EFFECTIVENESS OF CONTOUR BUNDS AND GULLY PLUGS AS TOOLS FOR WATERSHED TREATMENT

A Case Study of Khabji Village of Bharuch District

BY:
SULBHA KHANNA

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Sulbha Khanna

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INTRODUCTION

A watershed can be defined as an area demarcated by the ridgeline separating one drainage basin from another. In other words a watershed is the drainage basin or catchment area of a particular stream or river, and the catchment area is that from which rainwater drains into a reservoir, pond, lake or stream. The concept of watershed as a small unit for management and development of land and water resources was introduced by the Ministry of Agriculture of the Govt. of India in 1974. Since then the concept has been used for natural resource management together with judicious utilization of all natural resources. Watershed management is an integrated technological approach carried out within the natural boundaries of a drainage area for optimum development of land, water and plant resources. The management of natural resources through this approach leads to conservation of soil, increase in water retention capacity of soil, recharging of ground water levels and increase in vegetative cover. For convenience of planning and treatment, macro watersheds are further divided into micro and sub-micro watersheds.

The main components of watershed development include the following:

1) Soil and Water Conservation (SWC) which includes
   a) Contour bunding
   b) Gully plugging
   c) Land leveling
   d) Diversion channels
   e) Drainage ditches.
2) Water Harvesting Structures (WHS) which includes
   a) Check dams
   b) Percolation tanks and wells
   c) Direct well recharge
3) A forestation and pasture development
4) Agricultural development by introducing suitable crops and inputs for enrichment of soil.

Individual efforts of a farmer for treating a micro watershed through soil and water conservation measures will have a limited effect unless all farmers whose fields are located on the same slope treat their land collectively and progressively from top to bottom. For instance, if a farmer whose field is located on the middle of the slope treats her/his field, but the farmers from top and bottom do not treat their lands, the high flow of water from upper fields can damage the field of the farmer who has treated his/her land down the slope. Another important aspect is that due to water harvesting structures, although the flow of water may slow down on the treated field, it can lead to formation of gullies, so it may cause more erosion than if the whole micro watershed hill side had remained untreated. Thus it is advisable to treat a whole micro watershed collectively rather than treating single fields. Collective action of farmers treating a whole micro watershed can enrich the soil of the area and can increase availability of water. The efforts of Anna Hazare in Ralegaon Siddhi of Maharashtra in (1978) and P.R.Mishra the then Director of Centre for Soil and Water Conservation Research and Training Institute, Sukhomajari Village, located in Shivalik hills near Chandhigarh, (in 1975) are classic examples of collective action of people in the area of soil and water conservation, In a period of twenty years the scenario of the villages has changed and they have become self sufficient in food, fuel, fodder and water.

Aga Khan Rural Support Programme [AKRSP (I)] is an NGO working in three backward districts of Gujarat (India) namely (1) Bharuch (a predominantly tribal and hilly region with highly erratic rainfall), (2) Junagadh (salinity prone area) and (3) Surendranagar (drought prone area). AKRSP (I) is involved in soil and water conservation work since 1987 and has adopted the watershed development approach since 1994. The organisation is working for development of land, water and forest resources, and has had a significant impact. In some villages AKRSP (I) has treated almost all the land through contour bunds, gully plugs, check dams and land leveling from top to bottom. The present study was carried out in the Bharuch programme area. This area is hilly with heights ranging from 300 to 900 mts. above mean sea level. The average rainfall of the area is 1200 mm. Once, the area had dense deciduous forest which has considerably degraded over a period of time, and now the area is prone to soil erosion. About 85% population of the area is tribal. AKRSP (I) is working in 128 villages, for the management of natural resources through village institutions. This study is focused on Khabji village where about 80% of two sub micro watersheds have been treated under the soil and water conservation programme through contour bunds and gully plugs. By the end of 1997 almost all the potential area will be covered. This study highlights the outcome and effectiveness of contour bunds and gully plugs constructed in 1994, as soil and water conservation tools in Khabji.

