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WATER GOVERNANCE IN PRACTICE: PERFORMANCE INDICATORS AND INSTITUTIONAL DESIGN IN TWO TANK IRRIGATION SYSTEMS IN TAMIL NADU

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ABSTRACT

This study examines the effectiveness of Participatory Irrigation Management (PIM) in Tamil Nadu, India, focusing on water-user associations (WUAs) as key components of decentralised water-resource governance. Traditional centralised water management systems often lead to inefficient allocation and negatively impact economic and environmental outcomes. The National Water Policy (1987) introduced participatory irrigation management (PIM) as a transformative approach, emphasising local community involvement in water resource management through subsidiarity and decentralisation principles. WUAs are crucial in facilitating community participation, overseeing irrigation operations, and resolving conflict. While numerous studies have explored tank irrigation efficiency, there is a lack of data on the performance of WUAs in Tamil Nadu. This research addresses this gap by evaluating water performance indicators and conducting a semi-structured interview analysis based on Ostrom's design principles. This study compared two WUAs in the Kanyakumari district of Tamil Nadu: Periyakulam, Veeramarthandapuram tank WUA, and Theroor tank WUA. The results indicated a significant performance disparity between the two WUAs. By identifying and analysing the superior practices of the better-performing WUA, this study contributes valuable insights that can potentially be transferred to other WUAs in the region, thereby enhancing the overall irrigation management efficiency and sustainability in Tamil Nadu.

Keywords: Participatory Irrigation Management (PIM), Ostrom’s Design Principles, WUA, Community Participation

1. INTRODUCTION

1.1. BACKGROUND ON WATER RESOURCE MANAGEMENT IN INDIA

Traditional centralised water management systems in India have often led to inefficient allocation, negatively impacting economic and environmental outcomes (Jain & Kumar, 2014). Traditional centralised water management systems in India have faced significant challenges in efficiently allocating water resources, resulting in adverse economic and environmental consequences. These systems, typically controlled by government agencies, have struggled to address the diverse needs of various stakeholders, including farmers, urban dwellers, and industries (Rastogi et al., 2024). A centralised approach has often led to mismanagement, overexploitation of groundwater, and inequitable distribution of water resources across regions and sectors. Water allocation inefficiencies have had far-reaching impacts on India's economy and environment. Agricultural productivity is affected by inconsistent water supply, leading to crop failure and reduced yields in many areas. Urban areas have experienced water scarcity, which affects both residential and industrial users. Environmental degradation has occurred as a result of the overextraction of groundwater and the pollution of water bodies. Additionally, centralised systems have struggled to adapt to changing climate patterns and increasing water demand, thereby accelerating water stress in many parts of the country. These challenges highlight the need for more decentralised, participatory, and sustainable approaches to water resource management in India.

Participatory Irrigation Management (PIM) has emerged as a groundbreaking approach in water resource management following its introduction in the National Water Policy of 1987. This policy shift aimed to revolutionise the traditional top-down approach to irrigation management by actively involving local communities in the decision-making processes. PIM is rooted in the principles of subsidiarity and decentralisation, which advocate for decisions to be made at the lowest appropriate level and for the distribution of power away from centralised authorities. The implementation of PIM has led to significant changes in the management of irrigation systems in various regions. By empowering local farmers and water users to play an active role in system operation, maintenance, and water allocation, PIM has fostered a sense of ownership and responsibility among community members. This approach not only improves the efficiency of water use, but also contributes to a more equitable distribution of resources. Additionally, PIM has facilitated better conflict resolution mechanisms at the local level, as community members are directly involved in addressing issues that arise in water management

Water User Associations (WUAs) serve as vital intermediaries between government agencies and local communities in decentralised water resource management systems. These organisations are typically composed of farmers and other stakeholders who collectively manage water resources for irrigation purposes. WUAs are responsible for various tasks including water allocation, infrastructure maintenance, fee collection, and dispute resolution among water users. By empowering local communities to play an active role in water management, WUAs promote more efficient and equitable use of water resources.

