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Economic feasibility of renovating a water harvesting structure with package and practices of cultivation in Shivaliks – a case study of Himachal Pradesh.

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ABSTRACT: To study the economic feasibility of rainwater harvesting structures in Shivaliks, one village pond of 2 ha-m capacity was renovated with proper irrigation network at village Mandhala, District Solan, Himachal Pradesh. Ten hectare of land was brought under supplemental irrigation and crop diversification index of the area increased from 0 to .418 during *rabi* (winter) season. The net return of Rs. 9,25,450 was obtained during three years of time (2003-05) against the expenditure of Rs.8,70,717 for developing water resources. Besides, about 7271 man-days employment was generated as indirect benefit due to water resource development and implementation of improved crop production technologies. The cost of water storage in the renovated water harvesting structure was found to be Rs. 28.5 m^{-3}, whereas, a net return of Rs. 38.2 m^{-3} was obtained by utilizing the stored water for irrigation to the crops during three years period of the study.

Key words: Diversification Index; Economic feasibility; Net return; Shivalik region; Water harvesting structure

The cost of creating one ha of irrigation potential through minor irrigation scheme was estimated at only Rs.8000/- as against Rs.27000/- for medium and major projects during theVII plan (Samra *et al.* 2002). Hence, in order to derive equitable benefits at minimum cost and to ensure proper water conservation, emphasis may shift to constructing a series of small reservoirs on watershed basis. The success of Sukhomajri project and other similar projects in the country justify this proposition where small scale water harvesting and resource conservation have increased the biomass production, mitigated the drought, recharged the ground water, generated employment and improved the socio-economic condition of the people (Mittal *et al.* 1986; Grewal *et al.*1995; Samra *et al.* 1995). In addition to this, the rainwater harvesting systems are environmentally sound, and the stored water resource provides benefits to the local community. Participatory management of harvested water resources ensures effective utilization, maintenance and sustainable operation of the system.

The Shivalik foothill region of 3 million hectares, comprising parts of Uttar Pradesh, Uttarakhand, Punjab, Haryana, Himachal Pradesh and Jammu & Kashmir is situated above the Indo- Gangetic alluvial plain and below the rocky Himalayas. About 62% of the total area of Shivaliks falls in H.P. The principal land use in this hilly tract is rainfed agriculture in valleys, and grasslands and forest on slopes and hilltops. The erratic distributions of rainfall, lack of irrigation facilities, soil fertility depletion and small land holdings have made traditional agriculture uneconomical. The increasing bovine population has caused serious problem of excessive cutting and overgrazing of the forest cover leading to hill denudation. Therefore, the present case study has been focused upon integrated rainwater management for sustainable production in Shivalik foothills at Mandhala village, District Solan, H.P.

MATERIALS AND METHODS

A benchmark survey of Mandhala village in district Solan, H.P. was carried out to assess the pre-project socio-economic conditions of the farmers. Data were collected from 62 farm families comprising a total population of 375, out of which 10 families were landless, 28 were in marginal land category of below 1 ha, while 16 small farm families had land holding between 1 and 2 ha (Table 1). Only 13 percent of the households were in land holding category of above 2 ha while the average land holding was 0.40 ha only. It was observed that there is a concomitant relationship between the human population and standard animal unit. By analysing the number of standard animal units per individual, it was seen that the landless possesses the least animals (one among six individuals). The number of cattle per individual goes on increasing with increasing land holding class to one animal per individual (Table 1).

