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Impact of desilting of irrigation tanks on productivity of crop yield and profitability of farm income

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Irrigation tanks are one of the major water and common property resources in Southern Peninsular India. Declination of irrigation tanks threatens the agriculture productivity and water availability in the South and Southeast Asia especially in southern Peninsular India and Sri Lanka. The storage capacity of the tank has been decreased due to the factors such as siltation of supply channels, tank bed and irrigation courses. In order to reduce the factors causing decrease in storage capacity, desilting of tank has been chosen as rehabilitation work. Desilting of tank beds and supply channels may yield the expected benefit of crop productivity and farmer income. The study has evaluated the benefits and financial structure of the desilting of irrigation tanks project in the villages Ponpadi, district Thiruvallur in Tamil Nadu where a project under Public Welfare Department in Tamilnadu. Productivity indicator of yield has increased due to restoration and is from 4800 to 5400 in first season and 4425 to 5400 in second season. Profitability indicator of benefit cost ratio is increased from 0.64 to 1.04 in first season and from 1.13 to 1.31 in second season. The restoration project aims to bring about increase in agricultural production through improving groundwater recharge and consequently to improve the economic, social and environmental wellbeing of the rural population.

Key words: Tank irrigation, agriculture, crop productivity, desiltation, irrigation tanks.

INTRODUCTION

One of the most ingenious technologies appropriate to the peninsular India has been the creation of tank irrigation systems. Ingenious because, the tanks capture the runoff resulting from the unpredictable monsoon rains having a wide diversity of distribution (Shanmugam, 2001). Irrigation tanks have been serving both as flood moderators in times of heavy rainfall and as drought mitigators in times of long dry spell (Vasimalai, 2006).

The improved productivity of wells due to groundwater recharge is by far the most valuable benefit to farmers associated with tanks (Shah and Raju, 2002). Tank irrigation contributes significantly to agricultural production in the parts of South and Southeast Asia. Especially in South India and Sri Lanka, tank irrigation has a long history and many currently used tanks were constructed in the past centuries. Irrigation tanks account

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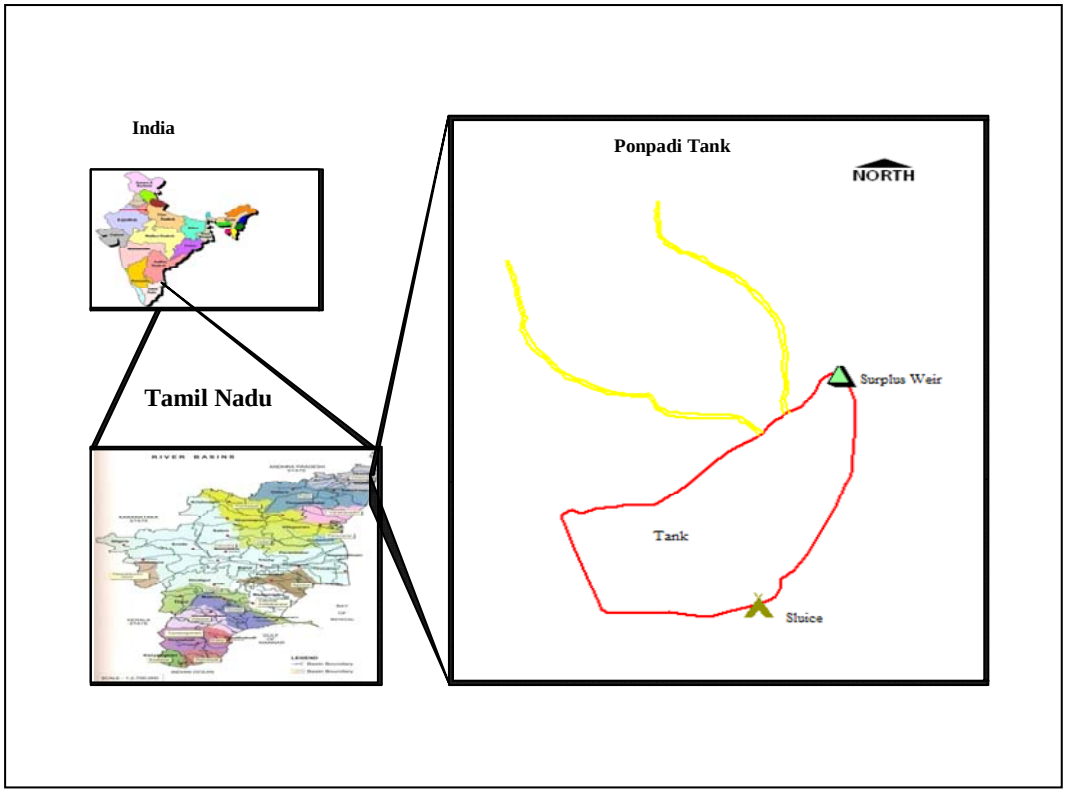

