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from these types of investments in tanks where water distribution between head and tail portions of the command area is a major problem. Technical assistance on water management, improvements in irrigation control structures and better water application methods can also help reduce transit losses and reduce over-irrigation.

Further research is needed to identify what investments are best suited for different types of tanks. This involves fitting the investment to each tank. Research is also needed to determine better methods for estimating future water supplies and disseminating the information to farmers. With better information about water supplies, farmers can adjust their planting and cropping patterns to maximize returns for the water available.

K. Palanisami and K. William Easter*

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FINANCIAL ANALYSIS OF AFFORESTATION OF COMMUNITY LANDS IN RAMGANGA CATCHMENT IN UTTAR PRADESH HILLS†

Afforestation of community lands in the rural areas seems to be a promising alternative for resolving, although only partially, the fuelwood and the fodder problems now facing many rural communities in the country. This measure could also substantially contribute to ease the growing pressure on the non-renewable fossil fuels for meeting the fuel requirements of the

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people for cooking and heating purposes. The National Commission on Agriculture has rightly emphasized the role of social forestry, which includes, among other things, planting trees in community lands, as an important source of timber, fodder and fuel.[1] Given this important role of afforestation of community lands in the national economy, an important question that comes to mind is whether it is a financially viable proposition and what are its income and employment effects at an aggregate level. This paper is addressed to examining this question partly on the basis of a study conducted by the authors in the Ramganga catchment in the Uttar Pradesh Hills and partly on the basis of data collected from various offices of the Uttar Pradesh Forest Department.

OBJECTIVES

The Ramganga catchment extends over a total geographical area of about 3,076 sq. km., of which about one-third could be classified as community lands. The community lands comprise panchayati forests, culturable waste lands and grazing lands. These lands are in a very bad shape. They are badly eroded and are denuded of all their vegetation due to over-grazing by animals and indiscriminate lopping by local people. They contribute a lot of sediment to the Ramganga river and its tributaries and through them to the Kalagarh reservoir constructed under the Ramganga River Valley Project. To protect the reservoir from rapid siltation, the Uttar Pradesh Forest Department prepared a comprehensive soil conservation plan of the catchment and set up a Soil Conservation Division (Forest) at Ranikhet in 1962 to implement the plan. Another Division was set up at Ramnagar in 1972 for the same purpose. A lot of soil conservation work including afforestation of community lands has been done in the catchment by these two divisions. No systematic attempt has been made so far to study the financial viability of the various soil conservation measures introduced in the catchment. This study is a modest attempt to do so for afforestation of community lands.

More specifically, the main objectives of the study were: (1) to determine the financial feasibility of afforestation of community lands in the Ramganga catchment; and (2) to project the income and employment effects of afforestation at the catchment level.

RESEARCH PROCEDURE

A two-stage stratified random sampling design was used for selecting a sample of 12 *gaon sabhas* from the catchment. In the first stage, the catchment was stratified into two divisions which corresponded to the two Soil Conservation Divisions with headquarters at Ranikhet and Ramnagar and one sub-catchment was randomly selected from each of the two divisions. In the

1. Government of India: Report of the National Commission on Agriculture 1976, Part IX—Forestry, Ministry of Agriculture and Irrigation, New Delhi, 1976, p. 120.

second stage, each selected sub-catchment was further delineated into *gaon sabhas* and a sample of 25 per cent of the total number of *gaon sabhas* was randomly drawn from each of the two sub-catchments. This process resulted in a sample of 12 *gaon sabhas*.

The Soil Conservation Divisions at both Ranikhet and Ramnagar mainly plant chirpine (*Pinus rox burghii*) and bhimal (*Grewia spp.*) trees in the ratio of 9 : 1 in the community lands in the catchment. Chir is a very valuable tree species yielding a number of direct benefits in the form of resin, timber, fuelwood, pine cones (used as fuel), and piru (chir needles used as litter for livestock). The economic life of a chir forest is about 100 years. Like chir, bhimal also is a multi-purpose tree species yielding a number of benefits like fodder, fuelwood, fibre, etc. The economic life of a bhimal afforestation project is about 20 years.

