A Study on Efficiency of Irrigation Tanks in Saline Zone of South 24 Parganas

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Abstract:

The present paper attempts to find the efficiency of irrigation tanks in saline zone of the district of South 24 Parganas in West Bengal in India. Total 65 water bodies have been selected from five blocks of South 24 Parganas (Patharpratima, Matharapur-II, Kakdwip, Sagar and Namkhana). Data Envelopment Analysis (DEA),a non-parametric approach, has been used for the present study to measure the tank efficiency scores.The results show that 7 water bodies have the efficiency score 1 and ranked 1, and almost 13 water bodies are close to the efficiency score 1. The study indicates that government, community and personal level initiatives in tank management activities can influence the efficiency of irrigation tanks.

Keywords: Irrigation; Tanks; Efficiency; Data Envelopment Analysis (DEA); South 24 Parganas

Introduction:

Irrigation plays the vital role in improving the yield or productivity in the agricultural sector (Roy, 2006; Anbumozhi et al., 2007; Jana et al., 2012). It is the most important factor behind the success of agriculture in Indian economy. Temporal and spatial variation of the rainfall in the country calls for a scientific and environmentally sustainable irrigation management in the country with a long term perspective. With the introduction of mechanized system of irrigation techniques, India relied much on ground water lifting for irrigation purpose, since independence. Due to the threat of global warming, environmental degradation and ground water depletion, tank irrigation is considered important as it plays a very critical role in the sustainable irrigation development, particularly in the dry and saline zones of India (Jana et al., 2012). Tanks store the monsoonal run-off which also acts as a recharge of ground water, are utilized for the multidimensional purposes. Tanks as a common property resources are generally used for the purposes of irrigated agricultural, for the domestic uses, for drinking water and for aquaculture. It also helps to restore sustainable ecological balance. In India, tank irrigation has strong historical background in the state of Tamil Nadu, Odisha, Andhra Pradesh, Kerala, Karnataka and West Bengal. Among the states, West Bengal is also one of the states with higher number of tanks(Jana et al., 2012).

With the increasing population, the freshwater sources are being exploited all over the world(Bhadra et al., 2018).This ultimately creates an upward pressure, leads to a crisis, conflicts and disagreement among the users. Moreover it generates excessive, unexpected and unhealthy pressure on ecology and environment which ultimately leads to environmental degradation (UN Water Report, 2007). India will be declared as water scarce region if per capita availability of fresh water falls to 1000 cubic meter per year (Das, 2009).

That’s why, in the rural economy of India, tanks are the lifeline. Stakeholders like small farmers, marginal farmers, landless agricultural labourers - all are heavily dependent on the tank for their livelihood. Tanks store this huge runoff and also act as a genuine moderator of flood. So, this century old rainwater harvesting irrigation system is still one of the important sources of irrigation in rural India in dry seasons and acts as an insurance against drought.Basic problems of this irrigation tank are the poor and insufficient maintenance and management of this common only used water bodies from time immemorial. Due to this negligence, siltation, reduction in storage capacity, encroachment, high degree of seepage in the delivery system are commonly seen in the tank irrigation system which is an obstacle in way of utilizing tank irrigation in a sustainable manner. Efficient tank can only influence the agricultural productivity and improve the socio-economic conditions of the rural areas.

Therefore, there is an urgent need of strong, effective and rational management system for socially, economically, environmentally sustainable use of this tank irrigation system for the better present and future use.For the sustainable management of irrigation system, there is a need to assess the tank efficiency.

The broad objectives of this study of tank efficiencyare:

- To understand the different characteristics of tank irrigation in the saline zone.
- To examine the efficiency of tanks.

Study Area:

South 24-parganas district is located in saline zone in West Bengal in India. It is situated in the extreme southern part of West Bengal (22º 33' 45" N - 21º 29' 00" N latitudes and 89º 4'50" E - 88º 3'45" E longitudes). The total geographical area of the district is 9960 sq.km.

The district is bounded by Kolkata and North 24 Parganas on the North, Sundarban and Bay of Bengal on the South, Bangladesh on the East and Hooghly River on the West.

