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*Research Article*

# An Analytical Study for Assessing Water Productivity in Pre- and Post-Rehabilitation Period of Rural Tank System

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Water productivity is the ratio of the amount of water applied to the field in cubic meter and the net return gained in rupees. Increased water productivity leads to an improved occupational value for the farmers. Tank rehabilitation allows for additional water to be added to an irrigation tank, increasing water production. Hence, this study is carried out to assess the net return for a unit of water used in the pre- and post-rehabilitated period of rural tank "Pelasur" in Thiruvannamalai district of Tamil Nadu. The findings reveal that during the post-tank restoration period, a higher percentage of tail reach and marginal farmers benefited. Farmers who irrigate solely with tank water have higher water production since their income per $m^3$ is higher. The significant impact of tank repair was demonstrated using the Statistical Package for Social Science (SPSS-21.0).

## 1. Introduction

The worldwide population, which arrived at 6 billion in 1999 and is anticipated to prevail at 7.8 billion in 2025, is squeezing the limited inexhaustible water assets because of the interest in nourishment and other water-subordinate merchandise and ventures. Inundated farming, which represents 72% of worldwide and 90% of creating nations' water withdrawal, should expand its profitability to alleviate the developing water emergency [1]. Variety in crop water efficiency is not exclusively a component of the environment [2]. Crop water efficiency is the measure of water required per unit of yield and it is a crucial limit to evaluate the presentation of inundated and rainfed farming. More crop per drop [3–6] is a contemporary quote around the world. Water productivity expresses the value or benefits derived from the use of water [7]. It is evaluated that increments of 30% and 60% in water efficiency from rainfed and flooded agribusiness individually will be required to satisfy the needs for nourishment security [8]. Water productivity releases stress on water resources [9]. Improvement in water productivity involves water conservation and neighborhood water saving in tanks and lakes, applying minor water system or setback water system, changing establishing period, and adjusting culturing practices to reduce evaporation [10–18]. Water harvesting frameworks assist with increasing water efficiency and might be characterized as "strategies for gathering and focusing different types of spill over (roof, overflow, overland stream, stream, and so on) from different sources (precipitation, dew, and so forth) and for different purposes" [19]. Generally, methods for expanding water usefulness, particularly when it is low, require practically no additional water [20, 21]. The perception of water productivity is different in different fields and at different research scales [5, 22–27]. It will change significantly as per the particular conditions under which the yield is developed and (redundancy, so can be removed) contrasts from the area of land, wellsprings of water utilized, and kind of farmers [12, 28]. Water productivity development can vary from 70% to 100% in rainfed classifications and from 15% to 30% in irrigated structures using resource-saving agricultural skills that augment soil productiveness and moderate water loss