Figure 1. Map of a study village.

for over 30% of the total irrigated area in South India and over 40% of the irrigated rice in Sri Lanka (Palanisami and Flinn, 1988). In India, the largest concentration of tanks are found in the three southern states of Andhra Pradesh, Karnataka and Tamil Nadu and the union territory of Pondicherry, which account for nearly 60% of India's tank-irrigated area (Vaidyanathan, 2001). Over the centuries, locally built water storage systems (e.g, tanks in South India, Johads in Rajasthan), have acted as insulation against droughts, helped in recharging groundwater, provided crucial irrigation for crop production, functioned as a source of multiple uses for the village community and played a role in the maintenance of a good natural environment (Raju and Shah, 2000). Tanks involve a combination of land and water resources that can be used for brick making, trees and grazing. In water-scarce regions, it is therefore not surprising that tanks are used for a variety of productive and domestic uses (Palanisami and Meinzen-Dick, 2001).

Encroachments, privatization and government appropriation of the tanks have been the main outcomes of failures of the local authority to enforce the institutional arrangement under the common property resource management (Vaidyanathan and Sivasubramaniyan, 2004). Due to rainfall uncertainties and lack of community involvement in tank management and maintenance inadequate and unreliable water supply to the tank, the performance has declined over the years (Sakthivadivel, 2005). In addition, there are problems such as poorly maintained structures (bund, surplus weirs) above the outlet. Catchment is mismanaged and forest land adjacent to the catchment has already been converted to human settlement by the Government. There are severe encroachments in the tank foreshore. Siltation of tank beds has reduced their water storage capacities (Palanisami, 2006). The accumulation of silt in the tank basin/bed has reduced the water-holding capacity of the tanks; the construction of dams/reservoirs in the upper watershed or catchment area has prevented the water supplies from reaching downstream tanks (Sivasubramanian, 2006); tank renovation and rejuvenation with peoples' contribution and looked upon as cost effective, equitable and powerful tool to alleviate rural poverty. Restoring the physical conditions of tanks through rehabilitation and modernizations is of course the necessary condition for doing this (Sakthivadivel and Gomathinayagam, 2004).

The present study attempts to examine the impact of partial desilting of irrigation tanks through a comparative analysis between, "before restoration" and "after restoration" of the selected study tanks.

MATERIALS AND METHODS

Ponpadi tank is situated in Thiruthani block of Thiruvallur district in Tamil Nadu, India as shown in Figure 1. The latitude and longitude

Table 1. Hydrology and hydraulic particulars of the tank.

S/N	Tank components	Quantity
1	Tank bund level	97.10 m
2	Full tank level	95.20 m
3	Maximum water level	95.60 m
4	Command area	145.35 ha
5	Crop	Paddy, sugarcane
6	Number of sluices	1

of the tank are 13°13' 58'' N and 79°35' 59'' E, respectively with an altitude of 99 m above m.s.l. It is situated about 0.6 km from Ponpadi village. Ponpadi tank is rainfed and a non-system tank has only one sluice, receives drainage from its free catchment of 10.35 km^2. The catchment is classified as good one. Irrigation depends on the tank as well as bore and open wells. The command area for the Ponpadi tank is about 145.35 ha. The works included desilting of the tanks and tank bund strengthening was carried out under the Public Works Department (PWD). The total expenditure incurred on restoration was Rs 4.00 lakhs which was incurred by the PWD. Secondary data of hydrology and hydraulic particulars of the tank is given in Table 1.

