this paper.

Table 2

Regression results

Explanatory Variables	Regression coefficients	
	Bivariate	Multivariate
Participation variable	0.168**	0.119**
Total command area (log of)		-0.0009*
Rainfall (in 100 cm per year)		0.010
Age of project (log of)		-0.0002**
Distance from capital (log of)		-0.0002*
Literacy (in %)		-0.0003**
Per capita income (in US$)		0.0009
Adjusted R square	0.53	0.68
Sample size	79	79

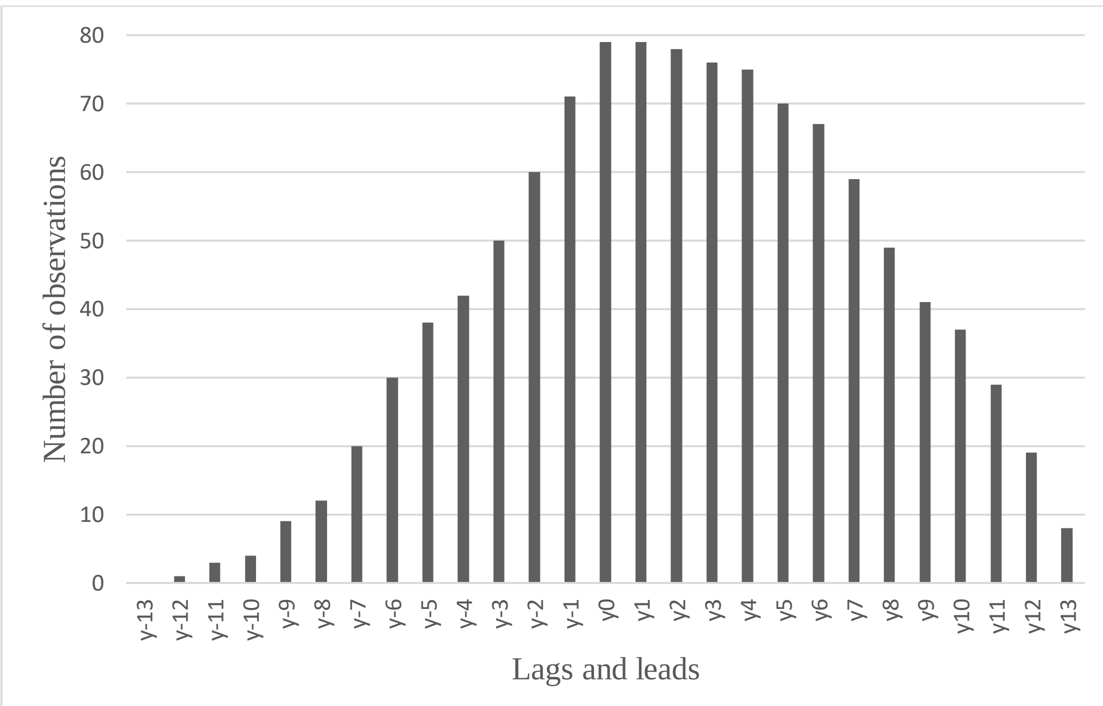
** Significant at 1% level; * Significant at 5% level

We find Participation variable highly significant. As for background variables, from the last column of Table of we see that the project effectiveness of smaller, newer projects is higher and that of projects located in remote areas is lower. While literacy has a positive effect on the project effectiveness, the coefficients of rainfall and per capita income in the area are not significant.

While the regression above estimates only the average effect of functioning of FWUC, it is also important to check how this effect looks over time. Since the implementations of participation was phased in over time and since all the projects covered in the regression were those where FWUC was established by 2010, the outcome data for all lags and leads for all projects was not observed. For example, we do not have Y_{+1} data for the years 2023 as no FWUC was established in 2022, and Y_{+2} for the years 2022 and 2023. Data availability is shown in Figure 2.

Figure2

Availability of data



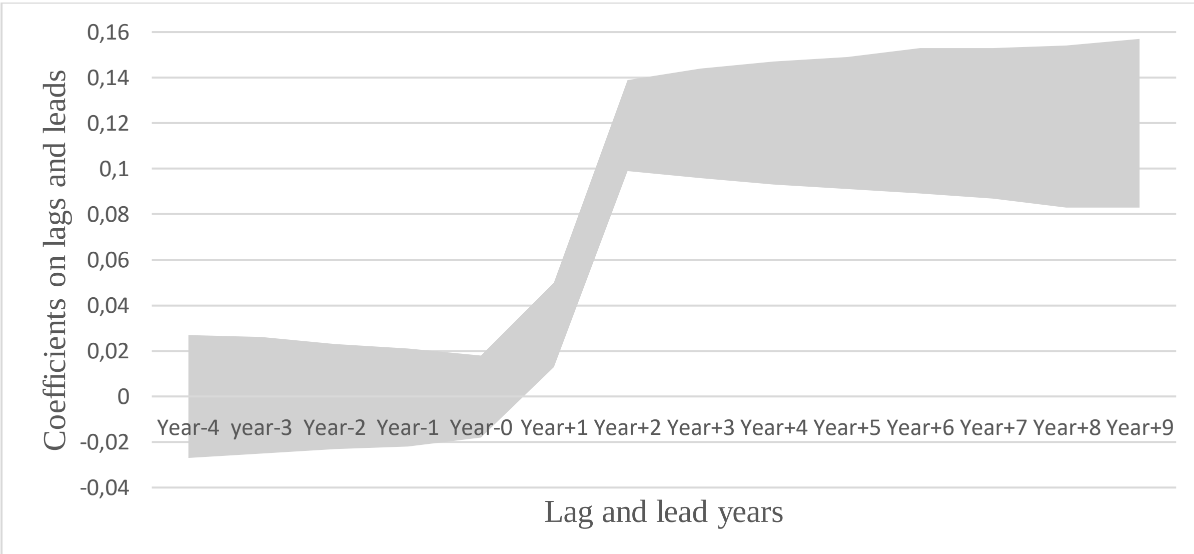
To check how this effect looks over time, we run the following regression with OLS:

