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Research Note

Construction of Rainwater Harvesting Structures and Economics of Crops in Parasai-Chhatpur Watershed in Bundelkhand Region of Central India

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Abstract

The study has ascertained the level of societal welfare achieved by the development of Parasai-Chhatpur watershed in Bundelkhad region of central India and has looked into the economics of this project. The study has revealed that after watershed interventions, the expenses on irrigation and labour will decrease, crop productivity will improve and benefit-cost ratio will increase. The economic analysis of different crops — wheat, groundnut, chickpea, sesamum, black gram and maize — cultivated in this watershed area has been presented along with employment generation potential in the area.

Key words: Watershed management, Parasai-Chhatpur watershed, societal benefits, economic gains, crop development

JEL Classification: Q16, Q12, Q25

Introduction

Soil and water are the two most vital natural resources for agriculture and the agricultural productivity depends on efficient use of these resources. Under the present scenario, India's land resources are under immense pressure. These share only 2 per cent of the world's geographical area, but support around 18 per cent of global population and over 15 per cent of the world livestock number (Katyal, 1998). It is estimated that by 2025, one-third of the world's population (especially in the developing countries) would face severe water scarcity (Secklar *et al.,* 1998). To achieve food security, minimize water conûicts and reduce poverty, it has become essential to increase the productivity of rainfed systems by harnessing the existing potential (Wani *et al.,* 2003). The Government of India has adopted watershed management as a strategy to address the sustainable agricultural productivity in the rainfed areas. The watershed is considered to be the most appropriate spatial arrangement and functional unit for managing complex environmental problems. Since 2003, watershed management has been adopted as a national policy (Joshi *et al.*, 2004). Thus, achieving food security for the country largely depends on the rainfed agriculture through watershed management **(**Sharda *et al*., 2006; Wani *et al*., 2009; Palsaniya *et al*., 2012; Singh *et al*., 2013a).

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Presently, the Goverment of India is investing more than ₹2500 crore annually on improving the condition of natural resources through watershed management under the Integrated Watershed Management Programme (IWMP) for better eco-system services. In the Bundelkhand region also several watershed projects are being implemented under IWMP schemes. The region is amongst the most degraded ecosystems characterized by undulating and rugged topography, highly eroded and dissected land, poor soil fertility and low water-holding capacity, scarce groundwater resources, erratic distribution of rainfall, lack of assured irrigation facilities, heavy biotic pressure on forests, inadequate vegetation cover and frequent crop failures, resulting in scarcity of food, fodder and fuel (NRCAF, 2012*)*. To overcome the problem of scarcity of water, food and fodder, local interventions on watershed basis are need of the hour. This study has ascertained the level of societal welfare achieved by implementation of the project and involves identification, quantification, valuation, and comparison of its various costs and benefits.

Study Area

The study was carried out at the Parasai – Chhatapur watershed in Jhansi district of Uttar Pradesh. The watershed covers two villages, namely Parasai and Chhatapur, with an area of 478 ha (4.78 km^2). It is located between 78°20′10.0″-78°22′0.0″ E longitude and 25°23′55.0″-25°25′30.0″N latitude. The elevation varies from 280 m to 314 m above mean sea level (MSL). This watershed falls in the agro-climatic zone of Central Plateau Hills Region. The annual rainfall in the Bundelkhand region varies from 800 mm to 1300 mm, about 90 per cent of which is received during south-west monsoon period (Singh *et al*., 2002). The winter rains are erratic, occasional, meager and uncertain. The length of growing season in Bundelkhand ranges between 90 and 150 days, depending upon rainfall and temperature regimes. Low rainfall, long dry spells and droughts are common features. Wheat is the major crop during *rabi* season and groundnut is the major crop in the *kharif* season along with black gram, green gram, sesamum which are mostly supplemental irrigated, depending on availability of water in open wells.

Methodology

Plan to Augment Water Resources in Watershed

A watershed action plan helps in identifying the available sources so that appropriate and effective solutions can be formulated. Presently, 30 per cent area gets life-saving irrigation during *rabi* season. The irrigation intensity could be enhanced through improved recharge of these wells by constructing rainwater harvesting structures at appropriate interval in the ephemeral drains. To get appropriate interval between consecutive rainwater harvesting structures (RWHS), reduced level at 30 m interval along the stream was obtained through the survey using dumpy level. The cross-section of the drains was also measured to design suitable cost-effective rainwater harvesting structures to augment water resources in the watershed. The cost-effective design of water harvesting structures is likely to contribute significantly in saving of public money (NRCAF, 2013; Singh *et al.*, 2013b). The location of seven RWHS was identified.

