Pond Renovation for Harvesting and Recycling of Rain Water: An Experimental Trial in Sub Himalayan Terai Region of India

Ganesh Das**, F. H. Rahman, Sankar Saha¹, Sandip Hembram¹, Sujan Biswas³, Samima Sultana¹, Suraj Sarkar¹, Augustina Saha⁴, R. Bhattacharya², Bablu Ganguly¹, Rahul Deb Mukherjee¹, Bikash Roy¹ and Prabhat Kumar Pal⁵

¹Cooch Behar Krishi Vigyan Kendra, Uttar Banga Krishi Viswavidyalaya, Cooch Behar, 736165, West Bengal, India.
²ICAR- Agricultural Technology Application Research Institute, Kolkata, West Bengal, India.
³Dhaanya Ganga’ Krishi Vigyan Kendra, Ramakrishna Mission Ashrama, Sargachhi, Murshidabad, West Bengal, India.
⁴Directorate of Plant Protection Quarantine and Storage, Govt. of India.
⁵Uttar Banga Krishi Viswavidyalaya, Cooch Behar, 736165, West Bengal, India.

Authors’ contributions

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

Article Information

DOI: 10.9734/IJECC/2021/v11i530403
Editor(s):
(1) Prof. Wen-Cheng Liu, National United University, Taiwan.
Reviewers:
(1) M. Rafiqul Islam, Verona University, Italy.
²Paulus Agus Winarso, State College Meteorology Climatology and Geophysics, Indonesia.
³Nitin Mishra, Graphic Era University, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/70032

Received 15 April 2021
Accepted 22 June 2021
Published 30 June 2021

ABSTRACT

Sub Himalayan Terai region of India falls under heavy rainfall zone and significant amount of rainfall occurs during Kharif season. Whereas in rabi season farmers struggle to cultivated crops due to shortage of water following minimum to no rainfall. To overcome the difficulty, Krishi Vigyan Kendra of this region had taken a initiative in the year 2011 to conserve rain water by renovating ponds so as to harvest and recycle the rain water under the project ‘National Initiative on Climate Resilient Agriculture’ (NICRA). Information on different aspect of livelihood status of farmers was
1. INTRODUCTION

India is an agrarian country with more than 70 percent of the population relying upon agriculture for maintaining the livelihood status. India is the world's biggest producer of milk, pulses and jute, and ranks as the second greatest producer of rice, wheat, sugarcane, groundnut, vegetables, fruit and cotton. It is additionally one of the leading producers of spices, fish, poultry, farm animals and plantation crops. According to FAO (Access 2019), it is a matter of concern that agriculture of our country is completely dependent on the nature of monsoon because of the fact that only 58.1 m ha of cultivated land is under irrigation. Further with increasing population, growing civilization and intensive agriculture the ground water is being exploited without paying utmost attention to its judicious use resulting in gradual depletion of ground water [1]. The use of irrigation ponds has been a common practice for domestic and agricultural purposes [2]. In India the irrigation pond supply water for agricultural production in which area varies between 1.5 and 50 hectares [3]. The water of agricultural ponds usually comes from rainfall, the storage of reused water and runoff [4]. The irrigation ponds allow farmers to conserve the rain water, store excess water from irrigation channels, and conserve water from other sources [5,6].

