A Study on Tank Irrigation Productivity in Saline Zone of South 24 Parganas

Subrata Naru
Research Scholar, Department of Economics, Vidyasagar University, Midnapore
Sebak Kumar Jana
Professor, Department of Economics, Vidyasagar University, Midnapore

Abstract

Tank irrigation is considered as most important irrigation source, particularly in the dry and saline zones of India. It plays the vital role in improving the yield or productivity in the agricultural sector. The present paper attempts to find the different characteristics of tank irrigation in the saline zones and draw lessons for improving the productivity of tank irrigation. Sixty five water bodies have been selected from five blocks of the district of South 24 Parganas to understand the influencing factors for the tank productivity in saline zones. The regression results show that large command area, proper management and less number of benefited families are responsible for higher tank productivity.

Keywords: Irrigation water; Tanks; Productivity; Saline Zone; South 24 Parganas

Introduction:

Water is the unique gift of nature and as a natural factor it has an important role in human civilization.Being natural resource water cannot be treated as pure public good; sometimes it acts as private good as it is available at private cost (Gatto and Lanzafame, 2005). With the increasing population, the freshwater sources are being exploited all over the world.Groundwater becomes the only source of potable water in the region where fresh surface water is not available (Bhadra et al., 2018). At least, half of the world's population depend on ground water to meet their potable water need (UNESCO, 2015). 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).With an increase in the consumption of water resources by 70% and withdrawals of water resources by 15%, agricultural production will be increased by 60% to feed 9 billion people by 2050. Due to this high rate of growth of population, demand for fresh water increases by lips and bound. If demand for the utilization of water resources is increasing at this repaid rate then about 1.8 billion people of this globe will reside in water scarce regions by 2025 (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).

Irrigation is the most important factor behind the success of agriculture in Indian economy, because of the geomorphological differences in the different region of the country. Among the irrigation sources, tank irrigation is considered important as it can play a very critical role in the sustainable irrigation development particularly in the dry and saline zones (Jana et al., 2012). There are many advantages of tank irrigation (Gulati, et al. 1994, Palanasai et al 2010, Agarwal 2001, Vaidyanathan 2006 , ADB 2006, Pain et al 2008, Reddy 2009, Jana 2009, Jana et al 2012, Jana and Lise 2013, Jana et al 2018, Reddy et al 2018, Lise et al 2019).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. But with the threat of global warming, environmental degradation and ground water depletion tank water irrigation through rain water harvesting can plays a significant role in agricultural production in arid and semi-arid region in India. 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.

In the rural economy of India, tanks are the life line through which people earned their livelihood. Stakeholders like small farmers, marginal farmers, landless agricultural labourers and women 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. 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 productivity. The broad objectives of this study of tank irrigation are:

- To investigate the different characteristics of tank irrigation in the saline zone.
- To understand the overall status of tanks in saline zone.
- To examine the performance of tanks and factors affecting it.

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.

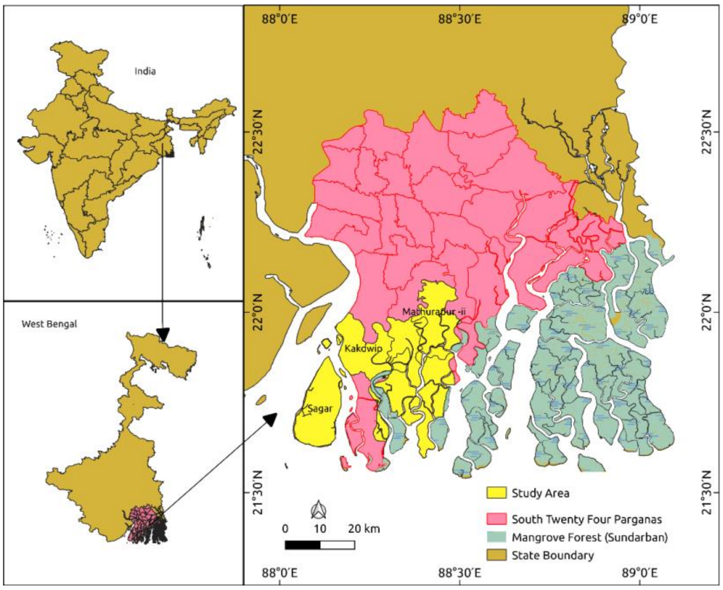

Figure 1. *The study area map of South 24 Parganas*

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 understand the controlling factors for the tank productivity in saline zones. To achieve the above mentioned objective, multiple linear regression model has been used for the present study in STATA and SPSS platforms.

