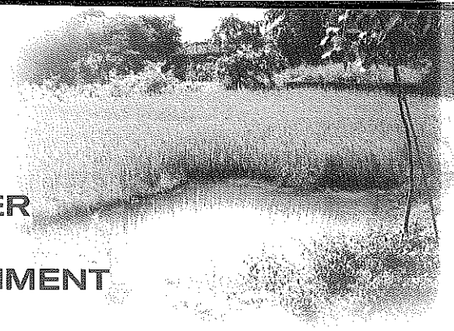

QUEST FOR OPTIMISING SOIL AND WATER CONSERVATION TECHNOLOGIES FOR REDUCTION OF SOIL EROSION AND SEDIMENT LOAD IN WATERSHEDS

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INTRODUCTION

More than 50% of the geographical area of India is subject to various forms of soil erosion and land degradation calling for urgent attention. Sheet and rill erosion alone affect about 72 million hectares. Another four million hectares are affected due to gully and ravine erosion in parts of central India. The annual loss of soil due to erosion is estimated to be about 5.33 billion tons (Dhruva Narayana, et al, 1983); equivalent to the loss of 1.16 mm/yr of top soil. Besides, the growing population has resulted in the reduction of per capita availability of cultivable land from 0.51 hectares in 1951 to 0.20 hectares in 1981 and is expected to dwindle to about 0.15 hectares by the turn of the century. Thus, the country is faced with the peculiar problems of not only horizontal shrinkage of land but also its vertical shrinkage through population pressure on the one hand and soil denudation on the other. A number of soil and water conservation (SWC) practices have, therefore, been evolved over the years and are being applied in different parts of the country. These practices include the treatment of land through agronomic as well as mechanical measures. The available technologies in this regard have been documented (Rama Rao, 1974, Rege, 1980, Gurmel Singh, et al, 1990).

The SWC measures are aimed at moderating the impact of raindrops on the soil surface and check the resultant transportation of the soil particles along with the surface runoff. The application of a particular SWC measures would depend upon the type and nature of the erosion problem. Strip cropping, broad base terracing and narrow base terracing for checking sheet and rill erosion on land slopes of upto 10%. Bench Terracing for steeper slopes, gully control structures like drop spillways, check dams for rehabilitating gullied areas are some of the examples. The evolution of the design specifications of the SWC structures were based on the results of various studies taking into account the climatic and physiographic factors like rainfall, runoff, soil texture, land slope etc. However, the combined influence of these measures in reducing soil erosion and sediment load in quantifiable terms from small drainage units and its financial implications have received attention only in recent years. Efforts have been made in this paper to discuss some of the experiences in this direction.

SOIL AND WATER CONSERVATION INTERVENTIONS

Watershed as a unit

The results of the interaction of climatic forces on land surface coupled with the exploits of the society are best understood, studied and tackled on the basis of small manageable drainage units such as watersheds. Therefore, a number of watershed based programmes were initiated in the country with the objective of reversing the soil erosion and land degradation process (Jose, et al., 1990). The initial efforts in this direction were made by the Damodar Valley Corporation (DVC) during the First Five Year Plan. At the national level, the watershed management concept gained momentum during the Fifth Plan (1974-75) for treating the watersheds in the catchments of River Valley Projects (RVP). Soil and water conservation measures form an essential component of the watershed management programmes in the RVP

catchmentes for reducing the sediment load from the watersheds. The watershed-based concepts and programmes in the Indian context have been explained by Das (1998).

Optimizing watershed management costs

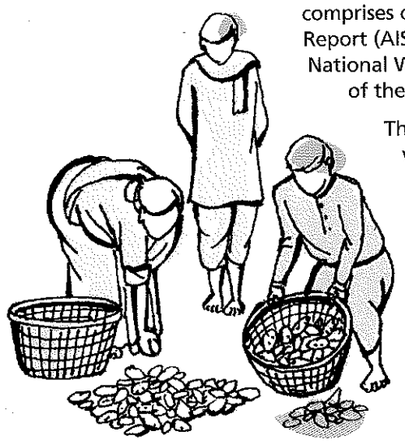
The technique of Linear Programming (LP), however, offers a tool to select the best combination of measures to achieve the set goal. The LP model involves one objective function and a set of constraints, which have a linear relationship among the variables involved

The package of SWC measures in watershed management programmes aim at minimizing soil erosion with minimum possible investments duly ensuring the production benefits also. In order to ensure optimum returns, it requires the integration of measures like soil and water conservation engineering, crop production technology, afforestation, pasture development etc. with judicious selection of cost effective items from within the multiple choices of a given package. In the normal course it may not be possible to discern and quantify the impact of the measures in physical and financial terms. The technique of Linear Programming (LP), however, offers a tool to select the best combination of measures to achieve the set goal. The LP model involves one objective function and a set of constraints, which have a linear relationship among the variables involved. This technique was initially developed by George B. Dantzig in 1947 for providing the US Air Force with an effective method of allocating resources (Rao, 1978). However, so far this method has been applied only to a limited extent in the area of watershed management. One such study by Wade and Heady (1978) revealed that investments to the tune of US $ 31, 958 could result in maintaining soil loss at the level of 394 million tons in the US by the year 2000 for feeding a population of 262.4 million.

Optimization study in Damodar watersheds

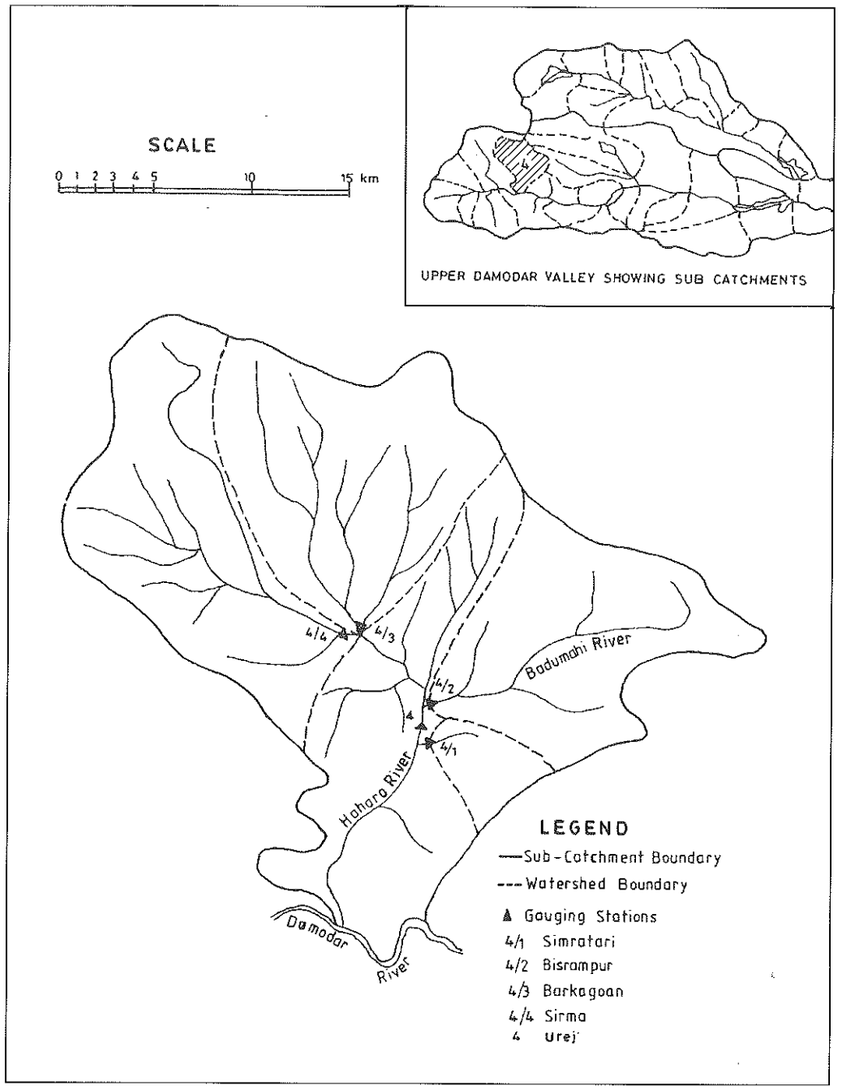
In India, the LP technique was applied to determine the investment required on SWC measures for reducing the sediment load from four watersheds in the Upper Damodar Valley (UDV) in the Damodar-Barakar Basin (Jose, 1995). The Damodar-Barakar catchment has been receiving integrated SWC treatment since the Third Five Year Plan under the Centrally Sponsored Scheme of Soil Conservation in the Catchments of River Valley Projects (RVP). The UDV, with an area of 1.82 million ha has a network of five reservoirs, namely Maithon and Tilaiya on the Barakar river and Panchet, Tenughat and Konar on river Damodar.

The DVC authorities took up soil survey as the first activity to plan SWC programmes in the catchment and delineated the UDV into 39 sub-catchments with sizes ranging from 40,000 ha to 50,000 ha Out of these optimization studies were conducted in one sub-catchment, namely Haharo sub-catchment (sub catchment No. 4). This sub-catchment comprises of four watersheds viz. 4/1, 4/2, 4/3 and 4/4. As per the Priority Delineation Report (AISLUS, 1980) it has been codified as Tg sub-catchment and as per the National Watershed Atlas it has been codified as watershed No. 2A2H3. The total area of the sub-catchment upto the gauging point on the main stream is 498 sq. kms.



The Haharo sub-catchment or the watershed 2A2H3 comprises of 21 sub-watersheds of various priority categories. Thirteen of these sub-watersheds come under very high and high priority categories having Silt Yield Index (SYI) of above 1301. Soil and water conservation measures were initiated in the identified very high and high priority sub-watersheds since 1978. Prior to this, some SWC measures were taken up in isolated pockets of the whole sub-catchment. The rainfall, runoff and sediment data were collected by the DVC authorities from four tributaries, besides the main stream of this sub-catchment since the year 1979. One gauging site was operated at the confluence of watershed No. 4/3 and 4/4 between the years 1964 and 1974. A map indicating the location of the gauging stations is given in Fig. 1.