One silted-up water harvesting structure (WHS) with 0.7 ha-m storage capacity was renovated by desilting and

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Table 1. *General demography and cattle population vis-a-vis land holdings of the study area of Mandhala village (H.P.)*

Sl. No.	Land Holding	No. of Families	Male	Female	Children		Cattle population
					Male	Female	
1.	Landless	10	16	13	8	9	10
2.	< to 1.0 ha	28	56	45	33	31	73
3.	1.0 to 2.0 ha	16	34	32	13	17	55
4.	2.0 to 3.0 ha	1	1	1	2	2	6
5.	3.0 to 4.0 ha	5	16	13	12	6	26
6.	> 4.0 ha	2	5	4	3	3	12
	Total	62	128	108	71	68	182

embankment stabilization. The catchment of the WHS was 4.32 ha. The pond was well equipped with inlet and outlet structures. A complete irrigation network system was laid out with 150 mm GI pipe initially and further transit the water through underground PVC pipeline of 150 mm diameter and another one was lift irrigation through 8 HP diesel engine provided by our Research Centre. Irrigation was done through a gravity (4 ha land) and lifting by centrifugal pump (6 ha land). Water User Society (WUS) was constituted for maintaining the irrigation network.

The WHS was renovated with an expenditure of Rs.8,70,717 including desiltation and embankment stabilization of pond (Rs.2,86346), purchase and laying of underground GI and PVC pipe line (Rs.2,77,183), sodding of grasses on embankment (Rs.21,153) and purchase of 8 HP diesel pumping set (Rs.23,892).

Crop Diversification Index

Crop Diversification Index (CDI) was used to assess the changes in the cropping patterns/systems due to crop improvement programmes (Sharda *et al*, 2005). It is defined as:

$$\text{Crop Diversification Index } (CDI) = \sum_{i=1}^{n} P_i \quad \log\left(1/P_i\right)$$

Where, Pi is proportion of ith crop in comparison with total cropped area and n is the total number of crops in the watershed. The CDI can attain any value >0 and higher value of CDI is an indicator of better crop diversification.

Table 2. *Area (ha) and yield (q ha^{-1}) of different crops along with Diversification Index(CDI) of kharif and rabi season at Mandhala village.*

Crops	Before intervention (2002)		After intervention (2004) (2003)		2004		2005	
	Area	Yield	Area	Yield	Area	Yield	Area	Yield
Kharif crops/C.D.I.								
Maize	7.03	9.5	6.68	26.5	7.12	30.0	6.82	30.0
Chari (Fodder)	0.28	196	0.52	240	0.30	250	0.14	270
Black gram	0.12	2.5	0.34	9.2	0.25	8.5	0.20	9.0
Green gram	-	-	0.32	6.0	0.04	6.5	0.08	7.0
Cowpea	-	-	-	-	0.04	0.30	-	-
Bitter gourd	-	-	-	-	0.08	4.0	0.04	4.0
Paddy	-	-	-	-	-	-	0.16	30.0
Total Area	7.43		7.86		7.83		7.44	
Crop diversi-fication index	.0982							0.8909
Rabi crops/C.D.I.								
Wheat	7.44	8.8	7.64	26.9	7.68	30.6	6.32	29.0
Tomato	-	-	0.48	254.0	0.36	255.0	0.64	244.0
Gram	-	-	-	-	-	-	0.44	8.8
Mustard	-	-	-	-	-	-	0.10	9.0
Taramira	-	-	-	-	-	-	0.20	6.0
Toria	-	-	-	-	0.48	6.0	1.90	10.8
Total Area	7.44		8.12		8.52		9.60	
Crop Diversi-fication Index	0							0.418

RESULTS AND DISCUSSION

Water harvesting structure came into operation in November 2002 and first irrigation was given to wheat crop. Data were collected from the command area starting from *Rabi* (2002-03) up to *Rabi* (2004-05) which showed a remarkable difference due to supplemental irrigation along with use of hybrid seed, balanced use of NPK and manure, timely sowing and method of sowing. In the first year, 82.5 hours of irrigation was provided to the farmers free of cost. Afterwards, the WUS was formed which was registered with the H.P. government and the maintenance and distribution of water was handed over to the society and the society fixed the rate of water. In 2003-04, a total of 235.65 hrs of irrigation was provided to the farmers @ Rs.45/hr. in 2004-05, total 65.2 hr irrigation @ Rs.60/- was provided. Rate of water charge was raised because of the rise in the rate of diesel and the maintenance cost of diesel engine. Society decided to charge same rate for both the systems i.e. gravity and lift irrigation.