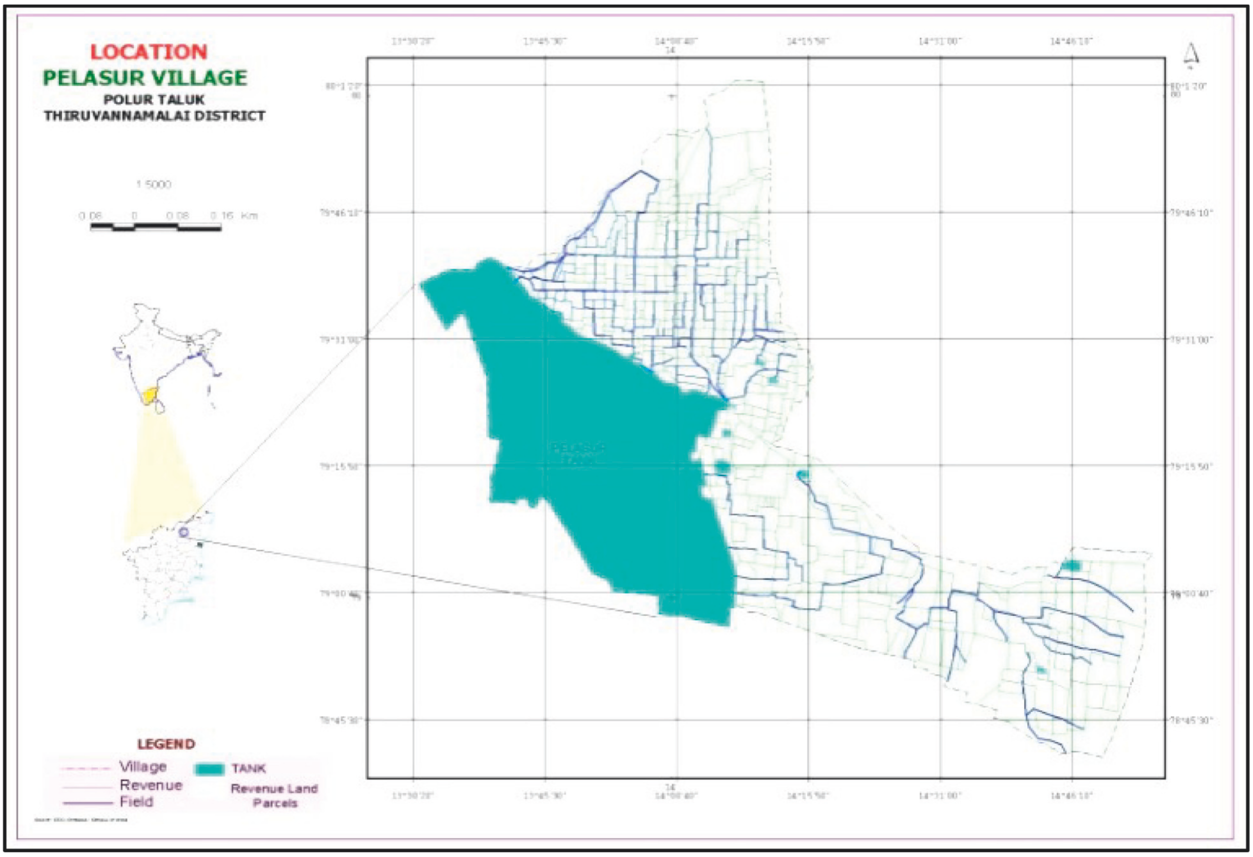


Figure 1: Location map of Pelasur village.

[29]. Change in cropping practice from seasonal to annual crops leads to an increase in income for farmers [30–33]. The study area is selected in such a way that the tank has been recently rehabilitated (i.e. in the year 2016–2017). Since the study focuses on pre- and post-rehabilitation work, “Pelasur” a rural tank in Thiruvannamalai district, the southern part of India appropriately matches the objectives. Moreover, any impact study after rehabilitation work should be done within 3 years of implementation. Hence the impact of the tank rehabilitation study was carried out in the year 2020–2021. Simultaneously detailed research on multiple use of irrigation tank was also carried out in the same study area since the tank involves various agricultural- and nonagricultural-related activities. Water productivity is eventually increased with respect to income incurred in the command area.

## 2. Methodology

*2.1. Study Area Description.* Pelasur village is located in Polurtaluk, Chetpet block of Thiruvannamalai district in Tamil Nadu at 12°27′40″ North Latitude and 79°11′30″ East Longitude. It is the main village of Panchayat having one hamlet called Malaimedu. The Panchayat has Villapakkam, Anaivadi, Koralpakkam, and Kambattu as its boundary in the East, West, North, and South, respectively. The village extent is 1308 ha with 495 households. Pelasur tank is a nonsystem tank located near Cheyyar river basin. Its free catchment area is 11.909 $km^2$, the intercepted catchment is 82.492 $km^2$, and the combined catchment is 94.401 $km^2$. The total runoff to the tank is 4.94 $Mm^3$ and the number of fillings is 1. Its tank capacity is 2.59 $Mm^3$ and its registered ayacut is 214 ha. It has 4 sluices and the length of field channels is 4.5 km. The study area map is shown in Figure 1.

