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Social and Institutional Factors Influencing the Performance of Tank Irrigation System – A Study of Uthiramerur Tank in the Indian State of Tamil Nadu

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Tanks were the major sources of irrigation for agriculture and storehouses of economic, social, aesthetic and environmental use values. However, in the present context, the current trends are showing that area and number of tanks are being reduced due to poor maintenance, encroachments, degradation of catchment area and siltation, etc. This calls for rehabilitation and rejuvenation of the existing tank irrigation systems so as to preserve this precious natural resource for the livelihood of future generations ahead. Hence this present study was undertaken to identify the social and institutional factors influencing the performance of tank systems in Kanchipuram district in the Indian state of Tamil Nadu.
Study Design: Quota and Multistage random sampling method was followed.
Place and Duration of Study: Command and Non-command areas of the Uthiramerur Tank in Kanchipuram district of Tamil Nadu during 2020-2021.
Methodology: A Sample size of 120 sample respondents from the different locations of the command areas (Head, Middle, Tail and Non-command area) of Uthiramerur tank were selected and interviewed.
Results: It was observed from the performance analysis that over the years the tank's performance was decreasing both in terms of filled in capacity vis-à-vis rainfall received (Above the tank outlet) and in terms of actual gross area irrigated vis-à-vis its potential command area (Below the tank outlet) . One of the important reasons for the decline in the performance of Uthiramerur tank was attributed mainly to institutional deficiencies wherein concrete action lacked thereof.
Conclusion: The study suggested the following actions for the improvement of tank's performance- streamlining the feeding channels of the tank by removing the encroachments, lining of channels to minimize the seepage losses and ensuring better water distribution, periodic desiltation ,strengthening the revenue collection mechanisms, encouraging the conjunctive water use and rejuvenating the water user association.

Keywords: Tank irrigation; above and below the outlet; command areas; performance and problems.

1. INTRODUCTION

Water is a social, economic and environmental good due to its multiple uses. Without water, it is impossible for irrigated agriculture to sustain and provide food for the fast-growing population. Agriculture, which accounts for about 70 percent of the global water withdrawal, is constantly competing with domestic, industrial and environmental uses for a scarce water supply [1]. In India, irrigation is by multiple sources such as tanks, canals and groundwater in which this study gives emphasis to tank irrigation, owing to its importance in sustainable water resource management.

Tank irrigation is an age old established system in most of the semi-arid tropical parts of India and of some other countries. In India, the largest number of tanks is found in the southern states of Andhra Pradesh, Karnataka, Telangana and Tamil Nadu and the union territory of Pondicherry, which account for nearly sixty percent of India's tank-irrigated area [2]. Tank irrigation systems capture monsoon runoff in the arid and semi arid areas where the problem of water shortage is faced. Apart from serving as a main source of irrigation, it also supports other sources by its supplementary and complementary role through the synergistic relationship of hydro-economic interactions.

1.1 Background of the Problem

In recent years, there has been a growing need to rehabilitate the tanks because their areas have been declining due to factors like improper management at farm level, encroachment, siltation, degradation of catchment area, pollution and urbanization, etc [3]. While the wells were developed for irrigation purpose, the importance given to tank irrigation declined sharply and steadily, and governments did not take necessary steps to reverse the situation [4]. Also the institutions created for managing the water bodies are not carrying out their role which may be attributed to the inherited problem of property right issues faced by most of the common property resources. Another major problem in the management of tanks is lack of financial support, stakeholders' involvement and coordination among the institutional agencies involved in the

operation and maintenance. Hence this study was carried out to address these problems to a larger extent by identifying the challenges and issues of managing the tanks in social and institutional perspectives.

1.2 Objectives

The core aim of the study is to establish the importance of tank irrigation in agriculture and to analyze the social and institutional factors influencing their performance so as to find and offer suggestions which will pave the way for its rejuvenation. Hence this study was carried out with the following objectives:

1. To study and classify the socio-economic profile of the sample farmers at the various locations of the command area.
2. To assess the performance and analyze social and institutional factors attributing to the status in above and below outlet areas of Uthiramerur tank.
3. To offer suggestions for improving the performance of tank irrigation in the command area.