Figure 1: Hahorao River sub-catchment showing location of gauging stations

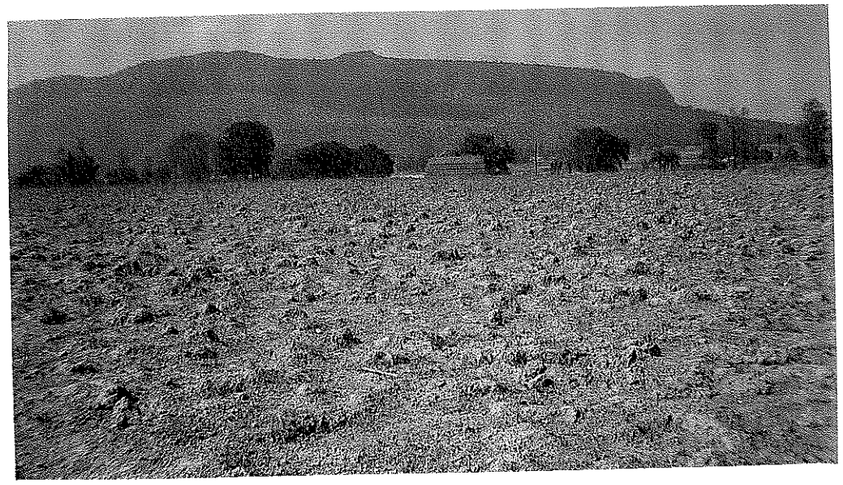


The major categories of land use in the watersheds are uplands, paddy lands, forest lands, gullied lands and miscellaneous land use. The uplands and forest lands are most vulnerable to over exploitation and misuse. The uplands and forest land could, therefore, be categorized into three groups viz. those portions which are well protected and do not need SWC treatment, portions which are in a degraded state and need treatment, and those portions which have received SWC treatment during the course of the treatment period. Over the years, the areas not needing treatment would continue to remain more or less at the same level if watershed management programmes are ongoing. However, during the treatment period the areas needing treatment would get converted to treated areas. The Sediment Production Rate (SPR) from these categories of lands would be different, although

there may not be much difference between the SPR from areas not needing treatment and from the areas treated.

Identification of treatable areas within a watershed is a pre-requisite for planning SWC programmes in the sub-watersheds. Usually, the treatable areas range between 30 to 40% of the total area of the watersheds which are under treatment. The priority delineation reports of Tenughat Dam catchment and the report of the evaluation study by the AFC (1991) were consulted for working out the area in Haharo sub-catchment. The categories of land thus identified in the Haharo sub-catchment is presented in Table1.

A typical view of the Uplands in Haharo sub-catchment



Estimation of SPR from different land uses

The available sediment load data from the watersheds were utilized to determine the SPR from different land use categories by employing constrained regression analysis in the form of a grid search method. The data used for this purpose is given in Table 2. The method involves assignment of coefficients (only positive) to different land use categories duly maintaining a zero intercept value. The sum of the product of the coefficient value with the corresponding area under the particular land use would result in the total sediment yield for the watershed. An algorithm was developed so that the standard error and degree of association could be compared by varying the value of the coefficients through iterations. The best result could be selected when the standard error is the lowest and correlation coefficient is the highest. The generalized equation for estimating the Sediment Yield could be expressed as:-

$$SY = \sum_{j=1}^{n} S_j * A_j \qquad (1)$$

where,

SY = sediment yield, tons,
S_j = sediment production rate from jth land use, tons/ha,
A_j = area of jth land use, ha and
n = number of land use categories.

The linear relationship in Equation1 facilitate its use in the LP model as one of the constraints for optimizing the SWC treatment costs. The results of the grid search analysis is given as follows:-

$$SY = 2.2 * A_{Unnt} + 30.9 * A_{Unt} + 0.12 * A_P + 0.16 * A_{Fnnt} + 2.09\ A_{Fnt} + 53.5 * A_G + 15.2 * A_M + 5.0 * A_{Ut} + 1.85 * A_{Ft} * 4.5 * A_{Gt} \qquad 2)$$

where the notations are as given in Table-1.

Table 1: Land use categories identified in the Haharo watersheds

Sl. No.	Land Use Category and Notation	Area (Ha_r)
1.	Uplands not needing treatment (A_{Unnt})	3307
2.	Uplands needing treatment (A_{Unt})	813
3.	Paddy lands (A_P)	11120
4.	Forest lands not needing treatment (A_{Fnnt})	14388
5.	Forest lands needing treatment (A_{Fnt})	0392
6.	Gullied lands (A_G)	384
7.	Miscellaneous land use (A_M)	765
8.	Uplands treated (A_{Ut})	145
9.	Forest lands treated (A_{Ft})	1860
10.	Gullied lands treated (A_{Gt})	224

Optimizing of SWC treatment cost

The details of LP model along with the objective function to minimize the cost of treatment (price level maintained at 1989 level) would be as follows

(i) Objective Function

$$\text{Min } Z = \sum_{j=1}^{n} C_j * A_j \qquad (3)$$

where,
C_j = Cost of treatment of jth land use including cost of cultivation, Rs/ha, and

A_j = area under jth land use, hectares.

(ii) Subject to the constraints:

$$\sum A_j = A_W$$
$$\sum A_{Uj} \leq A_U$$
$$\sum A_{Fj} \leq A_F$$
$$\sum A_{Gj} \leq A_G$$
$$\sum S_j * A_j \leq S_{Y1}$$

where,

A_j = area under jth land use, ha,

A_W = total area of the watershed, ha,

A_{Uj} = area in uplands, ha (j=1: not needing treatment, j=2: needing treatment, and j=8: area treated)

A_U = total area under uplands, ha,

A_{Fj} = area in forest lands, ha (j=4: not needing treatment, j=5: needing treatment and j=9: area treated)

A_F = total area under forest lands, ha,

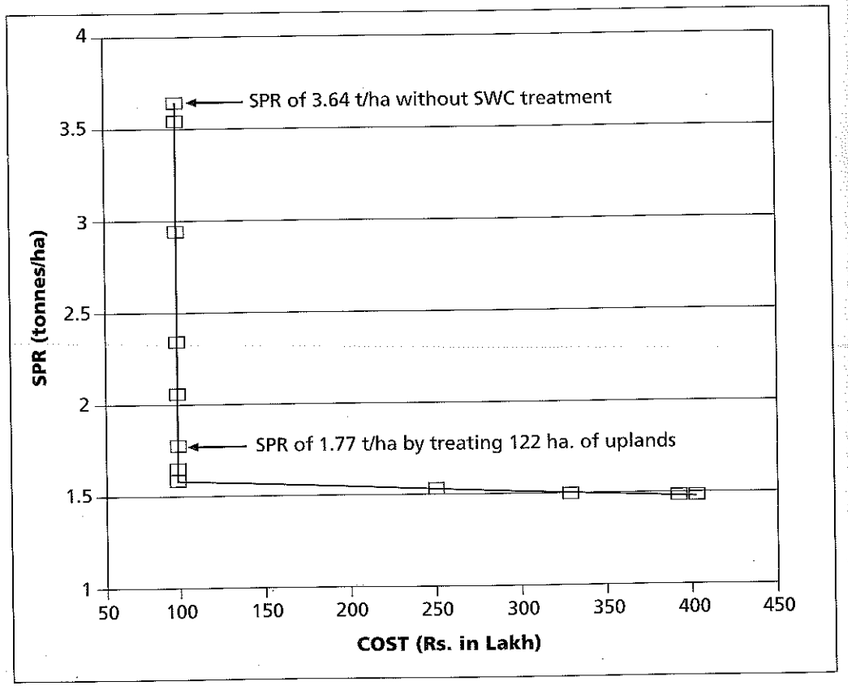
A_{Gj} = area in gullied lands, ha (j=6 untreated, and j=10: area treated)

A_G = total area under gullied lands, ha,

SY_1 = sediment yield limit, tons, and

The SWC treatment measures for the uplands mainly comprise of Tati-terracing. This involves the construction of field bunds of 0.75m. height on three sides of the field. These terraces help in converting the fields into leveled bench terraces, where paddy as well as other upland crops could be grown. The unit cost of terracing was Rs 800 per ha at 1989 price level. The unit cost of cultivation of one ha of uplands was only Rs 1200 per ha, but since 50% of the lands are kept fallow, the cost of cultivation of uplands needing treatment would be Rs 600 per ha (AFC, 1991). On the other hand, the cost of cultivation of uplands which have received SWC treatment was Rs 1800 per ha. The details of cost of cultivation for both the categories of uplands is given in Table 3.