Multiple Linear Regression for Determinants of Total Productivity:

Tank productivity is the value of production per acre of irrigated area, which depends on many factors (Jana et al 2012). To understand the influence of different variables/factors on the tank productivity multiple linear regression model has been used in the present study. This model is to find out whether the independent variables have any significant impact on the dependent variable. Based on literature surveys and collected primary data sets, six independent variables – capacity or volume of water body, management, water availability, command area, soil type, beneficiaries have been considered for this study. Due to less variation in the data and sample size, two or three relevant variables (fishery, tank conditions) haven't been used. In this study, the sample size (cases) is 65 (30 large water-bodies and 35 small water-bodies). The subjects-to-variables (STV) ratio is 10:1 (10 cases per variable), which is fair enough for the study.

The model is represented as follows:

TOTPODY = bo + b_1CAPCT + b_2MANGE + b_3WTAVL + b_4COMDA + b_5SOLTY + b_6BNFCS

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

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

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.

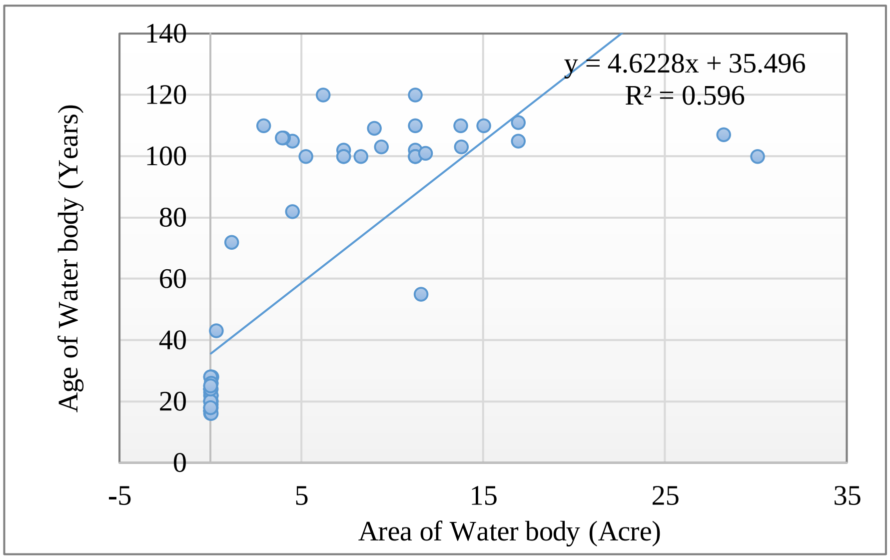

Figure 2.*Age and Size of All Water-bodies*

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.

