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Economic Viability of Rainwater Harvesting by Renovating Village Ponds in Small Agricultural Watershed of Johranpur (HP)

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Abstract

The study has evaluated the benefits and financial structure of the project in the village Johranpur, district Solan (Himachal Pradesh) where a project under the NATP on 'Rainwater Management on Micro Watershed basis' was undertaken in the year 2000. It has also studied the extent of employment generated by the project and has assessed the changes in the land-use pattern in the project area. The results have revealed that technology of diverting run-off from agricultural fields to renovated ponds and its recycling to the same area with peoples' participation and other technological interventions could produce remarkable results and have tripled the net agricultural income. The project was implemented at an initial cost of 9.21 lakhs and farmers incurred additional annual cost on inputs ranging from Rs 4963 to Rs 6346 per hectare due to supplemental irrigation, increased cropping intensity and higher input-use. The benefit cost ratio has been found as 1.71 using a discount value of 10 per cent for the project-life of 10 years. The project has also helped in generating additional employment opportunities on casual as well as regular basis.

Introduction

Integrated watershed management is considered to be an appropriate approach to develop both arable and non-arable lands in rainfed areas for stabilizing and increasing production by adopting improved soil and water conservation measures. Since an element of risk clouds the dryland production systems, diversified and mixed-farming systems are

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recommended to achieve the twin objectives of sustainable production and restoration of ecological balance in a harmonious manner through scientific management of land and rainwater resources (Singh and Sandhu, 1979; Gupta and Tiwari,1985). An analytical evaluation of such programmes is, however, essential to provide justification of scarce financial resources and strengthen the hands of decision-makers for future investments. The present article has evaluated the benefits and financial structure of the project in the village Johranpur, district Solan (Himachal Pradesh) where a project under NATP on Rainwater Management on Micro Watershed basis was undertaken in the year 2000.The study has also investigated the extent of employment generated and has assessed the changes in the land-use pattern in the project area.

The Project

The Johranpur watershed is located in the village Johranpur, district Solan (H.P.). It covers an area of 19.6 ha, out of which 16.5 ha is under cultivation and 1.5 ha is under two ponds. The major area of the watershed faces degradation problems of varying degree due to lack of proper drainage system, lack of awareness about soil conservation and water-harvesting systems and adoption of traditional method of farming. In a mixed watershed comprising hill catchment and agricultural command area, the run-off through natural drainage channel is harvested by constructing earthen embankment at appropriate sites. However, the agricultural watersheds, a majority of which have multi-dimensional slopes, need to be developed with respect to diversion of run-off and creation of suitable storage capacity.

Based on the existing data on rainfall, run-off characteristics of agricultural watersheds, suitability of regions for various land-uses and socio-economic conditions of the farmers, following technological interventions were made (Yadav *et al*. 2005):

- Construction of two water-harvesting ponds by renovating the old ones and drainage channels for diverting run-off to ponds for its recycling for irrigating farmers' fields
- Partial polythene lining to reduce seepage losses
- Crop diversification for optimum utilization of harvested rainwater
- Alternative land-uses on marginal lands
- Introduction of improved technologies for efficient moisture and nutrient use, and
- Constitution of watershed society for sharing the harvested rainwater and watershed management.

The harvested rainwater was used to provide supplemental irrigations to the same area, which contributed run-off to these ponds. Water was harvested from 8.5 ha area and about the same area was provided with supplemental irrigations after full implementation of the project. More than 8 ha area was provided with irrigation in the years 2002-03 and 2003-04 for field crops. About 1.6 ha area put under orchards was established with irrigation in the first two years. And, thus, in total about 10 ha area was provided with the supplemental irrigation.