Economics of Crop Production

To evaluate the economic feasibility of crop cultivation in the Parasai- Chhatpur watershed, the economics of all the crops grown during *kharif*-2012 and *rabi*-2012-13 was worked out. All the fields were digitized in the GIS environment and the coverage of different crops in both the seasons was marked on a map and estimated using ArcGIS ver. 10. Information on input cost and employment generation was gathered by personal interview using well-structured questionnaires from 30 respondents in each season. Income from different crops was worked out on the basis of current procurement price (CACP, 2013). The net return was calculated by subtracting the cost of cultivation incurred from sowing to harvesting, for each crop from the gross return and then benefit-cost ratio was worked out.

Results and Discussion

Plan to Augment Water Resources in Watershed

Rainwater harvesting during rainy season in ephemeral streams at appropriate interval is the only option to enhance the recharge of shallow open dug-wells. It improves the yield of wells for sustainable

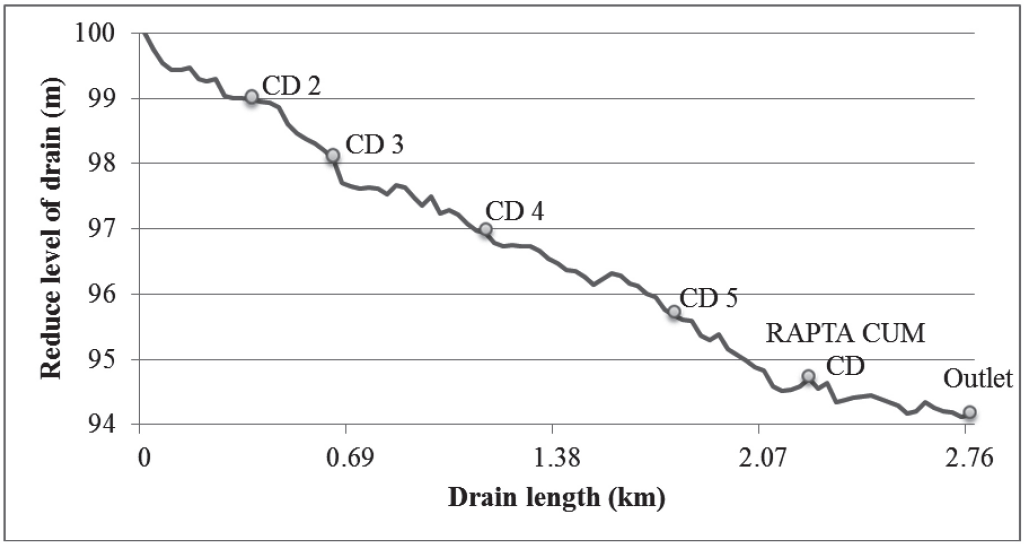

Figure 1. Horizontal and vertical intervals of rainwater harvesting structure in Parasai-Chhatpur watershed

Table 1. Technical details of Parasai-Chhatpur watershed checkdams

Sl. No.	RWHS No.	Height of headwall (m)	Length of submergence (m)	Volume of water (m^3)
1	Cheakdam 1 (*Haveli* Outlet)	1.04	465	55212
2	Cheakdam 2	1.02	360	2003
3	Cheakdam 3	0.9	270	1300
4	Cheakdam 4	1.1	480	3365
5	Cheakdam 5	1.3	660	4707
6	*Rapta* Cum Cheakdam	0.44	180	494
7	Outlet	1.01	810	6009
	Total			73090

crop cultivation. Reduced level and cross section at 30-m interval in the main ephemeral drains were utilized in appropriate site selection and cost-effective designing of rainwater harvesting structures. The horizontal and vertical intervals of different checkdams/ *rapta*-cum-checkdam (6 Nos.) is shown in Figure 1. The technical details of these checkdams (RWHS) are given in Table 1. The cost-effective checkdam No. 1 (*Haveli outlet*) was constructed on 2nd order stream which joins the main drain after checkdam No. 4. The storage capacity of *Haveli* was carried out by grid survey method using Dumpy Level at a grid of 30 m × 30 m. The contour map was prepared using surfer ver. 9.0 and the area of submergence and volume of CD 1 were found to be 8.79 ha and 55212 m^3, respectively. Its storage capacity was much higher than of other proposed checkdams. The cost of rainwater harvesting in *Haveli* was about ₹ 4.53/ m^3 of storage.