*2.2. Landholding Classification of Pelasur Village.* Classification of land holding size is adopted in the present study by referring “Alternative approaches to Tank Rehabilitation and Management-An Experiment-Phase I & II” a Baseline survey report, Centre for Water Resources, Anna University, Chennai, India. It is a Ford Foundation sponsored project. An article published in Hindu news magazine during the year 2016 titled “Farming in a fragmented landscape” revealed that land available for farming in Tamil Nadu is going down year by year. There seems no end to fragmentation. The average size of landholding has dropped from 1.45 ha in 1970–1971 to 0.80 ha in 2010–2011, according to the latest report of the Department of Evaluation and Applied Research (DEAR) on the State’s economic appraisal for the period 2011–2012 to 2013–2014. According to the report, the average size of landholding in the state is even smaller than the national average of 1.16 ha, based on the recent Agricultural Census (2010–2011). According to the report, a number of reasons, including increased industry, growing urbanization, and real estate and

Table 1: Landholding classification in Pelasur village.

| S.No. | Type of farmers | Landholding size | Number of households | Percentage of households |
|---|---|---|---|---|
| 1 | Marginal farmers | <1 ha | 50 | 10.13 |
| 2 | Small | 1 2 ha | 74 | 14.94 |
| 3 | Medium farmers | >2 ha | 287 | 57.97 |
| 4 | Landless | <50 cents | 84 | 16.96 |
| | Total | | 495 | 100.00 |

infrastructure development, have diverted farmland to nonfarm use, resulting in a reduction in the area under cultivation. Marginal and small farmers owning up to 2 ha account for 92% of the total number of landholdings. The medium (2–10 ha) and big (over 10 ha) farmers possess 8%. As for the area, the share of small and marginal farmers is 61%, whereas the medium and big farmers own 39%. While a marginal farmer holds, on average, 0.37 ha, a big farmer owns 20.59 ha. Since the land fragmentation in Tamil Nadu is high, the classification adopted in this research article is justified by the above-stated reference.

For study area named "Pelasur village" is presented in Table 1. It is very clear from the table that farmers owning land more than 2 ha are high in this village when compared with marginal (<1 ha) small(1-2 ha), and above 2 ha medium farmers (Agriculture Department policy note, Government of Tamil Nadu, 2020). Respondents owning less than 50 cents are also considered landless since the income incurred from this size of land alone is not sufficient economically for a household to survive. They have to involve in some other occupation to earn additional income. Only 16.96% of villagers are coming under the landless category. Most landless are involved in agricultural labor livelihood activities for their survival. The command map of Pelasur village is shown in Figure 2.

*2.3. Reach-Wise Landholding Size.* Table 2 presents the reach-wise landholding size of the respondents. The majority of them (40.2%) possess the land in the tail reach. Reasons cited by the respondents owning land in tail reach are mainly based on the soil quality parameters. Previously, soil salinity was common in the tail reach, and landowners sold their properties for a low price. Some of their fellow farmers bought a vast plot of land for a modest price. Following the purchase, they treated the soil with simple procedures such as combining sugar factory debris to make it more suited for sugarcane crop cultivation. Farmers were dissatisfied with traditional harvesting procedures, particularly at tail reach, due to a lack of resources and difficulties transporting their agricultural supplies and machinery. While looking at the geological conditions, the head and middle reaches are classified as hard rock area and the tail reach land comprises soft clay to the desired depth. This leads to good groundwater recharge and the water table remains high even during summer, which instigated the farmers to purchase land in the tail reach of the tank command [10, 34–36]. The head and middle reach each account for 26.5% of the sample responses. Only 6.9% of respondents, or 6.9%, cultivate their dry land exclusively using well water, which is designated as garden land. These garden land cultivators were chosen specifically to investigate the influence of tank rehabilitation in several aspects. Table 2 shows the size of Pelasur respondents' landholdings by reach.

While looking at the classification of the respondents based on their landholding sizes, it is very clear from Table 2 that 50% of them fall under a small category whose landholding size is greater than 2 ha. Interesting information noticed during data collection is that most of the small category farmers own farm machinery for weeding, harvesting, etc [37]. Respondents revealed two reasons viz., easy to operate machines in the field due to less land fragmentation, and financially they can buy machines by spending huge amounts [38]. Followed by this category, 27.5% are classified as medium farmers whose landholding size is between 1 and 2 ha.

Water productivity is calculated as follows:

$$W_p = \frac{G_i}{[AD_i(N_{it} + N_{iw})]}, \tag{1}$$

where $W_p$ is the water productivity as shown in equation (1) in Rs/m$^3$; $G_i$ is the gross income in Rupees; $A$ is the area cultivated in ha; $D_i$ is a depth of irrigation in $m$; $N_{it}$ is the number of irrigation using tank water; and $N_{iw}$ is the number of irrigation using well water [39]. Total water productivity is consisting of irrigation and effective rainfall [40].