Methodology

The input and output data were collected from the project area at two points of time, i.e. before the start of the project and every year till the completion of the project. The method was more accurate as the concurrent data were collected for each input as well as output, although it needed more time for evaluation (Seckler, 1978). The evaluation was mainly carried out for agriculture, horticulture and the whole project. The actual costs incurred, and the actual and expected returns in the future for each component were discounted at 8 as well as at 10 per cent interest rates to the net present worth (NPW) and benefit cost ratios (BCR) were worked out assuming 10 and 15 years as project life. The NPV, BCR and IRR were calculated using the formula given by Gittinger (1982).

Results and Discussion

Demographic Characteristics

There were 24 families in the village with total population of 154, which increased to 169 after the project period in 2004 (Table 1). The average family size also increased from 6.42 to 7.04 after the project period. The female population constituted 52 per cent of the total population, which reduced to 50 per cent in 2004. The average size of landholding per household was 0.7 ha. The total livestock population slightly increased from 1.6 animal units per household in 2000 to 1.9 in 2004.

Increase in Crop Production

The farmers of the watershed were sowing local varieties by broadcasting methods with application of urea fertilizer only. Since there was no source of irrigation, the whole cultivated area was rainfed. *Desi* maize in *kharif* and rainfed wheat in *rabi* were the sole crops of the farmers belonging to the region. The average yield of the maize crop was 13.6 q/ha and of wheat

Table 1. Demographic characteristics of village Johranpur (HP)

Particulars	Before the project	After the project
Total number of families	24	24
Total population, No.	154	169
Average size of family, No.	6.42	7.04
Total work force (male + female), No.	87	94
Total female population, No.	80	85
Number of people working outside the village	25	33
Average size of landholding per household, ha	0.69	0.69
Cultivated area, ha	16.5	16.5
Total number of animals		
Buffaloes	31	40
Cows	2	4
Bullocks	6	11
Average size of animals per family, units	1.6	1.9

Table 2. Change in cropping pattern after the project

(percentage area under crops)

Crops	Before the project	After the project
Wheat (rainfed)	44.44	25.12
Wheat (irrigated)	—	17.72
Mustard	—	3.29
Toria	—	2.20
Tomato (irrigated)	—	3.95
Ginger (irrigated)	—	2.46
Maize	50.00	35.12
Sorghum (fodder)	3.70	4.58
Orchard	1.85	5.56
Total cropped area	27.00	29.50

was only 12.4 q/ha (Table 2). Sorghum was also sown on a very small area for fodder purpose. Adoption of package of practices and integrated nutrient management enhanced the maize yield drastically from 13.6 q/ha to 23.35 q/ha in farmers' fields. Farmers had adopted line sowing across slope, improved varieties and other management practices. Similarly, wheat yield increased from 12.4 q/ha to 30.5 q/ha as a result of supplemental irrigation from harvested rainwater. About 50 per cent of the stored water was lost

up to December when not used for irrigation. For efficient utilization of stored water immediately after the withdrawal of monsoon, i.e. in October-November months, toria, ginger and tomato cash crops were introduced which were highly profitable.

Initial Investment Cost on Different Components

The total expenditure on the project was Rs 9.21 lakhs, which was incurred over a period of five years. The year-wise capital costs on the major components are given in Table 3. The major items of expenditure were digging of ponds and construction of drainage channels, which jointly accounted for two-thirds of the cost of the project.

Annual Costs / Variable Costs

The annual costs included the additional costs incurred under the various heads as a result of watershed development in the project area. The variable cost included in the crop production sector was increased use of inputs in farmers' fields, which was worked out on the basis of input-output data of five years (Tables 4 and 5). The annual incremental cost varied from Rs 794 to Rs 1290 per ha for the rainfed area whereas it ranged from Rs 4963 to 6346 per ha for the irrigated area. In horticulture, after the initial establishment of plants, the costs incurred in the subsequent years in management, intercultural, pruning, watch and ward, felling of trees and plucking of fruits and marketing were taken into account. The cost side also consisted of capital cost. The annual cost comprised capital recovery (CR)

Table 3. Details of initial investment made in the Johranpur watershed

(in Rs)

