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# Temporal analysis of the factors influencing performance of tank irrigation in the Union Territory of Puducherry in India

**[1*]P. Nirmal Kumar, [2]R. Venkataraman, [3]S. Ravichandran and [4]K. Dhanasekaran**

[1*]Research Scholar (Corresponding author)
[1*,2,3]Department of Agricultural Economics,
[4]Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Annamalainagar, Chidambaram, Tamil Nadu - 608002 (India)
E-mail of the corresponding author: nirmalpdy48@gmail.com
Mobile of the corresponding author: +91-9487585596 (India)

**Abstract**

Tanks are traditional irrigation structures which provide water for irrigation, drinking and flourish surrounding ecosystems with rich biodiversity of flora and fauna. The irrigation requirement of Puducherry district over the past years was catered by tanks, other surface water sources and groundwater. But as years passed, the net irrigated area by tanks and other sources barring groundwater had reduced to zero. However, tanks perform the passive role of groundwater recharge whenever reaching full capacity. But this alone was not sufficient to meet the recurring demand as the groundwater levels are declining due to overexploitation. It led to problems such as reversal of water gradient flow, seawater intrusion into the groundwater aquifers affecting the quality of groundwater along coastal Puducherry district. A decline in net sown area was observed in contrast to the area converted to non-agricultural uses which had been increasing gradually over the years marking a significant paradigm shift in the contribution of the primary agricultural sector versus the other sectors. This could be attributed to the significant reason of reduction the performance of tanks. Hence this study is taken to evaluate their performance in Puducherry evaluating its temporal change over the period of 60 years from 1962 to 2021.

**Key words :** Tank, groundwater, rainfall performance, irrigated area.

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[1*]Research Scholar, [2]Professor, [3]Associate Professor, [4]Professor

Tank irrigation was conceived widely and established in areas where the supply of water by natural sources especially in semi-arid regions[10]. The earlier civilizations around the world had devised various interventions and built many structures carrying water such as canals, dams, ponds and reservoirs and it has became an important traditional source of water management in the rural communities[12]. Changes in climate led to implications such as droughts and unseasonal rains which have become more common nowadays and maintaining the irrigation structures have become a great challenge[6]. In the case of tanks, their area has been observed to decline over the years due to factors like improper management at farm level, encroachment, unchecked siltation, pollution and urbanization, etc. [8]. According to latest figures, Tamil Nadu stands fourth (43,837) in the number of tanks, after Andhra Pradesh, Odisha and Himachal Pradesh. The share of tanks in irrigation had declined from 3.6 million hectares to 1.6 million hectares from 1950 up to 2019. Hence this research paper seeks to study the importance of tank irrigation as it has a wider economic use value in agriculture, domestic and other sectors, development and nurturing an ecosystem with biodiversity, role in groundwater recharge, etc with the following objectives.

*Objectives :*

1. To assess the performance of the tanks with respected to the irrigated agriculture in Puducherry region.
2. To identify the factors influencing the performance of the tanks.

*Tank Irrigation in Puducherry Region :*

Puducherry district of the union territory ever since times immemorial possessed largest irrigation tanks and management institutions established and maintained from 10$^{th}$ century C.E as the historical records mention, serving multiple purposes. It formed the most important source of freshwater to meet the requirements for the local people. There were special reservoir management boards formed by the erstwhile great monarchs of Tamil Nadu which indicated the functioning of a robust institutional system **(Source: Gazette of Puducherry, 1982).**

