https://doi.org/10.56093/ijas.v90i3.101490

*Indian Journal of Agricultural Sciences* **90** (3): 589–92, March 2020/Article

# Economic impact of tank rehabilitation in rainfed region of India

KIRAN KUMARA T M*, SHIV KUMAR, ADITYA K S, DHARAM RAJ SINGH, KINGSLY IMMANUELRAJ, HARISH KUMAR KALLEGA and PREM LATA SINGH

*ICAR-Central Soil Salinity Research Institute Karnal, Haryana 132 001, India*

Received: 17 June 2019; Accepted: 23 August 2019

ABSTRACT

The present investigation measures economic impact of tanks restoration on productivity and income of 240 farm households in rainfed region of India. The detailed information was collected with designed questionnaire for the period 2017–18 from farm households using tank irrigation in two districts in the state of Andhra Pradesh. Propensity score matching technique was employed to assess the impact of tank rehabilitation. Findings revealed that restoration of tanks leads to an improvement in production and livelihood of tank water users in the study area. Yield and income of rice crop is increased by a magnitude of 0.54–0.62 tonne/ha and ₹6045/ha to ₹8278/ha respectively. Study suggests that to achieve food security and to mitigate the scarcity of water, restoration of tanks is inevitable for rainfed regions. Further, recasting such protocols and replicating similar models to other regions not only enhance the sustainable agricultural production but also improve livelihoods of millions of small and marginal farmers in the country.

**Key words**: Propensity score matching, Restoration, Tank irrigation

Globally, rainfed farming is the principal agricultural production system of majority of the developing economy, accounts nearly 80% of cultivated area and 60% of global food production. India ranks first in rainfed farming both in area and production among other rainfed agricultural economies in the world. Rainfed areas are having mammoth share of about 44% of food grain production with 67% of net cultivated area and feed more than 40% of the population. However, the irrigation potential and agricultural production of these areas are unpredictable and hinges on the spatial and temporal variations in rainfall. Rainfall is highly erratic and frequency of precipitation is unpredicted due to adverse impact of climate change (Palanisami *et al.* 2010). Therefore, creation of water harvesting structures such as tanks and ponds acts as insulator against vagaries of rainfall, climate change and conserve water for irrigation.

Tank is a shallow water reservoir body constructed across the slope to conserve water either from rainfall or tube wells and use it for irrigation during dry season (Palaniswamy 2006). However, despite of several social, cultural, economic and environmental benefits most of the tanks are either neglected or mismanaged in the last few decades (ADB 2006). The area irrigated by tanks has significantly decreased from 4.65 million hectares in 1960 to 2.60 million hectares in 2014 with a magnitude of 2.05 million hectares (44%) reduction in the irrigated area. Disappearance and change in structure and functions of village level tank management institutions is one of the principal causes for decline in tank irrigation (ADB 2006, Jana and Lise 2013). Erratic rainfall, deterioration of physical structure, lack of community participation, poor canal system, weak bunds and accumulation of silt in the tanks are the other important reasons for poor performance of tanks (Bardhan 2000, Agarwal *et al.* 2001, Sakthivadivel 2005, Chakravarty *et al.* 2006, ADB 2006).

In this backdrop this study measures economic impact of rehabilitated tanks for rice crop in rainfed region of India. Study highlights the economic viability and importance of tank rehabilitation in enhancing food security and livelihood of small and marginal holders.

## MATERIALS AND METHODS

*Description of the study area*: In India, the largest concentration of tanks found in southern states which accounts nearly 60% of total tank-irrigated area (Vaidyanathan 2001). Andhra Pradesh is an agrarian economy and nearly 60% of livelihood depends on agriculture. However, recent growth performance indicated that crop subsector which accounts about two-third of state domestic product from agriculture is halted. Inadequate irrigation is one of the prime reasons for this stagnation. Andhra Pradesh has historically tank based irrigation system and endowed with largest number of tanks and supports livelihood for millions of rural communities. However, tanks have lost their significance during the past three or four decades and the proportion of area irrigated under tanks declined from 24% (TE 1990) to 10.07% (TE 2014) in the state. Though irrigation potential of tanks is estimated about 4.09 million hectares, the actual irrigated

*Corresponding author e-mail: mailkiran30@gmail.com

area is only half million hectares. Majority of the tanks operate below their designed capacity as wide gap has been observed between designed capacity and actual irrigation.

As part of the effort to revive and restore the tanks to their original structures, to improve community participation, Andhra Pradesh started Community Based Tank Management Project (APCBTMP) in the year 2007. The project has focused attention on the revival, restoration, and rehabilitation of minor irrigation tanks through a community-based approach. The main objective of the project is to improve the agricultural productivity of tank-based producers and enable water user associations to manage the tank system effectively.