The irrigation scenario in the district Cooch Behar of West Bengal is very poor as only 62% of cultivated area is under irrigation [7]. Although the district experiences high average annual rainfall (higher than 3000 mm) with an uneven distribution as 75% of average annual rainfall is received during the month of May - August whereas minimal or no rainfall is received during the winter months [8]. Keeping a large area uncultivated during rabi season though there remains an ample scope of harvesting rainwater received during the month of May – August. The village Khagribari located at Cooch Behar-II Block of the district Cooch Behar, West Bengal (latitude 26°26.4´ N, longitude 89°21.5´ E) was adopted by Cooch Behar Krishi Vigyan Kendra, Uttar Banga Krishi Viswavidyalaya under National Initiative on Climate Resilient Agriculture (NICRA) during the year 2010-11. Before the initiation of the NICRA (National Initiative on Climate Resilient Agriculture) project activities at Khagribari village, Cooch Behar only 32% of total cultivated area of the village was under irrigation mostly by lifting ground water using bore well. Scope of area expansion under irrigation through lifting of underground water by bore well in patches is also limited due to very low water table as well as existence of huge gravels and stones in underground portion. Primary information were collected from villages through participatory survey indicated that numbers of ponds exist in the village are mostly seasonal ponds with 1.5-2.0 meter depth and few having a depth greater than 2.5 meter are annual in nature. Annual ponds are used for year round fish cultivation, jute retting and irrigation to boro crops during December-March whereas seasonal ponds have no utility except for jute retting. Keeping all these in view, Cooch Behar KVK selected and renovated 15 numbers of seasonal ponds of different sizes during March, 2011 in areas of the village where lifting of underground water through bore well is not possible because of very low water table and presence of gravels and stones in different layers of soil. During renovation the depth of renovated ponds were extended upto greater than 2.5 meter and thus all seasonal ponds were converted to annual ponds. Renovated ponds were used for harvesting rain water during heavy rainfall months and utilize the same for irrigation of next boro crops, year round fish cultivation and also for jute retting depending upon size of ponds.

The study was conducted during 2011-15. The objective of this study is to find out the impact of pond renovation on livelihood status of pond owner and others adjacent farmers to renovated ponds.

2. MATERIALS AND METHODS

Preliminary data were collected from 15 numbers of pond owners which were seasonal in nature and other 100 numbers of farmers

Keywords: Krishi vigyan kendra; livelihood; NICRA; pond renovation; recycling; rain water.
adjacent to the selected ponds at Khagribari village, Cooch Behar, West Bengal (latitude 26°26.4′ N, longitude 89°21.5′ E) just before the initiation of the NICRA Project i.e. in the month of March, 2011 through structured schedule by individual contact method. The selected ponds were renovated under different specified depth viz. 3.7 meter (T$_1$), 3.4 meter (T$_2$), 3.1 meter (T$_3$), 2.8 meter (T$_4$) and 2.5 meter (T$_5$), from ground level. Three numbers of replication were taken for each treatment. 2.5 meter was considered as the minimum depth of renovated ponds because of the fact that all annual ponds existed at village before initiation of the programme were not more than 2.5 meter depth. Volumes of selected ponds were measured before and after renovation. Information on different aspect - volume of water used for irrigation, area of irrigation, wheat, potato and fish production and net income generation data were collected in 3 consecutive years 2012-13, 2013-14 and 2014-15. Information collected before initiation of NICRA project and after 3 consecutive years of the NICRA project was statistically analyzed separately for pond owners and adjacent farmers to find out whether pond renovation programme has any significant effect in changing the livelihood status of pond owner and adjacent farmers.