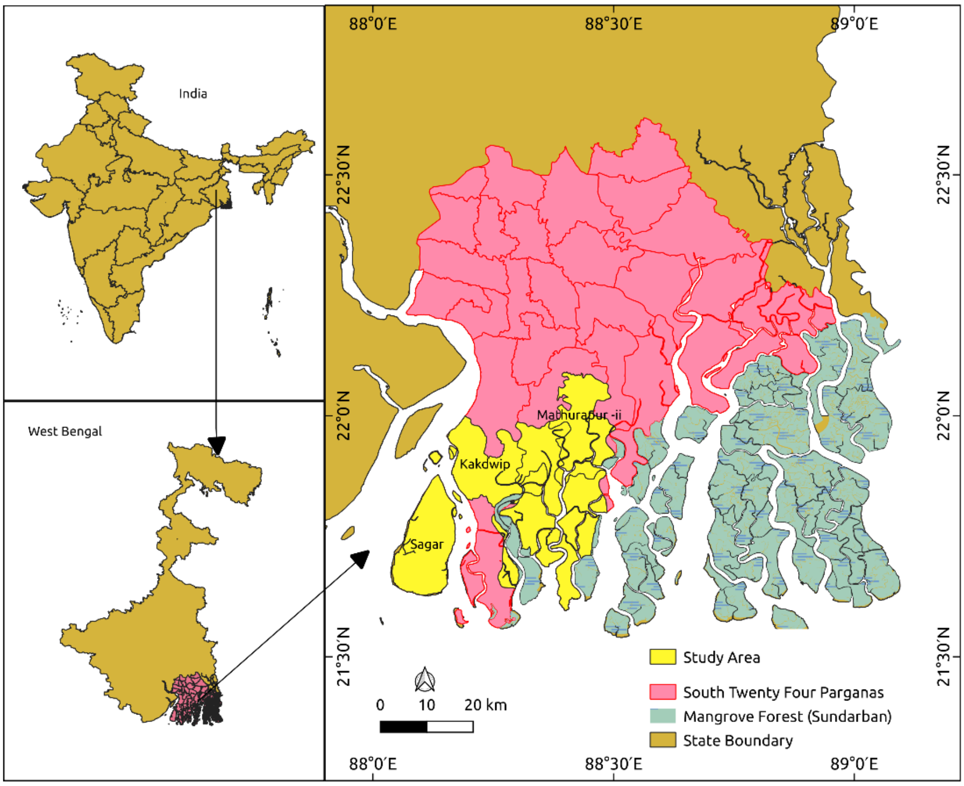

Figure 1. *The study area map of South 24 Parganas*

According to 2011 census, the total population of South 24 Parganas is 8.16 million and growing at an estimated rate of 1.82% per year, which is higher than that of the state of West Bengal (1.38%) and India (1.76%) between 2001 and 2011. People are mainly dependent on agriculture, working as cultivators and agricultural labourers. The major crop grown in the district is rice. The yield rate of rice is 2322 kg per hectare in South 24 Parganas (DSHB, 2011). Along with agriculture, rural people practice multiple secondary livelihood activities such as aquaculture, honey collection, crab collection.

Five blocks of South 24 Parganas district namely Patharpratima, Matharapur-II, Kakdwip, Sagar and Namkhana which are closer to Bay of Bengal have been selected for the study. There is high degree of salinity problem in the ground water and surface water (river water) in the selected blocks. Agricultural activities of these blocks mainly depend on the rain fed surface water irrigation system i.e. tanks (ponds, khal, and beals).

Methodology:

In the present study, total 65 water bodies (Khal = 30 and Tank = 35) have been selected from five blocks of South 24 Parganas (Kakdwip, Mathurapur-II, Sagar, Namkhana and

Patharpratima)to know the more about the efficient and inefficient tanks in saline zone of South 24 Parganas.To achieve the above mentioned objective, Data Envelopment Analysis (DEA) method has been used for the present study in STATA platform.