Figure 2: Minimum treatment cost vs SPR for W/S No. 4/1

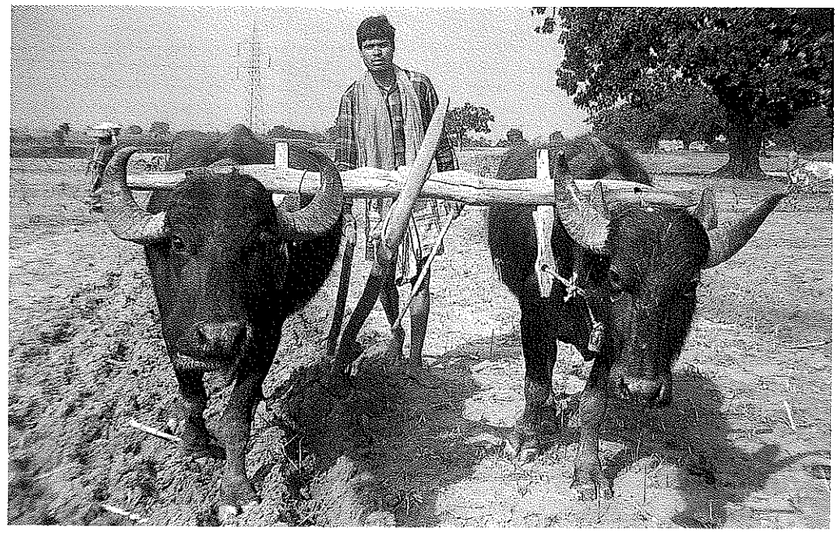


The yield of crops from the untreated uplands is to the tune of 250 kg/ha which include crops like paddy, pulses and oil seeds. The return from these lands works out to Rs 1250 per ha at the rate of Rs5 per kg. Similarly, the yield from the treated lands are reportedly 1300 kg/ha comprising of crops like paddy and wheat. The gross return from these crops works out to Rs 4875 per ha at the rate of Rs 3.75 per kg. The uplands, which do not need treatment, would also fall under the category of treated uplands.

The paddy lands in the UDV area are well bunded and do not require any significant SWC treatment measures apart from some command area development works to enhance the yield. The cost of cultivation for one ha of paddy land is Rs 3000. The breakup is given in Table 4. The average yield from the paddy lands was 2500 kg/ha. The gross income from the paddy lands, therefore, works out to Rs 6,250 per ha at the rate of Rs 250 per kg of paddy.

As regards the forest lands, the major species prevalent in the watersheds is Sal (Shorea robusta). The trees planted by the DVC authorities included Akashmani or Australian Babul (Acacia auriculiformis), Eucalyptus and Seesham (Dalbargia sisoo). The evaluation study of DVC (AFC, 1991) had considered the existing wage rate since 1961 for computing the cost of afforestation as well as cost of harvesting the forest produce. The cost of afforestation mainly include wages involving 480 man days per ha. The cost of planting material and land preparation are included within this. The cost of afforestation works out to Rs 7613 per ha at 1989 level when the average wage rate was Rs15.86 per man day. Similarly, the harvesting costs involved about 2107 man days per ha. The harvesting cost at 1989 level works out to Rs 33,400 per ha.

Bullock power being used for ploughing uplands



The DVC authorities derived an income of Rs1,944 lakhs from 2587 hectares of land under afforestation schemes between 1975 and 1985. The average return worked out to Rs 75,145 per ha, which could be considered as the gross return from the afforested lands.

The gullied lands are usually situated at the lower end of the uplands and by the sides of the drainage courses. Reclamation of gullied lands include construction of check dams and impounding structures which hold water and sediments. The hummocks are ploughed down from year to year so that the area upstream of the check dam may be silted up quickly to form a terraced paddy field. Diversion ditches are also constructed sometimes to prevent the gully heads from encroaching into the uplands. The cost of the construction of gully plugs along with partial leveling and other conservation measures adopted by the DVC was Rs3000 per ha (Table 4). The yield of paddy from the reclaimed lands was 2,500 kg. per ha. The gross income, therefore, works out to Rs 6250 per ha at the rates of Rs 2.50 per kg of paddy. The details of cost and net returns thus obtained are shown in Table 5.

Table 2: Sediment yield and sediment production rate of Haharo watersheds along with area treated

Uplands Not Needing Treatment	Uplands Needing Treatment	Paddy Lands	Forest Lands Not Needing Treatment	Forest Lands Needing Treatment	Gullied Lands	Misc. Lands
Watershed No. 4/1						
41.9	120	487.5	237.5	631	2	13
41.9	107	487.5	237.5	608	0	13
41.9	52	487.5	237.5	557	0	13
41.9	11	487.5	237.5	250	0	13
41.9	1	487.5	237.5	250	0	13
41.9	1	487.5	237.5	79	0	13
41.9	1	487.5	237.5	79	0	13
41.9	1	487.5	237.5	0	0	13
Watershed No. 4/2						
860	229	3218	3734	3387	127	327
860	205	3218	3734	2987	91	327
860	195	3218	3734	2764	10	327
860	142	3218	3734	2624	0	327
860	45	3218	3734	2624	0	327
860	45	3218	3734	2510	0	327
860	45	3218	3734	2410	0	327
860	45	3218	3734	2310	0	327
860	45	3218	3734	2210	0	327
860	45	3218	3734	2110	0	327
860	45	3218	3734	2010	0	327
860	45	3218	3734	1910	0	327
860	45	3218	3734	1810	0	327
860	45	3218	3734	1710	0	327
Watershed No. 4/3						
1022	213	3562	4961	3382	209	216
1022	183	3562	4961	3362	145	216
1022	151	3562	4961	3190	76	216
1022	151	3562	4961	3190	28	216
1022	151	3562	4961	3190	28	216
1022	101	3562	4961	3190	0	216
1022	51	3562	4961	3190	0	216
1022	51	3562	4961	2720	0	216
1022	51	3562	4961	2610	0	216
1022	51	3562	4961	2500	0	216
1022	51	3562	4961	2390	0	216
1022	51	3562	4961	2280	0	216
1022	51	3562	4961	2170	0	216
1022	51	3562	4961	2060	0	216
1022	51	3562	4961	1950	0	216
1022	51	3562	4961	1840	0	216
1022	51	3562	4961	1730	0	216
Watershed No. 4/4						
1383	251	3853	5455	2992	46	209
1383	227	3853	5455	2773	0	209
1383	227	3853	5455	2614	0	209
1383	227	3853	5455	2614	0	209
1383	227	3853	5455	2538	0	209
1383	227	3853	5455	2418	0	209
1383	227	3853	5455	2298	0	209

S denotes simulated values of rainfall and E denote estimated values of sediment yield

Uplands Treated	Forest Lands Treated	Gullied Lands Treated	Rainfall (mm)	Sediment Yield (tons)	SPR (tons per ha.)
Watershed No. 4/1					
8	156	2	699	3739.2	2.20
21	179	4	983	5403.2	3.18
76	230	4	841	4572.6	2.69
117	537	4	579	4718.2	2.78
127	537	4	849	4641.1	2.73
127	708	4	1098	5132.1	3.02
127	708	4	733	3690.6	2.17
127	787	4	12111	2626.0	1.55
Watershed No. 4/2					
0	200	18	699	26487.4	2.19
24	600	54	983	39009.4	3.22
34	823	135	769	13416.5	1.11
87	963	145	567	20876.9	1.73
184	963	145	849	20836.2	1.72
184	1077	145	1097	26731.3	2.21
184	1177	145	1211	20421.6 E	1.69
184	1277	145	1392	24111.5 E	1.99
184	1377	145	893	13641.0 E	1.13
184	1477	145	521	5815.2 E	0.48
184	1577	145	1210	20083.6 E	1.66
184	1677	145	1296 S	21791.0 E	1.80
184	1777	145	756 S	10468.8 E	0.87
184	1877	145	1003 S	15541.4 E	1.28
Watershed No. 4/3					
42	210	25	983	37111.3	2.68
72	230	89	773	24151.8	1.74
104	402	158	566	15474.4	1.12
104	402	206	770	17785.3	1.28
104	542	206	1186	27391.7	1.98
154	652	234	773	22070.6 E	1.59
204	762	234	606 S	14064.2 E	1.59
204	872	234	464 S	11069.9 E	080
204	982	234	1039 S	22902.4 E	1.65
204	1092	234	711 S	15991.1 E	1.16
204	1202	234	440 S	10250.2 E	0.74
204	1312	234	1013 S	22109.7 E	1.60
204	1422	234	1036 S	22493.1 E	1.62
204	1532	234	758 S	16620.9 E	1.20
204	1642	234	1010 S	21775.1 E	1.57
204	1752	234	639 S	13953.8 E	1.01
204	1862	234	1125 S	24005.8 E	1.73
Watershed No. 4/4					
95	1294	179	649	17950.1	1.14
119	1513	225	849	17129.4	1.09
119	1672	225	1120	33570.5	2.13
119	1672	225	723	19247.4	1.22
119	1748	225	1321	39633.3	2.52
169	1868	225	1309 S	30163.3 E	1.91
219	1988	225	840 S	15849.7 E	1.01

It could be assumed that the gullied lands and untreated forest lands do not yield returns as these lands are in a highly degraded state. Similarly, no returns could be expected from the miscellaneous land use as these lands are mostly under roads, etc.

The afore mentioned details form the basic input data in the LP model to determine the requirement of funds for achieving different levels of Sediment Yield limits (SY_l).

Table 3: Details of cost of cultivation in uplands

Sl. No.	Item	Cost of cultivation (Rs /ha)	
		Before treatment	After treatment
1.	Ploughing	125	300
2.	Seeds	75	200
3.	Fertilizer	–	200
4.	Manure	25	100
5.	Interculture	50	150
6.	Plant protection	25	100
7.	Harvesting	50	350
8.	Threshing	150	400
	Total	600	1800

Table 4: Break up of cost of cultivation of paddy lands

Sl. No.	Item	Cost of cultivation (Rs /ha)
1.	Ploughing	450
2.	Seeds	300
3.	Fertilizer	400
4.	Manure	100
5.	Planting	200
6.	Interculture	150
7.	Plant protection	100
8.	Irrigation	200
9.	Harvesting	450
10.	Threshing	650
	Total	3000

Optimization results

The summary details of the minimum investments required for maintaining different levels of SY and SPR by adopting different SWC treatments is given in Table 6. It is evident that in the case of watershed No 4/1, which is also the smallest of the four watersheds, the minimum investments required for bringing down the SPR from 3.64 tons/ha/year to 1.48 tons/ha/year would be Rs 412.3 lakhs. The

expenditure involved for maintaining different levels of SPR for the watershed is depicted in Fig.2. Watershed No. 4/1 being the smallest, the sediment yield is also the lowest while the SPR is highest among the four watersheds. This is in accordance with the established trend that the SPR is inversely related to the drainage area.