DEFINITION

Contour bund: Stone or earthen walls built across a slope (along the contours) to act as a barrier to runoff are called contour bunds. These are suitable for shallow slopes (2-5 percent) and are frequently used in conjunction with contour plantation. Contour bunds help in reducing soil erosion and increasing water retention capacity of soil. There is evidence from many countries of improved crop yields and reduced erosion following contour bunding. In Fanya Jun, Kenya, contour bunds have improved the yield of maize and beans by some 50-60 percent. In Ethiopia a study of the impact of contour bunds showed that crop yield in fields with contour bunds was 30-40 percent higher than the fields without contour bunds (Jules N. Pretty).

Gully plugs: Gully plugs can be defined as stones placed across gullies or valleys, so as to capture nutrients, silt and moisture. Stones are often embedded into the upper surface of spillway aprons and wells to provide support for the next layer. The principle is to capture runoff from a broad catchment area, thus transferring low rainfall into utilizable soil moisture, and to prevent soil erosion. Slowing of the flow of water helps in settling down organically rich soil. A well maintained gully plug creates a flat, fertile and moist field, where high value crops and trees can be grown. Examples of benefits of gully plugs are clearly visible in many developing countries such as India, Pakistan, Chad and Ethiopia. In many areas where gully plugs were built, agricultural production has increased, and farmers have shifted to high value crops.

OBJECTIVES OF THE STUDY

To assess the outcomes and effectiveness of contour bunds and gully plugs in a hilly, high rainfall area using the following indicators:

1. Change in cropping pattern.
2. Impact on agricultural productivity.
3. Impact on soil deposition/conservation of topsoil. Impact on net economic benefit.
4. Impact on migration.
5. Impact on women

METHODOLOGY

In Khabji village there are 220 farmers of which 76 have partially treated their land by contour bunding and gully plugging. Out of these 76, a total of 39 farmers who treated their land in 1994-1995 were selected for this study. Primary information was collected through a framed questionnaire. Secondary information was collected from AKRSP's records and from the Talati (village revenue official). The information has been analyzed through bi-variate and multivariate tables, and maps and diagrams have been used to give clarity to the readers. To assess the outcome of contour bund and gully plug treatment, a comparative analysis of treated and untreated fields of the same farmers have been done. The 39 selected farmers have a total of 183 acres of land of which 109 acres is treated either with contour bunds or gully plugs.

Total number of farmers in programme	:	76
Sample selected	:	39 (51%)
Total land holding of sample farmers	:	183 acres
SWC treatment	:	109 (59%) acres

Table 1: Categories of farmers based on land holdings in Khabji village

Type of Farmers	Acres of Land	No. of farmers in village	SWC beneficiaries	No of sample farmers
Marginal	0-2.5	67	8	4
Small	2.6-5	68	24	10
Medium	5-10	68	34	19
Large	More than 10	17	10	6
Total		220	76	39

Source: Talati (village revenue official) and fieldwork 1997

STUDY VILLAGE

Khabji village is located in Dediapada taluka of Bharuch district. The village has only two percent of its area under irrigation. A majority of the farmers (61.3%) belong to the marginal and small category and hold 33.1 % of the total cultivated land. Only 7.7 percent of the farmers have more than 10 acres of land, which occupying 21.5 percent of total cultivated area of the village. The land holding pattern of Khabji is similar to any Indian village, where a larger number of marginal and small farmers hold a very small portion of land, and a small number of large and medium farmers hold a large portion of land.

Table 2 : Land holding wise distribution of farmers

Type of farmers	No of farmers	No of land holding (in acres)	Total area (in acres)
Marginal	67	72	87.0
Small	68	138	263.7
Medium	68	204	481.4
Large	17	89	228.4
Total	220	503	1060.5

Source: Talati (village level revenue official) record 1995 and field work 1997

The village is divided into a total of eight sub micro watersheds of which two have been treated adopting a top to bottom watershed approach. Till June 1997 (period of the present study) 66% of potentially treatable area was covered under SWC treatment. Table no.3 indicates total potentially treatable land area needing SWC treatment and the actual treated area. The topography of Khabji is undulating with a slope between 2-12 percent. From 1994 to 1996 AKRSP (I) has treated 136 acres of land through contour bunds and 45 acres of land through 145 gully plugs. Twelve acres of land was brought under irrigation through one check dam.