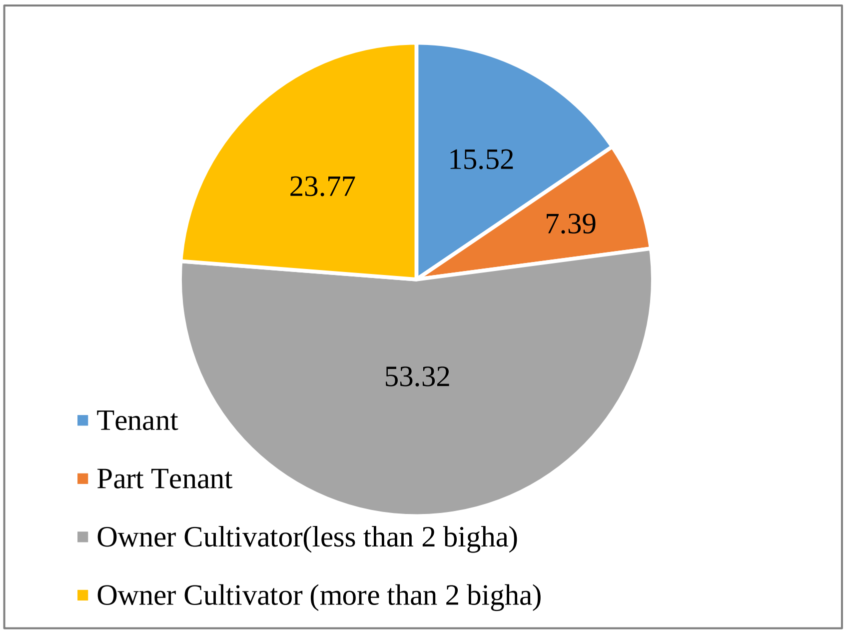

Figure 3.*Type of Farmers in the Tank Command Area*

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 productivity 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.

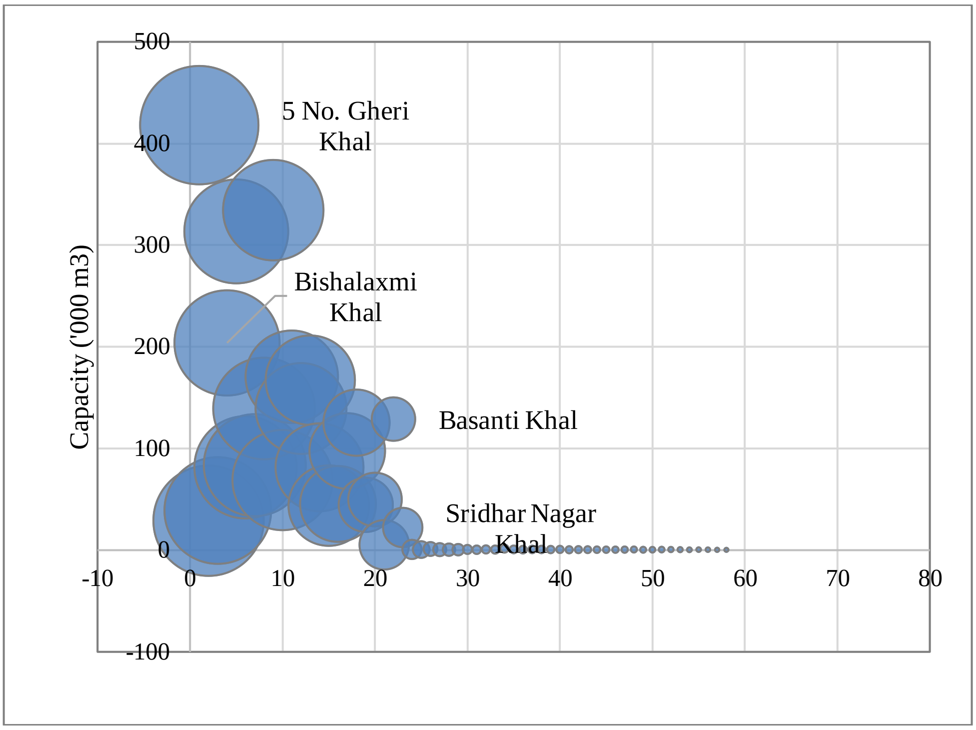

Figure 4.*Bubble Diagram showing Total Productivity (size) and Capacity of All water bodies*

Factors Influencing Tank Productivity in Saline Zone:

To understand the influence of different variables/aspects on the tank productivity multiple linear regression model has been used. Six variables – capacity or volume of water body ('000 cubic metre), management, water availability (months), command area (acre), soil type, beneficiaries (families) have been considered for this study. The correlation matrix of all selected variables is presented inTable 2. It is found that the selected variables are not highly correlated with each other, which suggests that there is no multi-collinearity issue.