Items	Expenditure					Total
	2000-01	2001-02	2002-03	2003-04	2004-05	
Diesel engine	12,500	—	—	—	—	12,500
HDPE pipe	28,879	—	—	—	—	28,879
Digging of pond	3,42,906	21,600	—	—	—	3,64,506
Cement pipe	24,840	3,240	—	—	—	28,080
Drainage channel	—	74,599	52,650	1,28,746	—	2,55,995
Polythene lining	—	—	24,278	—	—	24,278
Repair works	—	—	—	—	57,803	57,803
Irrigation pipeline	—	—	—	1,06,295	42,725	1,49,020
Total	4,09,125	99,439	76,928	2,35,041	1,00,528	9,21,061

Table 4. Crop-wise cost component (variable cost only) before and after the project

(Area in ha, costs in Rs)

Crops	Before the project		After the project									
			First year		Second year		Third year		Fourth year		Fifth year	
	Area	Costs	Area	Costs	Area	Costs	Area	Costs	Area	Costs	Area	Cost
Maize	12.0	65402	13.3	87281	9.43	61257	9.96	65036	12.2	87686	11.0	74210
Maize (I)	-	-	-	-	1.13	9907	-	-	-	-	-	-
Chari	1.0	3180	1.10	4158	1.24	4452	0.6	2428	0.3	1150	0.2	1145
Urd	-	-	-	-	1.4	7105	2.8	15820	-	-	1.1	5272
Tomato (I)	-	-	-	-	0.34	12727	1.14	42678	0.6	22462	1.3	27948
Soyabean	-	-	-	-	-	-	-	-	0.3	1410	-	-
Wheat (R)	13.0	69373	10.33	71424	7.68	57584	5.2	44838	4.47	33282	6.4	47918
Wheat (I)	-	-	4.29	40750	4.19	42775	7.1	84525	6.46	74742	5.6	57573
Mustard (I)	-	-	0.37	1672	0.97	6023	-	-	0.40	1800	1.6	7742
Mustard (R)	-	-	-	-	0.49	2583	1.0	7368	-	-	-	-
Ginger (I)	-	-	0.03	5848	0.13	20908	-	-	-	-		
Gram	-	-	-	-	0.7	3843	-	-	-	-	0.1	16083
Taramira	-	-	-	-	0.34	1275	0.4	1395	-	-	-	-
Toria (I)	-	-	0.12	522	0.12	944	-	-	0.54	2440	-	-
Paddy	-	-	-	-	-	-	-	-	-	-	0.8	10608
Total	26.0	148085	29.54	211655	28.16	231383	28.2	230330	25.27	224972	29.2	248941

I = Irrigated; R = Rainfed

Table 5. Crop-wise benefits before and after the project implementation

(Area in ha, Returns in Rs)

crops	Before the project		After the project									
			First year		Second year		Third year		Fourth year		Fifth year	
	Area	Returns	Area	Returns	Area	Returns	Area	Returns	Area	Returns	Area	Returns
Maize	12.0	115398	13.3	130396	9.43	129377	9.96	194170	12.2	205524	10.5	154800
Maize (I)	-	-	-	-	1.13	25741	-	-	-	-	0.8	18031
Chari	1.0	4000	1.1	7920	1.24	11400	0.6	7590	0.3	4080	0.2	4807
Urd	-	-	-	-	1.4	27412	2.8	34500	-	-	1.1	23496
Tomato (I)	-	-	-	-	0.34	77399	1.14	102348	0.6	53867	1.3	103200
soyabean	-	-	-	-	-	-	-	-	0.3	3480		
Wheat (R)	13.0	125511	10.33	104050	7.68	134552	5.2	97910	4.47	72935	6.4	108564
Wheat (I)	-	-	4.29	88618	4.19	110863	8.1	239121	6.46	171452	5.6	167712
Mustard (I)	-	-	0.37	5581	0.97	15384			0.4	4867	1.6	24680
Mustard (R)	-	-	-	-	0.49	5164	1.0	14261	-	-	-	-
Ginger (I)	-	-	0.03	15750	0.13	68250	.		-	-	0.10	48500
Gram	-	-	-	-	0.7	6195	-	-	-	-	-	-
Taramira	-	-	-	-	0.34	2917	0.4	4270	-	-	-	-
Toria (I)	-	-	0.12	1293	0.12	1450	-	-	0.54	12450	-	-
Paddy	-	-	-	-	-	-	-	-	-	-	0.8	21760
Total	26.0	244909	29.54	353608	28.16	616104	28.2	685685	25.27	528655	29.2	675550