Table 3 : Potentially treatable area and area treated by AKRSP(I) in Khabji village.

Treatment type	Total Potentially treatable area in Khabji (in acres)	Treated area in Khabji			Area treated (in %)
		Till '96	Jan-June'97	Total Till June'97	
Contour bund	714.5	136.5	303.5	440	61.6%
Gully plugs	346.0	45	191	236	68.2%
Total land	1060.5	181.5	494.5	676	64.9%

Source: AKRSP (I) records

Note: A check dam has been built in 1995 for providing support irrigation. In 1996, 12 acres of land was irrigated from this check dam.

The depth of soil is 6"- 9" which is considered shallow. The approach of AKRSP(I) was to treat the village by SWC from top to bottom. However, this could not be strictly followed and completed due to many practical difficulties.

As per organization's norms, farmers are asked to contribute about 50 percent of the total cost of treatment in terms of cash, kind or labour in order to get their participation and ownership. The process of convincing farmers through dialogue, demonstrations and exposure visits takes time. If a farmer takes initiative and comes forward to treat his/her land the organization goes ahead, even if his/her field is not falling in the watershed.

Farmers do not have enough money to treat all their fields at one time and therefore they often treat them in parts over a two-three Year period. In this process a one-time top to bottom treatment of watershed cannot be adopted. Moreover, farmers do not have their cultivated land in one piece and it is often fragmented. On an average a farmer has to travel 2-5 kms to supervise all of her/his fields.

FINDINGS OF THE STUDY

After treatment with SWC work, farmers have shifted to cotton crop from (millet) jowar. While Jowar matures in 3-4 months, cotton takes six months to mature and also requires water for longer duration. After the monsoon two-three support irrigations are required for cotton. Shifting from Jowar to cotton is an indication of availability of water for a longer period. Though a very small area has been brought under wheat and gram in rabi (winter) season in 1995 and 1996, it indicates that some water is even available in winter. During fieldwork it was observed that after treatment farmers had started cultivating cotton, wheat and gram in the beds of many nallas (gullies). Vegetables were also grown in small areas.

This is another indication of improvement of both water retention capacity and quality of soil, as vegetables need more water and better soil than other crops. Favourable conditions for growing vegetables are therefore created by SWC treatment.

Change in Cropping Pattern

Table 4:Area in acres under different crops: treated & untreated land from 1994-96

Crops	1994 (Rainfall 2000mm)		1995 (Rainfall 964mm)		1996 (Rainfall 1300mm)	
	Treated Land	Untreated Land	Treated Land	Untreated Land	Treated Land	Untreated Land
Paddy	52.6 (31.9)	33(34)	53.9(30.3)	33(40)	59.5(31.3)	33(35.9)
Pigeon Pea	51.8(31.2)	28(29)	51.6(29.1)	28(34)	58.1(30.6)	30(32.6)
Groundnut	14.3(8.7)	8.1(9)	15.7(8.8)	5(6.0)	13.9(7.3)	7(7.6)
Jowar(Sorghum)	27.9(16.9)	18.6(19)	24(13.5)	12(14.5)	15.0(7.9)	15(16.3)
Cotton	8.6(5.2)	3.9(4)	16(9.0)	0.5(0.7)	28.9(15.2)	2.0(2.2)
Urad (black beans)	10.6(6.4)	4.9(5)	13.7(7.7)	4.0(4.8)	14.6(7.7)	5.0(5.4)
Wheat	-	-	1.2(0.7)	-	2.8(1.5)	-
Gram	-	-	1.2(0.7)	-	1.8(0.9)	-
Vegetables	-	-	0.3(0.2)	-	1.3(0.7)	-
Total (in acres)	**165**	**96.5(100)**	**177.6**	**82.5(100)**	**195.9(100)**	**92.0(100)**

Source: Field work 1997

Note: Numbers given in brackets are percentages. Since mixed cropping pattern such as: Cotton & Paddy (one row of cotton and three rows of Paddy, and one row of Jowar and two rows of Paddy, Jowar & Cotton) is being carried out, it is difficult to calculate the area under each crop. The figures given in the above table are only approximate.

