ECONOMIC IMPACT OF WATER HARVESTING STRUCTURES ON FARMERS OF NORTH SAURASHTRA AGRO-CLIMATIC ZONE*

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India is endowed with vast natural resources. Efficient and sustainable use of natural resources is necessary for economic development, especially, in the agricultural dominated economies like India. India's agricultural production in general and food security in particular is critically dependent on the irrigation facilities created and their performance. Irrigation adds a very high value to the land, increases employment and income in the rural areas. Since irrigation is important for the development of agriculture and the nation's food security, Indian Planners have given high priority to its development and proper utilization. Thus, the irrigation is the crucial input in attaining sustained agricultural development, and importance of irrigation in crop production as well as increasing agricultural productivity has been widely recognized all over the world and same has been clearly brought out by the micro- and macro-level studies in India (Dhawan, 1988; Shah, 1989; Vaidyanathan *et al*, 1994; Vekariya, 1997, Narayanamoorthy, 2001 and Palanichamy *et al*, 2002). But irrigated agriculture in India has probably reached its limit and further sustainable increase in food production must come from dryland farming, especially through harvesting of rainwater and its management. Construction of water harvesting structures is, therefore, given due priority by various state governments and non-government organizations (NGOs). There have been some spirited efforts taken to capture the essence of available water harvesting knowledge from the successful initiatives in several places with varied geographical and water

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situations. This calls to analyze empirically the impact of such water harvesting structures on the farmers.

The water harvesting structures of Raj Samadhiyala of the North-Saurashtra Agro-climatic zone is one of the most admired water harvesting structures due to its higher water benefits. In 1986, villagers started to build check dams and tanks. Since then, they built 45 water harvesting structures over an area of 1090 hectares (Down To Earth, June 30, 2002). These water harvesting structures have been presented "Jalkranti Mahaprerak Award" for the year 1999-2000 by the Saurashtra Jaldhara Trust for their best and well managed work through community participation in resource management. Besides, these were also conferred upon by other two awards viz., "Namami Devi Narmade Award" and "Jal Bachavo Jivan Bachavo – Lokseva Award". The need of evaluating the impact of this water harvesting structures can hardly be over emphasized. This study was therefore, undertaken with the following objectives:

Objectives: i) to examine the impact of water harvesting structures on cropping pattern of farmers in the study area, ii) to evaluate the impact of water harvesting structures on crop yields and income of farmers, iii) to study the inequality between income of beneficiaries and non-beneficiaries, and iv) to estimate the water use efficiency in major crops of the study area.

Methodology

Sample design

Simple random sampling technique was used for selection of the villages as well as respondents in the North-Saurashtra Agro-climatic zone. Water harvesting structures of Raj Samadhiyala of this zone was selected since it is one of the best water harvesting structures in Saurashtra.

For the selection of farmers, 'with' and 'without' approach was followed to examine the impact of water harvesting structures (Ramanna, 1991; Deshpande and Reddy, 1991; Kshirsagar and Ghodake, 1991, Deshpande and Rajasekaran, 1997). For comparison purpose, a complete list of all the beneficiaries of water harvesting structures was obtained and 60 beneficiaries

were selected randomly. Similarly, an equal number of farmers who were deprived of the water benefits (non-beneficiaries), was selected randomly from the nearby villages. Thus, it constituted the total sample size of 120 respondents.

Data source

The relevant information on various aspects of farm inventory, which included the information about operational size of holding, particulars of human labour, bullock labour, irrigation facility, crop enterprises, family size, water use efficiency parameters, etc. was collected from the sample farmers by survey method with the help of well designed and pre-tested schedules through personal interview of the head of the family for the agricultural year 2001-02.

Empirical analysis

Tabular analysis was extensively used for estimating the costs and returns per hectare over different costs, input-output ratios etc. using various farm management concepts.

Cobb-Douglas production function was carried out in the present study to compare the resource use efficiency in crop production on beneficiary and non-beneficiary group of farmers. The general form of the regression equation per farm is as follows:

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10})$

Where,

Y = Value of crop yield per farm in rupees

X_1= Size of holding (ha)