The later period, *i.e.* during the period of modern imperialism in India by the European colonial powers, the French administration which was controlling Puducherry region had also gave importance to irrigated agriculture and constructed tanks, feeding channels and other water storage structures. They had established farmer and water management institutions such as ***'Caisses Communes' (association of cultivators of one or more villages) and 'Syndicats Agricoles'*** in order to regulate the consumption of irrigation water involving active participation from the stakeholders. After independence, the area irrigated by tanks in Puducherry which was 6,023 hectares (41.3 per cent from the total irrigated area of 14,598 hectares) during the 1960' had declined rapidly to a paltry area of just 20 hectares (0.1 per cent) during 1992 **(Directorate of Economics and Statistics, Government of Puducherry, 2021).** Today, Puducherry's tank irrigated area had became nil/zero which may be attributed to various factors such as encroachment of the catchment areas, non-availability of water during the

appropriate periods, urbanization/industrialization, poor or negligence in care and the abolishment of the institutions and transferring of maintenance of surface water bodies between the state authorities had also led to its decline **(Source: Water Policy, Govt. of Puducherry, 2016-17).** Puducherry is undergoing rapid urbanization which has accelerated the conversion of agricultural lands to serve various other purposes such as industrial, commercial and domestic sectors which led to the decrease of net sown area for about 50 per cent from 18,618 hectares during 1960's to 9,624 hectares at present in accordance with the decline in area of the irrigation sources. This also exacerbated the intersectoral transfer of water from agriculture to meet the other important needs of other sectors.

Puducherry district of the Union Territory is classified as a region having groundwater resources in a critical condition, which was attributed mainly due to its overexploitation as the other sources of freshwater had declined/ ceased to exist. It was found out by the hydrologists that the groundwater had reversed its gradient of flow from the regular side (directed towards the East coast). The water level had declined to a depth of 5 to 10 meters along the coastal tract and 25 to 40 meters in the inland northwestern parts of Puducherry region. The consumption of groundwater for agriculture occupies the highest position in Puducherry to the tune of nearly 75 per cent **(137 Million Cubic Meters, Source: CGWB, Govt. of India, 2020)**. The overexploitation of groundwater led to the intrusion of sea water for over 3 to 4 kilometers inside the southern parts of Puducherry region, 2 kilometers within the city and 1 km over the northern areas which rendered the aquifers saline deeming it unfit for consumption. This also led to deferring new projects like construction of recharge wells nearby the surface water sources **(State Groundwater Unit, Dept. of Agriculture, Govt of Puducherry, 2020).** Hence it is felt necessary to revive the tanks for direct irrigation, augment their performance and sustain the use of other water resources, thereby promoting sustainable agriculture and improvement in the livelihood of the people living in these regions. Thus, this study focuses on studying the factors influencing the performance of tank irrigation systems taking the period of 60 years from 1962 to 2021.

*Current status of Tank Irrigation systems in Puducherry Region :*

There are currently 84 tanks, about 609 ponds and other groundwater sources such as tube wells numbering around 6,000 which are engaged either directly or indirectly (stabilisation function through groundwater recharge) in irrigating the agricultural area of Puducherry region **(Economics and Statistics, Govt of Puducherry, 2022**). As the maintenance of the irrigation tanks is completely vested with the authorities of the Public Works Department of Puducherry government, they have classified the irrigation tanks as System tanks and Non-System tanks.

1) **System tanks-** They are the tanks connected with major surface water sources such as and receive water through the means of feeder channels or canals in addition to their catchment area.
2) **Non-system tanks**- They are unitary and not connected with any other water sources and hence completely depend on rainfall for filling their capacity. However, they can

be also connected with other tanks and hence form a series of tanks. **(K Palanisami, 1984).**

The classification of system and non-system tanks along with their details of Ayacut area located in Puducherry is given in the table-1 as follows:

Table-1. Distribution of System and Non system Tanks in Puducherry Region

| S.No | Commune Panchayat | No. of irrigation tanks | | Ayacut Area* (ha) | Actual area irrigated at present (ha) |
|---|---|---|---|---|---|
| | | System Tanks | Non System Tanks | | |
| **1** | Ariyankuppam | 1 | **-Nil-** | 308.90 | 0.00 |
| **2** | Bahour | 22 | **-Nil-** | 1789.28 | 0.00 |
| **3** | Mannadipet | 20 | 8 | 1288.17 | 0.00 |
| **4** | Nettapakkam | 9 | 3 | 836.13 | 0.00 |
| **5** | Oulgaret | **-Nil-** | 1 | 20.64 | 0.00 |
| **6** | Puducherry | 1 | **-Nil-** | 119.16 | 0.00 |
| **7** | Villianur | 7 | 12 | 2035.39 | 0.00 |
| **TOTAL** | | **60** | **24** | **6397.67** | **0.00** |
| | | **84 Tanks** | | | **0.00** |