Data Envelopment Analysis (DEA): DEA is a non-parametric approach that involves the use of linear programming methods to construct a non-parametric frontier and to evaluate the relative Input-Output efficiency of a Decision Making Unit (DMU). Efficiency estimates how effectively a firm is transforming its inputs into output. Technical Efficiency (TE) of a firm is measured either by (i) output-oriented measure or by (ii) input oriented measure. In case of output oriented measure the TE of a firm can be computed by comparing its actual output with the maximum producible output from its observed inputs i.e. by how much can output quantities be proportionally expanded without altering the inputs quantities used. In input oriented measure, the TE of a firm can be measured by comparing its actual input in use with the minimum input that would produce the targeted output level i.e. by how much can input quantities be proportionally reduced without changing the actual output bundle. On the other hand, under variable VRS the envelopment surface presents convexity as a consequence of the constraint in the model. The convexity condition essentially ensures that an inefficient DMU is only benchmarked against DMUs of similar size.

DEA methodology is as follows. In the output maximization approach, the farm seeks to maximize output given the input bundle. As per the Banker, Charnes, and Cooper (1984) orientation (under the assumption of the variable returns to scale) the problem is,

$$\begin{aligned} &\mathrm{Max}\,\phi \\ &\text{s. t.}\quad \phi Y^0 \le \lambda Y \\ &X^0 \ge \lambda X \\ &\sum \lambda_j = 1 \qquad \lambda_j \ge 0 \end{aligned}$$

In case we assume the operation of constant returns to scale then the condition $\sum \lambda_j = 1$ is dropped. The calculation of Technical Efficiency is contingent on the assumption about returns to scale. If one assumes constant returns to scale then the productive units are penalized more as compared to the case where the units are assumed to exhibit variable returns to scale. The ratio of VRS and CRS technical efficiency scores gives us the scale efficiency for the respective units.

Based on literature surveys and collected primary data sets, six input variables – capacity or volume of water body, management, water availability, command area, soil type, beneficiaries and one output variable namely total productivity have been considered for this study.

Output variable:

TOTPODY = Total productivity at tank level (rupees/acre)

Input variables:

CAPCT = Capacity or volume of water body ('000 m^3)

MANGE = Whether management is present for tank (=1 if present, = 0 otherwise)

WTAVL = Water availability for irrigation (months)

COMDA = Command area of tank (acre)

SOLTY = Soil character in the tank command area (=1 if loamy,

0=otherwise)

BNFCS = Number of beneficiaries in tank command area

The efficiency score (θ) is a scalar that measures the technical efficiency and ranges between 0 and 1. The efficiency score means the distance between the DMU and the efficiency frontier, which is defined as a linear combination of the "best practice" units. If $\theta < 1$, the DMU is inside the frontier and it will relatively inefficient, whereas $\theta = 1$, the DMU will be on the efficiency frontier and it will be considered technically efficient.

Results and Discussion:

Based on the collected primary data, the characteristics of water bodies have been discussed in three major parts – (a) tank conditions, (b) extent of irrigation by tanks and (c) tank productivity.

Table 1. *Some Basic Characteristics of the Selected 65 Water bodies*

Characteristics	**Tank (*N* = 35)**	**Khal (*N* = 30)**	**All Water bodies (*N* = 65)**
Area (acre)	0.04	10.27	4.76
Depth of water body (ft.)	11.20	9.50	10.40
Capacity ('000 m^3)	0.62	123.21	57.20

Number of beneficiaries (families)	2.14	223.40	104.26
Water availability (months)	12	8.80	10.50
Command area (acre)	0.92	95.37	44.51
Soil quality (1 = Bad – 5 = Good)	3.70	3.60	3.65
Irrigation water quality (1 = Bad – 5 = Good)	4.26	3.43	3.88
Management	Personal = 35	Government = 29, Community = 1	Government = 29, Community = 1, Personal = 35
Data Source: *Primary Survey, 2018*			

Tank Conditions: The average area of all water bodies is 4.76 acres, whereas it is 0.04 acre for tanks and 10.27 acres for khals. It is observed that average depth of tanks (11.20 ft.) is more than khal (9.50 ft.). The depth of water body is not uniform in all seasons. During rainy season the average depth of all water bodies is 10.04 ft. It is only 4.51 ft. during the time of summer. The age of all water bodies varies from 16 years to 120 years. Large water bodies are more than 100 years old. It is understood that large water bodies were constructed during the British period to manage or overcome from the drought situations.