X_2= Hired human labour cost in rupees

X_3= Bullock labour cost in rupees

X_4= Value of seed in rupees

X_5= Cost of FYM in rupees

X_6= Cost of chemical fertilizers in rupees

X_7= Cost of irrigation in rupees

X_8= Plant protection cost in rupees

X_9= Opportunity cost of family labour in rupees

X_{10}= Miscellaneous cost in rupees

Gini Concentration Ratio (GCR) was calculated to measure the inequality in the income between beneficiary and non-beneficiary groups of farmers using the formula given below:

$$GCR = 1 - \sum_{i=1}^{n} P_i(Q_i + Q_{i-1})$$

Where,

P_i = Proportion of number of farmers

Q_i = Cumulative proportion of income

Q_{i-1} = Preceding cumulative proportion of income

The water utilization by the crop is generally described in terms of water use efficiency (kg/ha-cm). It is expressed as ratio of crop yield per unit quantity of water used during entire growth period of crop. Water use efficiency (WUE) was finally calculated as:

$$WUE_{ij} = Y_{ij} / SIWC_{ij}$$

Where,

WUE_{ij} = Water use efficiency of j^{th} crop for i^{th} farmer (kg/ha-cm)

Y_{ij} = The yield of j^{th} crop for i^{th} farmer (kg/ha)

SIWCij = Seasonal irrigation water consumption of j^{th} crop for i^{th} farmer (which includes effective rainfall) in cm,

The effective rainfall (RF_j) was estimated using the following model given by Ghaghada *et al* (1997) for the Rajkot taluka:

$RF_j = 0.752\ TRF - LS$

Where,

RFj = Effective seasonal rainfall in cm,

TRF = Total seasonal rainfall in cm,

LS= Losses due to deep percolation and direct evaporation which

was taken as 1.0 cm.

In order to nullify the contribution of size of holding in WUE, the Net WUE for each crop using size of holding (ha) as a weight, was calculated as under:

Where,

$$NWUE_j = \frac{\sum_{i=1}^{n}(S_{ij} \times WUE_{ij})}{\sum_{i=1}^{n} S_{ij}}$$

$NWUE_j$ = Net WUE for j^{th} crop (kg/ha-cm)
S_{ij} = Size of holding of i^{th} farmer for j^{th} crop (ha)
WUE_{ij} = Water use efficiency of j^{th} crop for i^{th} farmer (kg/ha-cm)
n = Number of farmers

Results and Discussion

Cropping pattern

Kharif is the main crop-growing season; more than 74 and 89 per cent of the gross cropped area is cultivated during this season by beneficiary and non-beneficiary groups, respectively (Table-1). Groundnut is a ruling crop for both the groups of farmers as it covered highest acreage in *kharif* season. Cotton is the second important crop for both the group of farmers. In case of *rabi* crop, the proportion of area under wheat crop was maximum followed by cumin crop in both the groups of farmers. However, only beneficiary farmers were able to grow vegetables during summer season due to availability of irrigation water. Relatively higher gross cropped area was observed in case of beneficiary group. Thus, it implies the positive impact of water harvesting structures on the farmers of region.

Cost of cultivation

The average cost of cultivation per hectare of groundnut (Cost C_2) was Rs.24492/- and Rs.20199/- for beneficiary and non-beneficiary groups, respectively (Table-2). The share of operating cost was about 65 per cent in both groups. Human labour, seed, bullock labour, manure, chemical fertilizers and irrigation cost were the major items of expenditure in groundnut cultivation for both the groups. Similarly, Cost C_2 for cotton and wheat was Rs.29982/- and

Table-1: Cropping pattern of selected farmers

(Area in hectares)

Crop	Beneficiary		Non-beneficiary	
	Area	No. of farmers	Area	No. of farmers
A) *Kharif*				
Groundnut	110.68 (50.09)	57	105.36 (75.58)	60
Cotton	53.28 (24.11)	43	19.40 (13.92)	24
Sub-total	163.96 (74.20)		124.76 (89.50)	
B) *Rabi*				
Wheat	37.04 (16.76)	37	13.60 (9.75)	21
Cumin	14.56 (6.60)	14	1.04 (0.75)	2
Sub-total	51.60 (23.36)		14.64 (10.50)	
C) *Summer*				
Vegetables	5.40 (2.44)	10	0.00 (0.00)	0
Gross Cropped Area (GCA)	**220.96 (100.00)**		**139.40 (100.00)**	

Note: *Figures in parentheses indicate percentage to gross cropped area.*

Rs.19172/- for beneficiary farmers, respectively, while the corresponding figures for non-beneficiary group were Rs.23711/- and Rs.16873/-.

Relatively higher cost of irrigation in case of cotton crop was incurred by beneficiaries (Rs.2884/ha.) as compared to their counterpart (Rs.1853/ha.) due to the availability of irrigation water for harvesting higher yields. About 10 per cent of total cost of cultivation was incurred for protecting the cotton crop against heavy attack of bollworm during the season. However, proportion of irrigation charges to total cost in case of wheat crop was relatively higher for non-beneficiaries as compared to the beneficiaries because of higher cost of lifting the water.