2. METHODOLOGY

In this study, Kanchipuram district was selected as the area of research as it had the highest number of tanks in Tamil Nadu for irrigation since time immemorial [5,6]. In this district, Uthiramerur block was purposively selected as it had the highest area under tank irrigation [7]. This tank command flows about 15 kilometers in length cutting across various revenue villages.

A quota sampling selection procedure was used for this study. A sample size of 30 each of head (0-5km), middle (5-10 km), tail (10-15 km), and non- command region (above 15 km) from Uthiramerur tank command were contacted for collecting information and data. The tank irrigated areas were identified with the help of institutional information and random sampling technique was adopted. Various technical resource persons from the agriculture department and public works department (PWD) were contacted in the study area to get better clarity and elicit technical details pertaining to the tank.

The study relied on both primary and secondary data. All the analysis were carried out for head, middle, tail and non command area separately so as to understand the difference in the location advantage of the four regions of the tank command area. Garrett's ranking technique was used to rank the constraints and suggestions according to their mean scores. The respondents were asked to rank (in the order of priority) the suggestions and these ranks were converted to scores by referring to the Garrett table. In this analysis, rank one means the most important factor; and rank six means the least important factor. In the next stage, the rank assigned to each factor under suggestions and strategies opined by each respondent was converted into percent position using the formula:

$$\text{Percent position} = 100\,(R_{ij} - 0.5) / N_j$$

Where,

R_{ij} = Rank given for the ith factor by the jth individual

N_j = Number of factors ranked by the jth individual

3. RESULTS AND DISCUSSION

3.1 Socio-Economic Characteristics of the Sample Farmers under Tank Irrigation

Socio-economic status is a combined measure of economic and social position of an individual or a group in relation to others in the society. It gives a picture of the demographic, social and the economic position of the persons in a particular geographic region. The variables selected to classify the profile of the sample farmers in this study were age, education, experience of the farmers, size of their land holdings, cropping pattern and annual income. They are used to analyze the socio-economic profile of the farmers which will present a clear observation of the existing condition of the farmers around the Uthiramerur tank command and non command areas. The socio-economic profile of the 120 sample farmers is enumerated by means of simple percentage analysis method.

The proportion of farmers with higher experience was observed in head region indicating that the farmers of this region still sticking on to agriculture as their main occupation. The farmers of medium sized category were noticed only in the head region. Above all the crop income distribution revealed that the farmers of the head region only had a considerable share in the higher income category (Above 4 Lakhs).

Table 1. Agricultural and socio-economic profile of the sample farmers (N=120)

Sl.No.	Agricultural and Socio-economic characteristics	Category	Head	percent	Middle	percent	Tail	percent	Non command area	percent
1	**Age of farmers in years**	Below 40	3	10.00	6	20.00	9	30.00	9	30.00
		40-60	23	76.67	21	70.00	18	60.00	18	60.00
		>60	4	13.33	3	10.00	3	10.00	3	10.00
2	**Education**	Illiterate	12	40.00	9	30.00	6	20.00	6	20.00
		Primary	12	40.00	9	30.00	15	50.00	9	30.00
		Secondary	6	20.00	12	40.00	9	30.00	15	50.00
		College	0	0.00	0	0.00	0	0.00	0	0.00
3	**Experience**	10 and below	3	10.00	1	3.33	0	0.00	0	0.00
		11-20	5	16.67	7	23.33	14	46.67	18	60.00
		21-30	9	30.00	12	40.00	11	36.67	8	26.67
		31-40	10	33.33	8	26.67	4	13.33	2	6.67
		>40	3	10.00	2	6.67	1	3.33	2	6.67
4	**Size of Land Holdings**	Marginal (Less than 1 Ha)	14	46.67	15	50.00	18	60.00	18	60.00
		Small (1-2 Ha)	12	40.00	15	50.00	12	40.00	12	40.00
		Medium (4-10 Ha)	4	13.33	0	0.00	0	0.00	0	0.00
5	**Cropping Pattern**	Paddy (Thrice)	11	36.66	3	10.00	6	20.00	6	20.00
		Paddy (twice) and Black gram	3	10.00	9	30.00	9	30.00	9	30.00
		Paddy (twice) and Ragi	12	40.00	12	40.00	6	20.00	6	20.00
		Paddy and Black gram	0	0.00	0	0.00	6	20.00	6	20.00
		Groundnut and Black gram	4	13.33	6	20.00	3	10.00	3	10.00
6	**Annual crop Income**	Below 250000	10	33.33	12	40.00	12	40.00	16	53.33
		250000-40000	14	46.67	14	46.67	16	53.33	13	43.33
		Above 400000	6	20.00	4	13.33	2	6.67	1	3.33
	Number of farmers	**Total 120**	**30**	**25**	**30**	**25**	**30**	**25**	**30**	**25**