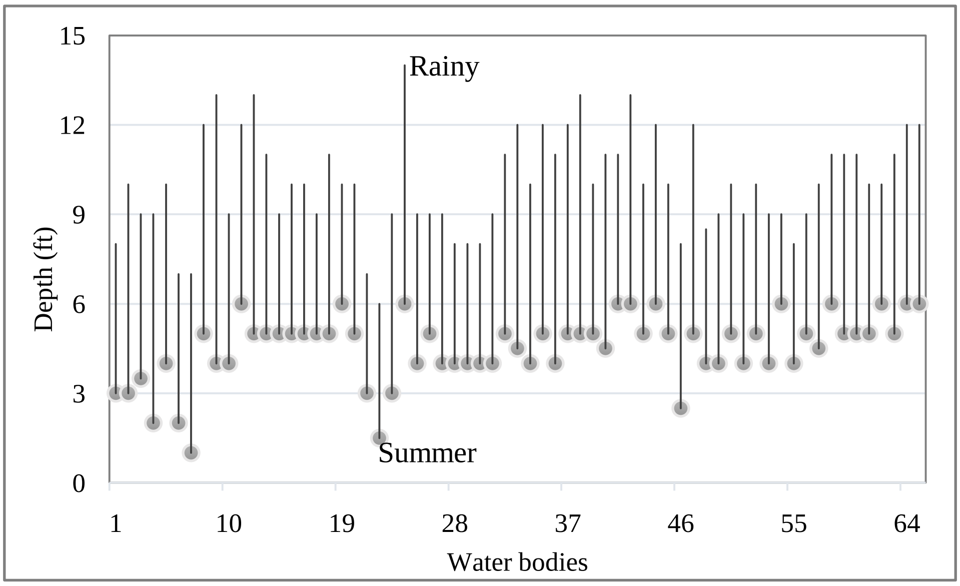

Figure 2.*Depth of all water bodies during summer and Rainy Seasons*

The capacity or volume of water body has been calculated from area and depth, and it is more than 57000 m^3 (average). This capacity is 123210 m^3 for khals and 620 m^3 for tanks. The average water availability of all water bodies is 10.50 months. During rainy season, 96 percent of total water spread areas are filled with rain water, and it is very low during summer (50%). In the last 10 years, on an average, 90-100% of the tank was filled for 2.1 years; 70-90% was filled for 6.2 years and below 70% was filled for 1.7 years.

Extent of Irrigation by Tanks: The average command area of all water bodies is calculated as 44.51 acre. *5 No.Gheri Khal* has the highest command area (363.64 acre), whereas *Chapla Khal* shows the lowest command area which is less than 1 acre. Average number of beneficiary farmer families per water body is 104. In other words, on an average, 100 farmer families are benefited from one water body. Khals like 5 No. Gheri, Tetulia, Gajir, Sodial, Jogendrapur and Raidighi give benefit to more than 300 families. Only 2 families are benefitted from one small tank.

Out of 65 water bodies surveyed, 29 water bodies are managed by the government organisations or departments and 1 water body managed by the community. 30 small water-bodies are owned and managed by famer families. More than 90 percent of all the water bodies are lift irrigation types.