Yield and returns

Yield levels and returns per hectare of all crops were found relatively higher in beneficiaries than those on non-beneficiaries. Yield per hectare of groundnut, cotton and wheat crops in case of beneficiaries was higher by about 42, 45 and 31 per cent, respectively than their counterpart in the region (Table-3).

Similarly, net income over Cost C_1 for groundnut, cotton and wheat crops was higher by about 216, 137 and 77 per cent respectively in case of beneficiary farms than those of in non-beneficiary farms. Farm business income for respective crops was found 76, 95 and 77 per cent higher in case of beneficiaries. The input-output ratio over cost C_2 for all crops were found relatively higher incase of beneficiary farms.

Resource use efficiency

Cobb-Douglas production functions for groundnut and wheat crops were used separately for both the groups. The results revealed that the size of

Table-2: Cost of cultivation of major crops of the study area

(Rs./ha.)

Sr No	Particulars	Groundnut		Cotton		Wheat	
		B	*NB*	*B*	NB	*B*	*NB*
1.	Human labour						
	a. Family	1617	1693	2520	3096	1278	1963
	b. Hired	2608	2110	3983	1852	2566	1403
2.	Bullock labour	2898	2792	2586	2670	621	1259
3.	Seeds	3298	3134	1072	1107	1629	1627
4.	Manures	2270	1254	2269	2124	0	0
5.	Chemical fertilizers	1193	1012	1905	1661	2062	2233
6.	Irrigation	830	429	2884	1853	1926	1887
7.	Insecticides/ Pesticides	668	492	2995	2276	330	130
8.	Miscellaneous costs	989	922	0	0	1575	688
9.	Depreciation	376	389	594	393	303	228
10.	Interest on working capital	670	588	1463	1115	492	370
11.	Rental value of owned land	4577	3259	4493	3090	4422	3375
12.	Interest on owned fixed capital	272	289	493	319	225	146
13.	Management cost	2226	1836	2725	2155	1743	1534
14.	Cost A	15800	13122	19751	15051	11504	9855
15.	Cost B	20649	16670	24737	18460	16151	13376
16.	Cost C_1	22266	18363	27257	21556	17429	15339
17.	Cost C_2	24492	20199	29982	23711	19172	16873

***Note**: B--Beneficiary; NB—Non-beneficiary*

Table-3: Yield and returns per hectare of different crops

Sl. No.	Items	Unit	Beneficiary			Non-beneficiary			% increase in beneficiary		
			Groundnut	Cotton	Wheat	Groundnut	Cotton	Wheat	Groundnut	Cotton	Wheat
1	Yield										
	A) Main product	Qn	21.01	14.50	33.97	14.75	10.03	25.91	42.44	44.56	31.11
	B) By-product	Qn	23.97		30.51	21.26		24.93	12.75		22.38
2	Farm harvest price (FHP)										
	A) FHP of Main product	Rs./qn	1196.80	1937	724	1163.00	1926	718	2.90	0.57	0.83
	B) Income from by-product	Rs.	3465		3048	3215		2494	7.74		22.21
3	Gross return	Rs.	28610	28086	27642	20370	19318	21097	40.45	45.38	31.02
4	Farm business income	Rs.	12810	8335	16138	7248	4267	11242	76.74	95.33	43.55
5	Family labour income	Rs.	7961	3349	11491	3700	858·	7721	115.16	290.33	48.82
6	Net income over Cost-C_1	Rs.	6344	829	10213	2007	-2238	5758	216.09	137.04	77.37
7	Net income over Cost-C_2	Rs.	4118	–1896	8470	171	-4393	4224	2308.19	56.84	100.52
8	Input-output ratios over										
	Cost-A	Rs.	1: 1.81	1: 1.42	1: 2.40	1: 1.55	1: 1.28	1: 2.14			
	Cost-B	Rs.	1: 1.39	1: 1.13	1: 1.67	1: 1.22	1: 1.05	1: 1.57			
	Cost-C_1	Rs.	1: 1.28	1: 1.03	1: 1.58	1: 1.11	1: 0.90	1: 1.37	.		
	Cost-C_2	Rs.	1: 1.16	1: 0.93	1: 1.44	1: 1.01	1: 0.81	1: 1.25			

Table-4: Ordinary least square estimates of production function for groundnut and wheat