Table 2.*Correlation Matrix of All Selected Variables*

Correlation Matrix						
	Capacity	Beneficia ries	Manage ment	Water availability	Soil type	Command area
Capacity	1.000	.784	-.526	-.642	.513	.729
Beneficiaries	.784	1.000	-.724	-.718	.621	.916
Management	-.526	-.724	1.000	.791	-.400	-.591
Water availability	-.642	-.718	.791	1.000	-.489	-.699
Soil type	.513	.621	-.400	-.489	1.000	.687
Command area	.729	.916	-.591	-.699	.687	1.000
a. Determinant = .004						

Table 3.*Collinearity statistics for Regression analysis*

Model		Collinearity Statistics	
		Tolerance	**VIF**
	Capacity	.345	2.901
	Beneficiaries	.206	4.848
	Management	.247	4.045
	Water availability	.257	3.884
	Soil type	.527	1.897
	Command area	.258	3.869
Dependent Variable: Productivity (Rs. /acre)			

The results show that the model is fit and almost 20 percent of variation in the tank productivity is explained by the variables included in the model.

Table 4.*Estimated Regression Coefficients of the Tank Productivity Analysis*

Tank Productivity	*Coefficient*	*Std. Err.*	*t*	*Sig.*	*[95% Conf. Interval]*	
Capacity	-0.041046	0.0227124	-1.81	0.076*	-0.0865099	0.0044179
Management	17.88614	5.94628	3.01	0.004***	5.983368	29.78891
Water availability	1.413835	1.236072	1.14	0.257	-1.060432	3.888102
Command area	0.3177473	0.0516272	6.15	0.000****	0.2144042	0.4210904
Soil type	0.3614115	5.093652	0.07	0.944	-9.834641	10.55746
Beneficiaries	-0.1383478	0.0261886	-5.28	0.000****	-0.1907699	-0.0859257
Constant	21.92468	10.66526	2.06	0.044**	0.5758365	43.27352
Observations = 65; F(6, 58) = 9.35; Prob.> F = 0.0000; R-squared = 0.1941						
**** p < 0.001, *** p < 0.01, **p < 0.05, * p < 0.1						
Data Source: *Estimated from Primary Survey, 2018*						

The results show that the significant variables are beneficiaries with negative coefficient value, and command area, management with positive signs. It can be interpreted that large command area, proper management and less number of benefited families are responsible for higher tank productivity. In the case of other variables, they have expected signs, but are not significant.

It is clear from the regression analysis that management aspect is very important in increasing the tank water productivity. Government, community and personal level initiatives and tank management activities can influence the productivity and change the socio-economic scenario of the study area. The command area is also expected to positively influence the tank water productivity. If the command area is large then production will be more and if the area is small then production will be less. Families who are dependent on tank water for irrigation and other domestic purposes use water as much as they can do. They are using tank water as public good, and overuse tank water sometimes which reduces the tank water productivity.

In the present analysis, water availability is not significant but it improves the tank productivity. It is quite possible to increase the water availability by improving the catchments and field channels. It is also observed during the survey that few tanks with good structures have the higher water availability. It can be suggested that according to the tank productivity, the tank rehabilitation options are important in improving the tank performance in the district as well as state.

It is true that proper maintenance of water body can increase or improve the productivity. 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.