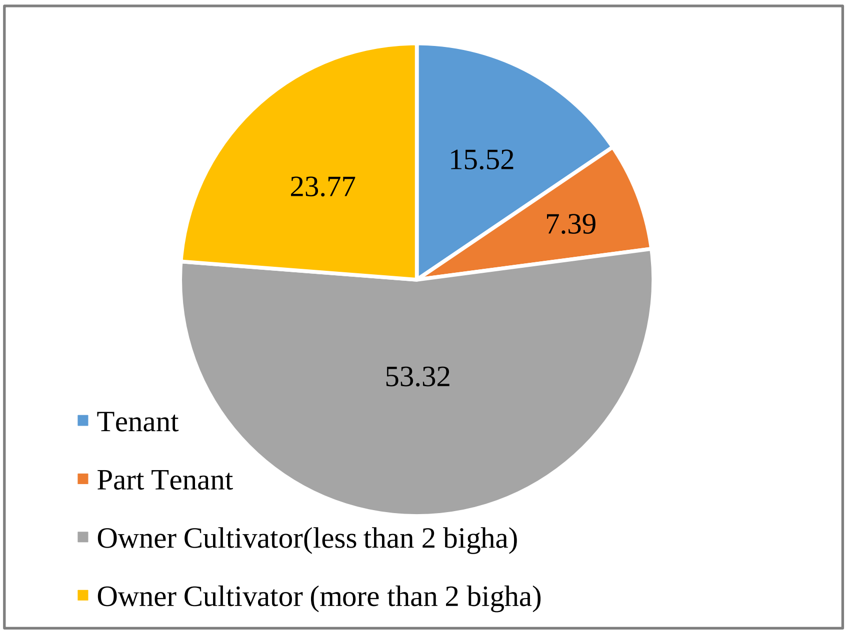

Figure 3.*Type of Farmers in the Tank Command Area*

All farmers, including small and marginal are dependent on tank water irrigation system for cultivation. Owner cultivators (less than 2 bigha) constitute 53.32% of the total farmers in the command area.

Tanks are used for many purposes. Other than irrigation, villagers use tank/khal water for different purposes like domestic uses, fisheries and Plantation. Many families dependent on livestock, keep cows, ducks, goat, and sheep in their homestead which supplements their income. They are rarely used for the family's own consumption. It can be said that all the water bodies in the identified location provides economic benefits to the rural people.

Tank Productivity: The efficiency of all water bodies has been measured by the value of production per acre of irrigated area, known as tank productivity. The average irrigated area and production value are 44.51 acres and INR 44, 934 respectively. It is understood that this productivity is related to many aspects of cultivation. Apart from the tank productivity, tank increases the land value and reduce the yield risk. The average land value for irrigated land is 1.53 lakhs per acre and 1.07 lakhs per acre for non-irrigated land in the study area.The crops grown in tank command area gets the benefit of life- saving irrigation as a result of which the yield loss is reduced. The yield of Kharif paddy is always higher than the crops outside the tank command areas. It is understood that the crop loss due to inadequate rainfall or dry spell is reduced in tank command areas. The primary survey data clearly reveals that tanks are still a crucial component of the rural livelihood of the South 24 Parganas, particularly in the saline zones.

Efficiency Analysis of Water Bodies: Seven variables for tank efficiency analysis have been used as input and output variables and presented in Table 2.

Table 2. *Statistical Summary of Input and Output Variables of Water bodies*

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Capacity ('000 m^3)	65	0.34	418.06	57.20	90.35
Beneficiaries (families)	65	1.00	800.00	104.26	144.75
Management	65	0.00	1.00	0.60	0.49
Water availability (months)	65	6.00	12.00	10.51	1.89
Soil type	65	0.00	1.00	0.14	0.35
Command area (acre)	65	0.00	363.64	44.51	71.83
Productivity (rs./acre)	65	0.00	224.35	44.93	37.24

The correlation matrix of all the inputs and outputs is presented in Table 3. It is found that the correlation coefficients among the variables are not so high which indicates that variables are not highly correlated with each other.

Table 3.*Correlation Matrix of Input and Output Variables of Water bodies*

Correlation Matrix[a]

		Capacity	*Beneficiaries*	*Management*	*Water availability*	*Soil type*	*Command area*	*Productivity*
Correlation	*Capacity*	1.000	.784	-.526	-.642	.513	.729	-.244
	Beneficiaries	.784	1.000	-.724	-.718	.621	.916	-.275
	Management	-.526	-.724	1.000	.791	-.400	-.591	.372
	Water availability	-.642	-.718	.791	1.000	-.489	-.699	.279
	Soil type	.513	.621	-.400	-.489	1.000	.687	-.091
	Command area	.729	.916	-.591	-.699	.687	1.000	-.140
	Productivity	-.244	-.275	.372	.279	-.091	-.140	1.000

a. Determinant = .003

Table 4.*Results of Data Envelopment Analysis (DEA)*

No. of DMUs	65
Average	0.52973834
Maximum	1
Minimum	0.138427
Standard Deviation	0.32591788
No. of Efficient DMUs	7
No. of Inefficient DMUs	58

