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Research Article

AN ECONOMIC IMPACT OF PARTICIPATORY IRRIGATION MANAGEMENT ON FARMERS OF NORTH SAURASHTRA OF GUJARAT STATE

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Abstract- Participatory irrigation management refers to the involvement of farmers (water users) in the different aspects of irrigation management such as planning, designing, construction and supervision, policy and decision making, operation and maintenance, and evaluation of irrigation system. The required information for the study were collected from primary and secondary sources. Based on highest number of water users' cooperative society, Rajkot and Jamnagar districts were selected purposively. Moreover, Cobb-Douglas production function was also employed to examine the resource use efficiency in wheat production, separately for both the groups. Major finding of the study revealed that there existed difference in cropping pattern and crop intensity, between two groups of respondents. The average gross return of wheat crop was Rs. 31200 and Rs. 21001 in case of farmers from functional and non-functional water uses' cooperative society, respectively. All variables, except plant protection chemical had positive and significant impact on wheat production in both the groups of respondent.

Keywords- Water uses' cooperative society, Resource use efficiency, Participatory irrigation management

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Introduction

Water is an important natural resource available for mankind. Water use can be divided into three major categories: agriculture, industry and domestic. Agriculture is by far the biggest user of water worldwide, the rate being more than 90 per cent in developing countries. Canals and tanks are the main sources of surface irrigation in India, while open wells and tube wells form the prime source of groundwater irrigation. Surface water provides irrigation to the extent of 42.5 million hectares accounting for 52.76 per cent of the total irrigation and groundwater irrigates 10.12 million hectares accounting for 12.56 per cent of total irrigation [1]. Participatory irrigation management context involvement of water user farmers in the various aspects of irrigation management such as planning, designing, construction, maintenance and supervision of minor canal, policy and decision making for water use and evaluation of irrigation system [2].

In the United States of America the efforts for participatory irrigation management began as early as in 1939. France and Taiwan also implemented the process in 1960's and 1970's respectively. Then after there have been spates of experiments in Asia, Latin America, Africa, Arabia and Europe. Similarly Colombia, Chile, Peru, Mexico, Brazil, Philippines and a number of other countries have adopted the programme with varying degrees of effort and success. The PIM programme is referred by different names in different countries. It is called as "Turn over" in Indonesia and Philippines, "Management transfer" in Mexico and Turkey, "take over" in Columbia, "Post-responsibility system" or "Responsibility contract system" in China and "Participatory Management" in Sri Lanka.

The Government of Gujarat has adopted a policy to encourage the management of irrigation projects on participatory basis in mid 1990s. Government has made various provisions through resolutions and circulars and enacted Gujarat Water Users' Participatory Irrigation Management Act, 2007 to facilitate participatory irrigation management in various irrigation projects of the state. The basic framework followed for the formation of water users' associations was as; the farmers' association would be registered under the Cooperative Act/Societies Registration Act/Indian Company Act. The ownership of head of canal and other structures has with the state government while, the farmer members would be involved in planning, administration, operation and management.

Materials and Methods

Saurashtra have 2 major State Irrigation Project Circle, *i.e.* Rajkot Irrigation Circle (RIC) and Bhavnagar Irrigation Project Circle (BIPC). Since the main objective of the study is to evaluate the performance of the water users' cooperative societies in North Saurashtra of Gujarat, two Districts were selected purposively, i.e. Rajkot and Jamnagar on the basis of the highest number of water users' cooperative societies. To study the physical and financial progress of water users' cooperative societies, two water reservoir dams were selected, i.e. Aji-2 from Rajkot and Und-1 from Jamnagar based on the availability of the highest number of functional water users' cooperative societies under head, middle and tail regions of irrigation canal. A comparative study was made to study the impact of water users' cooperative societies on farmers; thirty farmers were selected randomly from each reservoir under functional water users' cooperative societies and 30 farmers from non-functional water users' cooperative societies with equal number of head, middle and tail region. Thus, the total sample size of selected farmers was 120. Primary data on year of registration, year of handing over, quantum of water

agreed, canal maintenance, levy, water charges, financial status *etc.* in the command area were collected from the secretaries of water users' cooperative societies by survey method with the help of schedule specifically designed for the purpose. A number of variables were used to analyze the performance of selected water users' cooperative societies in the area. These included, a) Area of water users' association b) Number of farmers involved c) Irrigated area d) Total command e) Cropping intensity f) Cropping pattern g) Physical conditions of structures h) Levy collected i) Water management practices. Command and project wise data on the targets of area irrigated, number of registered water users' cooperative societies, number of water users' cooperative societies which have signed MoU and number of water users' cooperative societies which have been handed over and the corresponding area irrigated were collected from WALMI, Gandhinagar, Water Resources Department, Gandhinagar and Government District Irrigation Circle. Due to formation of water users' cooperative societies was started from 2007-2008, district wise seven years data on the number of water users' cooperative societies registered and division wise seven years data on the number of water users' cooperative societies that have been registered were collected from Water Resources Department, Gandhinagar. Following Analytical techniques were used. Primary data were collected for the rabi season of 2012-13 by personal visit