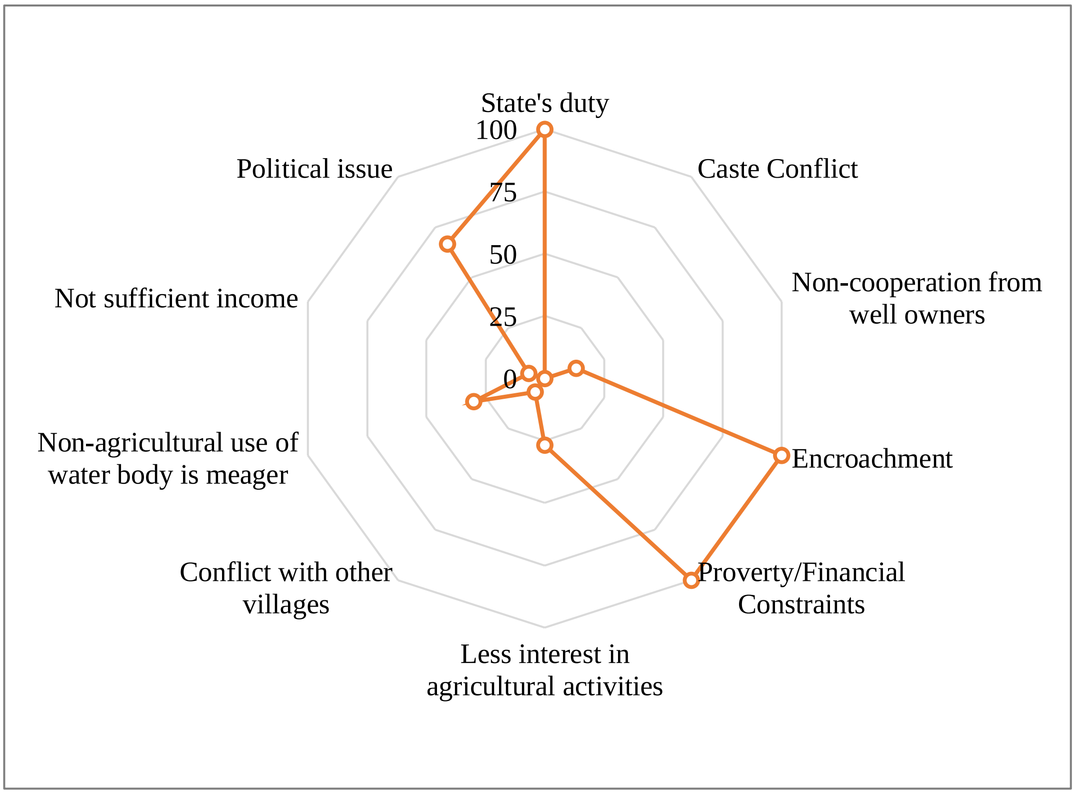

Figure 5.*Reasons for Lack of Maintenance of Water bodies*

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. The growth rate of production, before and after the renovation of water bodies will be more than 100%. In figure 6, the improvement in average value of production of different crops and items has been presented.

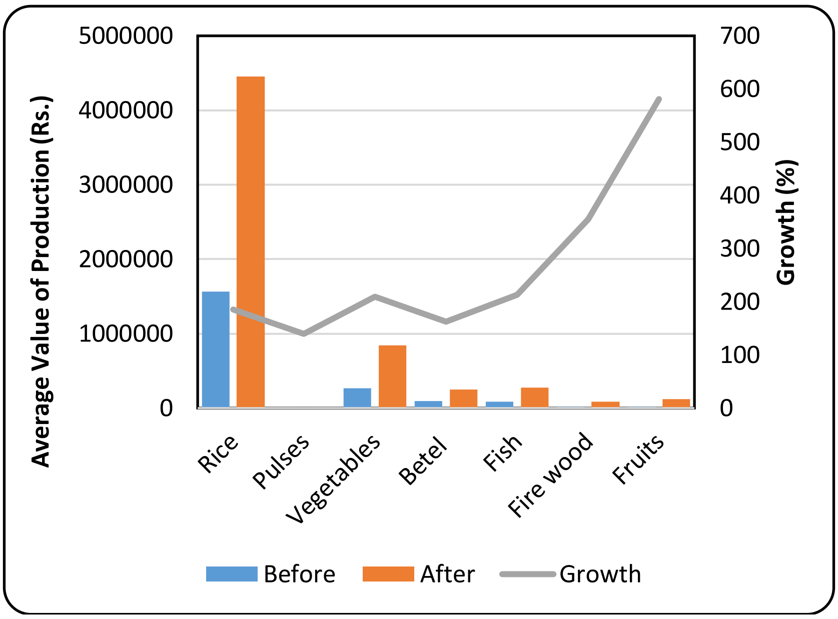

Figure 6. *Productivity Improvement after Water body Renovation*

Conclusion:

Tank irrigation is one of the practices of Indian irrigation system. The study reveals thatlarge command area, proper management and less number of benefited families are responsible for higher tank productivity. Government, community and personal level initiatives in tank management activities can influence the productivity and change the socio-economic scenario in saline zones. The renovation of water body is very much needed to increase the productivity. It can be said 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. For both farmers' and government perspectives, sustainability of irrigation systems is very important in the present days. Well-maintained channels, proper maintenance, adequate water supply, sufficient effort are very much needed in irrigation management. Further study on productivity analysis of all water bodies is needed to know the more about the efficient and inefficient tanks in saline zone of South 24 Parganas. This study will help to the policy makers to develop an implementable, efficient and district level policy for irrigation planning.

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