Sl. No.	Variables	Groundnut			Wheat		
		B	*NB*	*B*	NB	*B*	*NB*
1	Size of holding	0.9560** (0.1840)	0.2683 (0.3009)	0.4222* (0.1883)	0.5831* (0.2790)	-3.0321* (1.4579)	-0.8628* (0.4195)
2	Hired labour	0.0868 (0.0807)	0.2094 (0.1251)	0.1629* (0.0791)	0.0092 (0.0273)	-0.0242 (0.1371)	0.0390 (0.0424)
3	Bullock labour	-0.2603 (0.1182)	0.0966 (0.1683)	-0.0039 (0.1084)	-0.0064 (0.0228)	0.2343 (0.5359)	0.1444** (0.0267)
4	Seeds	-0.0254 (0.1601)	0.2077 (0.3012)	0.2730 (0.1742)	-0.0908 (0.2165)	1.6726 (0.8981)	0.6210 (0.3598)
5	Manures	-0.0017 (0.0064)	0.0024 (0.0086)	0.0108 (0.0056)	–	–	–
6	Chemical fertilizers	0.0131 (0.0156)	0.1265 (0.1801)	0.0206 (0.0240)	0.0162 (0.1369)	0.8920* (0.4385)	0.0588 (0.2148)
7	Irrigation	0.0226 (0.0178)	0.0222* (0.0090)	0.0357** (0.0070)	0.3376 (0.2160)	0.2540 (1.0092)	-0.0859 (0.3716)
8	Plant Protection	0.0891* (0.0430)	0.0043 (0.0186)	0.0261 (0.0148)	0.0214 (0.0117)	0.0271 (0.0342)	0.0309 (0.0162)
9	Family labour	0.0915 (0.0558)	0.2097* (0.1009)	0.1149* (0.0563)	-0.0340 (0.1005)	0.6216 (1.0824)	-0.0935 (0.1862)
10	Miscellaneous cost	-0.0263 (0.0504)	0.0985 (0.1041)	0.0401 (0.0578)	0.0988 (0.1455)	1.1774** (0.2132)	1.2293** (0.0835)
11	Constant	10.6424	2.5427	4.9743	7.7156	-24.5784	-2.9086
12	Adjusted R^2 ($\overline{R}^2$)	0.9073	0.8138	0.8323	0.8680	0.9717	0.9240
13	Residual sum of square	1.4532	4.4097	8.2984	2.1267	3.1883	15.4282
14	Chow's – F		3.59			7.23	
15	Returns to scale	0.9554	1.2456	1.1024	0.9351	1.8227	1.0812
16	t - value	0.1840	0.4648	0.3391	0.1375	0.3456	0.1111

Note: * *Indicate five per cent level of significance*

** *Indicate one per cent level of significance*

Figures in parentheses are the standard errors of regression coefficients.

B–Beneficiary; NB–Non-beneficiary; P–Pooled

holding was found to have positive and significant impact on groundnut production in both the groups as well as on wheat production in case of beneficiary group of farms (Table-4). Expenditure on irrigation, hired human labour and family labour contributed significantly to groundnut returns on non-beneficiary group of farms. Regression coefficients of expenditure on chemical fertilizers and miscellaneous cost were found positive and significant for wheat crop in case of non-beneficiary farms. However, constant returns to scale was found in groundnut and wheat production in both the groups.

Income inequality

The comparative picture with regard to the percentage share of both the groups of farmers in the total income during the year 2001-02 demonstrated that the share of upper 25 per cent beneficiary households in the total income was nearly 55 per cent in the respective income class (Table-5). However, proportion of non-beneficiary group of farmers in this class was only 8.33 per cent, which contributed nearly 27 per cent of the total income.

This was further investigated by estimating Gini concentration ratios and standard deviation of logarithms of income (Table-6). Gini concentration ratio was found lower in the beneficiary group of farmers (0.4640). This indicates that income was more evenly distributed in beneficiary group as compared to that in non-beneficiary group.

