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Impact of Watershed Management Technology on Resource Use, Production and Employment in Dry Regions of South-Eastern Rajasthan: A Case Study of Chhajawa Watershed

B.L. Dhyani[1], K.D. Singh[2], S.N. Prasad[2] and Ratan Singh[1]

[1] *Central Soil and Water Conservation Research and Training Institute, 218 Kaulagarh Road, Dehradun 248 195, India*

[2] *Central Soil and Water Conservation Research and Training Institute, Research Centre, Kota 324 002, India*

Abstract: Chhajawa watershed is one of the 47 model watersheds taken up by Indian Council of Agricultural Research in1983 to verify the results of three experimental watersheds implemented by it during 1970s. Watershed represents agro-climatic and agricultural resource use pattern of south-eastern Rajasthan. Watershed plan was prepared by Central Soil and Water Conservation Research and Training Institute, Research Centre, Kota, and implemented by State Soil Conservation Department during 1986-1989. After eight years of completion of the project, a study was taken up to judge the efficiency of watershed management technologies on sustainable agricultural production and gainful employment generation with environmental security. The primary data from 50 farm families and time series (secondary) data from records of the watershed were collected and analyzed using budgeting and functional approach. The study revealed that watershed management project at Chhajawa had improved resources availability to the farmers, increased resource-use efficiency and total production from arable and non-arable land, as well as animal base after the project. The program had significantly increased employment opportunities in the watershed. Irrigated area, capital recovery factor to investment on soil and water conservation technologies and cropping intensity were found to be the most important determinants for enhancement of regular employment opportunities in the watershed.

Key words: Watershed, resource-use efficiency, south-eastern Rajasthan.

South-eastern region of Rajasthan is spread over an area of 4.19 m ha. It is characterized by hills of Aravali and Vindhyan ranges, out rock uplands and almost flat alluvial plains. Out of 2 million ha cultivated area of the region, about 70% is rainfed. The annual rainfall in the region is about 800 mm and 90% of it is received during July to September in few intense storms (Singh *et al.*, 1997). Soil erosion in the form of sheet, rill, gully and ravines is a matter of great concern. Soil moisture stress, eroding soil fertility and traditional methods of agricultural production are the major contributors for low crop productivity of rainfed lands in the region. To verify the success gained through pilot watershed management projects in Sukhomajri (Shiwalik), Fakot (Garhwal Himalaya) and G.R. Halli (Karnataka), Indian Council of Agricultural Research (ICAR) took 47 model watersheds in different agro-ecological regions and socio-cultural settings of the country (Narayana, 1988). Under this model watershed program, Central Soil and Water Conservation

Research and Training Institute, Research Centre, Kota, selected Chhajawa watershed and formulated a plan in 1983. The plan was implemented during February1986 to March 1989 by the Rajasthan state Soil Conservation Department to demonstrate the efficiency of improved land management system for sustainable agricultural production and to generate employment with improvement in the environment. The present study was undertaken in 1997-98 to assess the impact of the watershed management program on productivity, resource use pattern and employment generation.

Materials and Methods

Experimental watershed

Chhajawa watershed has an area of 454 ha and is located at 25°05′N latitude and 76°25′E longitude in district Barana. The watershed covers three villages, namely Chhajawa, Gordhanpura and Barana with a total human population of 2300. The watershed is predominantly inhabited by marginal (44) and small (45) families, which constitute about 69% of total families (129). Further, 48.6% of total population belongs to weaker section (SC and ST) with low literacy rate (32%).

The prevalent climate of the region is dry sub-humid. The annual average rainfall in the watershed is 874 mm and distribution is highly erratic. The rainfall distribution analysis revealed that minimum assured rainfall of 10 mm at 70% probability is expected from 2nd July to 2nd September. It indicates that rainy season crops of 11 to 14 week duration can be grown successfully in 7 out of 10 years in the area. The topography of watershed is slightly undulating with 1 to 3% slope. The soils are typical Vertisols having 30 to 40% clay in surface layers. About 92% of land belongs to land capability class IIe and IIIe, which are suitable for agriculture, but suffer from sheet and rill erosion. The remaining 35.90 ha area of watershed belongs to class VI (19.90 ha) and VII (16.0 ha) and is prone to gully erosion. Most of the cropped area was rainfed and cropping intensity was very low (81%). Dwindling ground water supply from 16 open wells due to excessive runoff is of great concern. This is primarily due to poor vegetative cover in the watershed. Different watershed management activities implemented in the Chhajawa watershed during 1986 to 1989 by the Rajasthan state soil conservation department under the technical guidance of institute's research center, Kota, are presented in Table 1 (Prasad *et al.*, 1996).