### Table 1. Farmer wise details about pond volume before and after renovation (cu.m)

| Treatment | Replication | Initial volume (cum) | Final volume (cum) | Increase |
|-----------|-------------|-----------------------|--------------------|----------|
| T$_1$     | F$_1$       | 1409                  | 2590               |          |
|           | F$_2$       | 1307                  | 2590               |          |
|           | F$_3$       | 1345                  | 2590               |          |
|           | Mean        | 1354                  | 2590               | 1236     |
|           |             |                       |                    |          |
| T$_2$     | F$_1$       | 1278                  | 2380               |          |
|           | F$_2$       | 1292                  | 2380               |          |
|           | F$_3$       | 1265                  | 2380               |          |
|           | Mean        | 1279                  | 2380               | 1101     |
|           |             |                       |                    |          |
| T$_3$     | F$_1$       | 1236                  | 2170               |          |
|           | F$_2$       | 1222                  | 2170               |          |
|           | F$_3$       | 1314                  | 2170               |          |
|           | Mean        | 1257                  | 2170               | 913      |
|           |             |                       |                    |          |
| T$_4$     | F$_1$       | 1198                  | 1960               |          |
|           | F$_2$       | 1225                  | 1960               |          |
|           | F$_3$       | 1161                  | 1960               |          |
|           | Mean        | 1195                  | 1960               | 765      |
|           |             |                       |                    |          |
| T$_5$     | F$_1$       | 1119                  | 1750               |          |
|           | F$_2$       | 1195                  | 1750               |          |
|           | F$_3$       | 1166                  | 1750               |          |
|           | Mean        | 1160                  | 1750               | 590      |
| Total     |             | 23817                 | 41650              |          |
(690 cu.m) followed by T₂ (608 cu.m), T₃ (498 cu.m), T₄ (415 cu.m), and T₅ (329 cu.m). It is further observed from the experiment that irrigated area of potato crop was more in case of T₁ (1.38 ha) followed by T₂ (1.11 ha), T₃ (0.83 ha), T₄ (0.68 ha) and T₅ (0.50 ha). It is shown from the study that irrigated area of wheat crop was more in case of T₁ (0.43 ha), followed by T₂ (0.39 ha), T₃ (0.31 ha), T₄ (0.21 ha), and T₅ (0.15 ha).

Before renovation of pond (2011-12) in the village, the total potato and wheat production under irrigated area was only 1931.07 t and 63.38 t, respectively (Table 3). As area under irrigation was increased (2014-15) due to renovation of the pond in the village, potato and wheat production has also increased drastically up to 3399.31 t and 140.61 t, respectively (Table 3). Potato and wheat production in the village has been increased to a substantial amount as compared to the production obtained before renovation of the ponds which lead to a rise in the net income of Rs. 347224 and Rs. 46671 for potato and wheat respectively (2014-15) as compared to Rs. 210828 and Rs. 17965 for potato and wheat respectively (2011-12) before renovating the ponds (Table 3). Renovation of ponds (Table 3) in the village also provided an opportunity for the farmers of the village to increase fish production on the renovated ponds which led to an increase in approximately double the fish production as compared to before renovating the ponds. Fish production to a tune of 60.68q increasing net income from fish production of Rs. 38410 (2014-15) as earlier before renovating it was only 34.85q of fish production giving total net income from fish production of Rs. 10336 (2011-12). The finding is line with the results found by Chawla et al. [9], Desai et al. [10] and Prabha [11].

$\text{Table 2. Mean effect of pond renovation on irrigation coverage area during the year from 2012-13 to 2014-15}$

| Treatment Number | Replication | Pond water used for irrigation (cu.m) | Area irrigated (ha) |
|------------------|-------------|--------------------------------------|---------------------|
|                  |             | Potato | Wheat | Total |
| T₁               | F₁          | 670    | 1.31  | 0.36  | 1.67  |
|                  | F₂          | 702    | 1.44  | 0.50  | 1.94  |
|                  | F₃          | 698    | 1.39  | 0.44  | 1.83  |
|                  | Mean        | 690    | 1.38  | 0.43  | 1.81  |
| T₂               | F₁          | 624    | 1.21  | 0.37  | 1.58  |
|                  | F₂          | 606    | 1.06  | 0.45  | 1.51  |
|                  | F₃          | 594    | 1.06  | 0.36  | 1.42  |
|                  | Mean        | 608    | 1.11  | 0.39  | 1.50  |
| T₃               | F₁          | 486    | 0.79  | 0.27  | 1.06  |
|                  | F₂          | 526    | 0.88  | 0.30  | 1.18  |
|                  | F₃          | 482    | 0.82  | 0.36  | 1.18  |
|                  | Mean        | 498    | 0.83  | 0.31  | 1.14  |
| T₄               | F₁          | 418    | 0.7   | 0.21  | 0.91  |
|                  | F₂          | 385    | 0.59  | 0.15  | 0.74  |
|                  | F₃          | 442    | 0.75  | 0.27  | 1.02  |
|                  | Mean        | 415    | 0.68  | 0.21  | 0.89  |
| T₅               | F₁          | 359    | 0.59  | 0.2   | 0.79  |
|                  | F₂          | 296    | 0.43  | 0.12  | 0.55  |
|                  | F₃          | 332    | 0.48  | 0.14  | 0.62  |
|                  | Mean        | 329    | 0.50  | 0.15  | 0.65  |
| Total            |             | 9831   | 13.50 | 4.50  | 18.00 |
### Table 3. Mean effect of pond renovation on production and net income from crop and fish under irrigated area during 2012-13 to 2014-15