Since this review focuses on tank consumers both pre- and post-restoration, relative investigation in SPSS was endeavored to utilize paired sample $t$-test, [41]. The paired samples $t$-test compares the means of two variables [42–44].

$$t = \frac{\sum d}{\sqrt{n\left(\sum d^2\right) - \left(\sum d\right)^2/n - 1}}, \tag{2}$$

where $d$ is the difference per paired value and $n$ is the number of samples.

Field appraisal of water system framework execution and use of factual strategies for water conveyance execution assessment relies upon quantitative information concerning water conveyance [45].

## 3. Result and Analysis

*3.1. Season-Wise Total Area Cultivated before and after Rehabilitation by Pelasur Respondents.* Paired sample $t$-test is a test that depends on the contrasts between the single pair that is once removed from the former. The algorithm is shown in Equation (2). For a paired sample $t$-test, this distinction is documented as $d$. The equation of the paired

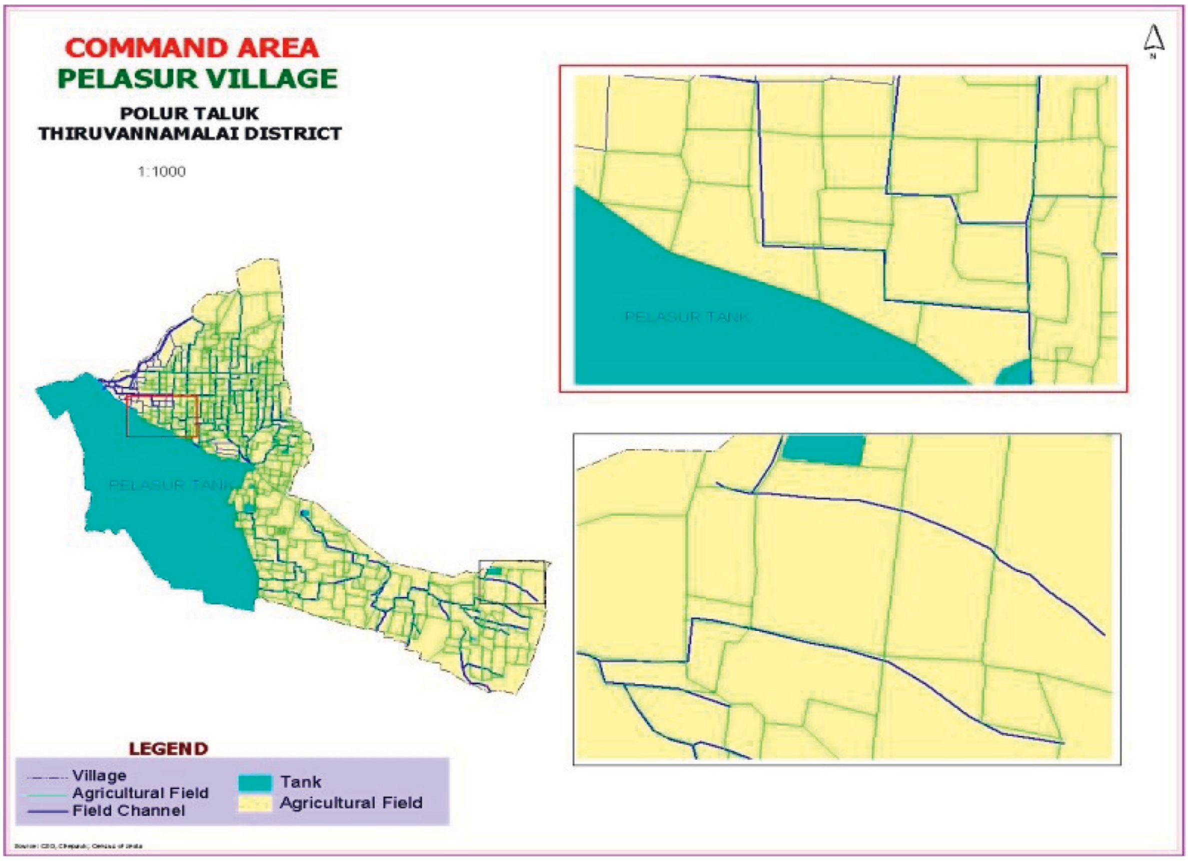


Figure 2: Command map of Pelasur village.