Table 2. Relationship between rainfall and the tank capacity- assessment of above the outlet performance

S. No.	Period	Uthiramerur Tank			
		Rainfall (mm)	Actual Tank Capacity (Mcft) (ATC)	Filled in Tank Capacity (Mcft) (FTC)	Performance in Capacity Filled (%)
1.	2011	1712	958.8	958.8	100
2.	2012	404	958.8	0	0
3.	2013	600	958.8	0	0
4.	2014	864	958.8	556.1	57.99
5.	2015	1867	958.8	958.8	100
6.	2016	1920	958.8	958.8	100
7.	2017	1023	958.8	908.6	94.76
8.	2018	789	958.8	632.8	65.99
9.	2019	1064	958.8	958.8	100
10.	2020	1632	958.8	958.8	100

**Performance is estimated by the formula (ATC/FTC X 100)*
(Source: Block handbook of Uthiramerur 2019 – 2020)

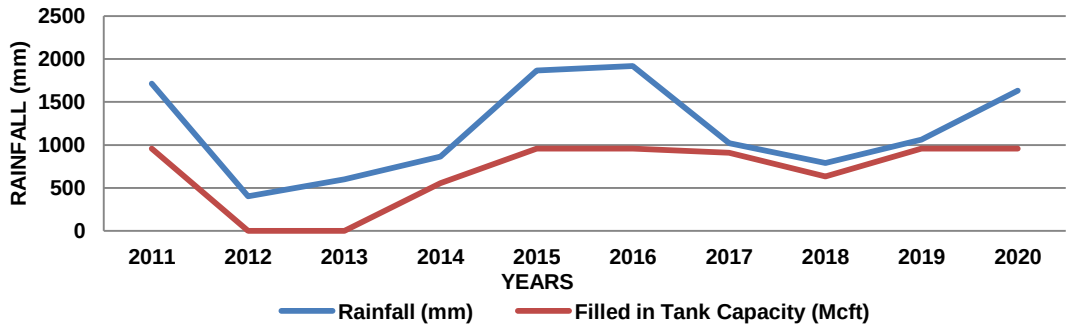

Fig. 1. Relation between rainfall and filled in capacity of the tank

Table 3. Above the Outlet Reasons for Decline in the Performance of Uthiramerur tank

S. No	Factors	Mean Score	Rank
1	Encroachment of the Catchment Area (Improper and mismanaged)	68.58	1
2	Desiltation & Strengthening of Weirs and Bunds of the Tank	60.10	2
3	Obstructions in Supply Channels	55.79	3
4	Growing Industrial Requirement	55.77	4
5	Urbanization and Rapid Growth of population	52.60	5

Table 4. Decline in the Catchment Area of Uthiramerur Tank over the Years (2010-2020)

S. No.	Period	Catchment Area (In hectare)
1	2010	320.25
2	2012	298.33
3	2014	250.50
4	2016	235.12
5	2018	228.23
6	2020	225.08

(Source: Block handbook of Uthiramerur 2019 – 2020)

3.2 Performance Assessment and Reasons Attributing to the Declining Performance Status of Uthiramerur Tank

The reasons for decline in the performance of Uthiramerur tank is broadly discussed under the following headings.

1 Problems Related to above the Outlet of the Tank
2 Problems Related to below the Outlet of the Tank
3 Institutional problems

3.2.1 Performance assessment and above the outlet reasons attributing to the status

The relationship between the rainfall and Uthiramerur tank's capacity is presented below in the Table 2. It shows that whenever the rainfall was above 1000 mm, the tank was filled to its total capacity and conversely rainfall of below 1000 mm was not sufficient for the tank to meet its total capacity.