***Ayacut area- Potential command area (Source: PWD, Govt of Puducherry, 2019)**

From table-1, it is observed that tanks had prevailed as one of the most important sources of irrigation in Puducherry. Altogether, there were 60 system and 24 non-system tanks which irrigated a command area of 6397.67 hectares. Of the total command area, system tanks occupied 87 per cent of the total ayacut area (5612.47 ha) whereas rest of the ayacut area (785.2 ha) was irrigated by the non system tanks in a cascading pattern.

This study completely relies on secondary data and hence the particulars such as the area irrigated by sources such as tanks, canals, groundwater and other sources were obtained for a period of 60 years (1962 to 2021) since the data is available for this period. To facilitate analysis, the available data was split by classifying the time period based on the rationale of the tank performance in the below (downstream) and above the outlet (upstream) regions of the tank areas from 1962 to 1992 (Period I) and 1992 to 2021 (Period II).

*Tools of Analysis :*

**1. Trend Analysis :** To study the share in contribution of tanks and other sources in irrigation and observe their performance over the periods I and II.

**2. Multiple Linear regression models :** To enumerate the temporal influence of the variables which influence the performance of tank, multiple linear regression models were adopted by framing two equations shown as follows:

**PTN=aRFP+bNAG+cATI+dNSA+Ui----1**
**PTN=aRFP+bNAG+cPOD+dNSA+Ui---2**

Where,
**PTN**-Performance of Tanks (percentage)

Performance of tank is calibrated as the average of both above and below the outlet regions of the tanks for both the periods I and II. The formula for calculating the performance is represented as follows :

**Tank performance = Performance above the Outlet+ Performance below the Outlet÷2**

Performance above the outlet (percentage) = Filled in capacity of the tanks/Actual capacity of the tanks x 100

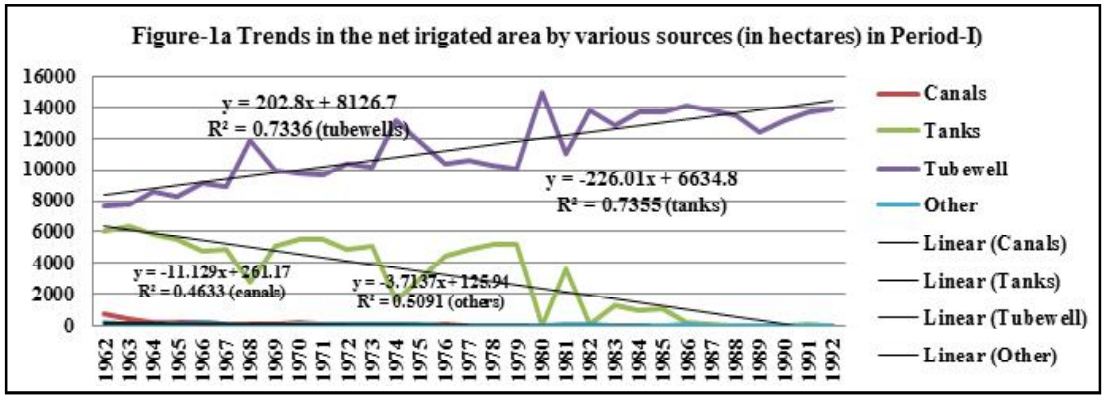
Performance below the outlet (percentage) = Total command area irrigated/Potential command area x 100