Since the gullied lands contributed the maximum SPR (@53.5 tons/ha) and a substantial reduction in the sediment contribution was possible by treating the treated gullied lands, it would appear as though the gullied lands would require the first priority treatment to reduce the overall sediment yield and SPR from the watershed. On the contrary, the study indicates that for optimum utilization of resources it would be more appropriate to treat the uplands first as it could result in the reduction in sediment yield by more than 50% by this measure alone. The average unit cost of treatment works out to Rs 800 per ha. The total investments required for achieving a SPR level of 1.77 tons/ha/ (SY of 3000 tons) would be Rs 97.8 lakhs only for treating 121.7 ha of uplands including the cost of cultivation in the entire watershed area. The net returns against this investment would be Rs 19.94 lakhs, excluding the returns from the forest lands. The requirement of funds for SWC treatment in the watershed would increase substantially to Rs 258.40 lakhs for achieving a SY level of 2600 tons. The increased investment is mainly on account of treating 390.7 ha of forest lands. Further reduction of SY and SPR would be possible with costlier investments for treating the gullied lands and then the forest lands, in that order. This was true in the case of watersheds No. 4/1, 4/3 and 4/4. The optimization result for watershed No. 4/2, however, reveals that in this case the forest lands needing treatment, which although yielded low SPR and had high treatment cost per unit area, should be treated first. It is worth noting that at the initial stage itself (SY level of 29,313 tons) all the forest lands are treated. The SY and SPR, however, remain high.

Table 5: Details of cost of treatment and net returns

(Cost in Rupees per ha)

Sl. No.	Land Use	Cost of cultivation	Cost of SWC treatment	Total Cost	Gross returns	Net returns
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	Uplands not needing treatments	1800	–	1800	4875	3075
2.	Upland needing treatments	600	–	600	1250	650
3.	Uplands treated	1800	8002	600	4875	2275
4.	Paddy lands	3000	–	3000	6250	3250
5.	Forest lands not needing treatment	33417*	–	33417*	75145	41745
6.	Forest lands needing treatment	0	–	0	0	0
7.	Forest lands treated	33417*	7613	41030	75145	34115
8.	Gullied lands	0	0	0	0	0
9.	Gullied lands treated	3000	3000	6000	6250	250
10.	Miscellaneous land use	0	0	0	0	0

* Harvesting cost.
In the case of forest lands not needing treatment, the net returns has been computed on the basis of Rs 33400 as harvesting cost.

Table 6: Land use, treatment cost and sediment load of Haharo watersheds using linear programming model

Sl. No.	Uplands Not Needing Treatment	Uplands Needing Treatment	Paddy Lands	Forest Lands Not Needing Treatment	Forest Lands Needing	Gullied Lands	Misc Land Use
Watershed No. 4/1 (Area=1699 ha.)							
1.	41.9	128.0	487.5	237.5	787.0	4.0	13.0
2.	41.9	122.1	487.5	237.5	787.0	4.0	13.0
3.	41.9	83.5	487.5	237.5	787.0	4.0	13.0
4.	41.9	44.9	487.5	237.5	787.0	4.0	13.0
5.	41.9	25.6	487.5	237.5	787.0	4.0	13.0
6.	41.9	6.3	487.5	237.5	787.0	4.0	13.0
7.	41.9	0.0	487.5	237.5	787.0	4.0	13.0
8.	41.9	0.0	487.5	237.5	787.0	4.0	13.0
9.	41.9	1.1	487.5	237.5	787.0	4.0	13.0
10.	41.9	1.1	487.5	237.5	787.0	4.0	13.0
11.	41.9	1.1	487.5	237.5	787.0	4.0	13.0
Watershed No. 4/2 (Area = 12100 ha.)							
1.	860.0	229.0	3218.0	3734.0	0.0	145.0	327.0
2.	860.0	101.1	3218.0	3734.0	0.0	145.0	327.0
3.	860.0	81.8	3218.0	3734.0	0.0	145.0	327.0
4.	860.0	0.0	3218.0	3734.0	0.0	14.8	327.0
5.	860.0	0.0	3218.0	3734.0	0.0	4.5	327.0
Watershed No. 4/3 (Area = 13842 ha.)							
1.	1022.0	113.7	3562.0	4961.0	3592.0	234.0	216.0
2.	1022.0	75.1	3562.0	4961.0	3592.0	234.0	216.0
3.	1022.0	0.0	3562.0	4961.0	3592.0	234.0	216.0
4.	1022.0	0.0	3562.0	4961.0	3592.0	234.0	216.0
5.	1022.0	0.0	3562.0	4961.0	3592.0	69.6	216.0
6.	1022.0	0.0	3562.0	4961.0	3592.0	49.2	216.0
7.	1022.0	0.0	3562.0	4961.0	3592.0	28.8	216.0
8.	1022.0	0.0	3562.0	4961.0	3592.0	8.4	216.0
9.	1022.0	0.0	3562.0	4961.0	1142.0	0.0	216.0
10.	1022.0	0.0	3562.0	4961.0	13.0	0.0	216.0
Watershed No. 4/4 (Area = 15757 ha.)							
1.	1383.0	346.0	3853.0	5455.0	4286.0	225.0	209.0
2.	1383.0	182.2	3853.0	5455.0	4286.0	225.0	209.0
3.	1383.0	0.0	3853.0	5455.0	4286.0	219.3	209.0
4.	1383.0	0.0	3853.0	5455.0	4286.0	137.7	209.0
5.	1383.0	0.0	3853.0	5455.0	4286.0	117.2	209.0
6.	1383.0	0.0	3853.0	5455.0	4286.0	15.2	209.0
7.	1383.0	0.0	3853.0	5455.0	3224.3	0.0	209.0
8.	1383.0	0.0	3853.0	5455.0	1141.0	0.0	209.0
9.	1383.0	0.0	3853.0	5455.0	99.3	0.0	209.0

Uplands Treated	Forest Lands Treated	Gullied Lands Treated	Total Area Treated	Cost of Treatment	Unit Cost of Treatment	Sediment Yield (tons)	SPR (tons per ha)
Watershed No. 4/1 (Area=1699 ha.)							
0.0	0.0	0.0	0.0	95.4	0	6177.0	3.64
5.9	0.0	0.0	5.9	95.5	800	6000.0	3.53
44.5	0.0	0.0	44.5	96.2	800	5000.0	2.94
83.1	0.0	0.0	83.1	97.0	800	4000.0	2.35
102.4	0.0	0.0	102.4	97.4	800	3500.0	2.06
121.7	0.0	0.0	121.7	97.8	800	3000.0	1.77
128.0	0.0	0.8	128.8	98.0	815	2800.0	1.65
128.0	0.0	2.8	130.8	98.1	849	2700.0	1.59
126.9	390.7	4.0	521.6	258.4	5920	2600.0	1.53
126.9	599.0	4.0	730.0	343.9	6403	2550.0	1.50
126.9	765.7	4.0	896.6	412.3	6628	2510.0	1.48
Watershed No. 4/2 (Area = 12100 ha.)							
0.0	3587.0	0.0	3587.0	2832.9	7613	29313.0	2.42
127.9	3587.0	0.0	3715.9	2825.5	7378	26000.0	2.15
147.2	3587.0	0.0	3734.2	2835.9	7344	25500.0	2.11
229.0	3587.0	130.2	3946.3	2845.3	7065	17000.0	1.40
229.0	3587.0	140.5	3956.5	2845.9	7055	16500.0	1.36
Watershed No. 4/3 (Area = 13842 ha.)							
141.3	0.0	0.0	141.3	1787.4	800	31000.0	2.24
179.9	0.0	0.0	179.9	1788.2	800	30000.0	1.85
255.0	0.0	41.9	296.9	1792.2	1111	26000.0	1.60
255.0	0.0	62.3	317.3	1793.4	1232	25000.0	1.54
255.0	0.0	164.4	419.4	1799.6	1662	20000.00	1.23
255.0	0.0	184.8	439.8	1800.8	1724	19000.00	1.17
255.0	0.0	205.2	460.2	1802.0	1781	18000.00	1.11
255.0	0.0	225.6	480.6	1803.2	1833	17000.00	1.05
255.0	2450.0	234.0	2939.3	2809.1	6655	16000.00	0.99
255.0	3579.0	234.0	4068.5	3272.4	6921	15729.0	0.97
Watershed No. 4/4 (Area = 15757 ha.)							
0.0	0.0	0.0	0.0	1965.4	0	39241.2	2.49
163.8	0.0	0.0	163.8	1968.7	800	35000.0	2.22
346.0	0.0	5.7	351.7	1972.7	836	30000.0	1.90
346.0	0.0	87.3	433.3	1977.6	1234	26000.0	1.65
346.0	0.0	107.8	453.8	1978.8	1322	25000.0	1.59
346.0	0.0	209.8	555.8	1985.0	1630	20000.0	1.27
346.0	1061.7	225.0	1632.0	2421.5	5533	19000.0	1.21
346.0	3145.0	225.0	3716.0	3276.0	6699	18500.0	1.17
346.0	4186.7	225.0	4757.7	3793.7	6899	18250.0	1.16

CONCLUSIONS

The sediment load data being collected from four watersheds of Haharo sub-catchment could be analyzed to ascertain the optimum SWC treatment package for maintaining different levels of Sediment Yield. In the process, a linear estimation model could be developed which quantifies the Sediment Production Rate from different land use categories of the watershed. These SPR values are, in a way, comparable to the Mapping Units of the Priority Delineation methodology of the All India Soil and Land Use Survey. The development model, however, has the added advantage as it can be used as a constraint in an Optimization model. A Linear Programming model was also developed which helped in determining the optimum investments required for maintaining different level of Sediment Yield for the watersheds. The experience thus gained could be availed for developing similar models for different regions of the country.