Yield improvement and diversification

Provision of irrigation and improved production technologies not only increased the yield of crops but also a considerable amount of diversification of crops took place in the watershed. The maize yield increased from 9.5 q ha^{-1} (pre-project period of 2002) to 30 q ha^{-1} during the project intervention period during 2004 and 2005. *In situ* moisture conservation also took place due to sowing across the slope, timely hoeing, weeding and proper intercultural operations in furrows. This practice helped in higher productivity of maize and wheat crops. Similarly wheat yield also increased by more than 3 times (Table 2). Yield increase to the tune of 230% in case of wheat and 216% in maize was attained during just three years of the project period. Green gram, cowpea, bitter gourd and paddy crops were included by the farmers in cropping sequence during *kharif* season, whereas, tomato, gram, *toria* and mustard were taken by farmers during *rabi* season. There was more crop diversification during *kharif* season with a Diversification Index (CDI) 0.89 as compared to *rabi* season (CDI = 0.42) during the year 2004-05. Yadav *et al.* (2005) also reported that increased crop diversification due to water resource development.

Economic feasibility

In Mandhala project, total expenditure of Rs. 8,70,717 was incurred for developing water resources. During pre-project period, the net returns from agricultural crops in 10 ha land of Mandhala was Rs. 64,910 (Table 3). But after the project interventions, in the first year (2003), the net returns were worth Rs.2,76,004 and in subsequent years 2004 and 2005 the returns were worth Rs. 3,30,087 and Rs. 3,19,359, respectively. Net returns per hectare increased remarkably from pre–project year (Rs.4,365) to project intervention years. There were Rs. 17,271, Rs. 20,799 and Rs. 18,741 during 2003; 2004 and 2005, respectively. The total net returns during

Table 3. *Gross and net returns (Rs.) of different crops (on the basis of 2005 rates)*

Crops	Before intervention (2002)		After intervention (2004)					
			(2003)		2004		2005	
	Gross returns	Net returns	Gross returns	Net returns	Gross returns	Net returns	Gross returns	Net returns
***Kharif* crops**								
Maize	56880	31853	137280	100874	175420	136616	168700	128121
Chari	4400	3700	10000	8700	6000	5250	3040	2620
Blackgram	510	174	5100	3910	3570	2695	3060	2360
Greengram	-	-	3610	2490	494	354	1067	784
Cowpea	-	-	-	-	390	250		
Bittergourd	-	-	-	-	3500	3100	1600	1400
Paddy	-	-	-	-	-	-	3396	1758
***Rabi* Crops**								
Wheat	55000	29183	165200	110574	198000	142320	150220	102188
Tomato	-	-	61000	49456	46000	37342	78000	62608
Gram	-	-	-	-	-	-	8000	6460
Mustard	-	-	-	-	-	-	1280	980
Toria	-	-	-	-	3600	2160	15000	9300
Total	116790	64910	382190	276004	436974	330087	435943	319359
Returns (Rs. ha^{-1})	7854	4365	23916	17271	27534	20799	25587	18741
Area (ha)	14.87		15.98		15.87		17.04	

2003 to 2005 of upper Mandhala were Rs. 9,25,450 from agricultural crops only. Therefore, it could be stated that in minor irrigation project like Mandhala, the expenditure cost of water resource development can be recovered in just three years. Apart from this, the B: C ratio for considering 10 years life period of WHS without any further desiltation was found as 1.57:1, which also indicated the economic viability of the project.