The five important reasons identified in the above outlet of the tank may be effectively addressed so as to improve the tank's performance even with the rainfall shortage of below 1000 mm. These attributes were ranked with the responses elicited from the tank stakeholders. This garret ranking analysis revealed the assessment of farmer's opinion regarding the factors influencing the decline in the performance of the Uthiramerur tank. The ranking preferences given by the respondents on the five reasons was analyzed and presented in the following Table 3.

3.2.1.1 Encroachment of the catchment area

From the below Table 4, it could be seen that the catchment area of Uthiramerur tank was 320 ha in the year 2010, which had decreased to 250 ha in 2014 and it was only 225 ha in 2020 recording a drastic reduction of 95 Ha within a decade.

Rainfall directly influences tank water storage, the irrigation potential and in turn the tank's performance positively, whereas urbanization and demand for land for non-agricultural uses negatively influence the tank's performance. In the process of urbanization, the waste and forest lands performing the ecological functions are converted into non-agricultural uses at a faster rate; reducing the tank water spread, catchment area, and the conversion of agricultural lands are converted for construction of buildings which reduces the tank's spread and irrigated areas.

3.2.1.2 Desiltation and strengthening of weirs and bunds

Desilting the tanks is essential as it plays a major role in recharge of groundwater [8]. Based on the data obtained from the survey, the tank was lastly desilted in the year 2016. Even though desiltation was carried out in the year 2016, after that the tank has been fully occupied by the weed *prosophis julifera* and within a year and it reduced the tank storage capacity. The benefits of desiltation did not bear any fruitful results for the society. From the opinion of the local people, necessary step has to be taken to overcome the problem of uncontrollable growth of *prosophis* trees at regular intervals. Since complete desiltation could not be attempted owing to many economic and social reasons, partial desiltation might be attempted with the coordinated efforts of the PWD and local bodies.

3.2.1.3 Obstructions in supply channels

The Uthiramerur tank has the supply chain from the Cheyyar river. This river has been feeding eight tanks and Uthiramerur tank is one among them. Though perennial in nature, the water source from the river is seasonal and irregular. Moreover, the supply channel from the Cheyyar river is encroached by the agricultural land, shrubs, prosophis trees etc which needs to be cleaned periodically.

3.2.1.4 Growing industrial requirements

After setting up of the State government's SIPCOT (State Industries Promotion Corporation of Tamil Nadu) at Cheyyar, massive industrialisation has occurred in the districts of Kanchipuram and Tiruvannamalai. This industrialisation resulted in the huge demand for water. This growing demand for water was catered from the Cheyyar river. Due to this huge water transfer to industries the water flow to the tanks has been decreased considerably over the years.

3.2.1.5 Urbanization and rapid increase in population

The water from the Cheyyar River serves as a major source for drinking and domestic purposes of many villages in Tiruvannamalai and

Kanchipuram districts. The growing population led to an increase in the demand for water from this river. Even though the Uthiramerur tank is majorly fed by rain, the supply from the Cheyyar river is being reduced by siphoning of water for domestic requirements.

Increase in rainfall alone was not going to make any appreciable improvement in area under tank irrigation unless adequate measures were taken up to improve the flow of water supply and storage capacity of the tanks [9]. Improper maintenance of catchment areas and encroachments interrupts the inflow towards the tank. Hence to ameliorate the above outlet problems, the following actions were suggested: efficient enforcement by the administration. Since the Cheyyar river is the major source of irrigation for domestic and industrial purposes, the competition for intersectoral water demand from this source starves the water supply from feeding the tank by diverting water before it reaches the tank.

3.2.2 Performance assessment and below the outlet reasons attributing to the status

The relationship between the capacity and command area of the Uthiramerur Tank is presented below in the Table 5 and it could be observed that, over the last two decades, there was a secular decline in the actual area commanded and it has almost reached 50 percent of its potential command area in 2020. This alarming trend of decline in actual command area had occurred despite the tank's full capacity as indicated in Table 2 in the years of 2015 and 2020. Hence it could be inferred that it was mainly due to below the outlet problems.