Table 4 shows the results of DEA analysis and mentions the numbers of efficient and inefficient tanks in the study area. The efficiency scores and ranks have been presented in figure 4. Out of 65 water bodies, 7 water bodies have the efficiency score 1 and ranked 1. Almost 13 water bodies are close to the efficiency score 1. The average efficiency score of the water bodies has been calculated as 0.53. The minimum efficiency and standard deviation are 0.14 and 0.33 respectively. Seven water bodies which have achieved 100% efficiency are: Gajir Khal, Sodial Khal, Panchamer Khal, Prasadpur Khal, Gamatala Khal, Netaji Tank and Pathik Bhunia's Tank.

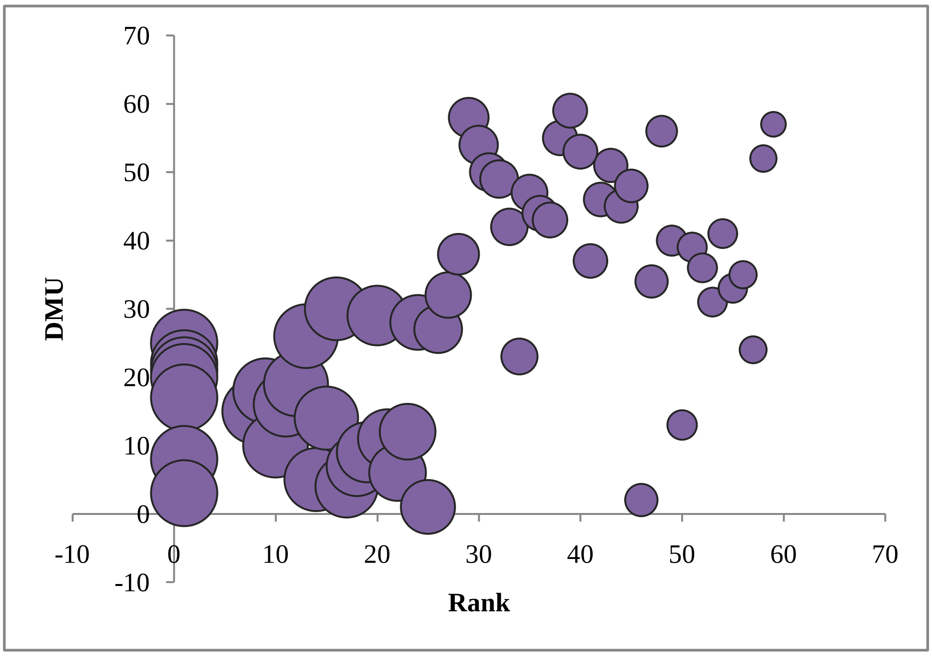

Figure 4.*Efficiency scores, DMUs and Ranks of all water bodies*

The proper maintenance of water body can increase the tank efficiency. Figure 5 shows the reasons for lack of maintenance of water bodies in the selected locations of South 24 Parganas. Most of the respondents reported that poverty/financial constraints, encroachment, political issue are the main reasons behind the lack of maintenance of water bodies.

