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ECONOMIC IMPACT OF WATER MANAGEMENT : A CASE STUDY

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ABSTRACT

Water is commonly regarded as plentiful, especially in the medium to high rainfall areas. But water is not equally distributed over the earth's surface. The increasing uncertainty over rainfall is hampering the normal economic activities especially agriculture. In rural West Bengal, man-made "chowka" is a beautiful example of water harvesting structure acting as lifeline to farmers during the dry season and minimising the risk of water-logging during uncommon heavy rainfall. This paper attempts to assess the economic impact of water management practices in a medium rainfall area in West Bengal. Also the effects of land size, expenditure on inputs and the role of panchayat are taken into account. The impact is evaluated in terms of cropping pattern, productivity, income, employment, and household assets. The study reveals that the overall impact is positive and significant, and hence, it demands a systematic and well-organised planning-execution approach to water management projects.

Introduction

In high and medium rainfall areas, rain-water acts as the predominant input in agriculture. However, the uncertainty over rainfall in recent years is becoming a stumbling block. Farmers are exploring alternative sources of water. Here comes the significance of water resource management – to explore new sources of water, to store water, to minimise water use for maximum output and to minimise water leakages and losses. The inland small and medium scale agriculture may find surface and groundwater as viable alternatives. However, groundwater extraction using shallow pumps are prohibited in different areas for various reasons. So the small and medium farmers fall back heavily on surface water resources. But very often, farmers are unaware or simply not interested to collect surface water, even when there is no pond or water-body nearby. The theory, process and benefit of rain and surface water harvesting is a new topic to many of them. But surface and rain-water harvesting in different structures within the landholding may contribute significantly to the agricultural productivity and income of small and medium farmers.

Pereira, H.C. (1973) has rightly pointed out that "the arable croplands carry the major burden of sustaining human food needs. The difficulties in farming them increase with

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increasing temperature and the declining amount and reliability of rainfall " and it is in this context that "small –scale water harvesting techniques are being studied afresh in India today". He has also pointed out that "Tying of ridges and structures of water harvesting improve rainfall penetration, increase crop growth and decrease soil erosion". Dikshit, G.S., Kuppuswamy, G.R. and Mohan, S.K. (1993) have shown the significance of small reservoirs in the context of water management practices in India from ancient to current period and analysed the structural, financial and institutional aspects of small reservoirs. Singh Katar (1994) finds that "tanks are still an important and the least expensive means of storing rain water and using it for supplemental irrigation and other purposes in many parts of India". He also points out that " the outcomes and impacts of management of irrigation tanks could be seen in crop pattern, input use, yield rates, net returns, economic viability of tank irrigation; and some intangible environmental changes". Baumann, P. (1998) has analysed the contribution of small reservoirs in the context of Panchayati Raj system in India. Goswami, S. (2006) has put forward an in-depth analysis of the practices and significance of tank irrigation in different parts of West Bengal. Nanda, P., Panda, D.K., and Swain, M. (2008) have shown the impacts of water harvesting measures in terms of cropping pattern and productivity of crops, impact on household income and employment, impact on employment generation and so on in seven villages in Digapahandi block of Ganjam district of Odisha. Pal, R.C. and Prasad, R. (2008) have shown the effects of water harvesting measures in six villages under the Rayachoty block of Kadapa district of Andhra Pradesh. The impacts upon the standard of life including livestock, water level in wells, change in cropping pattern, change in income generation activities, improvement in agriculture etc. are discussed.

Although our central aim is to find the economic impacts of water harvesting structures, we can find the effect of farm size on productivity as well. Economic theories show that the effects may be either positive or negative. Productivity does depend on the expenditure on inputs which may be traditional (less expensive) as well as modern (more expensive). Traditional inputs include low yielding seeds, plough and bullock, cow-dung and similar organic manure etc. while the modern inputs include high-yielding variety seeds, pesticides and chemical fertilisers, tractors, power-tillers, pumpsets etc. Economic theory postulates a positive relationship between expenditure on inputs and productivity, other things remaining the same. Here, we are in a position to verify this relationship.