Table 1. Watershed management activities carried out during 1986 to 1989 at Chhajawa

Activity	Extent of work done
Graded bunds (km)	27.4
Waste weirs (nos.)	170
Masonry drop spill ways (nos.)	7
Gabions (nos.)	7
Low height masonry checkdams (nos.)	29
Loose boulder checkdams (nos.)	8
Land levelling and smoothening (ha)	14.5
Crop demonstrations (ha)	45.0
Agro-horti development (ha)	4.0

Data and analytical techniques

Watershed was being monitored scientifically on different aspects continuously. Therefore, to accomplish the objectives of the study, secondary as well as primary data were collected. Secondary data from 1985-86 to 1996-97 were collected from the official records. A sample of 50 farmers consisting of 24 from Gordhanpura, 14 from Chhajawa and 12 from Barana village were selected randomly to collect primary data. Data on various socio-economic traits related to watershed management were collected through personal interviews during 1997-98 on a pre-tested schedule.

Budgeting technique was used to assess the changes in resource situation of farmers at two point of time i.e., before the project (1985-86) and after the project (1997-98). Time series data from secondary sources were used to measure the changes in resource-use pattern in the watershed. The significance of these changes was judged by the significance of regression coefficient of linear trend equation:

$$Y = a + bt.$$

where,

Y = gross irrigated area/gross cultivated area/use of N, P/ cropping intensity/animal population,

a = constant, and

b = regression coefficient whose significance was tested using t statistics.

Total food grain, fodder and milk production in the different years was estimated by adopting following statistics.

$$Yi = \sum_{l=1}^{11} \sum_{j=1}^{K} A_{ij} \times Y_{ij}$$

where,

Yi = total production of food grain/fodder/milk,

A_{ij} = area under or number of j^{th} activity in the I^{th} year,

Y_{ij} = average productivity of j^{th} activity in the i^{th} period, and

I = 1 to 11, j = 1--------n

Linear trend equation was estimated using ordinary least square method. Compound growth rates were estimated using statistics suggested by Rao (1980) as explained below

Compound growth rate (CGR) = $b/Y \times 100$

where,

b = regression coefficient of estimated function, and

Y = harmonic mean of output series under study during the study period.

Regular employment opportunities generated in the watershed were estimated by using the statistics:

$$Ri = \sum_{l=1}^{11} \sum_{j=1}^{n} A_{ij} \times Y_{ij}$$

where,

Ri = total regular employment opportunities generated in period i,

A_{ij} = area under j^{th} crop during i^{th} period,

L_{ij} = per hectare labor requirement for j^{th} crop in i^{th} period, and

l = 1--------11, j=1--------n.

To find out the factors responsible for employment generation, a double log linear function of following form was used:

$$E = a x_1^{b1} x_2^{b2} x_3^{b3}$$

where,

E = total employment generated in the watershed,

x_1 = net irrigated area (ha),

x_2 = cropping intensity (%), and

x_3 = capital recovery factor for investment on soil and water conservation measures (Rs.) was estimated using stepwise regression technique.