The primary data relating to cost of fencing, digging, nursery raising, transplanting, thinning, harvesting, etc., were collected from the selected *gaon sabhas* by holding personal interviews with the *gaon sabhapatis*, patwaris, village level workers, forest contractors, afforestation workers and other knowledgeable persons concerned. The secondary data relating to volume of output, cost of conversion of wood into commercial timber, cost of transportation, etc., were collected from various offices of the U.P. Forest Department and U.P. Forest Development Corporation located in Nainital, Ranikhet and Ramnagar. Data on output prices were collected from Haldwani and Ramnagar markets.

To achieve the first objective, discounted cash flows were computed for (*a*) pure chir plantation; (*b*) pure bhimal plantation; and (*c*) mixed chir and bhimal plantation in the ratio of 9 : 1 and the following three measures of financial feasibility worked out: (1) Net present value (NPV); (2) Gross benefit-cost ratio (GBCR); (3) Financial internal rate of return (FIRR).

Mathematically, these measures can be expressed as follows:

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t} \qquad \ldots.(1)$$

$$GBCR = \sum_{t=1}^{n} \frac{B_t}{(1+i)^t} \Big/ \sum_{t=1}^{n} \frac{C_t}{(1+i)^t} \qquad \ldots.(2)$$

$$FIRR = i \text{ such that } \sum_{t=1}^{n} \frac{B_t - C_t}{(1-i)^t} = 0 \qquad \ldots.(3)$$

where

t = time period in years, 1, 2,....., n,
B_t = gross direct benefits in rupees in year t,
C_t = total direct costs in rupees in year t, and

i = discount rate which is equal to the current interest rate on term deposits.

However, for estimating the FIRR, the following formula was used:

$$\text{FIRR} = \text{Lower discount rate} + \text{Difference between the next higher discount rate and the lower discount rate} \left\{ \frac{\text{Present worth of net cash flows at lower discount rate}}{\text{Absolute difference between the present worths of net cash flows at the two discount rates.}} \right\}$$

This formula is based on the theory of linear interpolation and is taken from Gittinger.[2]

To attain the second objective, uniform series of annual income were computed by dividing the total net present value per hectare over the rotation period by the appropriate annuity factor and then by multiplying the resultant quotient by the area of community land in the catchment. Average annual employment from afforestation was estimated by dividing the total projected man-days of employment in the project by the economic life of the project and then multiplying the resultant quotient by the afforestable area. Income and employment effects were projected with the following three alternative assumptions:

A. Afforestation of all the community lands in the catchment;
B. Afforestation of the community lands left after setting aside 50 per cent of the existing grazing lands to be used as pasture lands; and
C. Afforestation of the community lands as under B but excluding all of the unculturable waste lands.

RESULTS AND DISCUSSION

Table I presents the estimates of net present value, gross benefit-cost ratio and financial internal rate of return for the bhimal, chir, and bhimal + chir plantations in the Ramganga catchment.* Itemwise costs and returns at 1978-79 prices were projected over the entire rotation period for each of the three types of plantation and discounted at the rates of 5, 10, 15 and 20 per cent for bhimal and 5, 10 and 15 per cent for each of the chir and bhimal + chir plantations.

A perusal of the table would show that the bhimal plantation is financially feasible at the 5, 10 and 15 per cent discount rates in terms of both the NPV and the GBCR criteria. The FIRR estimated to be 17.27 per cent is the maximum paying capacity of the bhimal plantation. It implies that it would be financially desirable to invest money in bhimal plantation so long as the rate of interest on plantation loans is equal to or less than 17.27 per cent.

2. See for details, John Price Gittinger: Economic Analysis of Agricultural Projects, John Hopkins Press, Baltimore, 1972, pp. 56-59.

* The yearwise per hectare estimates of gross benefits, total costs and employment for bhimal and chir plantations in the Ramganga catchment are presented in Appendixes 1 and 2 respectively.