Table 2: Size of Pelasur respondents' landholdings by reach.

| S. No. | Reach | Type of farmers | | | | |
|---|---|---|---|---|---|---|
| | | Marginal | Small | Medium | Total | % of total respondents |
| 1 | Head | 6 | 5 | 16 | 27 | 26.5 |
| 2 | Middle | 6 | 6 | 15 | 27 | 26.5 |
| 3 | Tail | 9 | 13 | 19 | 41 | 40.2 |
| 4 | Garden land | 2 | 4 | 1 | 17 | 6.9 |
| Total | | 23 | 28 | 51 | 102 | 100.0 |
| Percentage of total | | 22.6 | 27.5 | 50.0 | 100.0 | |

sample $t$-test is characterized as the amount of the distinctions of each pair isolated by the square foundation of $n$ times the amount of the distinctions squared less the amount of the squared contrasts, by and large $n - 1$. The determined $t$ esteem is then contrasted with the basic $t$ esteem with $\mathrm{df} = n - 1$ from the $t$ distribution table for a selected certainty level. In case the determined $t$ value is more noteworthy than the basic $t$ value, then, at that point, we reject the null hypothesis and the reason that the means are altogether different [46].

The result presented in Table 3 supports the outcome that a significant positive relationship exists between the whole area cultivated and tank restoration ($r = 0.898$, $p < 0.05$). Consequently, the extended total area cultivated revealed in Table 4 and Figure 3 is related to tank restoration.

Table 5 shows the perceptions identified with total area cultivated prior to and then afterward tank recovery, which was haphazardly relegated to ensure that responses are because of the tank restoration. Paired sample $t$-test procedure was utilized to test the null hypothesis and contrast the outcomes to demonstrate that there is a distinction between total area extended cultivation prior to and then afterward tank recovery. The examination yield uncovers that there is a contrast between the total cultivated area by the respondents in pre- and post-restoration periods. Tank rehabilitation essentially further develops the area cultivated.

*3.2. Reach-Wise Water Productivity.* In terms of reach-wise water productivity, Table S1 reveals that tail reach has the largest percentage of enhanced water productivity. The

Table 3: Paired samples correlations for total area cultivated before and after rehabilitation.

| | Description | Number of samples | Correlation | Significance |
|---|---|---|---|---|
| Pair 1 | Total cultivable area before rehabilitation and total cultivable area after rehabilitation | 102 | 0.898 | 0.000 |

Table 4: Season-wise total area cultivated before and after rehabilitation.

| S. No. | Description | Area cultivated before rehabilitation in the year (2015–2016) (ha) | Area cultivated after rehabilitation in the year (2020–2021) (ha) | Increase in area cultivated (ha) |
|---|---|---|---|---|
| 1 | Total cultivated area | 191.04 | 235.32 | 44.28 |
| 2 | First season | 82.16 | 79.96 | −2.20 |
| 3 | Second season | 47.66 | 36.09 | −11.57 |
| 4 | Third season | 4.70 | 13.18 | 8.49 |
| 5 | Annual crop | 56.52 | 106.08 | 49.56 |

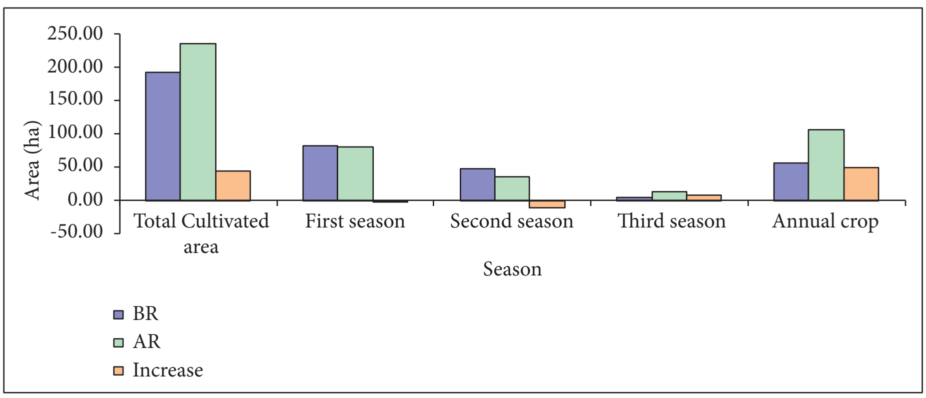


Figure 3: Season-wise total area cultivated before and after rehabilitation.