The total populations of landholders in the study village have been selected for assessing the crop productivity. 128 sample respondents were selected of which 83 respondents (65%) are total population of landholders. Their command area is 145.35 ha. The remaining 45 respondents (35%) are the households of landless labour. However, the households of landless people have been selected randomly. In Ponpadi village, paddy and vegetables are major crops and also some farmers cultivate sugarcane.

Quantitative approaches have been used for the evaluation. Data were collected through group discussion with different categories of farmers. However, the study mainly relies on the data collected by using an interview schedule. Three structured questionnaires were prepared in order to elicit information from the implementing schemes, villages and household levels. The data obtained through quantitative methods were classified and analyzed using a Statistical Package for Social Sciences (SPSS)

Profitability analysis involved assessment of the costs and benefits of the farm income, benefit of irrigated area, crop production and crop yield related to before and after implementation of the restoration schemes.

Evaluation of impact measures for desilting irrigation tanks

Water availability indices

Groundwater levels as observed from open wells can be used for determining changes by comparing water table and water yield through duration of pumping hours with that of before implementation of restoration schemes. Some indirect measures include increase in irrigated area by sources of tank and wells.

Productivity

The crop productivity and cropping pattern are in terms of production and yield per hectare. Cropping intensity is taken as the ratio of gross cropped area to the net sown area (Palanisami and Kumar, 2004)

Cropping intensity = (Gross cropped area / Net sown area) ×100 (1)

Net revenue

Input and output data were collected from the village at two points of time, that is, before the implementation of development program and after the development program by using the stratified sampling method. To estimate the financial costs and revenues of irrigated crop activities, information was collected on the type of crops, crop yields, quantity of inputs (seed, fertilizer, fuel, labor, insecticides and fungicides) and input and output prices.

Crop yields, output prices and labour data were collected at farm household levels, while input use and input prices were collected at scheme level. The local wage rate was used as the opportunity cost for labour. The results and data used for cost and revenue analysis were standardized for an hectare. The net revenue (Mengistu, 2008) obtained by farmers was calculated as:

$$GM = Q_y P_y - \sum X_i P_{xi} \quad (2)$$

Where: GM, Gross margin; Q_y, total quantity of crops in bags; P_y, total price of the crop yield; X_i, quantity of the input used (bags); P_{xi}, price per unit of the input (Rs).

Profitability

Profitability analysis involved assessment of the costs and benefits of the farm income for before and after implementation of the restoration schemes.

RESULTS AND DISCUSSION

Impact of desilting on irrigated area

In the village, the changes in irrigated areas of paddy and vegetables by tank and well irrigation due to restorations of the tanks were analyzed and the results are presented in Table 2.

Paddy cropped area in Ponpadi has increased from 64.75 to 83.77 ha with tank and well waters due to restoration. Tank water alone increased the area from 15.38 to 25.29 ha. The corresponding values for the vegetables area from 12.95 to 13.76 ha with tank and well and from 1.21 to 1.62 ha with tank alone. The non-irrigated area has come down to 20.56 from 50.71 ha. The area under vegetables cultivations have increased significantly, which clearly indicates that water was available for irrigating the crops either through the tanks

Table 2. Change in irrigated area before and after desilting.

S/N	Details		Cropped area (ha)	
			BR	AR
1	Total cultivated land by tank and well irrigation	Paddy	64.75	83.77
		Vegetable	12.95	13.76
		Total	77.70	97.53
2	Total cultivated land by tank irrigation	Paddy	15.38	25.29
		Vegetable	1.21	1.62
		Total	16.59	26.91
3	Total cultivated land		94.29	124.44
4	Total existing irrigated land		145	145
5	Non irrigated land		50.71	20.56

BR- Before restoration; AR- After restoration.

Table 3. Changes in cropping intensity.