TABLE I—NET PRESENT VALUE, GROSS BENEFIT-COST RATIO AND FINANCIAL INTERNAL RATE OF RETURN FOR BHIMAL, CHIR AND CHIR + BHIMAL PLANTATIONS IN THE CATCHMENT

Measure of financial feasibility	Type of plantation		
	Bhimal	Chir	Chir + Bhimal
1. Net present value (Rs./ha. over the project period) at discount rates of.			
5 per cent	7,366	20,222	19,414
10 per cent	2,675	1,051	1,298
15 per cent	481	—1,380	—1,191
20 per cent	—580	—	—
2. Gross benefit-cost ratio at discount rates of			
5 per cent	2·2110	3·5410	3·3812
10 per cent	1·6377	1·2928	1·3457
15 per cent	1·1500	0·5053	0·5864
20 per cent	0·7812	—	—
3. Financial internal rate of return ..	17·27	12·16	12·58

At the 20 per cent discount rate, bhimal plantation loses its financial viability. Of all the three types of plantation, it had the lowest NPV at the 5 per cent discount rate but had the highest NPV at the 10 per cent discount rate and the highest FIRR.

The chir plantation was found to be financially feasible at the 5 and 10 per cent discount rates in terms of both the NPV and the GBCR criteria. Of the three types of plantation, it had the highest NPV and the highest GBCR at the 5 per cent discount rate but the lowest NPV at the 10 per cent discount rate. At the 15 per cent discount rate, the NPV was negative and the GBCR less than one, implying that it was not an economically viable proposition at this rate of discount. The FIRR was estimated to be 12.16 per cent. This means that a chir plantation project cannot afford to bear an interest rate exceeding 12 per cent.

Like the chir plantation, the mixed plantation of chir and bhimal also was found to be financially feasible only at the discount rates of 5 and 10 per cent. It had the second highest NPV at both the 5 and 10 per cent discount rates and the second highest FIRR of 12.58 per cent.

Since the three types of plantation have varying economic lives, the (total) net present value per hectare over the economic life is not an appropriate measure for ranking them. Hence, we computed another measure, namely, projected (discounted) annual net income for each of the three types of plantation. Besides, we also estimated the employment effects of the plantations considering the need for generating employment opportunities for the local people in the catchment. The values of these two measures for each of the three types of plantation and for each of the three alternative situations are presented in Table II.

TABLE II—PROJECTED ANNUAL NET INCOME AND EMPLOYMENT EFFECTS OF AFFORESTATION AT THE CATCHMENT LEVEL UNDER THREE ALTERNATIVE ASSUMPTIONS

Alternative*	Type of plantation	Area under plantation (ha.)	Net income (crore rupees) at discount rates of			Employment (lakh man-days)
			5 per cent	10 per cent	15 per cent	
A	Bhimal	99,249	5·86	3·11	0·76	59·50
	Chir		10·11	1·04	—	83·86
	Bhimal + Chir		9·70	1·28	—	82·56
B	Bhimal	89,605	5·29	2·81	0·68	53·72
	Chir		9·12	0·94	—	75·71
	Bhimal + Chir		8·76	1·16	—	74·54
C	Bhimal	68,625	4·05	2·15	0·53	41·14
	Chir		6·99	0·72	—	57·98
	Bhimal + Chir		6·71	0·89	—	57·08

* Alternative A is the afforestation of all the community lands in the catchment, B is the afforestation of the community lands left after setting aside 50 per cent of the existing grazing lands to be used as pasture lands and C is the afforestation of the community lands as under B but excluding all the uncultivable lands.

A perusal of Table II would show that of all the three types of plantation, chir has the highest projected annual net income at the 5 per cent discount rate as well as the highest employment potential under each of the three alternative situations followed by bhimal + chir plantation. At both the 10 and 15 per cent discount rates bhimal has the highest annual net income. This is because of the shorter economic life of the bhimal plantation as compared to the chir plantation. The annual net income estimates of the order of Rs. 10.11 crores from chir plantation at the 5 per cent discount rate and of Rs. 3.11 crores from bhimal plantation at the 10 per cent discount rate represent quite substantial potential gains to the local community in the catchment.