Impact of local government organisations like panchayat on productivity is expected to be positive. Panchayats provide various inputs (seeds, fertiliser, irrigation etc.) and extension services (training, warehousing, marketing etc.) which are very much crucial for higher productivity. Panchayats organise training camps and workshops to impart new knowledge to the farmers. They try to spread awareness regarding the growing need, scope and mechanisms for water harvesting and water management. We also examine the role of panchayat in production and productivity of the farms.

This paper, basically, attempts to evaluate the economic impacts of simple rain-water and surface water harvesting practices upon agricultural productivity and hence on the standard of living of the farmers. However, the impacts of land size, expenditure on inputs and role of panchayat are also taken into account in this model. The economic impacts are evaluated in terms of differences in income and assets, employment, cropping pattern, production and productivity of different crops.

Methodology

Two villages with similar geographical and socio-economic features, namely, Keshabpur and Bajitpur under No.3, Chaitanyapur Gram Panchayat, Sutahata block, East Midnapore district of West Bengal were purposively selected. A complete enumeration of households was made and the pattern of land-use as well as the use of water harvesting structures was noted. From the total population, 100 households were selected at random. The sample consists of two distinctive groups. Group I consists of 80 households who constructed different water harvesting structures and consequently cultivated the land thrice in a year. Group II includes 20 households who did not care for water harvesting and depended mostly on rain-water, cultivated their land twice in a year.The sample households were administered with well-designed, semi-structured questionnaires to get required information. The data were collected in the year 2009-2010.

The pattern of crop production by the two groups of farmers is shown in the Table below :

Table 1 : Pattern of Crop Production

	Kharif Season	Rabi Season	Pre-kharif Season
GR-I	Aman Paddy, Vegetables, Betelnut	Boro Paddy, Vegetables, Betelnut	Aus Paddy, Betelnut, Vegetables
Gr-II	Aman Paddy, Vegetables	Boro Paddy, Khesari	———-

Source : Field Survey.

Multiple regression technique has been employed to assess the impacts of water harvesting structures along with land size, expenditure on inputs and role of panchayats on agricultural productivity and income.

Study Area

Keshabpur and Bajitpur villages are under No.3, Chaitanyapur Gram Panchayat, Sutahata block, East Midnapore district of W.B. The area comes under the gangetic plain agro-climatic zone of the State. The area lies between 22°7' N to 22°9' N latitude and 88°1' E to 88°8' E longitude. The area is covered with loamy soil. The average temperature varies between 10° C – 35° C, while the average annual rainfall varies between 150c.m. – 175c.m. In both the villages, farmers interested in water-harvesting techniques strengthened the existing bunds and built new bunds. They established vegetation on the upstream side of the bund. The slope of an individual land was made as minimum as possible. A grassed outlet was made according to the slope of the land for draining of rain-water. At the end of the slope along the boundary, small farm-ponds were dug out to collect the surface runoff as well as the rain-water. These are commonly called "chowkas" which act as the lifeline to farmers during the dry season. Again, during uncommon heavy rainfall, these chowkas act as buffer collecting the excess rain-water.

Model Specification

We use the following log-lin equation:

$$\ln Y = \beta 1 + \beta 2 \ln S + \beta 3 \ln E + \beta 4 (PN) + \beta 5 (CH) + u$$

where Y is average agricultural income (₹) per month per bigha, S is land size (in bigha),

E is average expenditure (₹) on inputs per month per bigha,

(PN) is the dummy for panchayat , (PN) = 1 if there is an influence of panchayat, (PN) = 0 if none,

(CH) is the dummy for chowka, (CH) = 1 if there is a role of chowka, (CH) = 0 if none.

u is the random error term normally distributed with zero mean and finite variance and satisfying the assumptions of the Classical Linear Regression Model. $\beta1$ is the intercept coefficient. $\beta2$, $\beta3$, $\beta4$ and $\beta5$ are the partial slope coefficients.

Result and Discussion

Table 2 : Impact on Cropping Pattern

Crop	% share of net sown area for Gr—I	% share of net sown area for Gr—II
Aman Paddy	83	58
Aus Paddy	40	—
Boro Paddy	60	30
Vegetables	30	20
Khesari	—	38
Betelnut	10	—

Source : Field Survey.