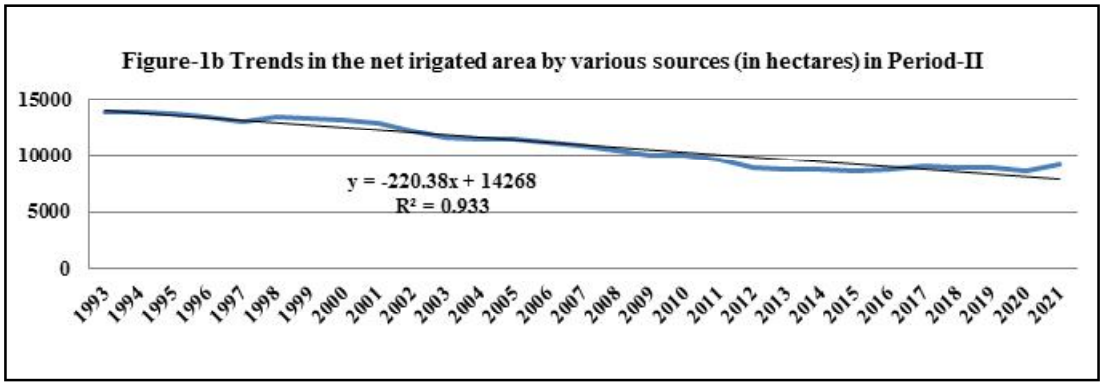
**ATI** (hectares)-Area under Tubewell Irrigation
**NAG** (hectares) – Area under non-Agricultural usage
**NSA** (hectares) - Net Sown Area
**PRF** (percentage) - Rainfall Performance (actual rainfall ÷ normal rainfall x 100)
**POD**-Population Density (Estimated population ÷ Area x 100)
$U_i$ - Error term

*Trend analysis on the Net area irrigated by Tanks and other sources :*

The following figures 1a and 1b present the trends in the net irrigated area by tanks and other sources for both the periods I and II. For Period II, as tubewell irrigation was only prevalent, the trend line was depicted for that particular source. Figures 2a and 2b present the share in the net area irrigated by various sources in Puducherry district over the period of time from 1962 to 2021 split into three decades in each period. It could be observed that the percentage share in contribution by tanks occupied the second highest position during the decade of 1962-63 to 1971-72. However, it had declined to a paltry share of merely three per cent in 1972-73 to 1981-82 and the same status quo persisted in the third decade of 1982-91 to 1991-92 also.

During the second period which started from 1992-93 to 2001-02, the tanks' share in the net irrigated area was very negligible and almost nil and in the subsequent decades of 2002-03 to 2011-12 and 2012-13 to 2021-22, it had completely vanished and tubewells accounted for a monopoly share of 100 per cent.





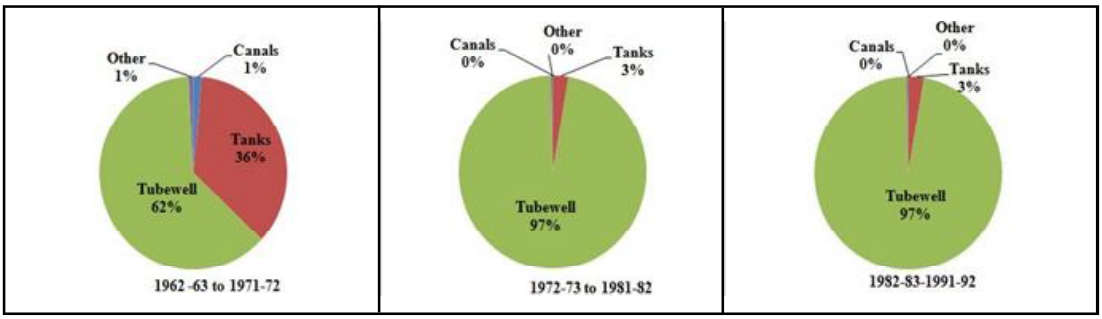




Figure-2a Percentage share in Irrigation sources for period-I in Puducherry region