The effectiveness of WUAs in promoting sustainable water management depends on several factors, including institutional capacity, the legal framework, and the level of support they receive from government agencies. Successful WUAs often demonstrate strong leadership, transparent decision-making processes, and effective communication channels with members and external stakeholders. Additionally, WUAs can contribute to improved agricultural productivity by facilitating the adoption of water-saving technologies and practices among farmers. As climate change and water scarcity continue to pose challenges to agricultural communities worldwide, the role of WUAs in promoting adaptive water-management strategies has become increasingly important. Research gap and study objectives

This study aims to address a significant gap in existing research on Water User Associations (WUAs) and their effectiveness. Although WUAs have been established in many regions to manage water resources, there is a lack of comprehensive data on their performance. To fill this gap, the research employs a dual approach: evaluating water performance indicators and conducting a Likert scale analysis based on Ostrom's design principles.

The evaluation of water performance indicators provides quantitative data on the efficiency and effectiveness of WUAs in managing water resources. This may include metrics such as water distribution equity, irrigation efficiency, and crop productivity. Complementing this quantitative approach, the Likert scale analysis based on Ostrom's design principles offers a qualitative assessment of the institutional aspects of WUAs. Ostrom's principles, which outline key factors for successful management of common-pool resources, serve as a framework to evaluate the governance structures, rules, and community engagement within WUAs. By combining these methodologies, the study aims to provide a holistic understanding of WUA performance, contributing valuable insights to the field of water resource management and potentially informing policy decisions and improvement strategies for WUAs.

2. LITERATURE REVIEW

2.1. EVOLUTION OF WATER MANAGEMENT POLICIES IN INDIA

The literature review explores the evolution of water management policies in India, highlighting a significant shift from centralised, top-down approaches to more participatory models. Initially, water management in India was characterised by government-led initiatives, with limited involvement from local communities. This centralised approach often resulted in inefficient resource allocation and failed to address the diverse needs of different regions and stakeholders.

As challenges in water management persisted, policymakers and researchers began to recognise the importance of involving local communities in decision-making processes. This led to the gradual introduction of participatory models, which aimed to incorporate the knowledge, experiences, and needs of local populations into water management strategies (Tariq et al., 2021).

These new approaches emphasised community engagement, capacity building, and the integration of traditional water management practices with modern techniques. The literature review likely examines case studies and empirical evidence to demonstrate the effectiveness of these participatory models in improving water access, conservation, and sustainable use across various regions in India.

2.2. THEORETICAL FRAMEWORK OF PARTICIPATORY IRRIGATION MANAGEMENT

The theoretical foundations of Participatory Irrigation Management (PIM) are rooted in broader principles of natural resource governance, particularly subsidiarity and decentralisation. Subsidiarity emphasises that decision-making should occur at the lowest appropriate level, closest to those directly affected by the decisions (Sivasubramaniyan, 1998). In the context of irrigation management, this principle suggests that local water users and farmers should have a significant role in managing water resources, as they possess intimate knowledge of local conditions and needs. Decentralisation, a complementary concept, involves the transfer of authority and responsibility from central government to local institutions or user groups.

These theoretical underpinnings of PIM reflect a shift away from top-down, centralised approaches to resource management. By incorporating local knowledge and fostering community engagement, PIM aims to improve the efficiency and sustainability of irrigation systems (Chouhan et al., 2017). This approach recognises that local stakeholders are often better positioned to make context-appropriate decisions, respond to changing conditions, and ensure equitable resource distribution. Furthermore, the application of subsidiarity and decentralisation principles in PIM can lead to increased accountability, reduced conflicts over water use, and enhanced capacity building within local communities.

2.3. PREVIOUS STUDIES ON TANK IRRIGATION EFFICIENCY

A comprehensive review of existing research on tank irrigation efficiency underscores the critical importance of Water User Associations (WUAs) in managing these systems. While numerous studies have examined various aspects of tank irrigation, there remains a significant gap in understanding the specific factors that contribute to WUAs' effectiveness (HAKE KUNAL SURESH, 2023). This knowledge gap hinders the development of targeted strategies to improve the overall efficiency of tank irrigation systems.

Further investigation into WUAs' performance is essential to identify best practices and areas for improvement. Such research could explore the organisational structure of successful WUAs, their decision-making processes, and the mechanisms they employ to ensure equitable water distribution among members (Basediya et al., 2018). Additionally, examining the role of local governance, community participation, and the integration of traditional knowledge with modern irrigation techniques could provide valuable insights (Ostrom, 2000). By addressing these aspects, future studies can contribute to the development of more robust and sustainable tank irrigation systems, ultimately enhancing water resource management and agricultural productivity in regions dependent on this form of irrigation.