Table 5: Paired samples $t$-test for total area cultivated before and after rehabilitation.

| Description | | Paired differences | | | | | $t$ | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. deviation | Std. error mean | 95% confidence interval of difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | Total cultivable area before rehabilitation and total cultivable area after rehabilitation | −0.339 | 1.197 | 0.118 | −0.575 | −0.104 | −2.866 | 101 | 0.005 |

change in cropping pattern from rice to sugarcane by tail reach farmers in the post-rehabilitation phase is the cause for this improved productivity.

For paddy, 90 watering are necessary at a depth of 1 cm irrigation/ha/season and the total amount of water required is 9000 $m^3$ ($10000 \times 0.01 \times 90$). But the net income acquired from 75 bags/ha is approximately Rs. 37,500/ha (Rs. 500/bag). Hence, water productivity is estimated at Rs. 4.16/ha. In the case of sugarcane, 40 to 44 watering is necessary for 10 months at a depth of 6 cm. Hence, the total amount of water required per ha is 24000 $m^3$ ($10000 \times 0.06 \times 40$). The net income received by farmers is Rs. 1,02,500/ha (Rs. 1025/ton). Therefore, water productivity is estimated at Rs. 4.27/ha. This demonstrates that sugarcane has higher water productivity than paddy. As a result of the shift in cropping patterns from rice to sugarcane, the tail reach farmers have benefited the most from the rehabilitation. The aforementioned argument is supported by Table S2.

Another intriguing explanation, according to the tail end replies, is that they may get tank water until the tail reach throughout the post-rehabilitation time using the lined channel. Previously, tail reach farmers relied solely on well water or the use of well and tank water. In addition, the alternate wet and dry conditions of their fields in the tail reach result in a higher production per hectare [47–52]. While looking into the pre- and post-rehabilitation periods, there is no significant change in water productivity in head reaches owing to the continuous supply of water to the fields through seepage from the tank. Water logging leads to salinity problems thereby there is a reduction in the number of bags produced per ha [53]. Since most of the marginal farmers are tank-dependent, they get benefited from increased water productivity in the post-rehabilitated period. Both in the middle and tail reaches, considerable changes in water productivity show the positive influence of the tank restoration in Pelasur village.

A one-way ANOVA is a category of statistical test that associates the variance in the group means within a sample though considering only one independent variable or factor [54–56]. It is a hypothesis-based test, significant in that it aims to calculate multiple conjointly limited theories about our data. Duncan's this MCP looks at all pairwise assessments among $k$ means, but the inaccuracy rate is neither on an investigate-wise nor on a contrast-wise basis [57]. The error rate is centered on the number of phases apart, $r$, the two means are when they are ordered. The probability of incorrectly declining the equality of two population means when the sample means are $r$ steps apart is $1-(1-\alpha)^{r-1}$.

Different alphabet among age groups in years denotes significance at a 5% level using Duncan multiple range test (DMRT).

Since $P$-value is less than 0.05, the null hypothesis is rejected at a 5% level of significance concerning the factor of the first season and annual post-rehabilitation water productivity. Hence there is a significant difference in water productivity with sources of water used for irrigation [58]. Based on Duncan's multiple related tests (DMRT), there is a significant difference in water productivity in the tail and other reach farmers shown in Table S2.