Table 2 shows that the cropping pattern is clearly better for the group using chowkas (Gr-I) compared to the group not using chowkas (Gr-II). Except khesari (one kind of inferior pulse), relative share of area under all other crops is more for Gr-I.

The total landholdings for Gr-I and Gr-II are 410 bigha and 90 bigha, respectively. So for Gr-I, the average landholding is 5.125 bigha and for Gr-II, it is 4.50 bigha. The cropping intensities for Gr-I and Gr-II are shown below.

Table 3 displays the gross cultivated areas under different crops for the two groups. Better availability of irrigation water from chowkas results in multiple cropping and mixed cropping systems for the Group-I farmers.Consequently, the cropping intensity for Gr- I is much higher than that for Gr-II.

Table 3 : Gross Cropped Area and Cropping Intensity

		Gross Cropped Area	Cropping Intensity
Gr-I	Kharif season	Aman Paddy – 340.30 bigha Vegetables – 20.00 bigha Betelnut – 21.00 bigha	(914.3/410)*100 = 223
	Rabi season	Boro Paddy – 246.00 bigha Vegetables – 68.00 bigha Betelnut – 10.00 bigha	
	Pre-kharif season	Aus Paddy – 164.00 bigha Vegetables – 35.00 bigha Betelnut – 10.00 bigha	
Gr-II	Kharif season	Aman Paddy – 52.20 bigha Vegetables – 18.00 bigha	(131.4/90)*100 = 146
	Rabi season	Boro Paddy – 27.00 bigha Khesari – 34.20 bigha	

Source : Field Survey.

Table 4 clearly shows that productivity for different crops is better when farmers adopt water harvesting techniques and structures. The productivity of Aman paddy and Boro paddy is higher for Gr-I farmers compared to Gr-II farmers by 50 and 60 per cent, respectively. Vegetables register 300 per cent higher productivity for Gr-I compared to Gr-II.

Table 4 : Impact on Productivity of Different Crops (Kg/ bigha)

Crop for Gr –I	Average Productivity for Gr –II	Average Productivity Adopting Chowkas	% Increase in Yield
Aman Paddy	900	600	50.00
Aus Paddy	750	—	—
Boro Paddy	800	500	60.00
Vegetables	400	180	122.22
Khesari	—	90	—

Source : Field Survey.

The number of cattle per household in Gr-I is 4.3 as against only 1.8 in Gr-II implying that average possession of livestock by Gr-I is 138.89 per cent more than that by Gr-II.

Table 5 : Impact on Livestock

	Total Number of Cattle	Average Number of Cattle / Household	Difference (%)
Gr-I	344	4.3	138.89
Gr-II	36	1.8	

Source : Field Survey.

Table 6 : Impact on Employment Generation

Activity	Gr—I	Gr—II	Difference in %
Average Mandays/ household/year	290	195	48.72
Average Power- tiller- days/ household/year	60	32	87.50
Average Tractor - days/ household/year	20	5	300.00
Total	370	232	59.48

Source : Field Survey.

The human labour utilisation for farmers in Gr-I is 48.72 per cent higher than Gr-II. For power-tiller-days and tractor-days, 87.50 per cent more power-tiller-days and 300 per cent more tractor-days have been generated by Gr-I farmers. Pooling all the employment generating activities, 59.48 per cent more employment opportunities have been generated by Gr-I farmers compared to Gr-II farmers and this difference can be attributed to more intensive agricultural activities undertaken by Gr-I farmers.

Impact on Household Income and Assets

Table 7 : Average Household Income from Agriculture

	Income/ Household /Month(₹)	Difference in %
Gr-I	18,780	85.48
Gr-II	10,125	

Source : Field Survey.

The average monthly income of sample households from agriculture in Gr-I is ₹ 18,780 compared to ₹ 10,125 in Gr-II, i.e., the average income in Gr-I is 85.48 per cent higher than that in Gr-II.

Table 8 : Valuable Assets of the Households

Asset	Gr-I	Gr-II
House with concrete roof	40	05
Fixed Deposit in Banks	12	01
Cycle	75	10
Motor cycle	18	01
Power tiller	07	00
Pumpset	11	00
Husking machine	08	00
T.V.	72	50
Phone	75	8
Refrigerator	08	01

Source : Field Survey.