Economics of water storage and utilization

The cost of creating storage of 2 ha-m (20,000 m^3) of rainwater was Rs, 8,70,717 . After that no recurring cost was incurred for harvesting the same quantity of water during the following years. Economics of storing and distribution of harvested rainwater in renovated WHS were worked out (Table 4). An amount of Rs.28.5 m^{-3} was incurred for renovation of WHS. In addition, Rs. 43.5 m^{-3} was spent for laying micro-irrigation system. The pooled analysis for three years (2003-05) including the recurring cost (diesel + operator's wages) for storing 6 ha-m water (3 years pooled storage), revealed that the cost of water stored and distributed was Rs. 14.9 m^{-3} only. The per unit cost of water storage would gradually decrease over time till the active life of the WHS, as initial expenditure of construction remains same, but the net returns continued from agriculture in subsequent years. The stored water was used to irrigate crops like wheat, tomato, toria, mustard, paddy and gram (Table 2). The irrigation was given through lift irrigation and or by gravity irrigation system for 383.85 hrs. during last three years (2003-05). Assuming discharge at the outlet of both the irrigation systems as 10 lit sec^{-1} (measured), it was estimated that 13800.6 m^3 water was used for irrigation in last three years to different crops. The net returns obtained from the crops were Rs.9,25,450 (Table 3). The net return of Rs. 38.2 m^{-3} was worked out under the study. Therefore, it was concluded that Rs. 14.9 was spent for storing one cubic meter of water based on 3 years pooled data, whereas, Rs. 38.2 per m^3 was obtained by utilizing the water for irrigation to the crops only in three years.

Table 4. *Cost of storage and distribution of rainwater in renovated water harvesting structure*

S. No.	Particulars	Cost (Rs.) (m^{-3})	Water stored (m^3)	Cost per unit quantity of water stored (Rs. m^{-3})
1.	Renovation of WHS (Desilting+sodding+embankment stabilization)	5,69,642	20,000	28.5
2.	Sl No. 1+ micro-irrigation system (laying out pipe lines+cost of pipes+ diesel pump)	8,70,717	20,000	43.5
3.	Pooled analysis Sl.No.2+recurring expenditure (pooled analysis of storing and distribution of water during 2003-05, including recurring cost)	8,94,677	60,000*	14.9

*Refers storing of 2 ha-m (20,000 m^3) in each year, so as a whole 6 ha-m in 3 years

Indirect benefit

The renovated WHS was effectively used for irrigation, fish cultivation and livestock. While, the old pond was used for only animal's consumption. Apart from the direct benefits, there are other indirect benefits of water harvesting and recycling, such as ground water recharging, reduction in soil erosion, improvement of soil fertility, employment generation, reduction of disparity and social tension etc.

Employment generation

The project works generated employment of 7271 man-days to people during the three years of the project duration. The employed people hailed from landless, small and marginal land categories in different activities. Maximum number of persons (42.5%) was employed in deepening and shaping of the pond. Over 22% of the men were engaged in plantation works in the catchment area of the pond. About 11% and 10% of the total employment was provided through watch and ward activities and irrigation pipe line laying, respectively. Total employment generated in different project activities is shown in Table 5.

Table 5. *Employment generated on various activities in Mandhala (2002-05)*

S. No.	Activities	Mandays	%
1.	Shaping and digging of the pond renovated and other mechanical watershed interventions	3085	42.5
2.	Plantation works	1625	22.3
3.	Watch and ward	817	11.2
4.	Irrigation pipeline laying	702	9.7
5.	Research Support	427	5.9
6.	Tailoring (activity for women)	270	3.7
7.	Crop demonstration	219	3.0
8.	Vermi compost soil samples	126	1.7
	Total	7271	100.0

CONCLUSION

Renovation of an existing small water harvesting structure in H.P. Shivaliks was found to be economically feasible as the cost of creating water resource could be recouped within a period of 3 years from the agricultural income only. Almost double returns were obtained by utilization of unit quantity of stored water as compared to the cost of storing unit amount of water. Crop diversification index increased 0.09 to 0.89 and 0.42 in case of *kharif* and *rabi* seasons, respectively due to water resource development and implementation of improved crop production technologies, which helped in fertility restoration and sustainable production.

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