Water use efficiency (WUE)

Distribution of WUE over the proportion of area covered by beneficiary and non-beneficiary groundnut growers shows that about 72 per cent of total area covered by beneficiary farmers had WUE greater than 50 kg/ha-cm, whereas corresponding figure for non-beneficiary farmers had only 23 per cent (Table-7). Similarly, larger proportion of area covered in cotton crop by beneficiary group had higher WUE than their counterparts, which is attributed to availability of water in the area of water harvesting structures leading to provide life saving irrigation to cotton crop by beneficiaries. In case of wheat, 60 per cent of area covered by beneficiary farmers has WUE greater than 70 kg/ha-cm, whereas it was

Table-5: Distribution of income among beneficiary and non-beneficiary group of farmers

Income Range (Rs.)	Beneficiary						Non-beneficiary					
	No. of farmers	% of farmers	Cumulative %	Income (Rs.)	% of income	Cumulative %	No. of farmers	% of farmers	Cumulative %	Income (Rs.)	% of income	Cumulative %
Upto 20000	0	0	0	0	0	0	10	16.67	16.67	128808	4.15	4.15
20001-40000	4	6.67	6.67	127816	1.96	1.96	25	41.67	58.34	721553	23.22	27.37
40001-60000	19	31.66	38.33	976686	14.97	16.93	8	13.33	71.67	418134	13.46	40.83
60001-80000	11	18.33	56.66	775928	11.89	28.82	7	11.66	83.33	503532	16.21	57.04
80001-100000	7	11.66	68.32	620503	9.51	38.33	2	3.33	86.66	166452	5.36	62.4
100001-120000	4	6.67	74.99	441239	6.76	45.09	3	5	91.66	328716	10.58	72.98
120001-140000	3	5	79.99	371581	5.7	50.79	3	5	96.66	385003	12.39	85.37
140001-160000	4	6.67	86.66	610528	9.36	60.15	1	1.67	98.33	140632	4.52	89.89
160001-180000	4	6.67	93.33	679549	10.42	70.57	0	0	98.33	0	0	89.89
Above 180000	4	6.67	100	1919718	29.43	100	1	1.67	100	314384	10.11	100
Total	60	100		6523548	100		60	100		3107214	100	

Table-6: Concentration of income among beneficiary and non-beneficiary farmers

Sl.No.	Particulars	Beneficiary	Non-beneficiary
1	Gini concentration ratio	0.4640	0.4817
2	Standard deviation of logarithms of income	0.6339	0.8245

Table-7: Distribution of WUE over % area covered in different crops by beneficiary and non-beneficiary group of farmers

Groundnut			Cotton			Wheat		
WUE (kg/ha-cm)	% of total area		WUE (kg/ha-cm)	% of total area		WUE (kg/ha-cm)	% of total area	
	B	NB		B	NB		B	NB
20-30	0	4.93	Upto 10	4.28	21.44	40-50	16.41	3.53
30-40	17.20	35.62	10-20	45.80	30.52	50-60	8.00	23.53
40-50	11.13	36.14	20-30	22.07	30.31	60-70	15.12	43.53
50-60	42.57	18.15	30-40	20.12	9.48	70-80	21.38	24.70
60-70	29.10	5.16	40-50	7.73	8.25	80-90	39.09	4.71
Total	100.00	100.00	Total	100.00	100.00	Total	100.00	100.00

Note: B—Beneficiary; NB—Non-beneficiary

only 29 per cent in case of non-beneficiary group. This implies that beneficiaries were able to supply enough supplemental irrigation to wheat crop as compared to their counterpart in the region.

Net water use efficiency (NWUE) of all the major crops was also computed in order to nullify the contribution of size of holding in WUE. Net WUE

Table-8: Net water use efficiency *(kg/ha-cm)* of different crops

Crop	Beneficiary	Non-beneficiary	% Change
Groundnut	54.13	43.26	25.13
Cotton	23.33	20.25	15.21
Wheat	71.37	67.52	5.70

of all the major crops grown by beneficiary farmers was higher as compared to their counterpart in the region. Beneficiaries were found to have 25.13, 15.21 and 5.70 per cent improvement in Net WUE over non-beneficiaries in groundnut, cotton and wheat crops, respectively (Table-8).

Conclusion

The study revealed that water harvesting structures has multifacet advantages to the beneficiaries. Increase in yield and net income from various crops, reduction in unit cost of production, efficient utilization of resources, higher labour productivity, decline in income inequality and improvement in water use efficiency were the major advantages to the beneficiaries of water harvesting structures as compared to non-beneficiaries. Thus, these visible gains will help further to increase the awareness and willingness among the people about benefits of water harvesting structures constructed by active community participation. Therefore, it is suggested that thrust should be given on water-saving technology than on land-saving and water-using technologies. Mass campaign to educate the farmers should be made to grow the right kind of crops and share water adequately amongst farmers. The Green Revolution was built-in by external resources like energy, variety of crops, chemicals etc. That is why agricultural production was concentrated on few areas and dry land areas have not been benefited much from the Green Revolution. An Ever-Green Revolution, as envisaged by Dr. M. S. Swaminathan is therefore, possible only by managing local resources like water.

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