Table 8 depicts that greater percentage of households in Group - I own different valuable assets as compared to households in Group - II. The higher income and assets of the farmers in Gr-I is basically due to increased productivity of crops and livestock and more employment generation. Those farmers have been encouraged to maintain and to undertake new water conservation measures due to benefits accrued from chowkas.

Table 9 : Role of Panchayats

1.	Distribution of Seeds	₹ 3,500/household/year
2.	Direct Purchase of Agricultural Output	₹ 5,000/household/year
3.	Organising General Meetings	One per month
4.	Organising General Training Camps	One per six months
5.	Special Meeting with Agricultural Development Officer (ADO) and Water Engineers	One per six months
6.	Direct Supervision & Encouragement for Building Chowkas (During last 3 years)	280 numbers
7.	Total Construction of Model Chowkas (During last 3 years)	18 numbers
8.	Total Allocation of Funds for Construction of Chowkas (During last 3 years)	₹ 31,520

Source : Field Survey.

The role of Panchayats in agriculture and allied activities is evident from Table 9. In our study villages, the Panchayats have distributed seeds worth ₹ 3,500 per household per year. They have made arrangements to purchase agricultural output worth ₹ 5,000 per household per year. They have organised general meetings once in every month and special training once in every six months. They have arranged meeting with the ADO and water engineers once in every six months. During the last three years, they have undertaken direct supervision for building 280 chowkas and have completely constructed 18 model chowkas. During the last three years, the Panchayats have allocated a total of ₹ 31,520 for construction of chowkas.

The Role of Chowkas in Irrigation : Our study villages lie in the medium rainfall gangetic plain of West Bengal. The average rainfall in the rainy season is 120-150 c.m. and 20-30 c.m. in the rest of the year. The rain-water acts as the predominant source of irrigation. There are two canals flowing through the villages. Canal water is available for irrigation in rainy season (kharif season) and winter (rabi season). However, the canals are heavily silted so that water available in winter is much less compared to demand for it and in pre-kharif season, the canals become completely dry so that they no longer remain a source of irrigation. On the other hand, fitting shallow pump is prohibited in both the villages. Under these circumstances, an alternative source of irrigation becomes relevant especially in the dry season. And, herein lies the significance of chowkas.

The model chowkas have the specification of 10ft x 10ft x 6ft. However, the chowkas vary in size and depth. For land size of 1 bigha or more, a series of two or more adjoining chowkas is suggested. These chowkas are built at the lower end of the slope of the lands. The chowkas collect the surface runoff as well as the rain-water. Again, during uncommon heavy rainfall, they act as buffers collecting the excess rain-water. For greater efficiency in storage, the inner walls and the bottom are suggested to be made of concrete. This will result in smaller loss of water. However, structures without concrete walls are also abundant. During the dry season, these chowkas therefore, act as the major source of irrigation. The pattern of irrigation for both the groups is shown in Table 10.

Table 10 : Distribution of Gross Cropped Area in Bigha (with %) in Different Seasons under Alternative Irrigation Systems for Gr-I and Gr-II

	Gr-I	Source of Irrigation			Total
		Rain-water	Canal water	Chowka	
S E	Kharif	275.00 (30.10%)	76.50 (8.36%)	29.80 (3.25%)	381.30 (41.71%)
A S	Rabi	52.00 (5.68%)	186.00 (20.34%)	86.00 (9.41%)	324.00 (35.43%)
O N	Pre-kharif	0.00 (0.00%)	00.00 (0.00%)	209.00 (22.86%)	209.00 (22.86%)
	Total	327.00 (35.78%)	262.50 (28.70%)	324.80 (35.52%)	914.30 (100.00%)

(Contd.)

Table 10 : *(Contd.)*

	Gr-I	Source of Irrigation		Total
		Rain-water	Canal water	
SEASON	Kharif	55.60 (42.31%)	14.60 (11.11%)	70.20 (53.42%)
	Rabi	8.50 (6.48%)	52.70 (40.10%)	61.20 (46.58%)
	Total	64.10 (48.79%)	67.30 (51.21%)	131.40 (100.00%)

Source : Field Survey.