S/N	Details	Cropping intensity (%)		Percentage change in cropping intensity (+/-)
		BR	AR	
1	Total cultivated land by tank and well irrigation	54	67	13
2	Total cultivated land by tank irrigation	11	19	8
3	Non irrigated land	35	14	-21

BR- Before restoration; AR- After restoration.

or the wells. Whatever may be the case, it should have been possible only by the consequences of tank restoration schemes. The effect of restoration measures is reflected by leading to better use of land, which is measured in terms of cropping intensity may be through increased groundwater recharge. Hence, the farmers grow crops throughout the year based on availability of water. Cropping intensity by using tank and well water for irrigation before and after implementation of the restoration schemes are presented in Table 3.

Paddy and vegetables are major crops and also some farmers cultivate sugarcane. Cropping intensity by tank and well irrigation increased due to restoration schemes from 54 to 67%. Cropping intensity of paddy by using tank irrigation is increased from 11 to 19%, respectively. The cropping intensity of non-irrigated land was reduced from 35 to 14% in these villages, respectively. Desilting of tank increased the cropping intensity. They have also improved the groundwater levels in the command area thereby increased the cropped area and cropping intensity.

Desilting of tank on increased irrigated area

Changes in area under irrigation are prime indicators of any impact of desilting of irrigation tanks on rural livelihoods, especially where the major livelihood activity is farming. It is observed that proportion of area under irrigation has been increased, though marginally, among all the households in study villages after the restoration of tanks as shown in Table 4. The irrigated area has increased in Season I: 22, 21, 62 and 72% and in Season II: 19, 62, 98 and 107% in large, middle, small and marginal farms, respectively. Therefore, the impact of tank restoration is significant increase in irrigated area among the large, middle, small and marginal farms in all three villages as shown in Table 4.

Irrigating intensity is taken as the ratio of gross irrigated area to the net area which has also increased after restoration is clearly indicated in Figure 2. Increased irrigating intensity changes in ranges between 25 and 156%. The restoration of tanks have provided an opportunity to expand area under irrigation and increased water availability during irrigation.

Major crop cultivated in the village is paddy and minimum quantity of vegetable crop is also grown here. Table 5 presents area of vegetable crop under irrigation before and after restoration schemes

All respondents in Ponpadi cultivated vegetable crops like lady's finger, cucumber, pumpkin etc. Implementation of the desilting of irrigation tanks has increased the cropping area of vegetables in both seasons.

Paired T-test analysis was carried out to identify the

Table 4. Changes in Irrigated area.

Type of season	Farm category	Total number of farmers	Total irrigated area (ha)		Changes in irrigated area (%)
			BR	AR	
I	Large	9	31.57	38.45	22
	Middle	16	22.46	27.11	21
	Small	20	14.37	23.27	62
	Marginal	38	11.74	20.23	72
	Total	83	80.14	109.06	36
II	Large	9	12.95	15.38	19
	Middle	16	11.74	19.02	62
	Small	20	9.51	18.82	98
	Marginal	38	5.87	12.75	117
	Total	83	40.07	65.96	65

BR- Before restoration; AR- After restoration.