Compound growth rate analysis

In order to analyse the growth in number of water users' cooperative societies at district and division level, compound growth rate technique was employed using the exponential function of the form:

$$Y = a\, b^t \quad \text{..... [1]}$$

Where,

Y= Dependent variable for which growth rate was estimated (number of societies)

a = Constant

b = Regression co-efficient

t = Time variable (1, 2..., n) for each period *i.e.* year

Thus, natural log on both the sides of [Eq.-1] was taken to convert it in to linear form.

$$\log Y = \log a + t \log b \quad \text{..... [2]}$$

and,

CGR (%) was worked out using following formula:

$$CGR\ (\%) = (\text{Anti log of } b\text{-}1) \times 100$$

The significance of regression co-efficient was tested using the students't' test. i.e.

$$t = \frac{bi}{Se(bi)}$$

Where,

b_i = Regression co-efficient

SEe (b_i) = Standard error of the coefficient

Analysis of resource use efficiency

In case of crop production function, the crop yield was postulated to be influenced by various factors like labour, seed, manure, chemical fertilizers, irrigation and plant protection cost. Multiple regression analysis was carried to compare the resource use efficiency in crop yield/production on farmers of functional and non-functional water users' cooperative society. The monetary values of all these inputs were considered. The resource use efficiency was studied by fitting the Cobb-Douglas production function to the farm level data of wheat crop of 2012-13. The regression equation per farm is as follows:

$$Y = a\, X_1^{b1}.\, X_2^{b2}.\, X_3^{b3}.\, X_4^{b4}.\, X5^{b5}.\, X_6^{b6}.\, e^u$$

In logarithmic form, it assumed a log-linear equation as under:

$$\log Y = \log a + b_1 \log x_1 + b_2 \log x_2 + b_3 \log x_3 + b_4 \log x_4 + b_5 \log x_5 + b_6 \log x_6 + u \log e$$

Where,

Y = Gross return (Rs/ ha)

X_1 = Seeds (Rs/ ha)

X_2 = Chemical fertilizers (Rs/ ha)

X_3 = Manure (Rs/ha.)

X_4 = Labour (Bullock labour and Human labour) (Rs/ ha)

X_5 = Plant protection chemicals (Rs/ ha)

X_6 = Irrigation (Rs/ha)

a = Constant/ intercept term

u = Random variable

Similarly, b_1 to b_6 elasticity co-efficients of respective inputs. The co-efficients of multiple determination (R^2) was worked out to test the goodness of fit of the model.

Estimation of marginal value product

Marginal value products (MVPs) of the inputs were estimated from the fitted production function. Since both the dependent and explanatory variables are in monetary terms, the first differential of the regression equation gave directly the MVP. Symbolically, it can be expressed as follow:

$$MVP_{xi} = \frac{dy}{dx_i} = bi \cdot \frac{\bar{y}}{\bar{x}_i}$$

Where, y is the dependent variable, and xi is an explanatory variable. The marginal value product was thus obtained by substituting the corresponding geometric mean value of y and xi in the above equation.

The allocative efficiency was evaluated by comparing MVPs of the input with their respective prices and the difference between MVP and price was tested for its statistical significance using student's 't' test. The ratio of MVP to the factor prices indicates the direction of change that should be made in resource allocation, if the profit is to be maximized. The formula for calculating 't' is given below:

$$\text{Cal. 't'} = \frac{MVPxi - Pxi}{SE\ (MVPxi)}$$

Where, SE (MVPxi) = SE (bi) $\frac{(\bar{y})}{(\bar{xi})}$ since the value of dependent and independent variables expessed in monetary terms were taken into account,

MVPxi = Marginal value product of xi resource

Pxi = Acquisition unit price of xi resource,

SE (MVPxi) = Standard error of MVPxi, and

SE(bi) = Standard error of regression coefficient associated with xi resource.