The six major downstream attributes were identified and the respondents were asked to rank them. This garret ranking analysis revealed the farmers opinion regarding the factors influencing the decline in the performance of the Uthiramerur tank below the outlet which are presented in Table 6.

Table 5. Relation between the capacity and command area of the Uthiramerur tank

S. No.	Period	Uthiramerur Tank		
		Potential Command Area (Ha) (PCA)	Actual Command Area Irrigated (Ha) (ACA)	Command Area Performance (%) (CAP)
1.	1995	2199	1210	55.03
2.	2000	2199	2195	99.82
3.	2005	2199	1975	89.81
4.	2010	2199	1523	69.26
5.	2015	2199	1312	59.66
6.	2020	2199	1100	50.02

(Source: Block handbook of Uthiramerur 2019 – 2020)
**CAP was calculated using the formula ACA/PCA X 100*

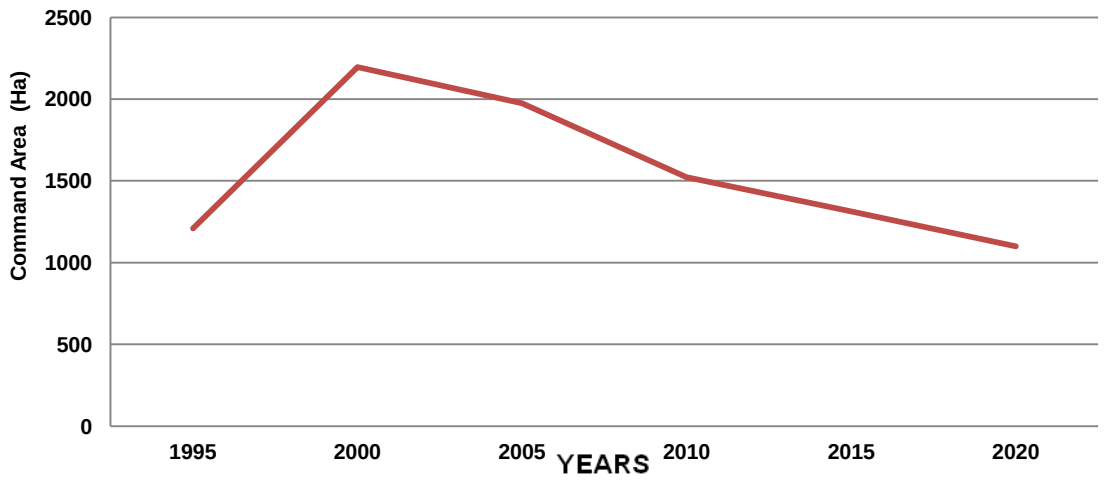

Fig. 2. Trend in the actual command area irrigated by the Uthiramerur tank

Table 6. Below the outlet reasons for the decline in the performance of Uthiramerur Tank

S. No	Factors	Mean Score	Rank
1	Improper Maintenance and encroachment of Sluice Gates	78.58	1
2	Poor Up keeping and Non-Lining of Distribution Channels	75.33	2
3	Irregularities in the Operation of Sluice Gates	73.21	3
4	Inefficient Water Distribution Methods	60.79	4
5	Growing of High water consuming Crops	58.44	5
6	Large scale Diffusion of Energised wells	57.77	6

3.2.2.1 Improper maintenance & encroachment of sluice gates

Uthiramerur tank has total of 13 sluices, of which 3 were major and 10 were minor. Each sluice has a separate canal to deliver the water. The major sluice gates were maintained by the PWD, Uthiramerur from time to time and the minor sluice gates were not maintained periodically. They were erected during the year 1891 and being old, the sluice gates were corroded. So, there was some water loss in poorly maintained sluice gates and some of the gates were even closed with sandbags to arrest the water loss.

The bund of Uthiramerur tank extends for about 5 km. In the minor sluices 4 of the sluice canals were encroached by the residential houses and lost their function due to poor maintenance of the bunds.