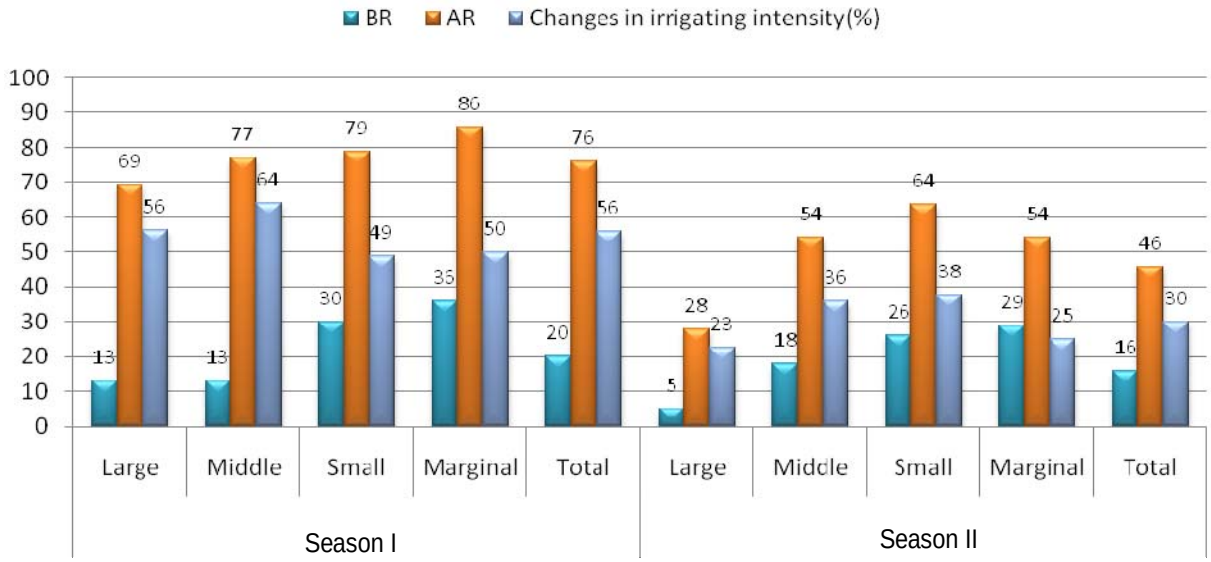

Figure 2. Changes in irrigating intensity.

impact of restoration of tanks and to investigate the significant relationship between before and after impact of restoration. Our null hypothesis is that the programme is not effective, that is, there is no difference between the productivity area before and after the program. The alternative hypothesis is that the programme is effective and the cropped area measured after is higher than that before restoration. Productivity area between before and after restoration of tank in Ponpadi village has a statistically significant mean as shown in Table 6. During Season I, t (78) = -2.095, P = 0.000 which is less than 0.05. In Season II, t (78) = -1.810, P = 0.000 which is less than 0.05. Therefore, the null hypothesis is rejected and the fitness is effective at 5% significant level. Hence, there is a correlation between restoration cultivation crop areas.

Desilting of tank on increased crop yield

Changes in cropped area are reflected in changes in crop productivity, which are measured in tones of food crop per hectare. The following analysis reveals that significant improvement is noticed in the yield of paddy crop in the restored irrigation tanks. The yield is measured in bags (1 Bag = 75 kg). Overall, changes in productivity of crop yield ranges among the farms in the ranges between 4 and 19% in the first season and 2 and

Table 5. Irrigated area of vegetables among different categories of farmers.

Type of season	Type of farm	Total irrigated area (ha)		Changes in irrigated area (%)
		Before	After	
I	Large	10	10	-
	Middle	1.21	2.02	3
	Small	2.83	3.24	1
	Marginal	-	-	-
	Total	14.04	15.26	1
II	Large	-	-	-
	Middle	1.21	2.02	3
	Small	2.83	3.24	1
	Marginal	-	-	1
	Total	4.04	5.26	1

BR- Before restoration; AR- After restoration.

Table 6. Paired t- test for irrigated area.

Irrigate area between BR and AR	Mean	Standard deviation	Standard error mean	95% confidence interval of the difference		T	Df	Sig
Season I	1.774	7.758	0.847	0.090	3.457	2.095	82	0.039
Season II	0.821	4.160	0.454	0.081	1.724	1.810	82	0.074

BR- Before restoration; AR- After restoration.

Table 7. Change in crop yield before and after desilting of tank.

Type of season	Types of farm	Crop yield per farmer (Bags)			
		BR		AR	
		Mean	SD	Mean	SD
I	Large	202	178	274	238
	Middle	81	56	117	81
	Small	55	34	89	53
	Marginal	25	23	46	26
	Total	64	85	94	112
II	Large	38	84	54	120
	Middle	44	63	78	94
	Small	28	38	66	57
	Marginal	14	24	33	30
	Total	26	47	52	68

BR- Before restoration; AR- After restoration.

19% in the second season. Total crop yield increased due to restoration in Season I was 13% and in Season II was 22%. Thus, in future years it is expected that the yield of paddy will continue to increase. Changes in cropped area are reflected in changes in crop productivity, which are measured in tones of food crop per hectare. The following analysis reveals that significant improvement is noticed in the yield of paddy crop in the restored irrigation tanks. The yield is measured in kg or tonnes per hectare. Season wise and farm wise yield of paddy crop before and after restoration are presented in Table 7.

Table 8. Paired t-test for crop yield.