*3.3. Water Sources Wise Water Productivity.* As per the data presented in Table S3, farmers using tank water alone are getting benefited widely, since the increase in tank storage helps them to go in for two seasons of paddy cultivation. With the support of nearby well owners, several of the respondents were able to cultivate a third season. Because of the rising water table, adjacent well-owning farmers were able to share their well water with neighboring fields, which was previously impossible. Few well-owning head reach farmers (those lands located nearer to the tank) revealed that they used only tank water for all three seasons after the tank rehabilitation owing to the increased tank storage. Farmers owning land under tank irrigation systems, particularly those who do not have wells, are the poorest among the irrigators [59]. According to the farmers, there is no gain in using diesel engines for pumping except for straw and a few bags of paddy for their use and very low profit in sugarcane crops. Since they are not aware of any other occupation other than agriculture and do not want to leave their land fallow, farmers are continuing agricultural activities with the help of diesel pumpsets [60]. Since the Government of Tamil Nadu declared free current for agriculture, there will not be any extra input charges for farmers having electric motors for irrigation. Farmers pumping water using electric motor could earn a net amount of Rs. 17,000/ha/season from paddy and Rs. 77,500/ha/year from sugarcane cultivation.

Farmers use 3 hp and 5 hp pumpsets for irrigating paddy and sugarcane crops ,respectively. For 1 ha of land, it is necessary to irrigate 6 hours for the paddy crop and 15 hours for sugarcane crops with 3 hp motor. With 5 hp motor, the paddy crop has to be irrigated for 4½ hours and sugarcane for 12 hours. A standard company motor of 1 hp can pump 1 lps, hence 3, 5, and 7.5 hp will pump 10,800, 18,000, and 25,200 l/h, respectively. The above statements may vary with respect to seasonal water surplus and scarcity. Diesel pump sets the need of heavy motor to suck water, hence 7.5 hp is used for irrigating crops.

As per Table S4, Since $P$-value is less than 0.01, the null hypothesis is rejected at a 1% level of significance about the factor of the first season before and after rehabilitation, second season, and annual post-rehabilitation water productivity. Hence there is a significant difference among sources of water used for irrigation. Based on DMRT, there is a significant difference in water productivity between tank and well water users in the second season and annual crop cultivation (Table S4).

*3.4. Landholding Size-Wise Water Productivity.* Table S5 depicts those marginal farmers are the highly benefited group with an increased percentage of water productivity after the tank rehabilitation. Before rehabilitation, both medium and small farmer categories have achieved equal water productivity and the marginal farmers were the least. But this scenario has completely changed in the post-rehabilitated period because the tank water fulfilled the need for irrigating fragmented lands owned by marginal farmers. Uninterrupted supply of water to the fields helped in an increased number of bags/ha (i.e. from 50 to 60 bags) helping the farmers to boost their household income [61]. Furthermore, the majority of marginal farmers do not possess wells, and respondents stated that before rehabilitation, they were only able to grow for one season. They were allowed to return for two seasons after recuperation (Table S6). Tank water is sufficient till the flowering stage of the second season and during the maturity stage, some 4 to 5 watering will be given to the crops with the help of adjacent field wells and paid back either cash or kind. The water productivity was thus increased for the marginal farmers during the post-rehabilitation period which is a positive impact of the tank rehabilitation.

Since $P$-value is less than 0.05, the null hypothesis is rejected at a 5% level of significance with regard to the factor of the second season and annual before rehabilitation water productivity as shown in Table S6. Hence there is a significant difference among sources of water used for irrigation [62]. Based on DMRT, there is a significant difference in water productivity between marginal and medium farmers in the second season post-rehabilitation period and all categories for an annual crop before rehabilitation.

Subsequently if $P$-value is lesser than 0.01, the null hypothesis is excluded at a 1% level of significance and there is a significant difference in annual crop water productivity during the pre- and post-rehabilitation period (Table S7).

The Wilcoxon test remains a nonparametric statistical test shown in Table S7 associates two paired groups and approaches in two forms—the Rank Sum test and the Signed-Rank test [63]. The objective of the test is to define if two or more sets of pairs are dissimilar from one another in a statistically significant manner using equation (3) [64].

$$w = \sum_{i=1}^{N_r} \left[ \mathrm{sgn}\left(x_{2,i} - x_1\right).R_i \right], \tag{3}$$

where $W$ = test statistics, $N_r$ = sample size, excluding pairs, where $x_1 = x_2$, Sgn = sign function, $x_{1,i}$, $x_{2,i}$ = corresponding ranked pairs from two distributions, $R_i$ = rank $i$.