I = Irrigated; R = Rainfed

and repair and maintenance. The CR factor was to provide a sinking fund for any capital facility that had a life shorter than the life of the project as a whole (Seckler, 1978). The basic idea behind CR was to find the amount, which, if continuously invested in a sinking fund over the life of the facility, would provide a sum sufficient to purchase a new facility at the end of its life. Similarly, the life of polythene lining had been assumed as five years. Repair and maintenance charges were calculated on the basis of 2 per cent per annum on capital cost. In horticulture, 819 fruit seedlings of guava, aonla, lemon, mausmi, papaya, mango and kathal were distributed over a period of three years. A total sum of Rs 51,155 was spent on planting. After the initial establishment of plants, the cost incurred in the subsequent years on management, irrigation, interculture, pruning, watch and ward, and plucking of fruits and marketing was taken into account, which ranged from Rs 44 to Rs 107 per plant per year over a period of 20 years.

Incremental Income from the Project

The economic parameters relating to annual benefits/impacts flowing on the completion of the agreed development programme were generated through conducting socio-economic surveys of crops, horticulture and soil-conservation components during the first five years of the project. These data were used to estimate the benefits from the development works executed under the project.

For the measurement of costs and benefits from horticultural plants, all the plants were grouped into three stages of development : (i) non-bearing, (ii) initial bearing, and (iii) full bearing for each year till all the plants reached their full-bearing stage (Dhyani *et al*., 1993). For the projection of future yields, the average of all the previous years' yields was taken as an average future yield for all the remaining years. The benefits projected in the column of soil conservation were calculated as follows. Taking Rs 60, 000 per bigha as the value of land at par with the market rate prevalent at the time of implementation of the project in 2000, it was assumed that without irrigation and soil conservation measures such as levelling, bunding, improved agricultural practices, the productivity of land would decline at an average rate of 0.5 per cent per annum.

Using the economic viability criteria, the present value of cost and benefit, net present value, internal rate of returns and benefit cost ratio were worked out for agriculture, horticulture and the whole project. The B:C ratio worked out for the agriculture sector was 2.57 and horticulture plantation was 1.91. For the whole project, the B:C ratio was 1.71, which clearly indicated the

Table 6. Benefit cost analysis of Johranpur Project at 8 per cent and 10 per cent discount rates for 10 years of project-life

Sector	Present value of costs (Rs)	Present value of benefits (Rs)	B: C ratio at 8% discount rate	B:C ratio at 10% discount rate
Agriculture	15,88445	40,84,009	2.57	2.56
Horticulture	3,26,608	6,23,808	1.91	1.81
Overall (including soil conservation and engineering works)	28,40,074	48,49,414	1.71	1.66

Table 7. Benefit cost analysis of Johranpur Project at 8 per cent and 10 per cent discount rates for 15 and 20 years of project-life

Sector	Project life of 15 years		Project life of 20 years	
	At 8% discount rate	At 10% discount rate	At 8% discount rate	At 10% discount rate
Agriculture	2.62	2.58	2.63	2.60
Horticulture	2.73	2.56	3.36	3.10
Overall (including soil conservation and engineering works)	1.95	1.87	2.10	2.01

economic viability of soil and water conservation measures taken on the watershed basis (Table 6). The payback period for the whole project was 6 years with an internal rate of return as 48.8 per cent. The B:C ratios were also worked out for the project assuming 15 years and 20 years as the project life (Table 7).The horticultural sector gave the highest returns for both 15 and 20 years of project-life simply for the reason that in the long-run the cost on maintenance and watch and ward decreased in proportion to the benefits because of the longer maturity period of fruit trees.