*Sampling and analytical framework*: The data used in this study has been collected by undertaking a primary survey during the period of 2017–18. About 240 farm households are randomly selected and interviewed from the command area tanks scattered in rainfed region of two districts of Andhra Pradesh, viz. Anathapur and Chittoor. The information regarding socio-economic characters and cost of cultivation of rice has been collected with pre-tested structured schedules.

*Propensity Score Matching (PSM)*: In social science studies aiming to estimate the impact of interventions, obtaining a suitable counterfactual is a challenge. Often, the units in treatment are different from the units in control, in variable other than treatment. Measuring impact without accounting for such dissimilarity can lead to sample selection bias. One way of circumventing the problem of bias is to match the farmers in treatment and control groups based on the variables, which can determine the programme participation and then measure impact as the average difference in the matched pair. This is the principle behind the Propensity Score Matching (PSM) technique (Wu *et al.* 2012). The first step in the application of PSM is to estimate the propensity score, also known as the conditional probability of treatment which allows identifying similar farmers. The propensity score can be estimated following Rosenbaum and Rubin (1983) method. The common support assumption improves the matching quality by excluding farmers at the tails of the propensity score distribution. It ensures that characteristics observed in the rehabilitated tank group can also be observed among the non-rehabilitated tank group (Bryson *et al.* 2002).

The next step in the implementation of the PSM method is to choose a matching estimator. Several alternative indicators of matching quality are suggested in the literature. A good matching estimator does not eliminate too many of the original observations from the final analysis while it should at the same time yield statistically equal covariate means for households in the treatment and control groups (Caliendo and Kopeinig 2008). It is a common practice to experiment with different matching estimators to check for the robustness of estimates. In the present study, nearest neighbor method (with 1:1, 1:3 and 1:5 matching) and caliper matching (with a caliper of 0.2) were used. However, the conventional standard error is not valid due to matching process. Hence, in nearest neighbor matching, the analytical standard error is used for testing the statistical significance, as bootstrapping is not valid with nearest neighbor matching. In case of caliper matching, bootstrapped standard errors are used.

The average treatment effect on the treated (ATT) was estimated as follows (Becker and Ichino 2002):

$$ATT = E\left\{Y_{1i}^{k} - Y_{0i}^{k} \mid C_i = 1\right\} = E\left[E\left\{Y_{1i}^{k} - Y_{0i}^{k} \mid C_i = 1, p\left(Z_i\right)\right\}\right]$$

$$= E[E\{Y_{0i}^{k} \mid C_i = 1, p(Z_i)\} - EY_{0i}^{k} \mid C_i = 0, p(Z_i)\} \mid C_i = 1],$$

where $Y_1$ and $Y_0$, values of the outcome variables of interest for rehabilitated farmers and non-rehabilitated farmers respectively; I, households; k, outcome variable being analyzed (income, yield).

## RESULTS AND DISCUSSION

*General characteristics of the sample households*: In order to obtain overview and composition of selected farmers in the tank command area, Table 1 shows general characteristics of farm households interviewed. Small and medium farmers are dominated in the tank command area and tanks are the major source of irrigation water for crop production in the region. The majority of household members had secondary school with 18.20% of the members are illiterate.

*Impact of tank rehabilitation*: Estimation of propensity scores: The propensity scores was estimated by using the probit model, based on conditional independence assumption all the relevant variables and which can influence the participation and the variables which can improve the income and productivity (two outcome variables) were

Table 1 Descriptive Statistics of respondents in the study region

| Particular | Rehabilitated tanks | Non-rehabilitated tanks |
|---|---|---|
| No. of farms | 144 | 96 |
| Age of the head of the family (years) | 46.48 (0.84) | 45.8 (1.05) |
| Experience of the head (years) | 23.44 (0.98) | 21.37 (0.82) |
| Farm size (ha) | 3.06 (0.44) | 2.57 (0.39) |
| Irrigation (%) | 76.63 | 71.82 |
| Tank irrigation (%) | 64.71 | 62.45 |
| Family size (No's) | 7.48 (0.44) | 5.66 (0.39) |
| *Literacy (%)* | | |
| Illiterate | 18.89 | 18.33 |
| Primary | 21.11 | 40.00 |
| Secondary | 33.33 | 35.00 |
| Graduation | 20.00 | 6.67 |

Figures in parenthesis indicate Standard Error, Source: Author's calculation based on field survey.