Economic Analysis

The total cultivable area under groundnut, sesamum, blackgram, maize, wheat and chickpea was 374.4 ha, 7.9 ha, 6.7 ha, 0.7 ha, 368.9 ha and 12.4 ha, respectively. The majority of area (> 88%) was under groundnut during *kharif* and under wheat during *rabi*. The cropping intensity was recorded as 93.2 per cent during *kharif* and 91.2 per cent during *rabi*, with 184.3 per cent for the whole year. The production of different crops (cereals, pulses and oilseeds) under the watershed was quantified through crop cutting. To compute the productivity of different crops, 30, 10, 10, 1, 30 and

Table 2. Economics of groundnut cultivation in Parasai-Chhatpur watershed

Particulars	Input or Output	Rate (₹)	Amount (₹/ha)
Seed (kg/ha)	100	50	5000
Ploughing/Sowing (hours/ha)	5	550	2750
Interculture-*Gana* (hours/ha)	2.5	300	750
Fertilizer (kg/ha)			
a) Urea	65	6.4	416
b) DAP	63	24	1512
Thresher (hours/ha)	3	600	1800
Labour (humandays/ha)			
a) Ploughing	1	150	150
b) Sowing	1	150	150
c) Irrigation (2 Nos.)	15	150	2250
d) Weeding	10	150	1500
e) Weedicide (Persut and Laso)	4	300	1200
f) Harvesting	25	150	3750
g) Threshing	13	150	1950
Irrigation- 2 Nos. (hours/ha)	35	55	1925
Weedicides			2125
Pesticides			190
Total cost			27418
Production (q/ha)			
a) Grain	8.10	3700	29970
b) Fodder	10.10	100	1010
Total income			30980
B:C ratio			1.13

10 crop samples of groundnut, blackgram, sesamum, maize, wheat and chickpea, respectively, were taken and processed for yield estimation. The economics of cultivation of two major crops, *kharif*- groundnut and *rabi*-wheat were calculated and are presented in Tables 2 and 3, respectively.

Considering all the inputs at prevailing market price and output at procurement price, benefit-cost ratio was worked out as 1.13 for groundnut and 1.12 for wheat. The output from cultivation was ₹ 30980/ ha against the input of ₹ 27418/ ha in groundnut and ₹ 27458/ ha and ₹ 24577/ ha, respectively in wheat. Presently, the cost on labour is ₹ 10950/ ha in groundnut cultivation and ₹ 11558/ ha in wheat cultivation. During pre-intervention phase, the majority of open wells supported continuous water withdrawal for 2-3 hours only, requiring more number of labourers and longer pumping hours to irrigate a unit area under groundnut cultivation. After watershed interventions, the expenses on irrigation and labour will decrease.

Water scarcity is the major problem in cultivation of *rabi* crops and wheat covering 88 per cent of area of watershed, requires about six irrigations. Open shallow dug-wells are the only means of irrigation in watershed and due to low specific yield, number of irrigation days and fuel consumption are high. Therefore, out of total requirement of 77 labourers per hectare, 34 labourers per hectare are required to provide only irrigation in wheat cultivation. The farmers were investing about 46.9 per cent of total input cost on labour. After watershed interventions, the expenses on irrigation component will reduce by about 50 per cent.

The economics of all the crops grown during *kharif* and *rabi* season, their productivity and cost of cultivation along with benefit-cost ratio were worked out and are presented in Table 4. The B:C ratio of all the crops was more than 1; it being 1.13 for groundnut, 1.02 for sesamum, 1.21 for black gram, 1.02 for maize, 1.12 for wheat and 1.61 for chickpea. The overall B:C