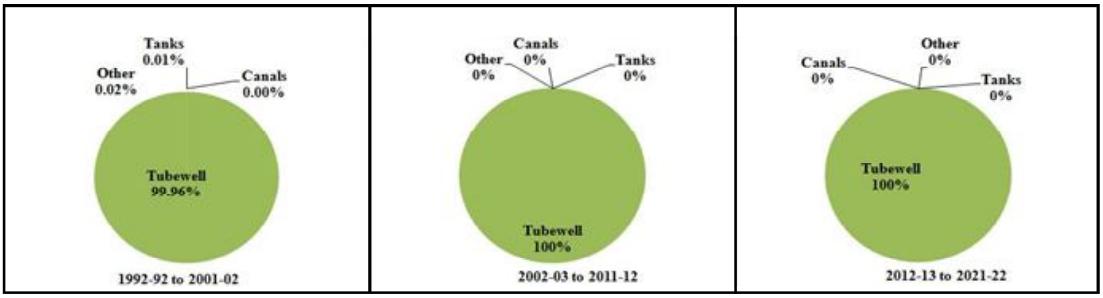



Figure-2b Percentage share in Irrigation sources for period-II in Puducherry region

*Above and Below the outlet performance of Tanks in Puducherry region :*

A performance evaluation of the irrigation tanks in Puducherry is attempted by classifying the tank performance in terms of above the outlet and below the outlet regions for the respective periods I and II and the results are shown as follows:-

Table-2. Performance analysis of the Tanks Vs Rainfall from 1962-2021 in

| Puducherry region | | | | |
|---|---|---|---|---|
| Years | Tank performance (%) Period-I | | | Rainfall performance (%) Period-I |
| | Above Outlet | Below Outlet | Average | |
| 1962-1971 | 91.5 | 81.4 | **86.5** | **103.19** |
| 1972-1981 | 82.5 | 58.9 | **70.7** | **97.65** |
| 1982-1991 | 88.7 | 5.9 | **47.3** | **100.94** |
| Years | **Period-II** | | | **Period-II** |
| | **Above Outlet** | **Below Outlet** | **Average** | |
| 1992-2001 | 90.0 | 0.0 | **45.0** | **100.88** |
| 2002-2011 | 87.6 | 0.0 | **43.8** | **95.96** |
| 2012-2021 | 73.6 | 0.0 | **36.8** | **101.38** |

Above the outlet which is basically an upstream characteristic region, refers to the main portion of the tank itself where the capacity filled is given more importance as the irrigation structures such as tank bund, weirs, sluice gates and supply channels of the tanks are situated[8]. Its performance did not follow any particular trend in period-I and was observed to be in accordance with the rainfall performance. The overall performance which is the average of both above and below outlet regions recorded a secular declining trend from period I to II following the same intra decadal behaviour.

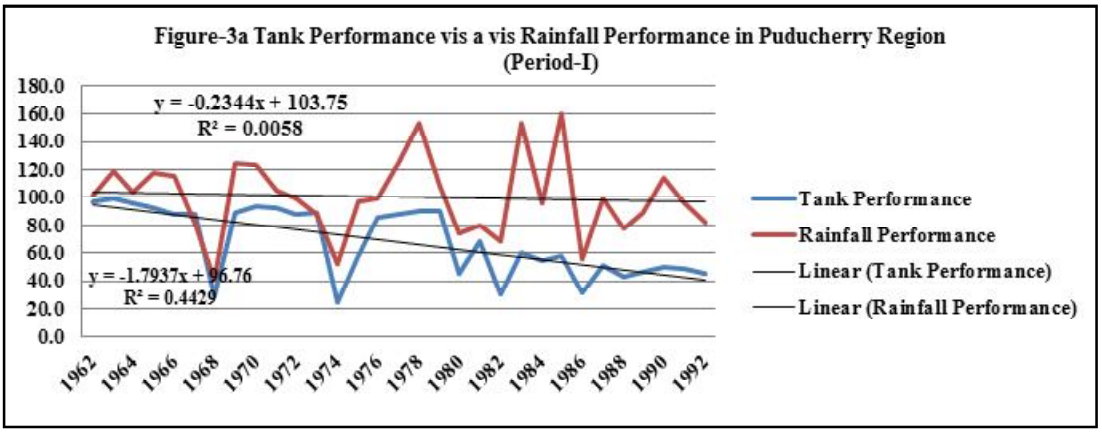
Below the outlet regions are basically the areas where the operation of distributing the irrigation water is done through the means of field channels by which the farmers can make the most use of it. It also refers to the region of the command area where wells are also present[11]. In the period I, the below outlet performance started with 81.4 per cent (refer section 2.1 for calculation) in the first decade and drastically fell to 58.9 per cent in the second decade (1972-81). The decade of 1982-91 witnessed a major slump in its performance recording a very low figure of 5.9 per cent. In the period II, the below outlet performance was completely absent which inferred that the area under tank irrigation was absolutely nil in all these three decades without any recovery.