It is important to note that in 1995 and 1996 although rainfall was much lower than in 1994, crops like cotton, wheat and vegetables which require more water were grown on treated areas. Yields in untreated fields under cotton fluctuated according to the rainfall.

Change in yield rate

As indicated in table 5, in the treated area, in spite of low rainfall in 1995, compared to 1994, yield rates of all crops were similar in both the years. Moreover also in 1996, rainfall was lower than 1994 but except for cotton, per acre yield of all crops were more. The decrease in the yield rate of cotton in 1996 was because it was grown for the first time on those fields. Before treatment, when these fields were under jowar crop, the fields were less fertile with a thin layer of soil. Farmers also did not have much experience in handling cotton. It takes time for farmers to understand the details of growing cotton crop, and also for the soil deposits to build up. Though the yield of cotton was low on the treated fields, it still provided a higher income than the jowar crop, which farmers were growing before treatment. The table indicates that in the initial year of treatment there is not much difference in yields of treated and untreated fields. However, as soil builds up in subsequent years, the yields of treated lands improve significantly compared to untreated lands. Apart from the overall increase in yield, it is also seen that on treated lands, even when the rainfall varies considerably, the yield is maintained, while in untreated land the yield vary considerably accordingly to rainfall patterns.

Table 5: Yield per acre in quintals on treated & untreated land on sample farmer's fields

Crops	1994 (Rainfall 2000mm)		1995 (Rainfall 964mm)		1996 (Rainfall 1300mm)	
	Treated Land	Untreated Land	Treated Land	Untreated Land	Treated Land	Untreated Land
Paddy	2.4	2.4	2.3	1.9	2.8	2.0
Pigeon Pea	1.3	1.3	1.6	1.0	1.6	1.2
Groundnut	2.2	2.2	2.5	1.8	2.9	2.0
Jowar	1.6	1.6	2.0	1.1	4.2	1.3
Cotton	2.5	2.5	2.07	1.9	2.3	2.14
Urad	0.8	0.8	0.4	0.4	0.8	0.6
Gram	-	-	2.0	-	2.5	-
Wheat	-	-	2.5	-	2.5	-
Vegetables	-	-	1.3	-	1.5	-

Source: Field work 1997

In short, we can say that gross yields increase after treatment and that yields are maintained even when rainfall fluctuates.

Increase in total crop production on sample farmers' fields

Total crop production has increased in two ways: first due to the improvement of soil quality and second due to availability of more area for cultivation by reclamation of gullies. In many fields due to continuous erosion, gullies had become quite wide, and were not suitable for cultivation. Due to gully plugging a thick layer (9" – 18") of soil was deposited in these which made them suitable for cultivation. Indeed they became better than other lands. Farmers use reclaimed gullies for growing high value crops like cotton, gram, wheat and paddy. There is another value addition to the total production through increase in good quality of fodder and fuel from crop residue. When agriculture production increases it leads to more availability of fodder, which results in improved health of animals which may in turn increase milk yields.

Table 6:
Total production in quintals on treated land(109acres)of sample farmers from 94-96

Crops	Pre Treatment (1994)	Value (in Rs. '000)	Post treatment		Value (in Rs '000)
			1995	1996	
Paddy	125.6	56.5	126.75	169.8	76.4
Pigeon Pea	72.3	79.5	83.0	91.3	100.4
Groundnut	32.27	48.4	39.4	40.0	60.0
Jowar	44.4	19.9	48.7	63.3	28.4
Cotton	22.08	26.5	33.18	61.9	74.4
Urad	8.1	8.5	6.3	12.6	12.6
Gram	-	0.3	2.4	4.5	4.9
Wheat	-		3.00	7.00	4.2
Vegetables	-		1.00	4.20	1.8

Source: Field work 1997

Table 7 : Total production of crop residue (fodder and fuel) in quintals on treated land (109 acres) of sample farmers.