Table 3. Economics of wheat cultivation in Parasai-Chhatpur watershed

Particulars	Input or Output	Rate (₹)	Amount (₹/ha)
Seed (kg/ha)	188	15	2820
Ploughing (hours/ha)	5	500	2500
Fertilizer (kg/ha)			
a) Urea	65	6.4	416
b) DAP	63	24	1512
Thresher (7.5% of production in kg/ha)	146.25	12.85	1879
Labour (humandays/ha)			
a) Ploughing	3	150	450
b) Sowing	1	150	150
c) Irrigation	34	150	5100
d) Weedicide	4	150	600
e) Harvesting	25	150	3750
f) Threshing	10	150	1500
Irrigation 4 Nos. (hours/ha)	60	55	3300
Weedicides			600
Total cost			24577
Production (q/ha)			
a) Grain	19.5	1285	25058
b) Fodder	24	100	2400
Total income			27458
B:C ratio			1.12

ratio of crop cultivation in Parasai-Chhatpur watershed was 1.18 with the total income of ₹ 223.43 lakh against the total input cost of ₹ 197.75 lakh. The highest B: C ratio was recorded for chickpea, followed by black gram mainly because of less expenditure on irrigation component as well as higher rate of produce. The net gain through crop cultivation in watershed has been estimated to be of ₹ 25.56 lakh (Table 5)

Employment Generation

The details about employment generation in cultivation of different crops, given in Table 6, reveal that it was highest in wheat (77 humandays/ ha), followed by in groundnut (69 humandays/ ha) and maize (54 humandays/ ha). The total employment generation in the selected crops was for 55435 human-days which accounted for ₹ 83.15 lakh at the prevailing wage rate of @ ₹ 150/ day in the watershed. It is expected that after watershed interventions, the labour requirement for crop cultivation will reduce. But, the total labour requirement will significantly increase because of the agroforestry intervention which generates employment throughout the year.

Conclusions

Rainwater harvesting during rainy season in ephemeral streams at appropriate interval is the only option to enhance recharge of shallow open dug wells. The study has estimated that total water harvested through constructed and proposed structures in the Parasai-Chhatpur watershed area would be 73090 m^3. The storage capacity of *Haveli* checkdam has been found higher than of other proposed checkdams. Groundnut, sesamum, black gram and maize are grown during *kharif* season, while wheat and chickpea are grown during *rabi* season in this watershed area. The overall B: C ratio of crop cultivation in the Parasai-Chhatpur watershed has been estimated as 1.18. The highest B:C ratio has been recorded for chickpea, followed by black gram mainly because of less expenditure on irrigation component as well as higher rate of produce. The employment generation was highest in wheat, followed by groundnut and maize.

Table 4. Economic analysis of crops grown in Parasai- Chhatpur watershed in Bundelkhand

Crop	Area (ha)	Productivity (kg/ha)		Production (t)		Rate (₹/q)		Income (in lakh ₹)		Total income (in lakh)	Input cost (₹/ha)	Total input cost (in lakh ₹)	B:C ratio
		Grain	Fodder	Grain	Fodder	Grain	Fodder	Grain	Fodder				
Wheat	368.88	1950	2430	719.32	896.39	1285	100	92.43	8.96	101.40	24577	90.66	1.12
Chickpea	12.37	1050	0	12.99	0.00	2800	0	3.64	0.00	3.64	18244	2.26	1.61
Groundnut	374.42	810	1010	303.28	378.16	3700	100	112.21	3.78	115.99	27418	102.66	1.13
Sesamum	7.85	350	0	2.75	0.00	4200	0	1.15	0.00	1.15	14453	1.13	1.02
Blackgram	6.70	400	0	2.68	0.00	4300	0	1.15	0.00	1.15	14229	0.95	1.21
Maize	0.66	950	2850	0.63	1.88	1175	100	0.07	0.02	0.09	13744	0.09	1.02
Total	770.88			1041.6	1276.4			210.66	12.76	223.43		197.75	1.18

Table 5. Net gain in different crops cultivation in watershed in Bundelkhand

Crop	Cropped area (ha)	Net gain (₹/ha)	Net gain in watershed (in lakh ₹)
Wheat	368.88	2880	10.625
Gram	12.37	11156	1.380
Groundnut	374.42	3562	13.337
Sesamum	7.85	247	0.019
Black Gram	6.70	2971	0.199
Maize	0.66	269	0.002
Total	770.88	21085	25.561

Table 6. Employment generation in different crops cultivation in watershed in Bundelkhand

Crop	Area (ha)	Employment generation (humandays/ ha)	Total employment generation in watershed (humandays)
Wheat	368.9	77	28405
Chickpea	12.4	47	583
Groundnut	374.4	69	25834
Sesamum	7.9	44	348
Blackgram	6.7	34	228
Maize	0.7	54	38
Total	770.9		55435

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