In the both periods, it could be observed that the performance of rainfall has been found to fluctuating as represented by the data. In both the figures 3a and 3b, there are some points in the trend line where both the tank and rainfall performance seem to be align each other. The analysis of the period-I exhibited a declining performance of both rainfall and tank performance. However, there was a widening gap between the trend lines due to the higher negative coefficients of the tank performance which could be interpreted as the tank performance was influenced negatively by factors other than rainfall such as intensive proliferation of tubewells, decline

of net sown area, etc. A notable observation is that despite the increasing trend in rainfall performance, tank performance registered a negative trend in the absence of below the outlet performance in period-II and only above outlet performance was the attributing factor for this declining nature.

*Factors Influencing the performance of Tanks- Enumeration by multiple linear Regression model :*

The regression model is developed on the basis that the tank irrigated area formed an important portion of the agricultural area and its decline led to the reduction of the latter. The performance of tank irrigated area was dependent on factors such as Rainfall performance, Proportion of area under non-agriculture uses and the Proportion of Net Sown Area to Total Geographical Area. These explanatory variables were identified through the literature reviews[7] which were matched with the ground reality in the study area. Population density variable was included in period-II keeping in view of the rapid urbanization and in period-I instead of that variable, Proportion of Tubewell Area to Total Irrigated Area was considered as period-II had solid 100 per cent share of tubewell irrigation. The regression analysis was carried out for the two periods and the results are tabulated as follows:



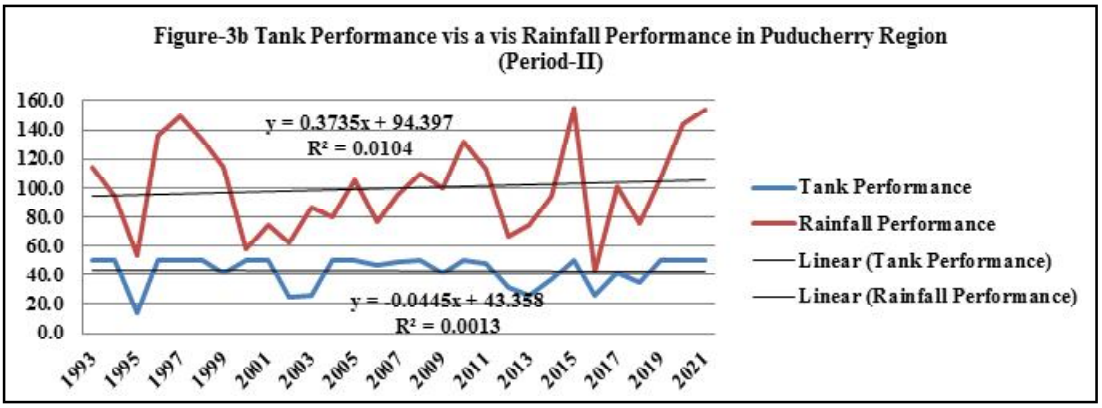



Table-3. Results of the multiple Regression Models-Factors influencing the performance of Tanks

| Period-I | | | Period-II | | |
|---|---|---|---|---|---|
| Variable | Coefficients | P-Value | Variable | Coefficients | P-Value |
| Intercept | -17.66 | 0.84 | Intercept | -109.81 | 0.26 |
| **Rainfall performance** | **0.26** | **0.0002*** ** | Rainfall performance | **0.22** | **0.0002*** ** |
| Non-Agricultural Area | 0.01 | 0.18 | Non-Agricultural Area | 1.85 | 0.15 |
| **Area Irrigated by Tubewell** | **-0.01** | **0.000*** ** | Population Density | 0.002 | 0.82 |
| **Net Sown Area** | **0.00** | **0.08*** | Net Sown Area | 1.27 | 0.20 |
| **R Square and Adjusted R Square** | **0.90** | **0.88** | **R Square and Adjusted R Square** | **0.48** | **0.40** |