Determinants of Agricultural Income Disparity : We have shown a significantly large difference in the income of Gr-I and Gr-II farmers in the study area. This difference can be attributed to some important socio-economic and farm characteristic variables. We have tried to analyse the contribution of land size (S), expenditure on inputs (E), panchayats (PN) and chowkas (CH) to agricultural income (Y) disparity between sample households. In our log-lin model, natural log of Y is regressed upon natural log of S, natural log of E, (PN) dummy and (CH) dummy. The estimated regression results are shown in Table 11.

Table 11 : Regression Results of Agricultural Income Disparity

	Coefficient	Standard error	t-statistic	p value
Intercept	2.071	0.392	5.284	0.000
In S	1.142	0.277	4.124	0.000
In E	0.346	0.151	2.287	0.027
PN	0.515	0.252	2.040	0.047
CH	0.758	0.283	2.678	0.010

n = 100, *k = 5.*

F- (4,95) d.f. = 65.816, p value = 0.000.

R^2 = 0.851, Adj R^2 = 0.838.

n (= 100) is the sample size and k (= 5) is the number of parameters to be estimated. The high t-values are indicative of the fact that all the estimated coefficients are statistically significant. The intercept coefficient $\beta 1$ takes the value of 2.071 and is significant at any level. The coefficient $\beta 2$ (= 1.142) is the elasticity of agricultural income with respect to land size. The positive sign of $\beta 2$ establishes a positive relationship between farm size and agricultural income. If land size increases by 1 per cent, average agricultural income increases by 114 per cent. β2 is significant at any level. The coefficient β3 (=0.346) is the elasticity of agricultural income with respect to input expenditure. If input expenditure increases by 1 per cent, average agricultural income increases by 34 per cent. β3 is significant at 5 per cent level. The panchayat dummy coefficient β4 takes the value of 0.515 and is significant at 5 per cent level. β4 = 0.515 signifies that the average agricultural income increases by 67 per cent (approx.) for the households getting panchayat services compared to the others. The chowka dummy coefficient β5 takes the value of 0.758 and is significant at 1 per cent level. β5 = 0.758 signifies that the average agricultural income increases by 113 per cent (approx.) for the households using chowkas for water harvesting compared to the others. F = 65.816 implies that all the coefficients are statistically different from zero and are significant at any level, d.f. = (4,95). R^2 = 0.851 signifies that approximately 85 per cent of the variation in the dependent variable (lnY) is explained by the regression model , R being the coefficient of multiple correlation. R^2 becomes 0.838 when adjusted for the degrees of freedom.

Conclusion

The case study supports chowkas as very effective tool for water harvesting and management. The construction and use of chowkas can enhance agricultural productivity and income. The paper argues that in our study village, the average agricultural income increases by 113 per cent for the households who use chowkas for agriculture compared to other households. This huge difference in agricultural productivity and income has induced the households and the panchayat to take interest in constructing chowkas.

We have shown in this paper that if land size increases by 1 per cent, average agricultural income increases by 114 per cent. In small holdings, capital- labour ratio is low and modern technology is hard to be employed. But as farm size increases, agriculture becomes more capital intensive and use of modern technology becomes more prominent. Consequently, our case study reveals a direct relationship between farm-size and agricultural income.

Expenditure on inputs has a direct influence on agricultural income. From our case study, we can conclude that as input expenditure increases by 1 per cent, average agricultural income increases by 34 per cent. The modern inputs compatible with modern technology are obviously more expensive and using these inputs can increase agricultural productivity and income to a great extent.

Last but not least, the panchayats can enhance agricultural productivity and income by providing various direct and indirect support services. Here, the average agricultural income increases by 67 per cent for the households who get panchayat services compared to the others.

The panchayats should encourage the farmers to construct small reservoirs/ chowkas and to maintain them properly. The technical support has to be provided by the panchayats. They should organise awareness campaigns. They should chart out proper management system of the chowkas and the system should be monitored by the households and panchayats jointly. This will be the key for a successful and sustainable management practice for the chowkas.

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