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HYDROLOGIC AND SEDIMENT MONITORING OF WATERSHEDS OF RIVER VALLEY PROJECTS AND FLOOD PRONE RIVERS PROGRAMMES

C.M. Pandey • Ministry of Agriculture • New Delhi

INTRODUCTION

Watershed management in India has become a thrust area for sustainable development of agriculture in recent years. Various central ministries are implementing programmes for watershed management and development. The Ministry of Agriculture is also implementing a few Centrally Sponsored Schemes viz Scheme for Enhancing Productivity of Degraded Lands in the Catchments of River Valley Projects and Flood Prone Rivers (RVP & FPR), Reclamation of Alkali Soils (RAS), Watershed Development Project for Shifting Cultivation Areas (WDPSCA) and National Watershed Development Project for Rainfed Areas (NWDPRA). In these schemes the concept of watershed approach is being adopted and every year about Rs 300 crores are spent for watershed development programme, in the country. From November 2000 most of these schemes have been subsumed under Macro Management Mode (MMM). After amalgamation the financing pattern of the scheme is in the ratio of 90:10 between central government and state government respectively and funds are provided as 80% grant and 20% loan to the state governments. However, the programme approval and monitoring of such schemes are being continued with concerned divisions.

STATUS OF CENTRALLY SPONSORED SCHEMES

The Centrally Sponsored Scheme for Enhancing Productivity of Degraded Areas in the Catchments of River Valley Projects and Flood Prone Rivers (RVP & FPR) was started in the 3rd Five Year Plan. The scheme has been approved for its continuation during the 9th Five Year Plan in the selected 45 catchments in 23 States through MMM. The State Government Departments (SGD) are the nodal implementing agencies and the fund is being provided as per guidelines of the scheme for programme implementation. Under RVP and FPR schemes there is an in-built provision of 3% of the total allocation for establishment of Sediment Monitoring Stations (SMS) prior to starting the works in the very high and high priority watersheds falling in the catchments of the schemes.

IMPORTANCE OF HYDROLOGIC AND SEDIMENT MONITORING

Hydrologic and sediment monitoring was an integral part of the watershed development programme that the Ministry of Agriculture had been emphasizing through watershed approach. In addition to the monthly, quarterly and annual progress of work monitoring is scientifically carried out by collection of hydrologic and sediment data for pre-treatment, during treatment and post treatment periods. This data is collected with help of instruments installed in Sediment Monitoring Stations (SMS). The SMS are established at least two years prior to adoption of soil and water conservation measures and monitoring continues for another five years from the year of completion of work. Data thus collected is sent by the respective inplementing agencies at the state level to the Natural Resources Management Division of Department of Agriculture & Cooperation for assessing the impact. This approach has

been accepted and the findings have been found very useful for adopting of corrective measures and also in commencing the Senior officers.

CURRENT SCENARIO OF SEDIMENT MONITORING STATIONS (SMS)

During the 9th Plan, a total of 210 SMSs are functioning in watersheds of RVP & FPR in 19 different catchments as per details given at Annex I. Out of these, 28 SMSs have been established under the Indo-German Bilateral Project on Watershed Managements and 182 SMSs are functioning under RVP & FPR programmes. So far no SMS has been established in 4 states namely Haryana, Mizoram, Sikkim and Tripura.

INDO-GERMAN BILATERAL PROJECT WATERSHED MANAGEMENT

The Indo-German Bilateral Project was started in the year 1989 to strengthen the hydrologic and sediment-monitoring programme in the ongoing RVP & FPR Schemes. In the beginning, thrust was given for establishment of SMS only. During 2nd phase i.e. 1993-94 it was observed that in addition to SMSs the project should also provide necessary technical and financial support for undertaking innovative need based soil and water conservation measures in Representative Watersheds (RWS). From 2nd phase onwards, in addition to establishment of SMS, RWS and Capacity Building/training in India and abroad for the official working for soil and water conservation have become major thrust areas. Since inception up to March 2001 a total of 41 SMSs were established out of which 13 are now closed and only 28 SMS are functioning. The RWS activities in five States namely, Rajasthan, Himachal Pradesh, Uttar Pradesh, Jharkhand and Tamil Nadu have been successfully completed. The programme has also been evaluated through outside agency and has been found very effective in:-

- Enhancing biomass in productive areas
- Increasing the productivity potential of watershed area
- Creating sources for providing life saving irrigation
- Increasing employment opportunities and;
- Helping in overall socio-economic development of the watershed inhabitants

ANALYSIS AND IMPACT ASSESSMENT

A few selected samples of data of the SMSs received from the state governments have been published in the past in bulletin form for the use of beneficiaries/state departments. In addition some analysis have also been conducted at national level. A few sample analyses are given here:-

Comparison of runoff and sediment through graphic method

The graphic comparative analysis reveals that prior to treatment there was a high rate of silt and runoff. The sediment yield was reduced to 45% as compared to pre treatment rate for the same amount of runoff. After completion of the treatment the sediment yield as compared to pre-treatment was very nominal.

Instantaneous Unit Hydrograph (IUH)

The runoff data prior to treatment of the watershed and a
collected keeping in view the parameters required for deve
amount and intensity of rainfall was same and the month c
pre and post data responses was also same. After developm
critical analysis it was concluede that:

- The rising limb of the IUH prior to treatment was very steep which indicates that water from the watershed rushed away within a short period of time whereas after treatment there is delay in run off.
- The run off peak was 15,680 cubic m. per hectare prior to treatment and after treatment the run off was 10,517 cubic m. per hectare only.
- Recession limb of IUH has lack of skewness prior to treatment whereas after treatment the same has been eradicated. This indicates that there was smooth flow after treatment period.
- The recession limb also reveals that after certain hours the flow of water is likely to discontinue from the watershed, whereas the post treatment scenario indicates that there is continuous flow.

Similar analysis has been conducted for many other watersheds and it has been concluded that run off peak and volume has been reduced by 30-34% as compared to pre treatment which reveals that more water has infiltrated in the soil profile and has also resulted in reduction of runoff peak and volume flow. The silt flow from the treated area has been also reduced for the same quantum of runoff. All these reveal that soil and water conservation measures adopted on watershed basis have helped in achieving the objective of RVP & FPR Schemes i.e. reduction of run off peak and volume and prevention of pre-mature siltation of dam and enhancing soil moisture regime and ultimately recharging ground water.

ORIENTATION TRAINING COURSE ON HYDROLOGIC & SEDIMENT MONITORING OF WATERSHED

The orientation training courses on Hydrologic & Sediment Monitoring of Watersheds of 10 days duration one each for Project Officers and Field Officers are being organized every year in collaboration with the Soil Conservation Training Centre, Damodar Valley Coorporation, Hazaribag, Jharkhand. Theses courses are basically to orient the officers with latest technological advances in the field of hydrologic and sediment monitoring especially for the officers directly involved in programme of RVP & FPR in different state governments.

SUBMISSION OF HYDROLOGIC & SEDIMENT DATA

The state-level officers looking after such projects need to supervise such studies and report to Government of India regarding success and failure, if any. The monthly data of all SMS functioning under the RVP & FPR programme as well as IGBP need to be regularly submitted to Govt. of India, Ministry of Agriculture, DAC, NRM Division, Room No.102, B-wing, Shastri Bhawan, New Delhi-110001 in the proforma given at Annexure-II.

Annexure – 1: State-wise sediment monitoring stations established under RVP, FPR and IGBP

S. No.	Name of State	Sediment Monitoring Station			Status of data reporting (As on Sept., 2001)
		RVP & FPR	IGBP	Total	
1.	Andhra Pradesh	8	2	10	P,Q,S, *Data from Forest Deptt. upto 99 & only P data for 2000 received
2.	Assam	2	-	2	Data after 1995 onward are still awaited
3.	Bihar	3	2	5	Data from 1993 onward are still awaited.
4.	Chhatisgarh	3	2	5	Data from 1998 are still awaited.
5.	Gujarat	10	2	12	Data for 2000 are received
6.	Haryana	-	-	-	SMS not yet established
7.	Himachal Pradesh	5	1	6	Data received up to September 2000 for IGBP SMS
8.	Jammu & Kashmir	4	-	4	Data received up to 2000
9.	Jharkhand	19	3	22	Data from DVC for 20 SMS upto 2000 received
10.	Karnataka	9	-	9	Received data up to 1996 for 5 SMS
11.	Kerala	4	-	4	Data of 2 years i.e. 1996 & 97 received
12.	Madhya Pradesh	12	-	12	Data after 1994 not received
13.	Maharashtra	19	4	23	Data of 4 SMS up to October 2000 received. For others data awaited
14.	Mizoram	-	-	-	SMS not established
15.	Orissa	22	2	24	Data up to 1996 received for 16 SMS only
16.	Punjab	-	-	1	Data not received due to non functioning of SMS
17.	Rajasthan	38	2	40	Data of 32 SMS up to 1998 received.
18.	Sikkim	-	-	-	SMS not established
19.	Tamil Nadu	3	3	6	Data for 2000 not received
20.	Tripura	-	-	-	SMS not established
21.	Uttaranchal	5	2	7	Data of SMS received up to 1998
22.	Uttar Pradesh	13	3	16	Data up to 2000 of 11 SMS received
23.	West Bengal	2	-	2	Data not received from 1996 onward
	Grand Total	**182**	**28**	**210**	

*For details of PQS see annexure 2

Annexure – II: Proforma for submission of Rainfall (P), Runoff(Q) and Sediment(S) data of Sediment Monitoring Stations (SMSs) established under RVP & FPR/IGBP

(Part –A)

Sl.No.	Activity	Status
1.	Name of State and Code	
2.	Catchment Code	
3.	Watershed Name and Code	
4.	Name of SMS	
5.	Year of starting observation	
6.	Year of starting treatment	
7.	Year of saturation of watershed	
8.	Area treated under RVP & FPR	
9.	Location of watershed	
10.	Name of District	
11.	Longitude	
12.	Latitude	
13.	Name of stream/nala/river	
14.	Physiographic details	
15.	Type of soils of watershed	
16.	General slope of area	
17.	Common land use practices	
18.	Type of common vegetation	
19.	Method of collection of rainfall	
20.	Method of collection of discharge/runoff	
21.	Method of collection of sediment	
22.	Watershed area in ha. & Treatment detail Land use / Total area / Treatable area / Area treated Agri Forest Waste Others Total	Remarks
23.	**Impact of treatment** ● Reduction in runoff ● Reduction in sediment yield ● Increase in bio-mass ● Increase in cropped area ● Increase in cropping intensity ● Increase in irrigation potential ● Increase in ground water table ● Increase in socio-economic status ● Increase in employment	
24.	Any other details	

Signature of Reporting Officer
Designation

Proforma for submission of monthly Rainfall(P-mm), Runoff(Q-mm) and Sediment Yield (S-ha.m./100 square k.m.)