Results and Discussion

Resource analysis/assessment

On an average, operational land holding in the watershed was 3.22 ha which showed a marginal decline over pre-project situations. Sample survey revealed that farm resources have improved after implementation of watershed management program. In the post-project period, about 60 % of the arable land had assured irrigation facility as compared to 6.2% during pre-project period. It was due to increase in the number of tubewells in the watershed area after the project implementation. Execution of various soil and water conservation measures, viz., graded bunds and gully control structures, etc., in the watershed had recharged the ground water aquifer. Improved ground water availability enhanced the number of wells and deep borewells in the area. Before the project, there were only 16 open wells, having command areas 32.5 ha. During 1997-98, there were 22 open wells, 11 deep wells and 24 tubewells in the watershed providing assured irrigation facilities to 359.6 ha area. It was observed that presently there is excessive use of tubewell facilities and water in the area, which may lead to depletion of ground water in future and was also realized by the farmers having open well on the upper portion or on the ridge of the watershed. Depletion of ground water forced them to convert two open wells into deep wells. Improved irrigation facilities led to intensive crop production and farm mechanization in the watershed. Gross cropped area increased from 336.1 ha in 1985 to 519.8 ha in 1998. It ultimately increased the cropping intensity from 81 to 122% in the watershed. It is evident from Table 2 that there were no thresher, tractor, seed drill, bund former and private well in the watershed during pre-project period, but after the project execution they had come up in good number. This resulted in a decline in use of bullock draught power in post-project phase. Number of cows and buffaloes also increased in the watershed after the project. These results are similar to findings of other watersheds in the country (Grewal *et al.*, 1981; Bhardwaj and Dhyani, 1994; Arya *et al.*, 1991).

Two hundred and sixty seven demonstrations on improved agricultural practices were carried out during 1986-1989. These resulted in significant positive change in resource-use pattern in the watershed (Table 3). Estimated trend equations with respect to gross irrigated and cultivated area, application of manures and fertilizers, etc., clearly indicated a significant increase in these attributes over time. All the regression coefficients were significant at 1% probability level. Further, the significance of estimated equations is

Table 2. Average resource situation of sample farmers

Resources of farm level	Pre-project (1985-86)	Post-project (1997-98)	Per cent change
Average farmily size (nos.)	5.6	8.0	42.9
Average holding size (ha)	3.24	3.22	-0.6
Average irrigated area (ha)	0.2 (6.4)	1.92 (59.6)	860.0
Rainfed area (ha)	3.04 (93.6)	1.31 (40.4)	-331.0
Livestock			
Cows (nos.)	1.7	3.0	76.5
Buffaloes (nos.)	1.1	2.6	136.4
Bullock (pairs)	0.9	0.6	(-)33.7
Goats (nos.)	0.3	0.4	33.3
Thresher (nos.)	Nil	7	–
Tractor (nos.)	Nil	12	–
Seed drill (nos.)	Nil	16 (+6 Bukkhar)	–
Private well (nos.)	Nil	12	–
Private tubewell (nos.)	Nil	2	–
Bund former (nos.)	Nil	16	–

Figures in parenthesis indicate percentage of total land holding.

also supported by their high values of 'R' ranging from 0.96 to 0.99. Maximum increase of 11.8 time was recorded in gross irrigated area followed by use of N and P fertilizers, and cropping intensity.

Impact on production

Arable and non-arable land and livestock are the basic production units in a complex agricultural production system in India. Watershed management program is aimed to enhance the total production from these areas by improving their productivity in a coherent manner. Total production from arable and non-arable land was estimated through budgeting landuse and cropped area under each crop. Productivity of each crop under different situations was collected from secondary sources. The average productivity of arable land increased from 670 kg ha^{-1} (1985-86) to 2240 kg ha^{-1} in the year 1997-98. Total fodder production from arable land also increased from 506 ton (1985-86) to 849 ton during 1997-98. It was possible through grass sowing and natural regeneration of grasses on graded bund. Total production was estimated by summing up the area under a product and average productivity of respective crop. Estimated trend equation indicates that food grain production in the watershed increased from 280 ton (during 1985-86) to 1026 ton (during 1995-96) with a compound growth rate of 12.6% per annum. It was mainly attributed to improved water management system and mechanization of field operations, which in turn increased the cropping intensity.