3.2.2.2 Poor up keeping and non-lining of distribution channels

Even in the other channels which have been maintained properly, there was a conveyance loss while transferring through intra channel distribution among the farms. Most of the channels were damaged and required repair and maintenance which led to conveyance loss through seepage. Each sluice has a separate canal to deliver the water, of which only the major canals were lined and the minor canals were non-lined. The tank irrigates for about 15 km horizontal stretch covering about 13 villages. The advantage of lining the canal would effectively reduce the conveyance loss, seepage loss, reduce the maintenance of canal bunds etc., Even the major canals were lined only up to 5 kms in the head region of the tank and the remaining areas were left non-lined. By lining and ensuring proper maintenance, the water loss can be minimized and the area under command may be expanded which will benefit particularly the tail end farmers. Thus proper and equal distribution can be ensured from head to tail which will pave the way for enhancing the production and productivity.

3.2.2.3 Irregularities in the operation of sluice gates

The officials from PWD Uthiramerur operate the major sluice gates only during the time of heavy rain by issuing a flood alert to the villagers. There was no proper person in charge for the operation of sluice gates for irrigation purpose. The sluice gates were opened by the needy farmer themselves using their own tools and the water was being diverted to the farmers' field directly by making an obstruction in the main canal. So, there was a huge conveyance loss during transport of the water from the tank which results in unavailability of water in the tail region of the tank irrigated area.

3.2.2.4 Inefficient water distribution methods

For the tanks, the major technical and physical constraint is the inadequate distribution system which is improperly operated. Although the government constructs the tanks and provides the main canals for large tanks, the laterals and field channels are the farmer's responsibility. In most cases the channels and laterals have never been constructed while the main canal is allowed to deteriorate because of little or no maintenance.

3.2.2.5 Growing of high-water consuming crops

Paddy, which consumes high water, is the most cultivated crop in the entire command area in all three seasons. In the head region almost 87 percent of the respondents cultivate paddy. Then next to paddy, ragi is predominantly cultivated in the head region. Generally, farmers in some tanks with water scarcity had already adopted crop diversification [10] which will reduce the water demand pressure from tank source by which fish culture enterprise can be taken up with the saved water in the acute seasons also.

3.2.2.6 Large scale diffusion of energised wells

Nowadays in the study area, there are large number of energized wells used for irrigation which results in decrease in ground water level and an increase in the cost of irrigation in the study area. Use of motor increase the machinery cost and maintenance cost in the tail and non-command areas. In the head reach of the tank command area there were only five respondents who had possession of wells when compared to 100 percent respondents in the non-command area.

To address the below outlet problems, Gram Panchayats (Village Councils- Local body) should be entrusted with the judicial power and task of eviction and prevention of irregular water use. While regulating the water use, the panchayats which use the tank water should have the rules and regulation in for using the tank water and all decisions should be taken in Grama Sabha specially convened for this purpose. If any one of the Panchayats performs well in this context, it should be given additional grants for developmental works like cleaning the bunds, lining of canals etc.

3.2.3 Institutional Factors Attributing to the Decline in the Performance of Uthiramerur Tank

Five major institutional attributes were identified and the respondents were asked to rank them. This garret ranking analysis revealed the farmers opinion regarding the institutional factors influencing the decline in the performance of the Uthiramerur tank.

3.2.3.1 Lack of coordination among the law enforcement institutions for evicting encroachments

Collective management is essential in the maintenance of public irrigation structures [11]. At the block level, the Tahsildar (Revenue Official) is having judicial powers to evict the encroachers. Normally, he/she act on the report/complaint of the PWD and direct the surveyors to survey the land under consideration and evict the encroachers without paying any compensation. However, this is not happening due to non-reporting of the encroachments periodically by the PWD, who are the custodians of the tanks. Therefore, the task of identifying and preparing the list of encroachers and submitting to the Tahsildar for eviction should be entrusted to any one of the village level functionaries, viz., Village Administrative Officer or Village Panchayat, or the Tank Water User's Association (TWUA). Alternatively, judicial powers for eviction must be given to the concerned Engineer or TWUA or Gram Panchayat which necessitates the need for decentralization [12].

Encroachment of catchment area is one of the major problems. The NGOs in several places are involved in the formation of self-help groups and watershed development programs, which have yielded positive results. Therefore, they should be involved in the initial phases of tank restoration and eviction of encroachers through motivation.