Part – B

Name and Code of Watershed

Name of SMS

Month/ Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
2000	P													
	Q													
	S													
2001	P													
	Q													
	S													
2002	P													
	Q													
	S													
2003	P													
	Q													
	S													
2004	P													
	Q													
	S													
2005	P													
	Q													
	S													
2006	P													
	Q													
	S													
2007	P													
	Q													
	S													
2008	P													
	Q													
	S													
2009	P													
	Q													
	S													
2010	P													
	Q													
	S													

Signature of Reporting Officer

Designation

EXPERIENCES WITHIN THE REPRESENTATIVE WATERSHED PROGRAMME OF THE INDO-GERMAN BILATERAL PROJECT "WATERSHED MANAGEMENT"

(OPPORTUNITIES, CONSTRAINTS, RECOMMENDATIONS)

E.M.Tideman • IGBP • New Delhi

PROJECT SET UP AND APPROACHES

The watershed management activities of the IGBP-WSM started in 1992 with the second phase of the project. The first phase of the project started in 1989 with the installation of Silt Monitoring Stations (SMS) equipped with German instruments. The project activities were centered around technical issues, collection of hydrological data and training of government field level staff in the collection of data and the handling of instruments and computers.

However, it was soon realized, that these activities were not addressing the causes and problems of erosion. The need for additional activities became obvious and in the second phase the new project component of Representative Watersheds (RWSs) was added.

Each RWS should represent a typical agro-meteorological region of India. The activities to be undertaken in a RWS should serve as an example to be replicated in the surrounding watersheds

The original concept of a RWS was that each RWS should represent a typical agro-meteorological region of India. The activities to be undertaken in a RWS should serve as an example to be replicated in the surrounding watersheds. For this reason a RWS is a watershed that is similar in most physical and socio-economic features to the surrounding watersheds in that region. It should be possible to implement in the surrounding watersheds, the same soil and water conservation measures as well as other activities that are carried out in the RWS.

In a "normal" watershed the state authorities formulate and implement the conservation plan with little or no consultation with the people concerned. Work is implemented with paid labour from within the watershed or elsewhere. A two-year maintenance period follows the completion of the work, at the end of which all state involvement ceases. In many cases no further maintenance is carried out as the farmers do not consider the conservation works carried out as their own - rather as the state's - and therefore do not take over maintenance as expected.

In a RWS the people are involved from the early stages of planning, through implementation and finally take responsibility for the created assets and social infrastructure.

To create a sense of ownership the beneficiaries should contribute either in cash or kind otherwise the feelings that the assets belong to the Government or the German Project, will always remain.

It should be avoided to make the RWS "a little Germany" (this means with the extra manpower and German funds available, activities are carried out which require an input level that will be too high to be replicated and applied in the surrounding watersheds, either due to lack of funds or due to lack of qualified and trained manpower). Of course the results of these high input activities in the RWS would be better in comparison with the results of a non-RWS but they cannot be replicated and as such the RWS would be not representative.

In the RWS, three types of activities are carried out. The first one is the "classical" soil and water conservation works carried out by the State Department concerned and funded with Central Government (RVP or FPR) money on government lands or wastelands. However, due to financial constraints, the Government has set fixed

maximum amounts for the various conservation works, either per hectare treated or per structure made. As a consequence there is seldom enough money available to carry out all the conservation works required for a complete "saturated" approach.

This results in the second type of activity. These are the soil and water conservation works carried out with German funds. These activities are not limited by the government guidelines on physical activities and maximum financial expenses. They can include works at higher than government permitted unit costs but the sustainability aspect should be always considered. Furthermore, it was intended to include under the German funded activities, those which were of a more innovative character.

The planning and design for these works would be done by the State Department concerned in close cooperation with the IGBP. As the State Department is usually the only organization at the moment having the manpower (directly or through contractors) and the experience to carry out these works, they will be also used in the implementation.

The third type of activity to be carried out in the RWS are those by the NGO. The NGO concentrates on motivation and awareness raising, training, income generating activities, organization of self-help groups and activities on private land.

For the second and third types of activities, the IGBP signs agreements with the State Department and NGO, specifying which activities are carried out when, planning is on a quarterly basis and is based on initial surveys carried out by the NGO.

Funds are released according to this planning on a quarterly basis directly from the Project to the organization.

By 1997, the main points of the approach of the RWS programme were formulated as:

- Watershed Management activities are carried out jointly by the State Departments and the NGOs.
- The State Departments work mainly on government lands, while NGOs work on private lands and common lands to prevent overlapping of activities.
- Each organization works in its field of expertise, viz, State Departments in the major soil and water conservation works, plantations etc., NGOs in the motivation and awareness raising of the local people as well as plantations, etc.
- The Project creates a platform for cooperation and coordination between the two partners (State Department and NGO), and acts as a facilitator between them for the development of the watershed and protection of natural resources. It also imparts technical advice to both the partners as and when needed.
- Besides this, the Project focuses on innovative activities for watershed management. These may include besides soil and water conservation techniques activities in the fields of rural development and community organization.
- Ultimately, the establishment of a Watershed Committee, which will handle the coordination of development activities in the future, is envisaged.

EXPERIENCES AFTER 4-5 YEARS (based on the first 5 RWS)

The first socio-economic survey and the planning activities linked with it could be carried out only by the end of 1994. The first 2 years of the Second Project Phase were needed to sort out the modalities of the transfer of project funds. The funds are transferred directly from the Project to the organization the Project signed the agreement with.

Principles and Practices of Integrated Watershed Management in India
Experiences within the Representative Watershed Programme of the Indo-German Bilateral Project "Watershed Management"
(Opportunities, Constraints, Recommendations)

The planning process

Planning in all 5 RWSs was based on a socio-economic survey carried out by the NGO, including village-planning meetings. In some watersheds partial PRAs were carried out. The time constraint was such that no PRA according to the handbook could be carried out. Of course, like all other projects the planning should be participatory, involving the people of the watershed, conducting the fashionable PRAs in every village for 5 days at least.

However, it is highly debatable if proper PRAs could have been carried out, even if plenty of time were available. The only ones having the time and sometimes the patience to sit through a 5 day or even longer PRAs are the elderly people, children and unemployed, certainly not the active (and probably most influential) part of the population. Based on the reported attendance which was confirmed during field visits, the number of people attending the planing meetings or PRA sessions was always rather limited and there was quite a lot of coming and going. Even those who had the interest to come could not make time available for day-long meetings or did not have the patience for them.

Furthermore, the PRA approach with village meetings presumes that consensus can be reached among the people of a village so that a common course of action can be agreed upon. This is often not the case even in a village itself, let alone between villages. Villages are seldom homogenous, different castes, religions and well-being create different attitudes, expectations and demands. The differences between villages are usually even more distinct. As an example one can refer to the water harvesting structure made in Larahi, DVC, Bihar where the people of one disunited village even blocked the water use by another village.

A common complaint of the people in the watershed (and probably in all development projects) was that too much time is spent in planning the project activities and mobilizing the people in groups, like self-help groups and too little was done to improve the living conditions by physical implementation of project activities.

As a result of this stretched out process, the involvement of the beneficiaries in project planning becomes rather limited as they lose interest when no activities are visible for a while.

Participation and contribution

Another factor contributing to the lack of involvement and interest is the common attitude towards government funded projects. According to the people, the government should give it all for free. Moreover, the government plans and implements various activities and usually the maintenance is also the government's responsibility as it is their activity. Thus the people are in no way involved.

This attitude has been promoted over many years since India's independence in 1947 by a government system which only in the last few years is changing its approach from everything, heavily if not 100% subsidized to an approach where those who are benefiting should contribute in cash or in kind (usually 10%). Whether this (contribution) can be called beneficiaries' participation is a relevant question, more so if the programme is implemented only after the village has contributed or proven to be willing to follow an approach as stipulated by the project, one probably should not talk about people's participation but people's cooperation in achieving certain project objectives which have already been set by the project or donor. This so called participation is only used to fit the local community into the project.

The contribution of the people in cash or kind becomes a type of tax without which the project will not be implemented. If a group or village does not contribute (pay their tax) the activity will not be done. How voluntary or involuntary this contribution should be is usually not made clear, and if this should be called people's participation is rather debatable.

Looking at the results of those watersheds where the planning was done as much as possible in the participative manner, one wonders how useful they are to carry out the project objective of soil and water conservation.