So far as the choice of a particular type of plantation is concerned, depending upon the discount rate considered realistic under the given circumstances, one could rank the three types of plantation in terms of both their projected average annual net income and their employment potential. The projected average annual net income discounted at the rate of 5 per cent and the employment level both give the same ranking of the three plantation projects. But at both the 10 and 15 per cent discount rates, bhimal plantation ranks the highest in terms of the former and the lowest in terms of the latter. To make a choice at these two discount rates, the decision-maker will need to assign some weights to the income and employment goals and then choose the type of plantation having the highest combined weighted value. Needless to say, the weights should reflect local community's preferences. To illustrate, if we assign 60 per cent weight to income and 40 per cent to employment, and if the discount rate is taken to be 10 per cent, then chir plantation turns out to be the best with the combined weighted value of 34.16.

Table III presents the estimates of average annual increase in per capita net income from afforestation for each of the three types of plantation and under each of the three alternative situations. At the 5 per cent discount rate, chir plantation ranks the highest in terms of increase in per capita net income in each of the three situations and bhimal plantation at both the 10 and 15 per cent discount rates. This ranking is the same as the one based on the criterion of projected annual net income presented in Table II. However, the per capita net income figures are considered a better measure of contribution of an activity to economic well-being of a society than the aggregate net income figures.

TABLE III—PROJECTED AVERAGE ANNUAL INCREASE IN PER CAPITA NET INCOME FROM AFFORESTATION IN THE CATCHMENT UNDER THREE ALTERNATIVE ASSUMPTIONS

Alternative*	Type of plantation	Average annual increase in per capita income (Rs.) at the discount rates of		
		5 per cent	10 per cent	15 per cent
A	Bhimal	254	135	33
	Chir	438	45	—
	Bhimal + Chir	420	56	—
B	Bhimal	230	122	30
	Chir	396	41	—
	Bhimal + Chir	380	50	—
C	Bhimal	176	93	23
	Chir	303	31	—
	Bhimal + Chir	291	39	—

* Alternatives A, B and C are the same as defined in the footnote to Table II.

The average annual increase in per capita net income at the 5 per cent discount rate ranged from Rs. 176 from bhimal plantation in situation C to Rs. 438 from chir plantation in situation A. At the 10 per cent discount rate the range of increase in net income was between Rs. 31 from chir to Rs. 135 from bhimal plantation. Annual increases in per capita net income of this order represent substantial increase in the total per capita income in the catchment.

CONCLUSIONS AND IMPLICATIONS

Each of the three types of plantation, namely, bhimal, chir, and bhimal + chir, was found to be financially feasible at both 5 and 10 per cent discount rates in terms of both the GBCR and the NPV criteria. The bhimal plantation was a financially feasible proposition even at the 15 per cent dis-

count rate and of the three types of plantation, it had the highest paying capacity. A mixed plantation of bhimal + chir is recommended for the community lands in the catchment. This would provide benefits from bhimal trees in the short run and from chir trees in the long run. Alternatively, if the local community attaches higher weight to short-term benefits than long-term benefits, then it would be a financially better proposition for them to go in for bhimal plantation. Or, if the local people have a longer planning horizon, then the chir plantation is a better choice. In any case, the local people could expect substantial gains in terms of income and employment from afforestation of the community lands now lying almost barren. What is needed to realise these potential gains is an appropriate institutional structure for managing the afforestation of community lands.