Types of Crops	Quantity of fodder (in quintals)		
	Pretreatment 1994	Post treatment 1995	Post treatment 1996
Paddy	62	63	85
Pigeon pea	36	41	34
Groundnut	13	15	16
Jowar	67	73	95
Urad	8	6	13
Wheat	-	2	4
Vegetables	-	1	2
Cotton & Pigeon pea sticks (as fuel)	22	34	62
Total	**186**	**201**	**249**

Source: field work 1997

Table 6 indicates that production of all crops has gone up over a period of two years after SWC treatment. Here it is important to note that AKRSP (I) has promoted agriculture extension and marketing activities in this area. This support helps farmers to improve their agriculture practices. Improved variety of cotton was introduced about seven years back in the area, which increased the total production of cotton. AKRSP encouraged its village institutions to get involved in cooperative marketing of cotton and other agriculture products. Overall, we can say that value of crops grown increases by least 50% after treatment.

Expenditure on inputs

Table 8: Per acre expenditure(in Rs.) from 1994 to 1996

Year	On treated land	On untreated land
1994	548	490
1995	578	507
1996	577	520

Source: field work 1997

In 1995 farmers lost their seedlings due to a hiatus in the rains, and had to purchase more seeds and sow again. If we discount for that, then we can see a gradual increase in expenditure over the 3 years in line with inflation. However there is about 10% more expenditure on input for treated land as against untreated lands.

Table 9: use of chemical fertilizers from 1994-1996 on treated land

Year	Urea (in Kg)	DAP (in Kg)	Total (in Kg)	Per acre (in Kg)
1994	460	360	820	7.5
1995	560	380	940	8.6
1996	690	440	1130	10.3

Source : field work 1997

Table 9 shows that there is a trend towards increasing use of chemical fertilizers which indicates that availability of water has increased, as chemical fertilizers generally need more water. However at the same time, AKRSP explains the benefits of using organic manure and the disadvantages of use of chemical fertilizers in the long term through demonstration, training programmes, and exposure visits under its agriculture extension programmes.

SOCIO ECONOMIC BENEFITS

Reduction in migration

Even prior to AKRSP (I)'s intervention, traditionally farmers were using contour bunds for saving their lands from erosion. They used to work on their fields during the off agricultural seasons. Now due to land fragmentation they own very small pieces of land, and in addition the land is deteriorating due to various reasons, and therefore, it does not provide enough income to support their families. To earn extra income they have to migrate when they are not cultivating their lands. Due to the migration they are now not able to take proper care of or improve their lands. AKRSP contributes 40-50% for SWC work in terms of payment for wages. Since farmers earn partial wages by working on their own field, they are prepared to migrate for a lesser period, and stay back to treat their land. Once their land is treated, they start getting sustainable income from their field. There are incidences where farmers used to migrate for 150-180 day in a year. They used to stay in the village only during the Kharif season and during festivals. Now after treating their land their agriculture income has increased and their number of days of migration have reduced to 60-90 days. In many cases, except old people, the whole family used to migrate. Now the number of migrating family members have reduced as well.

Benefits to women

Benefits of the programme for women cannot be seen in isolation. Usually the treatment is done by both men and women as one family unit, and AKRSP's contribution in terms of labour payment goes to the family as a lump sum. Often this is collected by men, and an area which needs to be to looked into is whether women are able to exercise any right on this income. In some cases homestead fields are treated, where women grow vegetables and fruit or other useful trees for their household purposes. Through SWC treatment, (mainly contour bunds) these fields are improved and women are able to produce surplus vegetables, which they can market. AKRSP provides these women with improved varieties of vegetable seeds and fruit tree saplings. Women have control over these homestead or wada lands, so we may assume that they also control the produce from the same.