Afforestation and improved ground water recharge enhanced the total fodder production in the watershed at a rate of 4.25% per annum. Milk production also

Table 3. Level and trend of resource-use in Chhajawa watershed

Resources	Pre-project (1985-86)	Post-project (1996-97)	Estimated trend equation		
			Constant (a)	Coefficient (b)	R
Gross irrigated area (ha)	32.5	351.3	30.26	1.03** (18.33)	0.99**
Gross cultivated area (ha)	336.1	507.7	342.37	0.17** (9.73)	0.96**
Use of nitrogen (kg)	3125.7	29996.0	2531.78	0.93** (11.23)	0.97**
Use of phosphorus (kg)	4134.7	16604.7	4036.60	0.63** (18.59)	0.99**
Cropping intensity (%)	80.5	121.5	82.68	0.17** (9.8)	0.96**
Animal population (Nos.)	648.0	1229.0	638.30	1.12** (16.16)	0.98**

** Significant at 1% probability level. Figures in parenthesis are calculated t values.

increased at the compound rate of 0.86% per annum during the same period (Table 4). It is primarily due to availability of good quality fodder in large quantity after the implementation of the project. Analysis further revealed that there was a major shift in the crop preferences in the area. Farmers have diverted most of their arable land towards mustard. The contribution of cereals, pulses and coriander in the total production decreased from 49 to 32.2%, 26.2 to 13.7% and 16.0 to 3.4%, respectively, during 1985-86 to 1996-97, whereas the contribution of oilseed increased from 8.8 to 48.8% during the same period. These results are similar to those of Hamirpur watershed in Bundelkhand region (Bhushan *et al.*, 1997).

Employment

Underemployment or disguised unemployment is a common phenomenon in the Indian agriculture. It results in out migration of young and healthy rural workforce to sub-urban and urban areas. Thus agriculture is left on physically weaker workers of the village society. Therefore, generation of gainful employment opportunities in the rural area was also aimed through watershed management program. Total available workforce in the

Table 4. Trends of production in Chhajawa watershed

Item	Estimated trend equation		
	Constant (a)	Coefficient (b)	R
Total food grain production (q)	2524.80	0.57** (10.20)	0.97**
Total fodder production (t)	429.93	2.68* (02.81)	0.68*
Total milk produciton ('000 lit)	53.06	0.40** (12.86)	0.97**

* and ** denotes significant at 10 and 1% probability level, respectively. Figures in parenthesis indicate calculated 't' values.

Table 5. Employment impact in Chhajawa watershed

Particular	Pre-project (1985-86)	Post-project (1997-98)	% increase over pre-project
Available workforce (std. human units)	380	500	31.6
Total regular employment in agril. (,000 man days)	36.05	70.07	95.8
Working days/worker/yr	94.9	141.3	48.9

watershed increased from 380 to 500 standard human units (i.e., by 31.6%) during 1985-86 to 1997-98 (Table 5). With the adoption of watershed management program, regular employment opportunities in agriculture increased from 36 to 70 thousand man-days. It resulted in an increase in working days not only for the workers at the beginning of the project but for total work force also. The total annual gainful working days for all workers in the watershed were increased by 49% (Table 5).

To identify the factors responsible for generating regular employment opportunities, the estimated equation is:

$$E = 15392\ x_1^{0.1574*}\ x_2^{0.1906***}\ x_3^{0.0898**} \qquad (R^2 = 0.813)$$

*, ** and *** are significant at 1, 5 and 10% level of significance, respectively.

where,

- E = total regular employment opportunities (mandays/annum),
- x_1 = net irrigated area (ha),
- x_2 = cropping intensity (%), and
- x_3 = capital recovery factor for investment on soil and water conservation (Rs.).

The estimated equation clearly showed that all the selected variables i.e., net irrigated area (x_1), capital recovery factor for investment on soil and water conservation activities (x_3) and cropping intensity (x_2) were important determinants of regular employment generation in the watershed. The R^2 value was significant at 5% probability level indicating that about 81.3% of the total variation in the regular employment opportunities in the watershed is explained by the included three variables. Thus, it can be concluded that watershed management program had significant positive impact on generating employment opportunities at the farm level. Similar results were obtained in the watershed management at Fakot in Tehri Garhwal district of Uttaranchal (Dhyani *et al.*, 1997).

Conclusion

Overall, the watershed management project Chhajawa had improved the resource situation of the farmers, enhanced eco-friendly resource-use pattern and generated ample regular employment opportunities in the watershed. Net irrigated area, cropping intensity and investment on soil and water conservation had significant positive impact in generation of gainful employment opportunities. Therefore, the study concludes that watershed management program is a key to enhance the productivity of land and animal and to generate gainful

employment opportunities in the dry region rural setting of the south-eastern Rajasthan.

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