If one keeps to the subject of watershed management one should concentrate on soil and water conservation, the improvement of the natural resources in the watershed

Poverty ranking, family composition (joint or nuclear family), age and gender composition, distance from post office or bus stop, caste composition of watershed, etc. can be all very interesting to know but what can one do with all this information in order to improve the final results of the project and consequently give the greatest benefit to the people.

If one keeps to the subject of watershed management one should concentrate on soil and water conservation, the improvement of the natural resources in the watershed. This does not mean that only checkdams should be built or only trees planted, the improvement of the living conditions of the people in the watershed is an important achievement too, but if this should mean that any type of income generating activity, like tailoring or any type of education, (balwaris) is justified, it certainly leads to the question as to what is the difference between soil and water conservation, watershed management and rural development.

Quite a few of the activities carried out is the various RWSs especially by the NGOs are more in the area of rural development than watershed management. This is partly explained by the difficulty in organizing people around more technical activities such as soil and water conservation. Whereas people can be motivated to be involved in water conservation as scarcity of this commodity is directly felt, soil conservation is hard to sell as it is a long term gradual process where the benefits of soil conservation are hard to quantify and take a long time to materialize but the costs of conservation have to be borne from the very beginning.

Furthermore, a major part of the conservation measures are based on technical factors. The slope of the land is a fact and consequently the need for a structure to reduce the erosive force. People can be involved in deciding the exact location of such a structure, but the degree in which changes can be made is rather limited and does not sell very well for a NGO as being oriented towards the people.

Another reason could be the lack of ideas or the lack of knowledge of the organizations concerned. This aspect will be discussed later in this paper.

Of course, while discussing people's participation in soil and water conservation activities, one should not forget that many of the activities are of general interest and also benefit the people downstream. While a check dam can have the direct tangible benefit of providing irrigation or drinking water to a farmer if it is close enough to the farmer's field, the silt retention structures in the steeper upstream part of a water course could result in less siltation in the dam whereas the electricity generated is for villages and cities many kilometers away. It will be near impossible to expect those beneficiaries to contribute or participate in the construction or maintenance of these structures.

Conservation measures of general importance should be taken care of by the government or an organization representing and paid for by the government

Conservation measures of general importance should be taken care of by the government or an organization representing and paid for by the government. After all even people in the so-called developed world where the people have usually far higher available incomes and often more spare time, one does not contribute in cash or kind to the maintenance of a (river) drainage network or

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plant trees in the nearby government forest on one's free Saturday ! The issue of taxation is not to be discussed here.

Summarizing, one could conclude that people's participation in the real sense from the planning stage onwards is very hard to achieve in many of the necessary activities in a soil and water conservation project. This explains why so many projects in this field include in their programmes more populist activities which give a direct benefit to the people.

Cooperation between SGD and NGO

The "classical" subdivision of what State Department and NGO can or should do is less valid than earlier thought. Awareness raising and group formation can be done very well by a governmental organization if the right officers are available

In the original project set up the importance of cooperation between the SGD and NGO was stressed. As already mentioned under the approach, the watershed management activities are to be carried out jointly by State Departments and NGOs. To avoid overlapping of activities the State Department works mainly on government land and does the major soil and water conservation works whereas the NGO works on private and common lands in activities like motivation and awareness raising, plantation, self-help groups, etc.

The "classical" subdivision of what State Department and NGO can or should do is less valid than earlier thought. Awareness raising and group formation can be done very well by a governmental organization if the right officers are available. As an example one should mention DVC. The DVC as parastatal organized the user group for a lift irrigation project (Banha). Here DVC did not do only the technical work of dam and spillway construction but also got the people involved in digging the trenches for the water supply pipelines. The reduced, daily wages the people received for this work were deposited in a separate bank account as start up capital for the water user group. This account is used for paying the operation and maintenance for the pump and the operator's wages and for depositing fees paid for the pump usage. The user group now independently runs the lift irrigation scheme.

The other way around, the NGO and the people can do more technical work too. Once the people are organized, united in a group they can take up small civil engineering works if necessary by directly hiring a contractor. A good example of the technical ability of a NGO is the 5% ponds made by PRADAN in eastern India which is discussed in detail elsewhere in this publication in the paper by D.Karmakar, called "Jaldhar Model ("30 x 40 model" and "5% model") of in-situ rain water harvesting. This technique if applied correctly in the right conditions gives excellent results.

An example where the people did it all themselves with the project only giving financial assistance (50% of the cost) is in the RWS in Tamil Nadu. Here a reinforced concrete footbridge with a span of 5 meters was made by a user group. One of their members, a retired government engineer made the design including reinforcement calculations and under his guidance the group built the complete bridge of a high standards.

Although the above examples may serve as illustrations that the separation of work responsibilities should not be taken to be too

absolute, it is justified to state that usually the NGOs are weaker in the more technical aspect of watershed management than the State Department. However, in general, the quality of the technical works offers scope for improvement, not only in the case of the NGOs, the State Departments too have difficulties in achieving an acceptable engineering standard.

The need for more training in the technical aspects of watershed management was illustrated many times in all RWSs by most organizations

Many structures were seen over the years in various watersheds, which were technically not sound. They were sometimes over-dimensioned or under-dimensioned, like in the case of earthen bunds or the walls of buildings; loose boulder checkdams which were incomplete, either the apron doesn't exist at all or was far too small; poor quality plantations; spontaneously collapsing gabions; poor timing in the various nurseries, etc. The need for more training in the technical aspects of watershed management was illustrated many times in all RWSs by most organizations.

The degree of cooperation between State Department and NGO varied enormously in the various RWSs. It was in most cases to a great extent dependent on the person responsible. By far the best cooperation was in the RWS in Tamil Nadu. Here many activities were planned and implemented in close cooperation between the people, the State Department and the NGO.

This is elaborated in more detail in the paper called: "Collaboration Between Government Organization and NGO - A Case Study of the Kattery Watershed" by Aparna Kanungo. On the other side were those RWSs where even holding a joint meeting once a month was a major effort.

In the approach mentioned, "the project creates a platform for cooperation and coordination between the partners (State Department and NGO)" is certainly true in the respect that in some RWSs to hold a joint meeting would require a visit by project officials, certainly in the early stages of the programme.

There is a lot of mutual distrust between State Departments and NGOs. The present very strong promotion of NGO involvement is very much pushed by foreign donors.

State government officials often feel that NGOs are just against the government and its officials. This feeling is justified in certain cases as there are NGOs with an anti-government attitude and a political agenda. There is a lot of variation in the quality and sincerity of NGOs. The strong demand for NGOs by foreign donors has caused a prolific growth of NGOs, some of them are hardly more than a postal address and of course a bank account. In this process the quality aspect is not always duly considered. These greedy NGOs spoil the name of the many other NGOs which are doing good quality and useful work and are sincere in achieving their clearly stated objectives.

The other way around, not all government officials are without faults either. The often-heard accusation of rampant corruption must have a certain truth. The lifestyle of some of them makes one wonder how they can finance it out of their rather meagre official government salary.

Being assured of a life long job where promotion is more dependant on seniority and political connections than on performance, does not motivate towards committed hard work in the field either.

The concept of NGO involvement and the related approach of people's participation is promoted strongly by foreign donors, but is also accepted and encouraged by senior government officers in Delhi and state capitals. However, the middle or lower ranking government officer does not necessarily agree to this approach. To start with, the middle or lower ranking officer does not have the same exposure to new developments and changing attitudes as the senior officers in the bigger cities. For him NGO involvement and people's participation are just orders from higher up, in which there is little to gain and a lot to lose.

At present, the middle-ranking officer has quite a lot of status. He gets certain funds from his state headquarters, where these funds are to be used and who or which contractor will receive the contract can be decided by him for a major part. Increased people's participation means that this officer has to account for more of his actions. This is especially true if the people contribute to a part of the project costs and want to be involved in selection and supervision of the contractor.

The people will then rightly ask for more accountability and transparency and insist on having a say in the decisions taken. This all undermines the previously strong position and status of the officer concerned.

Better information about and joint training in various aspects of people's participation could reduce the tension and misunderstandings which at present prevail between State Department and NGO field representatives.

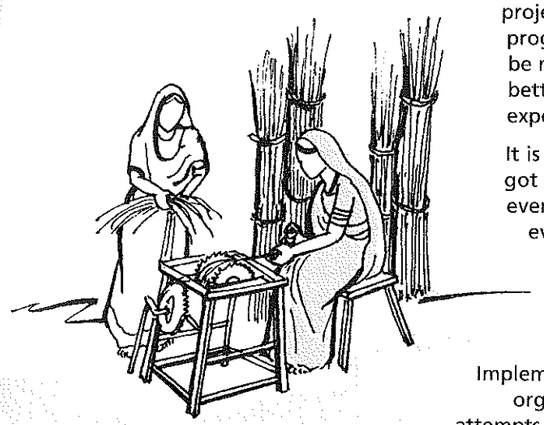
One can envisage that during the first one or two years of a programme, the project convenes at least one joint meeting each month where all matters of general concern are discussed

Certainly in the beginning of a joint State Department - NGO approach a major responsibility of the project is to bring these two partners together in a constructive atmosphere and solve problems in the early stages when they arise, and avoid misunderstandings from the very beginning.This would require from the project side regular interaction with both partners. One can envisage that during the first 1 or 2 years of a programme, the project convenes at least one joint meeting each month where all matters of general concern are discussed. This would mean also that the project officers should make a visit to each RWS at least every month. The frequency of the present field visits is about once every 3 or 4 months only, which is in many cases clearly not sufficient to bring the State Department and NGO together.

Planning and implementation

As stated earlier the project signs agreements which specify activities and their related costs on a quarterly basis. The planning of the activities is for a major part left to the organization concerned, as they should know the specific local condition much better. Project officials would discuss the proposal of course and in many cases advise to scale it down to more realistic quantities and a slower speed of implementation. This was sometimes a source of annoyance for the organization proposing the activities.