$$y_{it} = \alpha + \beta_i + \gamma_t + \Sigma\delta_l Y_{li} + \varepsilon_{it} \quad (2)$$

where Y_l is a set of dummy variables for lag and lead years relative to the time of implementation in a given project. For example, Y_{-1} is equal to one for the last year before the FWUC became operational whereas Y_{+1} is equal to one for the year after the year in which the FWUC started working. Keeping in view the limitations of data availability, we limit this regression to observations that fall between Y_{-5} to Y_{+9}. Y_{-5} is also the 'omitted' as all other observations are being compared with this observation. We do not expect smooth plots of confidence because the sample size in each year is different causing 'missing data' problems. Figures 3 shows the plot of the coefficient of participation over time.

Figure 3

Effect of participation on project performance over time



While this study provides compelling evidence for the benefits of stakeholder participation, there exist a few avenues for future research. A more granular examination of the specific mechanisms through which participation enhances efficiency—be it through improved maintenance, better water allocation, or reduced conflicts—would provide valuable insights for refining participatory management models. Additionally, a comparative analysis of different models of participatory management across various contexts could yield a more nuanced understanding of best practices and context-specific adaptations. The interaction between participatory approaches and technological innovations in irrigation management represents another fertile area for exploration, as does the potential for spillover effects of participatory irrigation management on broader community development and social capital formation.

Conclusion

This study has embarked upon a comprehensive exploration of the impact of stakeholder participation, specifically through the implementation of Farmers Water User Committees (FWUCs), on the production efficiency of irrigation systems in Laos. The findings herein proffer robust evidence that participatory approaches can significantly enhance the effectiveness of irrigation projects, thereby offering valuable insights for policymakers and practitioners in the field of public enterprise management. The results of our difference-in-difference analysis demonstrate a strong positive correlation between the establishment of FWUCs and improved project effectiveness, with the participation variable exhibiting high statistical significance in our multivariate regression model. This empirical evidence suggests that the introduction of participatory management structures leads to a substantial increase in irrigation project efficiency, even when controlling for various background variables such as project size, age, location, and socio-economic factors.

Our analysis yields several salient observations that merit further consideration. Notably, smaller and newer projects tend to exhibit higher effectiveness, which may be attributed to more modern infrastructure or a greater facility for adapting to participatory approaches. Conversely, projects situated in remote areas face greater challenges, as evidenced by the negative coefficient for distance from the capital. This geographical disparity underscores the need for targeted interventions to support remote communities in their efforts to implement and benefit from participatory management structures. Furthermore, the positive influence of literacy rates in the project area on effectiveness highlights the critical role of education in facilitating successful participatory management. These findings collectively suggest that the benefits of stakeholder involvement are not uniformly distributed and that contextual factors play a significant role in determining the success of participatory approaches.

The temporal analysis of participation effects reveals a nuanced picture of the benefits accruing from stakeholder involvement. Rather than manifesting immediately, the positive impacts of participation appear to grow and consolidate over time. This temporal dimension suggests that the development of social capital and the learning curve associated with participatory management play crucial roles in realising efficiency gains. Such a finding underscores the importance of long-term commitment to participatory management strategies, as the full spectrum of benefits may only become apparent after sustained implementation.

These empirical results carry significant implications for public enterprise reform, particularly in the context of irrigation management. Policymakers would be well-advised to prioritise the establishment and support of participatory structures such as FWUCs as a means to improve the efficiency of irrigation systems. However, this approach should not be viewed as a panacea but rather as part of a holistic strategy that also encompasses capacity building and literacy programmes in project areas to enhance the effectiveness of participatory approaches. Moreover, the challenges faced by remote projects highlight the need for differentiated strategies that account for geographical disparities and allocate additional resources to overcome location-specific obstacles.

In conclusion, this study makes a significant contribution to the growing body of evidence supporting the efficacy of stakeholder participation in public enterprise management. By demonstrating the tangible benefits of participatory approaches in irrigation systems, we provide a compelling case for their wider adoption and integration into public policy. As governments worldwide grapple with the dual challenges of enhancing the performance of public enterprises and addressing resource management issues, the lessons drawn from this research offer valuable guidance for creating more efficient, equitable, and sustainable irrigation systems. The path forward requires a nuanced approach that recognises the complexities of participatory management while harnessing its potential to transform public enterprise efficiency and, by extension, contribute to broader socio-economic development goals.

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