Ostrom's design principles for common-pool resource management provide a framework for understanding and evaluating the governance of shared resources, such as irrigation systems. These principles, developed by Nobel laureate Elinor Ostrom, offer insights into the conditions that enable successful collective management of resources (Smout, 1993). The principles include clearly defined boundaries, congruence between appropriation and provision rules and local conditions, collective-choice arrangements, monitoring, graduated sanctions, conflict-resolution mechanisms, minimal recognition of rights to organize, and nested enterprises for larger systems (Ostrom, 1990).

In the context of Water User Associations (WUAs) in irrigation management, Ostrom's principles serve as a valuable tool for assessing their effectiveness. WUAs are typically formed to manage and maintain irrigation systems, allocate water resources, and resolve conflicts among users. By applying Ostrom's framework, researchers and policymakers can evaluate how well WUAs establish clear membership criteria, develop rules that match local conditions, involve members in decision-making processes, implement monitoring and sanctioning mechanisms, and interact with other levels of governance. This analysis can help identify strengths and weaknesses in WUA structures and operations, ultimately contributing to more sustainable and equitable management of irrigation resources.

3. METHODOLOGY

3.1. STUDY AREA

The Kanyakumari district, located at the southernmost tip of Tamil Nadu, India, is a region of diverse landscapes and rich cultural heritage. It is bounded by the Western Ghats to the north and west, while the Arabian Sea, Indian Ocean, and Bay of Bengal converge at its southern coast (Ganesh et al., 2024). This unique geographical positioning contributes to the district's varied topography, which includes coastal plains, hills, and lush forests. The climate of Kanyakumari is characterised by its tropical nature, with temperatures ranging from 23°C to 35°C throughout the year. The district experiences two monsoon seasons: the Southwest monsoon from June to September and the Northeast monsoon from October to December. This abundant rainfall, coupled with the region's fertile soil, supports a diverse agricultural sector (Balachandran, 2008). The primary crops cultivated in the area include paddy, tapioca, coconut, rubber, and various fruits and vegetables. Additionally, the coastal areas of Kanyakumari support a thriving fishing industry, contributing significantly to the local economy and food security.

In Kanyakumari, there are 46 registered WUAs spread across 6 taluks. In this study, the two WUAs chosen are Periyakulam, Veeramathandapuram Kulam Neerinai Bhayanpadthuvar Sangham from Thovalai Taluk and KKM4 Theroor Kulam Neerinai Bhayanpadthuvar Sangham from Agastheeswaram taluk. In this paper, the two WUAs will be referred to as Periyakulam, Veeramarthandapuram tank WUA, and Theroor tank WUA for ease of understanding. The two WUAs were chosen based on their distinct characteristics and operational contexts. These WUAs represent different geographical areas, varying sizes of water bodies, and diverse management approaches, allowing for a robust analysis of their functioning and effectiveness. By comparing these three WUAs, the study aims to identify best practices, common challenges, and potential areas for improvement in water resource management at the community level.

3.2. DATA COLLECTION METHODS

The data collection involved two strategies, semi-structured interviews and data collection through a structured questionnaire. To further assess the reliability of the questionnaire, Cronbach's alpha reliability test was conducted for each principle (Saeed et al., 2014), and the score was above 0.7, indicating strong reliability. The semi-structured interview was held with each WUA chairman and three farmers from Periyakulam, Veeramarthandpuram WUA and Theroor tank WUA. Surveys were utilised to collect quantitative data from 50 farmers out of 60 in Periyakulam, Veeramarthandpuram tank WUA and 120 farmers out of 153 farmers in Theroor tank WUA, allowing for statistical analysis and generalisation of findings. These surveys were carefully designed to address specific research questions and included both closed-ended and open-ended questions to capture a range of responses. Interviews, on the other hand, provided in-depth qualitative data, offering insights into participants' experiences, perceptions, and motivations. Both structured and semi-structured interview formats were employed to balance consistency across participants while allowing for flexibility in exploring emerging themes.

The combination of these data collection techniques enabled triangulation, where multiple sources of evidence converged to support the study's conclusions. Additionally, each method compensated for the limitations of the others, resulting in a more comprehensive and nuanced understanding of the research subject.