Table 2 Results of probit estimation of propensity scores

| Variable | Coefficient | Z-value |
|---|---|---|
| Age | 0.043 | 0.54 |
| Age square | 0.000 | -0.49 |
| Education dummy | 0.156 | 1.52 |
| Household size (in No.) | -0.425 | -6.97 |
| Experience (Years) | 0.024 | 1.36 |
| Location of the farm dummy | 0.270 | 2.01** |
| Farm size (ha) | -0.072 | -0.77 |
| Farm size square (Hectares) | 0.010 | 1.78*** |
| District dummy | 0.010 | 0.05 |
| Irrigation (%) | 0.011 | 1.89** |
| Constant | -0.489 | -0.26 |
| Balancing | Yes | |
| Observation | 240 | |
| Pseudo $R^2$ | 0.266 | |

***and **indicate significance at the 1 and 5% level, respectively.

selected (Table 2).

Explanatory variables include household size, an age of the head of the household, the experience of the farming, the location of the farm in the command area, education level of head of the household, and farm size, percentage of irrigated area and a district dummy. However, variables like irrigation, farm size square and location of the farm from the tanks turned out significant. After calculation of propensity scores, balancing property was tested across different blocks.

*Testing for common support*: Once propensity scores are calculated and balancing property is satisfied, common support was tested using graphically. It was found that there was sufficient overlapping of propensity scores across treated and control groups (Fig 1). This indicates that the two groups are comparable through matching and common support assumption is satisfied.

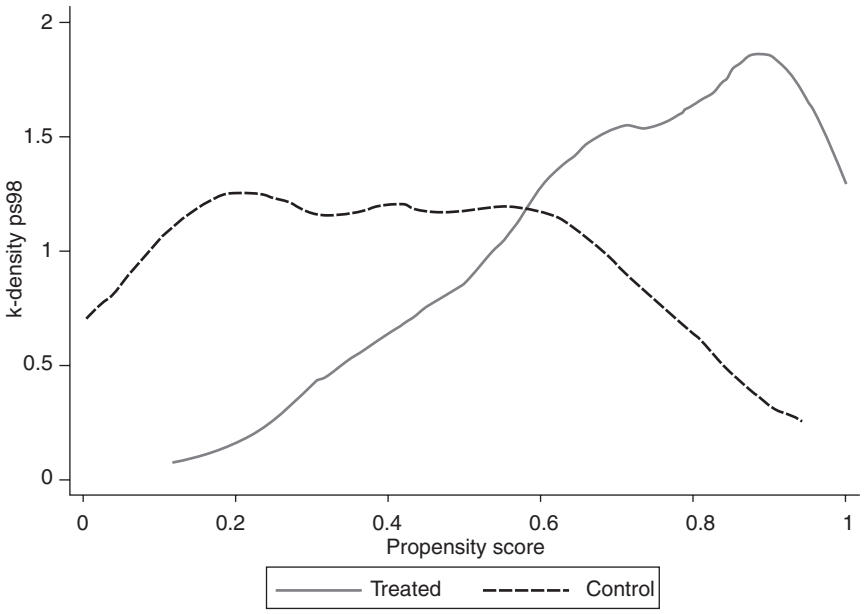


Fig 1 Density of the propensity scores.

Table 3 Impact of tank rehabilitation on income and yield of paddy; Average Treatment effect on Treated (ATT)

| Matching estimator type | ATT | Standard error | Z-value |
|---|---|---|---|
| *Yield (ton/ha)* | | | |
| Nearest neighborhood matching (1) | 0.62 | 0.26 | 23.11 |
| Nearest neighborhood matching (3) | 0.61 | 0.24 | 25.12 |
| Nearest neighborhood matching (5) | 0.60 | 0.24 | 24.66 |
| Caliper matching (Cal of 0.1) | 0.54 | 0.29 | 18.23 |
| *Income (₹/ha)* | | | |
| Nearest neighborhood matching (1) | 8278 | 722.32 | 11.46 |
| Nearest neighborhood matching (3) | 8095 | 699.5 | 11.57 |
| Nearest neighborhood matching (5) | 7870 | 664.45 | 11.85 |
| Caliper matching (Cal of 0.1) | 6045 | 1028.43 | 5.88 |

Nearest neighbor matching has bias-adjusted standard errors and caliper matching estimators has bootstrapped standard errors.

*Average treatment effect on the treated (ATT)*: The Propensity Score Matching (PSM) method is used to determine the impact of rehabilitation of tanks on income and productivity of paddy of farmers in the command area. Average Treatment Effect on Treated (ATT) is considered as impact, based on theoretical expectation the impact of tank rehabilitation was measured on income and productivity (outcome variables). The impact is assessed using alternative estimators to ensure robustness (Table 3). All the matching estimators have shown similar results and tank rehabilitation has a positive and statistically significant effect on income and productivity of farmers in the command area. As expected, the yield of paddy crop was increased about 0.54–0.62 ton/ha for farmers of rehabilitated tanks than non-rehabilitated tanks. The increase in yield could be attributed to increased availability of water which helped the farmers to use it during critical stages of the crop as a life-saving irrigation. Further, following integrated nutrient management practices and application modern inputs in the production as result of tank rehabilitation led to further improvement on the yield.