3.2.3.2 Defunct water user associations and improperly defined common property rights

There was a water user association till 2014 run by a village head man. After his death, it did not function. The panchayats involved in using the tank water should have the water user association for regulation of the water use from the tank. Hence, required steps have to be taken to create a fresh water user association for the Uthiramerur tank by reviving and strengthening of Water User Association with due authority and responsibility by giving due representation of stakeholders group with clear cut objectives and bylaws which will serve as a conflict resolution machinery [13]. Hence, if Common Property Right (CPR) is ensured by this arrangement, it will solve many practical problems that may arise from time to time and lead to better performance of the tank irrigation system [14]. The problem of tragedy of commons will be confronted in tank water use and its maintenance.

3.2.3.3 Disappearance of madayans role

Madayans were the people entrusted with the role of maintenance and operation of the tank bunds during earlier period in the Uthiramerur region. They were respected by the people of the region for their job and were given perks like free accommodation, food etc. Madayans do the weeding operation to render the bunds free from weeds, strengthen them periodically and performed water distribution operations. The Madayans were there even during 1980s until then due to the availability of modern machinery and urbanization they migrated to nearby towns and cities in search of better job opportunities. Hence, steps have to be taken to bring back

Table 7. Institutional Factors Influencing the Tank's Performance

S. No	Factors	Mean Score	Rank
1	Lack of Coordination among the Law Enforcement Institutions for Evicting Encroachments.	68.58	1
2	Defunct Water User Associations and Improperly defined Common Property Rights	65.40	2
3	Disappearance of Madayans***** Role	52.79	3
4	Absence of Multipurpose Water Use and Failure in Revenue Collection	50.77	4
5	Caste & Politics	50.40	5

***Madayans are the people entrusted with maintaining and operation of the tank*

them in the system to perform role in tank water management with due government support.

3.2.3.4 Absence of multipurpose water use and failure in revenue collection

Proper fund mobilization and allocation were neither attempted for the periodic maintenance by the local bodies nor by the PWD in this aspect which is an issue of no or poor public spending in irrigation sector [15]. This might be due to the absence of multiple use of water for various purposes like fishery, livestock rearing, social forestry etc.

In the absence of water tax for crop production, these value additions to tank water through allied activities would pave the way for revenue generation by the competent authorities. This revenue collected through these sources could be used for proper maintenance of the tank irrigation system which in turn would improve the tank's performance.

3.2.3.5 Caste and politics

The study on caste composition of sample respondents revealed that two dominant castes namely 'vanniyar' and 'agamudaiyar' had lands in the head region. Together, they accounted for 65.73 percent of the sample respondents interviewed. The more vulnerable castes, (viz. the Scheduled Castes and Scheduled Tribes) also constituted a significant proportion of the land holdings (20.73 and 10.98 percent, respectively). This indicated that the tank water had been used not only by the dominant caste groups but also by a significant proportion of weaker sections of the society. This finding ruled out the general belief that only the dominant caste groups hold the land and uses tank water due to their political and caste clout.

4. CONCLUSION

Tanks for irrigation are one of the valuable common property natural resources. Their mammoth potential will be appreciated only when their direct and indirect values in various dimensions and sectors are realized. Considering their importance, rejuvenation and sustainable management of this previous natural resource bears the great responsibility of all the stakeholders, planners and policymakers. In these aspects, the present study suggests the following options which emanated as the outcome of the research study:

1. Catchment and feeding channel encroachments should be removed to augment the water supply to the tank through the concerted coordination efforts of the official machinery. Periodic desiltation should be attempted to increase the storage capacity. Proper maintenance of sluices and strengthening of bunds should be done.
2. Distribution channel repairs and lining of channels should be carried out by the stakeholders which will augment revenue generation and ensure equal physical access to tank water from head to tail.
3. Institutional arrangements such as water user association must be rejuvenated so as to instill in the minds of farmers a sense of belongingness by providing a common property right by the government on priority basis.
4. Recommending the establishment of decentralized tank water management institutions.
5. Multiple uses of tank water such as fishery, social forestry, recreation park etc., should be promoted which will augment the revenue source and increase the total economic value of the tank thereby many

problems related to revenue collection, water sharing and improper maintenance of this tank irrigation system will be solved to a larger extent.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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