3.3. WATER PERFORMANCE INDICATORS

The methodology describes the specific water performance indicators used to evaluate the efficiency of the selected WUAs. Performance indicators used for evaluating the performance of the WUA irrigation project as proposed by Nelson (2002). These indicators are grouped into four categories, namely, Water deliveries, Maintenance, and Financial indicators.

1) Water deliveries

The quality of water deliveries in irrigation systems is primarily assessed through the tail-end supply ratio, which measures the proportion of water reaching the furthest points of the distribution network (HAKE KUNAL SURESH, 2023). Water User Associations (WUAs) play a pivotal role in managing this process, with their primary function being to ensure adequate water supply to all fields within their jurisdiction. By overseeing water allocation and distribution, WUAs aim to maintain consistent water availability throughout the system, particularly focusing on tail-end areas that are often prone to water scarcity. Effective management by WUAs can lead to improved crop yields, reduced water conflicts among farmers, and overall enhanced agricultural sustainability in the region.

2) Tail-end Supply Ratio (TSR)

The most straightforward measure of water delivery effectiveness is determining if enough water is reaching the farmers at the canal system. The Tail-end Supply Ratio (TSR) is calculated by dividing the number of days when adequate water reached the canal's end by the total number of days. Ideally, this ratio should be close to one. While TSR is a simple and cost-effective measure, it serves only as a qualitative indicator.

Tail-end supply ratio = Ns/Nt

Ns = the no.of days in which sufficient water reached the end of the canal system.

Nt = the total no. of days the canal system was delivering water.

3) Maintenance

The evaluation of maintenance work within the water user's association is conducted through the poor structure ratio.(Ingle Balasaheb Sawant Konkan Krishi Vidyapeeth, 2022) The primary role of the WUA is to oversee operations and maintenance. Ensuring the proper upkeep of shutters, sluices, and channels is essential for delivering water to all fields. Additionally, regular debris removal and desilting are crucial to maintaining the tank's capacity.

4) Poor Structure Ratio (PSR)

The Poor Structure Ratio is calculated by dividing the number of structures in unsatisfactory condition by the total number of structures. A structure is considered poor if it is not operating properly or is likely to fail within the next year. Ideally, this ratio should be zero.

5) Poor Structure Ratio = Np/Nt

Np = is the number of structures in poor condition (not functioning adequately or at risk of failure) as per observation during the survey.

Nt = is the total number of structures on the system as per the WUA record.

4. FINANCIAL

Financial indicators, namely, fee collection performance and manpower number ratios, are used to evaluate the financial status of WUA. Financial indicators play a crucial role in assessing the financial health of Water User Associations (WUAs). Two key indicators used for this purpose are fee collection performance and manpower number ratios (Basediya et al., 2018). Fee collection performance measures the efficiency and effectiveness of the WUA in collecting fees from its members, which directly impacts its revenue stream and overall financial stability. On the other hand, manpower number ratios evaluate the organisation's human resource utilisation and efficiency. These ratios compare the number of staff employed to operational metrics, like the area served. By analysing these financial indicators, stakeholders can gain valuable insights into the WUA's financial management, operational efficiency, and long-term sustainability, enabling informed decision-making and targeted improvements in resource allocation and organisational structure.

5. FEE COLLECTION PERFORMANCE

Collection Performance is the annual irrigation fees collected, divided by the total annual fees assessed. This indicates the effectiveness of the collection program of WUA, but it can also be affected by the economic condition of the irrigators and the degree to which they feel the system is worth supporting. The values greater than 1 are possible if some delinquent assessments from previous years are collected.

Fee collection performance = Fc/Fa

Fc = the annual amount of water tariff collected as per WUA records

Fa = the annual amount of water tariff assessed as per WUA records

6. MANPOWER NUMBERS RATIO

The manpower numbers ratio is the number of staff (full-time equivalent), divided by the total irrigated area. The optimum value for this indicator may vary widely among different regions of the world because of differences in labour availability and intensity of irrigation.

Manpower Ratio = Ns/At

Ns = is the number of staff (full-time equivalent) as per records of WUA.

At = is the total irrigated area as per records of WUA.

7. RESULTS AND ANALYSIS

7.1. COMPARATIVE ANALYSIS OF WATER PERFORMANCE INDICATORS

The results present a detailed comparison of water performance indicators between the two selected WUAs, highlighting significant differences in efficiency.