Increase in Employment Opportunities

One of the most important objectives as well as benefits of the soil and water conservation programmes was the generation of employment opportunities in the watershed area. This could be casual as well as on sustained basis. Casual employment of 8580 mandays was generated in the project area by way of executing soil conservation works, digging of ponds, laying out the pipe lines and other demonstration works over a period of

Table 8. Increase in employment in agriculture (per hectare basis)

(in mandays)

Category (ha)	Total	Male	Female
	Before the project		
£ 0.4	45.01	20.31	24.70
0.4 – 0.8	49.83	23.77	26.06
³ 0.8	48.04	26.81	22.87
Total	47.13	22.73	24.39
	After the project		
£ 0.4	77.80	26.15	51.65
0.4 – 0.8	81.56	28.66	52.90
³ 0.8	73.70	30.47	43.23
Total	76.63	29.21	47.41

four years. Besides, two skilled (technical) staff in the form of Senior Research Fellow (SRF) and Junior Research Fellow (JRF) were engaged, thus generating 2370 mandays of employment during the project period. Enhanced productive potential owing to a change in agricultural practices and diversification of cropping system helped in increasing per hectare employment in the agriculture sector from 47 to 77 mandays (Table 8). Female labour consistently contributed more than their male counterparts across the farms both before and after the project period. Division between genders showed higher increase in the employment of females than males.

Intangible Benefits from the Project

The planned development had resulted in conserving land, water, nutrients and vegetation resources. The agricultural fields covering an area of 8.9 ha earlier subjected to sheet and rill erosion had been conserved and stabilized through earthen diversion channels and land levelling. Besides, nutrients carried away with run-off were recycled back through irrigation water for which the monetary returns were calculated taking the values of N, P and K @ Rs 10.96, Rs 45.80 and Rs 10.40 per kg, respectively. Thus, the total savings were of Rs 20,677 on annual basis. The other benefit was the increase in value of agricultural land from Rs 35,000 per bigha at the beginning of the project to Rs 74,000 per bigha at the time of withdrawl of the project. As a result of renovation of ponds and a network of earthen diversion channels, water table has risen. Due to the groundwater recharge, two

deep tube-wells had been dug by the farmers at the depth of more than 100 metres. Grass vegetation had come up in the bed and banks. A watershed Society, *" Krishi Vikas Sangh, Johranpur"* was constituted and registered with HP Govt before starting the project . The Society was entrusted with the management and sharing of water resources developed by the project. Harvested rainwater was distributed equally among all the members @ Rs 30 and Rs 50 per hour. The Society had earned Rs 21,907 from water charges, membership fees and fish production. Thus, the project besides making remarkable impact on the socio-economic conditions of the farmers had created favourable impact on biomass production, resource conservation and water utilization.

Conclusions

The technology of diverting run-off from agricultural fields to renovated ponds and its recycling to the same area with peoples' participation and other technological interventions have produced remarkable results and could triple the net agricultural income. The project was implemented at an initial cost of Rs 9.21 lakhs and farmers incurred additional annual cost on inputs ranging from Rs 4963 to Rs 6346 per hectare on supplemental irrigation, increased cropping intensity and higher input-use. The benefit cost ratio of 1.71 has been obtained using a discount value of 8 per cent for the project-life of 10 years. The project has also helped in generating additional employment opportunities on casual as well as regular basis. Besides making impact on the socio-economic conditions of the local farmers, the project has created favourbale impact on biomass production, resource conservation and water utilization.

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