If Cal. 't' < Tab. 't' 0.05 (n-k-1) degrees of freedom, than it can be concluded that difference between MVP of a resource and its acquisition unit price is statistically non significant which implies that this resource is used optimally.

Results

Growth in participatory irrigation management

It was noticed from the result presented in [Table-1] that the trend of water users' cooperative societies registered in North Saurashtra was negative. The numbers of water users' cooperative societies registered in North Saurashtra decreased significantly at the rate of 2.5 per cent per annum during 2007-08 to 2012-13.

It was seen that irrigation maintenance division- Rajkot and Rajkot irrigation division showed negative compound growth rates i.e. -18.25 and -4.22 per cent for annum during 2007-08 to 2012-13, respectively, Whereas, Jamnagar irrigation division and Surendranagar irrigation division showed positive compound growth rates i.e. 18.61 and 14.70 per cent, respectively.

The trend of year wise registration of water users' cooperative societies showed a positive trend during 2010-11. This was due to the fact that registration started in 2007 and it took some time for awareness about participatory irrigation

management. In 2012-13, all irrigation division reported positive trend. This was due to continuous effort for awareness about participatory irrigation management by Government, irrigation department and non-government organizations in a North Saurashtra. These findings are supported by the research of Mazumdar [3] and Talati and Pandya [4].

Table-1 *Irrigation divisionwise progress of water users' cooperative societies registered in North Saurashtra region of Gujarat state*

Name of the division	YEARS						CGR(%/Annum)
	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	
Irrigation Maintenance Division-Rajkot	9-	6(-33.33)	5(-16.67)	2(-60.00)	3(50.00)	4(33.33)	-18.25**[0.415]
Jamnagar Irrigation Division	4-	2(-50.00)	1(-50.00)	3(200.00)	4(33.33)	7(75.00)	18.61**[0.748]
Rajkot Irrigation Division	7-	11(57.14)	13(18.18)	17(30.76)	4(-76.47)	9(125)	-4.22**[0.523]
Surendranagar Irrigation Division	2-	1(-50.00)	1(0.00)	2(100.00)	2(0.00)	3(50.00)	14.70**[0.468]
Total	22-	20(-9.09)	20(0.00)	24(20.00)	13(-45.83)	23(43.47)	-2.50**[0.245]

Note: Figures in small parenthesis indicate percentage change over the years., Figures in large parenthesis indicate standard error.
** Significant at 1 per cent level of significance, * Significant at 5 per cent level of significance

Changes in irrigation area

It was noticed from [Table-2] that the increased in area of irrigation in the command area was low even after the formation of water users' cooperative society in middle and tail region as compare to head region. Head region had the highest of 24.67 per cent increased in irrigation area in command region as compared to other region and the middle regions had the lowest increased in irrigation area. This was because in the middle region on an average money spent on operation and maintenance work was low in each society. In head region, irrigation area was increased because of 33.33 per cent of the societies were regularly attended to operation and maintenance work which lead to increased in area of irrigation. These findings are also similar with the findings of Bhatt [5] and Ghosh and Kumar [6] who reported water availability to members had improved after the formation of the water users' association.

Table-2 *Changes in irrigation area after the formation of water users' cooperative society*

Region	Area irrigated by canal (ha.)		
	Before	After	Per cent change
Head	184.36	229.84	24.67
Middle	125.28	145.38	16.04
Tail	336.21	391.21	16.36
Total	654.85	766.43	17.04

Production elasticities and resource use

The geometric means of inputs used and output per farm in wheat production, as well as the result of regression analysis and ratio of marginal value product to marginal factor cost are presented in [Table-3] and [Table-4], respectively. The values of geometric means of all the inputs were higher in case of functional farmers groups except manure. Remarkable differences in geometric means of irrigation and labour between two groups of farmers were observed. The results of regression analysis revealed that the variation explained in the gross income from wheat production by explanatory variable included in the production function ($\bar{R}^2$) of functional farmers was 84.84 per cent, whereas, it was 59.42 per cent in respect of non-functional farmers. Higher value of adjusted R square ($\bar{R}^2$) indicated the fitness of Cobb-Douglas production function in analysis of wheat crop.

Table-3 *Geometric means of value of inputs and output in wheat production*

Variables	Geometric mean	
	Functional	Non-functional
Seed	2561.12	1986.55
Manure	1335.35	1415.53
Chemical fertilizers	3886.75	3341.151
Plant protection chemical	382.00	333.67
Irrigation	4461.13	1671.60
Labour	12301.20	7753.83
Gross income	62364.33	40930.73

Positive and significant impact of seed, manure, chemical fertilizers, labour and irrigation were noticed in case of farmers of functional and non-functional water users' cooperative societies.