7.2. PERIYAKULAM, VEERAMARTHANDAPURAM WUA

The Tail-end Supply Ratio of 0.92 falls within the ideal range of 0.50–1.00, indicating a fairly equitable water distribution across the command area. This high ratio suggests that tail-end farmers receive sufficient water with minimal delay, ensuring that even the most distant parts of the irrigation system are adequately served. The near-optimal value of 0.92 implies that the water distribution system is well-designed and efficiently managed, minimizing water losses and ensuring fair allocation among all users. This equitable distribution likely contributes to overall farmer satisfaction and productivity within the command area.

The Poor Structure Ratio of 0 is an ideal value, confirming that the Water User Association (WUA) has effectively maintained its irrigation structures. This finding aligns with the interview responses, where farmers mentioned self-funded renovations for the shutters. The perfect score in infrastructure maintenance indicates that the WUA has been proactive in identifying and addressing structural issues, preventing deterioration that could lead to water losses or distribution inefficiencies. This level of maintenance not only ensures the longevity of the irrigation system but also contributes to its optimal performance, supporting the high Tail-end Supply Ratio observed.

The Fee Collection Performance of 0.53 falls below the reference range of 0.62–1.0, indicating partial financial sustainability but with significant room for improvement. This suboptimal performance suggests that the WUA faces challenges in collecting fees from its members, which could potentially impact its ability to fund future maintenance and improvement projects. The reasons for this lower-than-ideal fee collection rate could be multifaceted, possibly including economic constraints faced by farmers, lack of enforcement mechanisms, or insufficient awareness about the importance of timely fee payments.

The Manpower Ratio of 0 suggests a lack of dedicated personnel for the WUA's operations. This absence of formal staffing likely explains why WUA members take on various responsibilities themselves, including maintenance and fee collection. While this volunteer-based approach demonstrates community engagement, it may also contribute to the suboptimal fee collection performance and could potentially lead to burnout among active members. The lack of dedicated personnel might also limit the WUA's capacity to implement more sophisticated management practices or to pursue funding opportunities that could enhance the irrigation system's performance and sustainability.

Table 1 Performance of Periyakulam, Veeramathandapuram Water User Association

Sr. No	Parameter	Performance Indicator	Input Value	Value	Reference Range
1	Water Deliveries	Tail-end Supply Ratio	280/304	0.92	0.50-1.00
2	Maintenance	Poor Structure Ratio	0/3	0 (0 is the ideal no)	0.01-0.20
3	Financial	Fee Collection Performance	25000/47000	0.53	0.62- 1.0
		Manpower Numbers Ratio	0/38.44	0	0.0004- 0.001

8. THEROOR TANK WUA

The tail-end supply ratio of 0.98 falls within the optimal range of 0.50-1.00, indicating highly efficient water distribution throughout the irrigation system. This near-perfect score suggests that water is reaching the furthest areas of the network with minimal losses, ensuring equitable access for all users. Such a high ratio is particularly noteworthy as it demonstrates the system's ability to overcome common challenges such as water seepage, evaporation, and unauthorised usage along the distribution channels.

The manpower ratio of 0.00355 exceeds the recommended range of 0.0004-0.001, potentially indicating adequate labour for the irrigation system's operations and maintenance. This higher-than-recommended ratio could lead to increased operational costs and reduced overall efficiency. However, it is essential to consider local factors that might necessitate additional manpower, such as complex terrain, extensive infrastructure, or specific maintenance requirements unique to the region's climate or soil conditions.

The fee collection performance ratio of 0.77 falls within the expected range of 0.62-1.00, suggesting a moderately effective revenue collection system. While this ratio indicates that a significant portion of fees are being collected, there is still room for improvement to achieve optimal financial sustainability. Factors contributing to the current collection rate may include socioeconomic conditions of water users, effectiveness of billing systems, enforcement mechanisms, and overall satisfaction with the irrigation services provided. Implementing targeted strategies to address these factors could potentially improve the fee collection performance and enhance the system's financial viability.