Crop yield between BR and AR	Mean	Standard deviation	Standard error mean	95% confidence interval of the difference		t	Df	Sig
				Lower	Upper			
Season I	53	65	4	46	52	3.41	83	0.048
Season II	43	58	5	37	46	2.56	65	0.049

BR- Before restoration; AR- After restoration.

Table 9. Paired sample test for employment opportunity.

Irrigate area between BR and AR	Mean	Standard deviation	Standard error mean	95% confidence interval of the difference		t	Df	Sig
				Lower	Upper			
I	36	48	5	26	46	7.19	83	0.000
II	15	28	3	10	21	5.38	83	0.000

BR- Before restoration; AR- After restoration.

The results of the crop yield indicate that this productivity of yield is higher in the after restoration than in before restoration. The percentage deviation in the crop yield of paddy crop reflects a significant change in the crop yield of after the restoration over the productivity of crop yield of before restoration. The analysis reveals significant improvement in the crop yield due to restoration of tanks in all three villages among all the farms.

Crop yield between before and after restoration of tank in Ponpadi village has a statistically significant meanas given in Table 8. During Season I, t (78) = -3.41, P = 0.000 which is less than 0.05. In Season II, t (78) = -2.56, P = 0.000 which is less than 0.05. Therefore, the null hypothesis is rejected and the fitness is effective at 5% significant level. The values of 't' in both seasons are highly significant. Hence, there is a correlation between before and after restoration on crop yield.

Impact of tank restoration on employment opportunity for land less labour

The quantitative survey collected data on days was employed through working the farm labour during the cultivation period. The average number of days employed has been analyzed. Paired T- test analysis was carried out to identify the impact of restoration of tanks and to investigate the significant relationship between before and after impact of restoration as presented in Table 9. Our null hypothesis is that the programme is not effective, that is, there is no difference between the employment opportunity for before and after the program. The alternative hypothesis is that the programme is effective and the employment opportunity after is higher than that before restoration.

Employment opportunities between before and after restoration of tank in Ponpadi village have a statistically significant mean. During the Season I, t (78) = -2.095, P = 0.000 which is less than 0.05. In Season II, t (78) = -1.810, P = 0.000 which is less than 0.05. Therefore, the null hypothesis is rejected and the fitness is effective at 5% significant level and t-value is significant in both seasons. Hence, there is a correlation between restoration employment opportunities.

Productivity and profitability due to restoration of tank

Impact of irrigation tank development on crop yield and income is due to the improvement in agriculture. In Table 10, the analysis is based on productivity of yield and profitability of farmer's income before and after restoration of tank. Profitable indicators of total cost, net income and benefit cost ratio and productivity indicator of crop yield after restoration is significantly higher than that of before restoration. However, cost benefit ratio is slightly higher than that of before because input cost of labour wages, fertilizer, machinery etc are very high compared to before.

Conclusion

Desilting of irrigation tank aims to bring about increase in agricultural production through improving groundwater recharge and consequently to improve the economic, social and environmental wellbeing of the rural population. Tank irrigation system plays a role in meeting

Table 10. Productivity of crop yield and profitability of income.

S/N	Indicators for productivity and profitability	Season I		Season II	
		BR	AR	BR	AR
1	Total cost (RS)	2339260	3068175	995370	1379350
2	Net income (Rs)	1499990	3202275	1129055	1810650
3	Total area (ha)	145	145	145	145
4	Total yield	4800	5400	4425	5400
5	Total cost of Rs/ha	16133	21160	6865	9513
6	Net income	10345	22085	7787	12487
7	NI/TC ratio	0.64	1.04	1.13	1.31
8	Cost of Rs/kg	3	4	2	2

BR- Before restoration' AR- after restoration.

the growing demand for food and to achieve long-term food security. The results of desilting of tank carried out in Ponpadi shows that increasing recharge in the command area wells and correspondingly increasing irrigated area proves productivity of crop and profitability of income. The high yields obtained in irrigation and other benefits such as increased incomes, employment creation, food security, are indication that irrigation can bring a sustainable agriculture and economic development without severe effect on the environment.

Conflict of Interests

The authors have not declared any conflict of interests

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