After 5 years of field activities a few conclusions can be drawn. None of the 10 organizations (2 in each RWS) were able to keep to the original planning. The difficulties in the actual working conditions were clearly underestimated in the eagerness to achieve improvements for the people in the watersheds. Here is also an aspect involved of learning by the project staff. Agreements made in the later stages of the programme have in general a quarterly planning which could be much better realized. Not only time-wise was the planning better followed; also financially the actual and anticipated expenditure was much closer to each other.



It is interesting to note that although most organizations got extended periods for implementation, in some cases even more than twice as long as was originally planned, even then almost all organizations were not able to spend fully the originally allocated funds. The rather tight monitoring including detailed field visits by project officials could be a possible explanation or was it just a case of optimism?

Implementation was slowed down in many cases due to the organizational structure of the organizations and by the attempts to have some innovative activities.

The organizational structure of the government is well known. A strict top-down approach where all decisions and orders come from the senior officers only to be implemented by the lower ranking officers. Questions and discussions are usually not encouraged. It will be clear that this approach does not promote taking initiatives or responsibilities or to try something a bit different or innovative.

Unfortunately, many NGOs do not have a much better organizational structure either. Also here, most, if not all power rests with the founder or director of the NGO. He decides without much consultation with his fellow NGO workers what will be done according to his own likes and dislikes. Sometimes it becomes also a kind of family operation. This at times demotivates the staff who do not have the same perks and are usually paid lower salaries than government officials, the staff turnover is high.

All discussions concerning approach and objectives held in the planning stage are not conveyed to lower level staff, these remain with the head office

In many cases, after having "won" the contract, the director of the NGO is hardly involved in the actual field activities. Sometimes the field staff is unaware of anything more than is stated in the contract, which is rather limited. All discussions concerning approach and objectives held in the planning stage are not conveyed to lower level staff, these remain with the head office. The often enthusiastic but young and inexperienced field workers are lost due to lack of guidance.

In this respect, it is disappointing to observe that none of the NGOs made much use of the funds allocated for training their staff. Usually, these funds were left unutilized or reallocated. The opportunity to build up in house knowledge and experience was not made use of.

Finally, the innovative failure. The project, like any foreign-funded project ought to do, intended to encourage innovative activities. This has not really happened. No organization, neither state department nor NGO, could come with realistic innovative ideas. Even with the project taking the financial risk of a failure, nobody dared to take risks of a new initiative. All concentrated on those activities they had done before and were familiar with.

There is clearly a culture of risk avoidance and a total lack of creativity. Apparently, the roots of this problem are based in the Indian schooling system, where creativity and independent thinking are not promoted. Probably the idea of innovative activities is a very foreign concept, may be supported by a few very senior government officers in Delhi, but too far away from the mainstream India. As such, the inclusion of innovative activities was inappropriate and a good example of a top-down dictate.

Most systems, also outside India, are still very much geared towards standardization and setting of targets. The project plans of most development cooperation projects are good examples of this.

CONCLUSIONS

In spite of the not always easy relation between the two, the concept of a joint involvement of government and NGO is still the most promising approach, as it can make use of the strongest qualities of both. The aspect of coordination between government department and NGO is a major project responsibility.

Usually, there will be a need for a development agency to motivate and organize the people. It is not important if this is done by a government department or a NGO.

Certainly in the present conditions in India it is very hard to implement a watershed management project with emphasis on soil and water conservation without government involvement. NGOs are no substitute for the government, their roles are complementary. NGOs usually work on a small scale, their strength is in organizing and involving people,

Implementation of physical activities on a large scale is only possible with the facilitating frameworks and supportive mechanisms set up by the Government which is also the major financier in the country of watershed management activities

awareness raising and motivation. Implementation of physical activities on a large scale is only possible with the facilitating frameworks and supportive mechanisms set up by the government which is also the major financier in the country of watershed management activities. Direct hiring of contractors by a group of people with or without NGO assistance, is only possible if the necessary technical knowledge is available within the group or NGO. Often that knowledge is not available.

Realising the weaknesses of government and NGO, the latest fashion of some donors is to give the money directly to a village (group) and let them plan and implement or subcontract it. Even ignoring the fact that in many of those situations powerful local persons or political factions will take the money and decide in a rather unparticipative manner how it will be utilized, this approach is like throwing a child in the water presuming it will swim, not only swim to survive but even to develop useful strokes which will bring it to the right destination.

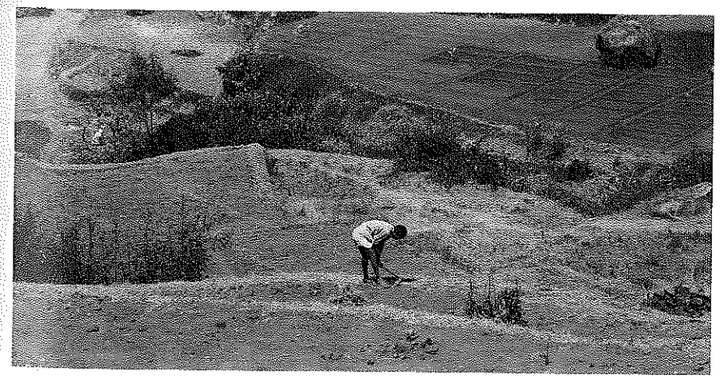
The child can't swim and drowns. The village receives the money and will waste it or can't use it efficiently. Even if the intentions are good, one still has to know how to do it. One does not swim automatically, neither does one develop a watershed automatically. Both require training, motivation and assistance of professionals to become independent and survive.

However, community organizations for ownership, supervision and maintenance, like a watershed committee, are crucial for the success of a project. Either an existing group or institute should be used or if not possible an alternative institute should be established. NGOs are not a substitute for a locally-based institute as it is found that participation ends with the withdrawal of the NGO if no village organization is available.

One should be careful not to over-organize in creating too many groups. There is a tendency to establish in the watershed many different types of groups like self-help groups, saving and credit groups, user groups, etc. All these groups require members joining regularly in their meetings and activities. If there are too many groups and people are members of several of these groups, time constraints will force them to be selective about the number of meetings they are able to attend. The participation of only a part of the group members will weaken the group and the objectives it would like to realize.

From the foregoing discussion it is clear that there is need for more training at all levels of watershed management from the technical issues such as how to estimate a peak runoff to social issues of how to organize a group or motivate them.

The training should be practically oriented, based on the prevalent situation on the ground. Simple, low cost, people-oriented technologies should be promoted. It should be at different levels for government and NGO representatives.



Trainings are not popular in India. It is considered more of a punishment than an incentive. These should be made more attractive. Promotions to higher posts for those who have received training over those not trained could be a motivating factor. Moreover, the trainings themselves should become more enjoyable by having professional trainers as not every technically qualified person makes automatically a good trainer, and with good training manuals treating practical subjects without endless unnecessary theory.

Furthermore, trainings should be compact and not too long, a maximum of 2-3 weeks in accommodation that is pleasant. The few short duration trainings of good quality at present available in India are well received by the trainees concerned.

The project responsibility in bringing government department and NGO together, will certainly in the beginning require frequent meetings between the representatives of the department, the NGO and the project. These regular meetings require frequent visits by the project personnel. For practical reasons alone this would be already sufficient justification to have a cluster of watersheds as this would reduce the time consumed by travel, considerably.

A group of watersheds close to each other, but not adjacent, will have a considerable spillover effect to the watersheds not taken up and will have a far longer lasting effect in the area

An even more valid reason for clustering is the increased impact it will have. One watershed of 2000 ha in a state has very little impact on the people outside the watershed and on the officials involved. A group of watersheds close to each other, but not adjacent, will have a considerable spillover effect to the watersheds not taken up and will have a far longer lasting effect in the area.

Furthermore, certain facilities created can be used more efficiently. Not every watershed needs a nursery or a training centre, these can service a far larger number of people or area than just one watershed.

Finally, the sector most closely related and influenced by watershed management in general and more specifically soil and water conservation is the agricultural sector. Far more attention should be paid to improvements to be made in agriculture. They are often simple and cheap with considerable results, like higher yields or better grazing land, directly improving the living conditions of the rural population.

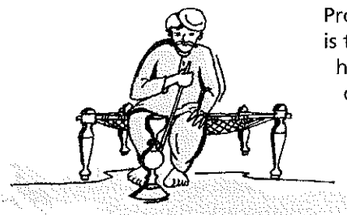
The positive effects of contour farming and intercropping are well known, but the dissemination of the available knowledge and active encouragement of its implementation is done only in very few cases.

Fuel-fodder-fruit trees are another under-utilised opportunity which deserves far more attention. Biogas is relatively popular although often less successful than the less promoted but cheaper and easier to do composting which seldom fails completely unlike biogas plants. In general, increased biomass production is neglected in many projects.

Improving the productivity of livestock should be stressed more as in the long term this could result in reduced number of cattle and consequently less overgrazing and degradation of grazing land, especially of the government and common lands.

Tree plantations on the hill slopes and bunds and the strengthening of the field bunds could be done in many cases by the farmers themselves, but the long period of several years before trees produce any product of benefit, require motivation which can be stimulated by awareness raising and training in these subjects.

The quality of many seeds is rather poor. Improved quality seeds and teaching better methods of seed storage will result in higher yields in the short period of one growing season with better quality products and less crop failure.



Probably the most threatening development for sustainable agricultural productivity is the decreasing availability of good quality water sources. The importance of water harvesting structures which can be small scale and simple to maintain cannot be overstressed. Good examples of these types of structures are the staggered contour trenches and small loose boulder checkdams and field bunds (not necessarily exactly on the contour). At present in many parts of India the groundwater table decreases by more than 0.5m a year, some wells are already reaching in the bedrock. This development can not continue for much longer without causing severe water shortage and crop failures.