Table 2 Performance of KKM4 Theroor Kulam Neerinai Bhayanpadthuvar Sangham (WUA)

Sr. No	Parameter	Performance Indicator	Input Value	Value	Reference Range
1	Water Deliveries	Tail-end Supply Ratio	300/305	0.98	0.50-1.00
2	Maintenance	Poor Structure Ratio	0/5	0 (0 is the ideal no)	0.01-0.20
3	Financial	Fee Collection Performance	98000/1,40,000	0.7	0.62- 1.0
		Manpower Numbers Ratio	1/281.5	0.00355	0.0004- 0.001

9. WATER DISTRIBUTION EFFICIENCY

Water distribution efficiency, measured by the tail end supply ratio, is a critical indicator of equitable resource allocation in irrigation systems. The high values observed in Periyakulam, Veeramarthandpuram WUA (0.92) and Theroor tank WUA (0.98) demonstrate exceptional performance in delivering water to farmers across all sections of the distribution network. These ratios suggest that farmers at the tail end of the system receive nearly the same amount of water as those at the head and middle sections, which is a significant achievement in water management.

The primary factors contributing to this robust delivery system are the diligent maintenance of the tank infrastructure and the abundant water availability in the tanks. The channel-fed nature of these tanks, coupled with the favorable rainfall patterns in Kanyakumari district, ensures a consistent water supply throughout the year. This reliable water source, combined with well-maintained distribution channels, allows for efficient water allocation to all farmers, regardless of their position in the network. The high tail end supply ratios reflect the effectiveness of local water management practices and the natural advantages of the region's geography and climate in supporting sustainable irrigation systems.

10. INFRASTRUCTURE MAINTENANCE

Infrastructure maintenance, as measured by the poor structure ratio, plays a crucial role in the effectiveness of Water User Associations (WUAs). The Periyakulam Veeramarthandapuram WUA and Theroor tank WUA have demonstrated exemplary performance, achieving an ideal score of zero. This score indicates that these WUAs have successfully maintained their infrastructure, including shutters, channels, and sluices, in optimal condition. Regular and periodic maintenance activities have been carried out, ensuring the longevity and efficiency of the water management systems in these areas.

The commitment to infrastructure maintenance is further evidenced by the actions of the WUA leadership and the community. In the case of Periyakulam Veeramarthandapuram WUA, the chairman took the initiative to invest personal funds for tank maintenance, showcasing a high level of dedication to the cause. Similarly, the Theroor tank WUA has established a separate fund specifically allocated for tank maintenance, demonstrating foresight and financial planning in their approach to infrastructure upkeep. These proactive measures not only contribute to the excellent poor structure ratio scores but also reflect the overall effectiveness of these WUAs in managing and preserving their water resources.

11. FINANCIAL PERFORMANCE:

The financial performance analysis of water user associations (WUAs) through fee collection performance ratio and manpower ratio provides crucial insights into the operational efficiency and sustainability of tank irrigation systems. Proper fee collection from members is vital for the ongoing operation and maintenance of tanks, while adequate financial health enables the appointment of dedicated staff for effective tank monitoring and rule enforcement. In the case study presented, Periyakulam and Veeramarthandapuram WUA scored 0.53 in fee collection performance, while Theroor tank WUA achieved a higher score of 0.70. This disparity in performance can be attributed to varying levels of community participation and the socio-economic characteristics of the farmers in each area.

The manpower ratio further illustrates the differences between the WUAs. Veeramarthandapuram WUA currently lacks appointed staff, which may hinder its ability to manage the tank effectively. In contrast, Theroor tank WUA benefits from dedicated staff, contributing to its superior fee collection performance. The higher level of community participation in Theroor tank WUA is reflected in the active involvement of members in agriculture. Conversely, Veeramarthandapuram tank faces challenges due to a predominance of tenant farmers with lower willingness to pay, compounded by absentee landowners who have settled outside the district. These factors collectively influence the financial health and operational effectiveness of the respective WUAs, highlighting the importance of community engagement and appropriate staffing in ensuring the sustainable management of tank irrigation systems.

Institutional Dynamics of the tanks: a comparative perspective based on semi-structured interviews

12. LEADERSHIP AND RELIANCE ON INDIVIDUALS

Both systems currently depend on charismatic presidents, but vulnerability is higher in Periyakulam because procedures (elections, accounts) are not institutionalised. Theroor’s rotation of leadership through regular elections mitigates leader-dependency.

13. FINANCIAL GOVERNANCE

Theroor tank’s dedicated account, transparent books and emergency reserve exemplify good fiscal practice and enable hiring of staff. Periyakulam’s innovative paddy-procurement scheme generates resources, yet the use of a personal bank account obscures audit trails and may deter government grants.