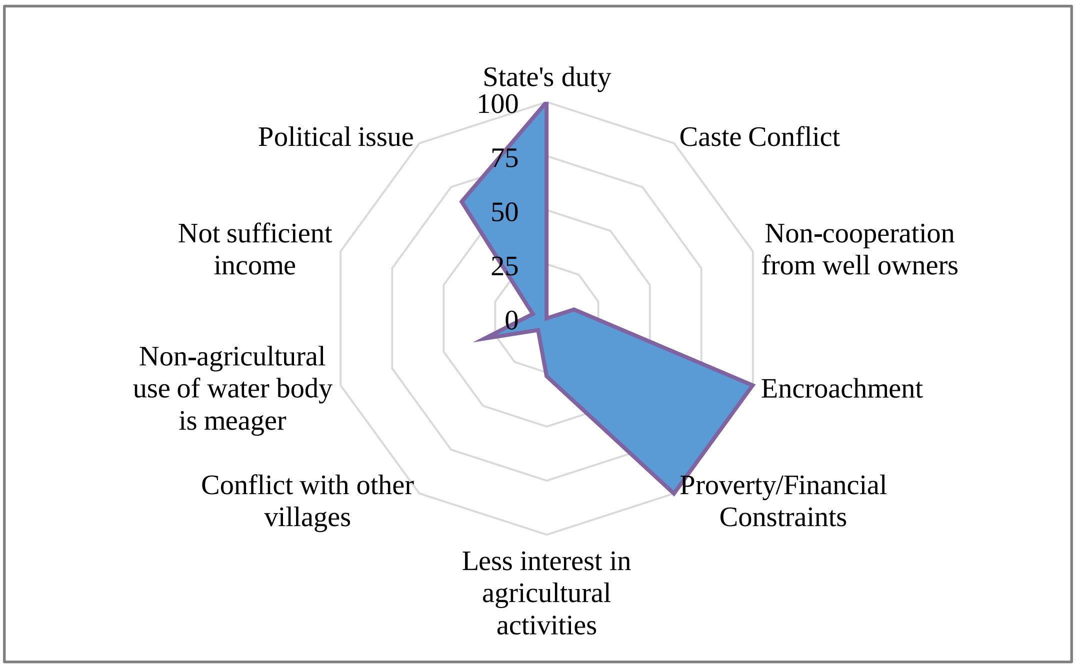

Figure 5. *Reasons for Lack of Maintenance of Water bodies*

The survey reveals that after the renovation of water bodies, the area of cultivation in the command area and value of production will be significantly changed in the study area.

Conclusion:

The study reveals thatseven water bodies which have achieved 100% efficiency are: Gajir Khal, Sodial Khal, Panchamer Khal, Prasadpur Khal, Gamatala Khal, Netaji Tank and Pathik Bhunia's Tank. Capacity, beneficiaries, management, water availability and soil type are instrumental for increasing tank efficiency. The command area is also expected to positively influence the tank productivity and efficiency. If the command area is large then production will be more and if the area is small then production will be less. Water availability increases the tank efficiencyby improving the catchments and field channels. It is also observed during the survey that few tanks with good structures have the higher water availability. Tank rehabilitation options are also important in improving the tank performance/efficiency in the district as well as state.Government, community and personal level initiatives and tank management activities can influence the productivity and change the socio-economic scenario of the study area. In spite of some steps taken by the government, adequate practical implementation is yet to be developed. There is required a dedicated wing for the implementation of efficient irrigation system and proper irrigation management system in the water department in Government of India as well as Government of West Bengal.

References:

1. Anbumozhi V., K. Matsumoto and E. Yamaji (2007), "Sustaining Agriculture through Modernisation ofIrrigation Tanks: An Opportunity and Challenge for Tamil Nadu, India",http://cigrejournal.tamu.edu/submissions/volume3/LW%2001%20002.pdf.
2. Bhadra, T., Das, S., Hazra, S., & Barman, B. C. (2018). Assessing the demand, availability and accessibility of potable water in Indian Sundarban biosphere reserve area. Int J Recent Sci Res, 9(3), 25437-25.
3. Das .B. (2009). India's Water Resource Availability, Usage and Problems.
4. Jana, S. K., Palanisami, K., & Das, A. (2012). A study on tank irrigation productivity in the dry zones of West Bengal. Indian Journal of Agricultural Economics, 67(902-2016-67294).
5. Roy, S. (Ed.) (2006), Oxford Handbook of Agriculture, Oxford University Press, New Delhi.
6. Water, U. N. (2007). Coping with Water Scarcity: Challenge of the Twenty-First Century; Prepared for World Water Day. *World Health Organization: Geneva, Switzerland*.