Micro-watershed Development Programme goes into the Wadas !

The treatment of the Wada lands taken up in 1996 under the micro-watershed programme has started to yield encouraging results this year. From the report obtained from Khabji village, the women claim that the wada land which earlier had a low productivity in the yield of vegetables, has now become a means to ameliorate their miseries. The vegetable yield data of the six wada lands was collected before and after the treatment, and its analysis shows a significant increase in productivity. The yield of bhindi (ladies finger) went up from 28kgs to 145 kgs chauri (beans) from 27 kgs to 128 kgs and chilly from 7 kgs to 51 kgs. Additionally, the women were able to harvest 61 kgs of wal papri(common bean) and 28 kgs of guar sing (cluster bean), which was not grown earlier. In a significant change, the women who earlier were dependent on the market purchase of vegetables, now grow all their own vegetables, and have also been able to augment the family income by selling their surplus produce.

Source: Half Yearly Progress Report (Jan-June) 1997 of Aga Khan Rural Support Programme (India).

Economic Cost Benefit Analysis

In an undulating hilly area, soil and water conservation treatment should be a combination of contour bunds, gully plugs and land leveling. Thus per acre cost of treatment should be calculated on the basis of a combination of activities depending on ratio of all treatment. Per acre cost of each of these activities is given below.

In case of Khabji village, due to the heavy soil erosion over a period of time fields have become almost barren, and therefore, it will take longer to regain the fertility of land, so the payback period is 3-4 years (annexure 1). In other areas where soil is better the pay back period is between two to three years (Vikas Nath, 1997). In this discussion, another angle of benefit that should be indicated is if the treatment is not done, soil erosion will continue and in turn reduce production over a period of time. In that case the gap between net income received from the treated land and from the untreated land will increase. During informal discussions with the local people it appears that in general agriculture yields have decreased over the past 10-15 years. If this process continues, the land might eventually become totally barren. From a social point of view also these measures are beneficial. They help in reducing migration, and increase the availability of food, fodder and fuel.

Except in extraordinary cases like floods, the per year maintenance cost of one acre contour bunds and gully plugs is 2-4% of the total construction cost. In the present study Rs. 60 per acre maintenance cost was taken into consideration. If the bund is maintained regularly, the minimum expected life of it is 25 years.

Soil deposition

Both contour bunds and gully plugs show significant deposition of soil. Out of 39 farmers 32 gave a response about the quality of soil deposition due to contour bunds. Of these 32 farmers, 20 could give further information about the quality of siltation due to the gully plugs. Table no. 10 gives a clear picture of farmers observations.

Table 10:
Silt deposition after SWC treatment in Khabji village as per farmers' observation.

Contour Bunds		Gully plugs	
No. of Respondents	Silt deposition reported	No. of respondents	Silt deposition reported
12	6"	6	9"
12	9"	6	12"
8	12"	8	18"

Source: field work 1997

On the basis of farmers perceptions and information given by technical experts of AKRSP, the average rate of silt depositions on different slopes have been calculated. One gully plug collects 7.06 tons of soil and through contour bunding on one acre of land, 24.3 tons of soil is deposited and saved. Thus, it can be said that in Khabji village through contour bunds and gully plugs 4,341 tons of soil is conserved. Table 12 shows deposition of soil as per slope of the area. (Calculation of silt deposition through gully plugs and contour bunds are given in the Annexure 2).

Table 11: Soil Deposition due to gully plugs

Slope	Near the Gully plugs	Average length in feet	Width of gully plug (meter)	Average depth of soil deposition (units)	Width of soil deposited area	Volume of siltation (in cubic feet)	Weight of silted soil (in tons)
2%	4”	16.6	40	0.17	65.5	174	7.9
6%	9”	12.5	25	0.38	41	189.6	8.6
12%	15”	10.4	8	0.63	16	103.6	4.7

Source : field work 1997 and SWC specialists of AKRSP (I)

Note : Average deposition of soil due to gully plug in Khabji village is estimated to be 7.06 tons per year.