14. PARTICIPATION AND SOCIAL CAPITAL

14.1 HIGH SOCIAL CAPITAL IS EVIDENT IN BOTH TANKS, YET IT MANIFESTS DIFFERENTLY

Periyakulam relies on informal norms, participation is voluntary and sporadic, meetings are perceived as costly.

Theroor formalises participation, frequent meetings, recorded minutes, penalty framework. The latter aligns more closely with Ostrom’s prescriptions that legitimate sanctions complement trust.

14.2 INFRASTRUCTURE MANAGEMENT

Periyakulam excels in rapid, self-funded physical upkeep (steel-reinforced bunds, routine desilting) because it operates outside bureaucratic controls. Theroor, situated in a protected wetland, must navigate multi-agency approvals; consequently, weed overgrowth persists despite ample funds. This underscores how external regulatory complexity can offset internal capacity.

14.3 EQUITY OF WATER DISTRIBUTION

Both WUAs achieve year-round supply to head, middle, and tail users. Theroor's practice of pre-season water-need declarations and synchronised shutter schedules is a noteworthy innovation ensuring tail-end security.

Table 3 Performance of both the tanks based on Ostrom's Design Principles

Design Principle	Periyakulam Tank WUA	Theroor Tank WUA	Comparative Insight
Clearly defined boundaries	Boundaries are marked	Boundaries are marked	–
Proportional equivalence between benefits & costs	Low fee payment	High fee payment	Theroor tank demonstrates better cost-sharing
Collective-choice arrangements	Limited participation; decisions are taken by a small group	High meeting turnout; democratic voting	Theroor tank better community participation
Monitoring	No dedicated staff; Farmers take turns	Dedicated paid staff	Monitoring is stronger in Theroor tank
Graduated sanctions	No system exists	Sanctions and penal mechanisms are established	Enforcement is lacking in the Periyakulam tank
Conflict-resolution	Informal, quick	Formal, documented & quick	Both effective; a Structured system exists in Theroor tank
Minimal recognition of rights to organise	Legal recognition enables the WUA to function better.	Legal recognition enables the WUA to function better	–
Nested enterprises / external linkages	Informal tank-networks & other WUAs	Better relationship with PWD and the government.	Theroor tank has a better relationship with higher levels of organisation

15. POLICY SUGGESTIONS AND POLICY TRANSFER PATHWAYS

15.1. LESSONS FROM THEROOR TANK WUA FOR STRENGTHENING PERIYAKULAM–VEERAMARTHANDAPURAM TANK WUA

The comparative institutional performance between Theroor Tank Water Users Association (WUA) and Periyakulam–Veeramarthandapuram Tank WUA reveals a significant opportunity for horizontal policy learning and adaptation. Both associations demonstrate commendable levels of participatory decision-making, particularly in the collective determination of cropping calendars and water release schedules through member meetings. However, the operational robustness and institutional embeddedness observed in Theroor WUA offer scalable practices that can be contextually adapted to strengthen the governance capacities of Periyakulam WUA.

A key differentiating factor lies in the institutional formalisation and rule enforcement mechanisms employed by Theroor. The WUA conducts regular elections, maintains formal registers and meeting minutes, and enforces rules through graduated sanctions. While Periyakulam WUA also demonstrates leadership commitment and a functional meeting culture, the absence of codified rules and election cycles risks institutional discontinuity. It is recommended that Periyakulam WUA initiate a process to draft formal by-laws, ideally in consultation with district-level agricultural or irrigation departments, to institutionalise leadership roles and standard operating procedures. Legal recognition under the Tamil Nadu Farmers' Management of Irrigation Systems Act (2000) could further enhance the WUA's autonomy and access to state support.

Theroor's transparent financial management practices—including a dedicated WUA bank account, accessible financial records, and the establishment of an emergency fund through surplus fee collection—have fostered high levels of trust and financial resilience. In contrast, Periyakulam's informal handling of finances, though functional, may constrain its long-term sustainability and accountability. Transitioning to a formal financial system, supported by simple community-friendly tools (e.g., triplicate receipt books, quarterly reporting formats, and digital payment systems), could improve Periyakulam WUA's credibility and capacity to mobilise external funds.

Despite both WUAs convening meetings for crop planning and water scheduling, Theroor's proactive enforcement system and conflict-resolution mechanism offer a replicable framework. Theroor employs verbal warnings, peer mediation, and temporary exclusion from water access in cases of non-compliance, though these are rarely required due to strong social capital. Periyakulam could benefit from a locally accepted sanctions protocol, agreed upon by members and publicised across user groups, to reinforce compliance and deter free-riding behaviour.