| Treatment | Farmers | Crop Production in irrigated area (t) | Net income (Rs.) from crop production in irrigated area | Fish Production (q) | Net income from fish Production (Rs.) |
|-----------|---------|---------------------------------------|-------------------------------------------------------|---------------------|---------------------------------------|
|           |         | Potato | Wheat | Total | Potato | Wheat | Total |                                           |                                      |
| T₁        | F₁      | 331.43 | 11.96 | 343.39 | 34322 | 4515  | 38837 | 4.56 | 2886                                    |
|           | F₂      | 357.12 | 15.09 | 372.21 | 34848 | 4599  | 39447 | 4.30 | 2722                                    |
|           | F₃      | 360.01 | 14.36 | 374.37 | 39754 | 5238  | 44992 | 4.93 | 3121                                    |
|           | Mean    | 349.52 | 13.80 | 363.32 | 36308 | 4784  | 41092 | 4.60 | 2909.67                                 |
| T₂        | F₁      | 304.92 | 12.22 | 317.14 | 31218 | 4567  | 35785 | 4.96 | 3140                                    |
|           | F₂      | 271.36 | 13.34 | 284.70 | 29044 | 3872  | 32916 | 4.43 | 2804                                    |
|           | F₃      | 262.88 | 11.34 | 274.22 | 25652 | 3834  | 29486 | 4.05 | 2564                                    |
|           | Mean    | 279.72 | 12.30 | 292.02 | 28638 | 4091  | 32729 | 4.48 | 2836.00                                 |
| T₃        | F₁      | 194.34 | 8.06  | 202.40 | 18486 | 2382  | 20868 | 3.82 | 2418                                    |
|           | F₂      | 223.52 | 9.59  | 233.11 | 23408 | 3350  | 26758 | 4.11 | 2602                                    |
|           | F₃      | 205.00 | 11.56 | 216.56 | 20500 | 4072  | 24572 | 4.39 | 2779                                    |
|           | Mean    | 207.62 | 9.74  | 217.36 | 20798 | 3268  | 24066 | 4.11 | 2599.67                                 |
| T₄        | F₁      | 179.90 | 6.43  | 186.33 | 19460 | 2029  | 21489 | 4.11 | 2602                                    |
|           | F₂      | 148.09 | 4.89  | 152.98 | 14986 | 1779  | 16765 | 3.73 | 2961                                    |
|           | F₃      | 186.25 | 7.85  | 194.10 | 19050 | 2151  | 21201 | 3.41 | 2159                                    |
|           | Mean    | 172.08 | 6.39  | 178.47 | 17832 | 1986  | 19818 | 3.75 | 2374.00                                 |
| T₅        | F₁      | 145.14 | 5.74  | 150.88 | 15806 | 1510  | 16316 | 3.04 | 1924                                    |
|           | F₂      | 108.79 | 3.88  | 112.67 | 11266 | 1390  | 12656 | 3.41 | 2159                                    |
|           | F₃      | 118.56 | 4.31  | 122.87 | 11424 | 1383  | 12807 | 3.43 | 2171                                    |
|           | Mean    | 124.16 | 4.64  | 128.81 | 12165 | 1427  | 13593 | 3.29 | 2084.67                                 |
| Total     | 2012-13 | 3399.31 | 140.61 | 3539.92 | 347224 | 46671 | 393895 | 60.68 | 38410                                    |
|           | 2011-12 | 1931.07 | 63.38  | 1994.45 | 210828 | 17965 | 228793 | 34.85 | 10336                                    |
Fig. 1. Compare the sustainability of crop production from the experiment