***** Significant at 1 per cent level** *** Significant at 10 per cent level**

From the results, it could be observed that among the explanatory variables Rainfall Performance and Tubewell Area (to a level of 1 per cent) and Net Sown Area (to a level of 10 per cent) were found to influence the tank performance significantly in period-I. It showed that the intense proliferation of tubewells for irrigation resulted in the negative performance of the tanks' performance. In period II, as the role of direct irrigation by tanks had became nil they had to perform the passive role of aiding groundwater recharge wherein rainfall performance was found to influence the tanks' performance positively. In both periods I and II, the increase in rainfall performance had positively influenced tank performance. The results of the study seem to suggest the point that the increase in rainfall alone will not suffice and hence adequate measures should be advocated to improve the water supply distribution and enhancing storage capacity of the tanks[9]. Required measures also have to be done in exploring the untapped potential of the tanks.

The role by the tank irrigation systems in irrigation is time tested and is also a classical example of public goods with positive social benefit. By not realising the multiple use values that these systems offer, a significant loss is bound to the society as well as the state which should be accounted in future diligently. Hence restoring of these structures are the need of the hour which will reap multiple benefits in terms of increased revenue, enrichment of local flora and fauna, promote tourism and reduction of dependence on groundwater thus conserving energy and reducing carbon footprint thereby promoting sustainable livelihood amongst the local communities.

References :


1. Data on Groundwater details of Puducherry, Central Groundwater Board, Government of India, 2020.
2. Data on Irrigation sources (Net Area)-Economics and Statistics, Government of Puducherry, 2021.
3. Data on Irrigation-Ministry of Agriculture, Govt of India, 2022.
4. Historical details of Irrigation tanks in Puducherry-Gazette of Puducherry, 1982.
5. Indiastat.com- Details of irrigation, 2023.
6. Kundzewicz, Z. W., L. J. Mata, N. W. Arnell, P. Döll, P. Kabat, B. Jiménez, K. A. Miller, T. Oki, Z. Sen, and Shiklomanov (2007) Freshwater resources and their management. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (ed. by M.L. Parry, O.F. Canziani, J. P. Palutikof, P. J. van der Linden & C. E. Hanson), 173–210. Cambridge University Press, Cambridge, UK.
7. Kumar, D. S., and K. Palanisami, (2020). *Agricultural Economics Research Review, 33*(2): 161-176.
8. Kuzhalarasan, T., P. N. Kumar, R. Venkataraman, S. Ravichandran, and K. Dhanasekaran (2022). *Asian Journal of Agricultural Extension, Economics & Sociology, 40*(12): 146-156.
9. Narayanamoorthy, A. (2022). Tank Irrigation in India: Why Is It Declining? In: The Irrigation Future of India. Global Issues in Water Policy, vol 29. Springer, Cham. https://doi.org/10.1007/978-3-030-89613-3_9
10. Oppen, M.V. and K.V. Subba Rao, (1987). *Tank irrigation in semi-arid tropical India economic evaluation and alternatives for improvement*. International crops research institute for the semi-arid tropics.
11. Palanisami, K., and K. W. Easter, (1984). *Indian Journal of Agricultural Economics*, *39*(902-2018-2262): 214-223.
12. Sathiyamoorthy, S., K. Kajisa, and T. Sakurai (2023). Performance of community based tank irrigation system and its determinants: Evidence from Tamil Nadu, India. *The Developing Economies*.
13. State Groundwater Unit, Department. of Agriculture, Govt of Puducherry, 2020.
14. Water Policy of Government of Puducherry, 2017.