A Wilcoxon signed-rank test (Table S8) showed that there is a significant difference ($Z = 6.444$, $P$-value >0.01) between water productivity before and after tank rehabilitation in annual crop cultivation at a 1% level of significance. But in the second and third seasons, there is a significant difference ($Z = 2.157$, $P$-value >0.05) at a 5% level of significance. The first season result shows that there is no change in water productivity ($Z = 0.701$, $P$-value = 0.089).

A Kruskal–Wallis test (Table S9 and Figures S1–S3) indicated that there is a significant difference in water productivity among head, middle, and tail reach farmers at a 5% level of significance in the third season during post-rehabilitation. The highest mean rank (55.78) proves that the highest water productivity is achieved by head reach farmers in third season paddy cultivation [65].

Correlation analysis through equation (4) in the study is a statistical method used to find out the strength of the linear relationship among two variables and calculate their relationship. Simply place-correlation analysis estimates the status of change in one variable with respect to other [66].

$$r = \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{[N\sum x^2 - (\sum x)^2][N\sum y^2 - (\sum y)^2]}}, \tag{4}$$

where $N$ is the no. of pairs of scores, $\sum xy$ is the sum of products of paired scores, $\sum x$ is the sum of $x$ scores, $\sum y$ is the sum of $y$ scores, $\sum x^2$ is the sum of $x$ squared scores, $\sum y^2$ is the sum of $y$ squared scores.

Table S10 elucidates that the correlation coefficient among the first season before and after rehabilitation is 0.518, which indicates a 51.8% positive relationship between first season water productivity before and after rehabilitation and is significant at a 1% level. The correlation coefficient between annual crop water productivity before and after rehabilitation is 0.561, which indicates 56.1% positive relationships at a 1% level of significance. There is the least correlation in the second season and no correlation in the third season water productivity.

For one-way recurrent measures study of variance by ranks, the Friedman test using equation (5) is used. It is similar to the Kruskal–Wallis one-way analysis of variance by ranks in its use of ranks [67]. The Friedman test is widely supported by many statistical software packages and the results are shown [68].

$$\mathrm{QR} = \frac{12}{Nk(k+1)} \sum_{i=1}^{k} R_i^2 - 3N(k-1), \tag{5}$$

where $k$ = number of comparison groups, $n$ = total number of samples, $R$ = sum of the ranks in the group.

Subsequently, if $P$-value is smaller than 0.01, rejecting the null hypothesis at a 1% level of significance. Henceforth decide on a substantial modification among mean productivity of water on seasonal crop cultivation. According to the earlier studies, in rainfed areas rehabilitating tank systems are mandatory to attain food security and minimize water constraints [69–71]. With respect to mean rank, annual crop like sugarcane (5.66) gives more returns in terms of money for 1 $m^3$ of water used followed by second season paddy cultivation (4.98) and first season paddy cultivation in the post-rehabilitation period (Table S11).

## 4. Conclusions

The predominant focus of tank rehabilitation is to augment the efficacy per unit area, per unit time, and unit of water prevalent focus of tank recovery. Tank upgrades are needed to limit tank water adversities and to support subsurface water development into the tank from the upstream region. After tank rehabilitation, productivity has been increased both in farming and off-farming activities. Reach-wise analysis shows that tail reach farmers are benefited from a high income per $m^3$ of water used and the head reach farmers are acquiring the least water productivity. Farmers using only tank water gives higher water productivity with the help of the lined channel, where they could receive tank water till tail reach during the post-rehabilitation period. Marginal farmers are the highly benefited group with an increased percentage of water productivity after the tank rehabilitation owing to an uninterrupted supply of water to the fields. The impact of tank rehabilitation should show a positive impact on tail reach and marginal farmers and hence the objective of the water storage structures rehabilitation project has been attained. Since collecting runoff in irrigation tanks, then again, considers concurrent water system and recharging of groundwater is essential, it is mandatory to revive the existing storage structures for sustainable agriculture.

## Data Availability

The data used to support the findings are included in the article.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

## Acknowledgments

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## Supplementary Materials

Tables S1 to S11 and Figures S1 to S3 mentioned in the main article are presented in the Supplementary file. (*Supplementary Materials*)

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