Fig. 2. Compare the sustainability of fish production from the experiment

Plate 1. Experimental centre for wheat and potato

4. CONCLUSION

The study explores that after renovating the seasonal ponds to annual ponds, potato and wheat production was increased immensely which might be the result of timely and regular supply of water from the ponds to various parts of the village. Apart from this, it can also be seen from the study that farmers were getting additional income throughout the year by cultivating fish in those renovated ponds. From the above cases, it may be concluded that pond renovation had a potential impact on agriculture and allied sectors. Crop production, productivity,
net farm income and area of irrigation were increased through construction and renovation of pond and recycling of rain water. Different national and international organisation may disseminate this technology to the farmers for recycling and harvesting of rain water which may help to increasing global agriculture and fish production thus uplifting the socio-economic conditions of the farmers. It is concluded from the study that treatment 1 (Pond depth 3.7 meter) might be adopted by the farmers for harvesting and recycling of rain water in sub Himalayan terai region of India. It is further concluded from the study that treatment 1 is more sustainable in case crop production and farmers net income generation in sub Himalayan terai region of India.

CONSENT

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

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Yoshihide WO, Ludovicus PH, Van Beek, Cheryl M, Van Kempen, Josef WTM, Reckman, Slavek Vasak, Marc FP Bierkens. Global depletion of ground water resources, Geophysical Research Letters, 2010;37(20):1-5.
2. Anjum SA, Wang LC, Xue L, Saleem MF, Wang GX, Zou CM. Desertification in Pakistan: Causes, impacts and management. J. Food Agric. Environ. 2010;8:1203–1208.
3. Gunnell Y, Krishnamurthy A. Past and present status of runoff harvesting systems in dryland peninsular India: A critical review. Ambio. 2003;32:320–324.
4. Ouyang Y, Paz JO, Feng G, Read JJ, Adeli A, Jenkins JN. A model to estimate hydrological processes and water budget in an irrigation farm pond. Water Resour. Manag. 2017;31:2225–2241.
5. Mushtaq S, Khana S, Hafeez M. Evaluating the impact of ponds in sustaining crop production: A case of Zhanghe irrigation system in China. Water Policy. 2009;11:236–249.
6. Fuentes-Rodríguez F, Juan M, Gallego I, Lusi M, Fenoy E, León D, Peñalver P, Toja J, Casas JJ. Diversity in Mediterranean farm ponds: Trade-offs and synergies between irrigation modernisation and biodiversity conservation. Freshw. Biol. 2013;58:63–78.
7. Ministry of Agriculture; 2019. Available: agricoop.nic.in/sites/default/files/WB.pptx. Date Accessed: 20.12.2020.
8. Biswas S, Das G, Rahaman FH, Sarkar S, Sarkar S, Saha S, Das SK, Saha A, Roy B. Impact of NICRA project through analysis of different success point, International Journal of Agriculture Sciences. 2018;10(8):5863–5866.
9. Chawla JK, Khepar SD, Siag M. Economic feasibility of renovation of village ponds for irrigation in Kandi Area of Punjab, Ind. in. of Agri. Econ. 2002;57(1):91-98.
10. Desai R, Patil BL, Kunnal LB, Jayashree, H, Basavaraj H. Impact Assessment of farm ponds in dharamsawad district. Karnataka J. of Agric. Sci. 2007;20(2):426-427.
11. Prabha UL. Impact of farm ponds on cropping pattern – A case study on Vembedu Village in Tamilnadu, International Journal of Innovative Research in Advanced Engineering (IJIRAE). 2014;1(4):50-52.

© 2021 Das et al.: This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here: http://www.sdiarticle4.com/review-history/70032