Plant protection chemical was statistically non-significant in case of both groups. Return to scale, that is, response of output to a proportionate change in all the input simultaneously, in Cobb-Douglas production function can be estimated directly by adding the regression coefficients of all the variables. In wheat crop except plant protection, the coefficients of all other variables were found to be significant and all the variables had a positive influence on the output. This shows that with the increase in the use of these resources the output would also increase.

The resource use efficiency in terms of ratio of marginal value product to marginal factor cost presented in [Table-4] clearly indicate that seed (0.99), chemical fertilizers (0.76), labour (0.71) and plant protection chemical (0.77) were over utilized, since the ratio of marginal value product to marginal factor cost was less than one in wheat cultivated by farmers of functional water users' cooperative societies. While on the other hand, the ratio of the marginal value product to marginal factor cost in seed (1.42), manure (1.48), plant protection chemical (1.11) and irrigation (1.03) were more than one in wheat cultivated by farmers of non-functional water users' cooperative societies, that means all these inputs were under utilized.

Positive impact of participatory irrigation management was observed through the higher net return on wheat production in case of farmers of functional water users' cooperative society (Rs 31,200.2) as compare to farmers of non- functional water users' cooperative society (Rs 21,001.3). The results reported by Muhammad, et al. [7], Singandhupe, et al. [8] and Sisodiya [9] were closer to these findings.

Table-4 *Production elasticities of resources used in wheat production*

Variables	Functional WUCS		Non Functional WUCS	
	Production elasticities	MVP: MFC	Production elasticities	MVP: MFC
Intercept	8.0468 (0.2290)**	-	7.5966 (0.3870)**	-
Seeds	0.0408 (0.0185)*	0.9926	0.0694 (0.0269)*	1.4295
Manure	0.0284 (0.0118)*	1.3270	0.0514 (0.0171)**	1.4856
Chemical fertilizers	0.0475 (0.0118)**	0.7626	0.0552 (0.0254)*	0.6763
Labour	0.1410 (0.0134)**	0.7147	0.1463 (0.0290)**	0.7722
Plant protection chemical	0.0048 (0.0051)	0.7763	0.0091 (0.0105)	1.1115
Irrigation	0.0858 (0.0199)**	1.1991	0.0421 (0.0131)**	1.0318
Multiple R	0.9294		0.7971	
R Square	0.8638	-	0.6355	-
Adjusted R Square	0.8484		0.5942	
F value	56.04	-	15.40	-
Total cost	31177.1	-	19930.9	-
Gross returns	62377.3	-	40932.2	-
Net returns	31200.2	-	21001.3	-

Conclusions

The variants of participatory irrigation management were in vogue in different parts of India with partial success here and there. Due to continue effort of irrigation department, NGOs and various institutes, participatory irrigation management was starting adapted by farmers. However PIM nneds a simultaneous legislative initiative with full involvement of grass-root NGOs. Without capacity enhancement of WUAs, the full benefit of an expanding irrigation infrastructure cannot be achieved [10]. In the overall situation, negative trend (-2.50%) was observed in division-wise progress of North Saurashtra region of Gujarat State. It also showed that the irrigation area increased more in the head region *i.e.* 24.67 per cent. While the middle region, the area increased was just 16.04 per cent and in the tail region it increased 16.36 per cent.

Positive impact of participatory irrigation management was observed through the higher net return on wheat production in case of farmers of functional water users' cooperative society (Rs 31200.2) as compare to farmers of non- functional water users' cooperative society (Rs 21001.3). The Cobb-Douglas production function was found to be better fit in case of wheat production, as was judged by the explanatory power of the function ($\bar{R}^2$). All variables, except plant protection chemical had positive and significant impact on wheat production in both the groups of respondent. It could be concluded from the results of ratio of marginal value product to marginal factor cost of seed (0.99), chemical fertilizers (0.76), labour (0.71) and plant protection chemical (0.77) were less than one, it means these inputs were over utilized in the group of functional water users' cooperative societies. While in case of non-function water users' cooperative societies, seed, manure, plant protection chemical and irrigation were under utilized. It indicated that there was the scope for increasing the income from wheat crop by reducing the use of seed, manure, plant protection chemical and irrigation in the group of functional water users' cooperative societies.

Abbreviations: PIM: Participatory Irrigation Management

Conflict of Interest: None declared

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