Devi D. Tewari and Katar Singh*

APPENDIX 1

YEARWISE PER HECTARE ESTIMATES OF GROSS BENEFITS, TOTAL COSTS AND EMPLOYMENT FOR BHIMAL PLANTATION IN RAMGANGA CATCHMENT

Year	Gross benefits* (Rs.)	Total costs** (Rs.)	Employment (man-days)
1	0	2,279	98
2	0	77	9
3	0	50	7
4	0	50	7
5	0	50	7
6	0	50	7
7	0	50	7
8	0	50	7
9	0	50	7
10	2,400	750	107
11	2,400	700	100
12	2,400	700	100
13	2,400	700	100
14	2,400	700	100
15	4,400	840	120
16	1,300	420	60
17	1,600	508	73
18	1,600	508	73
19	2,000	665	95
20	5,000	805	115

* Gross benefits represent the projected direct benefits valued at 1978-79 prices.
** Total costs are the actual/projected total direct costs valued at 1978-79 prices.

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APPENDIX 2

YEARWISE PER HECTARE ESTIMATES OF GROSS BENEFITS, TOTAL COSTS AND EMPLOYMENT FOR CHIR PLANTATION IN RAMGANGA CATCHMENT

Year	Gross benefits* (Rs.)	Total costs** (Rs.)	Employment (man-days)	Year	Gross benefits* (Rs.)	Total costs** (Rs.)	Employment (man-days)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	40	2,382	117	21	2,440	406	58
2	40	114	16	22	2,440	406	58
3	40	114	16	23	2,440	406	58
4	40	114	16	24	2,440	406	58
5	40	114	16	25	2,440	406	58
6	40	106	16	26	2,440	406	58
7	40	106	15	27	2,440	406	58
8	40	106	15	28	2,440	406	58
9	40	106	15	29	2,440	406	58
10	40	106	8	30	2,440	406	58
11	40	56	8	31	2,440	406	58
12	40	56	8	32	2,440	406	58
13	40	56	8	33	2,440	406	58
14	40	56	8	34	2,440	406	58
15	40	56	8	35	2,440	406	58
16	40	56	8	36	2,440	406	58
17	40	56	8	37	2,440	406	58
18	40	56	8	38	2,440	406	58
19	40	56	8	39	2,440	406	58
20	2,440	406	58	40	2,440	406	58

(Contd.)

APPENDIX 2 (*Concld.*)

Year	Bross benefits* (Rs.)	Total costs** (Rs.)	Employment (man-days)	Year	Gross benefits* (Rs.)	Total costs** (Rs.)	Employment (man-days)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
41	2,440	406	58	71	3,055	496	62
42	2,440	406	58	72	3,404	566	73
43	2,440	406	58	73	3,055	496	72
44	2,440	406	58	74	3,404	566	81
45	2,440	406	58	75	9,085	1,145	95
46	2,440	406	58	76	10,439	1,241	112
47	2,440	406	58	77	10,090	1,171	108
48	2,440	406	58	78	10,439	1,241	118
49	2,440	406	58	79	10,090	1,171	116
50	4,600	1,082	99	80	10,439	1,241	126
51	4,466	651	90	81	10,090	1,171	116
52	4,558	794	114	82	10,439	1,241	116
53	4,120	651	93	83	10,090	1,171	116
54	4,558	794	114	84	10,439	1,241	126
55	4,120	651	93	85	10,090	1,171	116
56	4,558	794	114	86	10,439	1,241	126
57	4,120	651	93	87	10,090	1,171	116
58	4,558	794	114	88	10,439	1,241	126
59	4,120	651	93	89	10,090	1,171	116
60	19,684	4,598	182	90	10,439	1,241	126
61	4,225	666	95	91	10,090	1,171	116
62	4,710	764	101	92	10,439	1,241	126
63	4,225	666	95	93	10,090	1,171	116
64	4,710	764	109	94	10,439	1,241	126
65	4,225	666	95	95	10,090	1,171	116
66	4,710	764	109	96	10,439	1,241	126
67	4,225	666	95	97	10,090	1,171	116
68	4,710	764	109	98	10,439	1,241	126
69	4,225	666	95	99	10,090	1,171	116
70	27,677	6,384	194	100	2,40,777	58,737	836

* Gross benefits represent the projected direct benefits valued at 1978-79 prices.
** Total costs are the actual/projected total direct costs valued at 1978-79 prices.