Human resource engagement is another area where Periyakulam can adopt best practices. Theroor's appointment of a paid operator to monitor the tank throughout the year ensures consistent maintenance and timely water distribution. This professionalisation of operations reduces dependence on voluntary labour, which can be unreliable during peak periods. Periyakulam WUA may consider employing part-time operators during the irrigation season, potentially drawing from government employment schemes such as MGNREGS for routine maintenance tasks like weed removal and bund repairs.

In terms of external linkages, Theroor's collaboration with the Public Works Department (PWD) and Forest Department officials has been instrumental in securing infrastructural support and managing the complexities associated with its wetland status. Although Periyakulam is not a designated protected site, the WUA can proactively develop institutional relationships with line departments to expedite approvals for tank rehabilitation and desilting. Entering into formal MoUs or participating in multi-stakeholder forums can improve inter-agency coordination and resource mobilisation.

One of the more systemic issues that both WUAs face relates to leadership fatigue and youth disengagement. Theroor's experience shows that managing a high-performing WUA involves significant personal responsibility and pressure, often leading to reluctance among experienced leaders to seek re-election. To address this challenge, a rotational leadership model with fixed terms, leadership training workshops for young farmers, and exposure visits to successful WUAs could be introduced. Establishing a Youth Engagement Wing within the WUA may also help nurture future leaders and sustain institutional momentum.

While both WUAs show a degree of participatory governance and cooperative decision-making, Theroor's operational sophistication, financial transparency, and institutional resilience provide a valuable template for policy transfer. Through adaptive replication, rather than rigid emulation, Periyakulam WUA can strengthen its governance structures and build long-term sustainability. A facilitated policy-transfer programme, supported by local agricultural extension services and civil society actors, can catalyse this transition and contribute to more equitable and efficient irrigation management in tank-irrigated regions of Tamil Nadu.

16. CONCLUSION

The comparative study of Theroor and Periyakulam–Veeramarthandapuram Water User Associations underscores the critical role of institutional design, community participation, and local leadership in achieving sustainable and equitable tank irrigation management. Both WUAs exhibit commendable strengths, particularly in water distribution efficiency and infrastructure maintenance. The exceptionally high tail-end supply ratios (0.98 in Theroor and 0.92 in Periyakulam–Veeramarthandapuram) reflect equitable water access across the canal network—an achievement facilitated by consistent rainfall, robust tank maintenance, and collaborative cropping decisions made through participatory meetings.

Infrastructure maintenance has emerged as a particularly strong dimension for both associations, with a recorded poor structure ratio of zero. This outcome is a testament to proactive local leadership, community engagement, and financial foresight—evident in Theroor's dedicated maintenance fund and the Periyakulam chairman's personal investment in tank upkeep.

Despite these shared strengths, the analysis highlights significant differences in financial performance and institutional capacity. Theroor's higher fee collection performance (0.70) and the presence of dedicated manpower for operational oversight contrast with the relatively lower financial mobilisation (0.53) and absence of appointed staff in Periyakulam–Veeramarthandapuram. These discrepancies are shaped by socio-economic factors such as the prevalence of tenant farming, absentee landowners, and weaker incentives for sustained participation in the latter region.

The findings affirm that while biophysical conditions and infrastructure quality are crucial, the institutional arrangements and social capital embedded within WUAs play an equally, if not more, decisive role in ensuring the long-term viability of tank irrigation systems. Theroor's success story offers a pragmatic model for policy transfer, where adaptable governance practices—such as financial transparency, staff appointment, rule enforcement, and multi-stakeholder coordination—can be replicated or modified to strengthen the Periyakulam, Veeramarthandapuram WUA. However, such transfers must be sensitive to local socio-economic contexts, ensuring that adaptations align with the unique challenges faced by tenant-dominated communities.

In conclusion, this study reinforces the importance of strengthening participatory irrigation management (PIM) through locally grounded, community-driven, and institutionally supported interventions. The evolution of successful WUAs like Theroor exemplifies how formal structures, embedded social norms, and dedicated leadership can collectively foster resilient water governance systems capable of withstanding socio-ecological and institutional pressures.

CONFLICT OF INTERESTS

None.

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