The result shows that rehabilitation has a positive and significant impact on income (Table 3). More specifically, the income of farmer's increases by a magnitude of ₹6045 to ₹8278/ha due to rehabilitation of tanks which enhance the yield and income of the

farmers. These results were in conformity with the results of Amarnath and Karthik (2006), Reddy and Behara (2009), Deivalatha and Ambujam (2011), Naveena *et al.* (2014), Karthi and Balamurugan (2017).

Tank irrigation plays crucial role in the sustainable irrigation development of rainfed regions due to erratic rainfall and scarcity of water for crop production. This study measures the impact of restoration of tanks in rainfed region of India. It is clear that rehabilitation of tanks has positive and significant impact on crop yield and income. Several studies indicated that the benefits of restoration of the tanks outweigh costs and improve socio-economic and livelihood status of small and marginal farmers. Therefore, considering the need for irrigation, conservation of groundwater and to achieve food and livelihood security, policy initiative has to be undertaken to extend the restoration of tanks in all the rainfed regions concerned.

## REFERENCES

Agarwal A, Narain S and Khurana I. 2001. *Making Water Everybody's Business*.New Delhi, Centre for Science and Environment.

Amarnath J S and Raja P K. 2006. An Economic analysis of rehabilitation in Madurai district of Tamil Nadu. *Agricultural Economics Research Review* **19**: 187–94.

Asian Development Bank. 2006. Rehabilitation and management of tanks in India: A study of select states. ADB, Philippines.

Bardhan P. 2000. Irrigation and Cooperation: An Empirical Analysis of 48 Irrigation Communities in South India. *Economic Development and Cultural Change* **48**(4): 847–65.

Becker S O and Ichino A. 2002. Estimation of average treatment effects based on propensity scores. *The Stata Journal* **2**(4): 358–77.

Bryson A R, Dorsett and Purdon S. 2002. The use of propensity score matching in the evaluation of active labour market policies. A study carried out on behalf of the Department for Work and Pensions *working paper, 4*. Department for Work and Pensions.

Caliendo M and Kopeinig S. 2008. Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys* **22**(1): 31–72.

Chakravarty K K, Badam G L and Paranjpye V. 2006. *Traditional Water Management Systems of India*. New Delhi, Aryan Books International.

Deivalatha A and Ambujam N K. 2011. Sustainable agriculture productivity through restoration of tank irrigation system with stakeholder decision: case study in rural tank eco system. *International Journal of Biodiversity and Conservation* **3**(11): 527–39.

Jana S K and Lise W. 2013. Participation in tank irrigation management in dry zones in India. *European Water* **42**: 35–50.

Karthi M and Balamurugan P. 2017. An appraisal of restoration of rural tanks with traditional participation (kudimaramathu) in Cuddalore district, Tamil Nadu. *International journal of creative research thoughts* **5**(4): 1273–78.

Kumar Jana S, Palanisami K and Das A. 2012.Prospect of sustainable tank irrigation option in the dry zones of West Bengal. *Indian Journal of Agricultural Economics* **67**(2): 225–37.

Naveena K P, Mangala K P and Somashekhar K S. 2014. Financial feasibility on rehabilitation of tank systems and its impact on farm economy. *International Journal of Agriculture and Food Science Technology* **5**(4): 279–86.

Palanisami K R. 2006. Sustainable management of Tank irrigation system in India. *Journal of Developments in Sustainable Agriculture* **1**: 34–40.

Palanisami K R Meinzen Dick and Giordano M. 2010. Climate change and water supplies: Options for sustaining tank irrigation potential in India. *Economic and Political Weekly* **45**(26): 183–90.

Reddy V R and Behera B. 2009.The economic and ecological impacts of tank restoration in South India. *European Journal of Development Research* **21**(1): 112–36.

Rosenbaum P R and Rubin D B. 1983. The central role of the propensity score in observational studies for causal effects. *Biometrika* **70**(1): 41–55.

Sakthivadivel R. 2005. Two decades of tank rehabilitation in India: Investment, institutional, and policy issues. Fourth IWMI-Tata Annual Partners Meet, 2005, Anand, India.

Vaidyanathan A. 2001. Tanks of South India. Delhi: Centre for Science and Environment.

Wu H S Ding, Pandey S and Tao D. 2010. Assessing the impact of agricultural technology adoption on farmers' well-being using propensity-score matching analysis in rural china. *Asian Economic Journal* **24**(2): 141–60.