Table 12: Deposition of soil due to contour bunds

Slope	Siltation width	Depth of soil	Siltation length (in feet)	Silt deposition tons (per acre)
2%	8.35	2’	177	5 tons
6%	5.0	4”	531	18 tons
9%	5.5	6”	796	50 tons

Source: field work 1997 and SWC specialist of AKRSP (I)

Note : Average soil deposition in one acre in Khabji village is 24.3 tones.

Table 13: Total Deposition of Soil in One Year

Measures of treatment	Area in acre	Per unit deposition of soil	Total soil deposition in tons.
Contour bunds	136.5	24.3	3317
Gully Plugs	45.0 acres (145 number)	7.06	1024
Total	181.5 acres	-	4341 tons.

The above table gives the impression that contour bunds are more effective in comparison to gully plugs. However, gully plugs have their own importance in soil and water conservation. While through contour bunds 6”-9” soil is deposited, through gully plugs 12”-18” soil can be deposited. Even though gully plugs cover less area, they reduce the water flow very effectively which can save other structures from damage. Contour bunds and gully plugs together can work effectively in the field of soil and water conservation.

Gully plugs cover a smaller area but they trap a higher concentration of nutrients than contour bunds. Therefore, in treated gullies high value crops like cotton, paddy can be grown. Moreover, agriculture productivity in treated gullies is quite high. There of the sample farmers, namely Surendra Morji (Survey No. 52) Champak Kolidas (Survey No. 337) Rupa Gimka (Survey No. 175) reported that earlier they were not cultivating in the beds of nallas located in above fields, but after treatment they started taking cotton, paddy and Gram crops from silted area of nallas (gullies).

Agricultural extension can also contribute a lot in the area of soil and water conservation. After treatment farmers should be given information about new cropping patterns and crop rotation which can help in increasing their income, and at the same time do no harm to the soil. Some crops which help in enriching the soil should be introduced. Farmers should be encouraged to reduce the use of chemical fertilizers and pesticides and use natural inputs like organic manure, integrated pest management and improved local varieties of seed. Farmers should also be given information about availability of these inputs. During the study many farmers informed us that they want to use natural farming methods but their demand for organic manure is not met by the local market, and therefore they have to depend on chemical fertilizers.

Biogas is another area where AKRSP is working on a large scale. This programme can be linked with soil and water conservation through agricultural extension. Farmers are given training for composition of biogas slurry and other biotic waste for preparation of organic manure, which has a high value for enrichment of soil and in turn increases the water retention capacity.

CONCLUSION

Contour bunds and gully plugs are important and low cost treatments for soil and water conservation. With little economic assistance, even very poor farmers can treat their fields. If proper maintenance is done, they are very effective for improvement of land fertility. Better results can be achieved through top to bottom treatment. This process can be adopted only if more time is spent with those farmers whose fields are located in the same watershed. They have to be convinced about the benefits of SWC work and ultimately watershed development. Village institutions can be a common platform to discuss these aspects where people are given an equal chance to participate in developmental issues.

As mentioned in the beginning, the SWC programme is a part of the watershed development approach. SWC programme cannot achieve the expected results independently. The programme has to be linked with other programmes including forestry, agriculture extension, animal husbandry and biogas. Linkages with other programmes can help in achieving multiple results, and also lead villages towards socio-economic and environmental sustainability.

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Annexure 1

Methodology for calculating economic cost-benefit analysis.

Average per day per person wages paid by AKRSP	35.00
Farmers contribution in terms of labour in 40% of his/her wages	14.00
Wages received by farmers of SWC work	21.00
Average per day wages paid in Village	25.00
Actual contribution given by a farmer	25.0-21.0=4
No. of persondays work for one acre of contour bunding	49 persondays
Therefore contribution of a farmer for one acre contour bunding	4x49=196
Amount paid by AKRSP	21x49=1029
Over Head cost	50.00
Total expenditure for one acre contour bunding is	1275
Expenditure on one acre gully plug (calculation is done as per above method)	2075
For treating one acre of land the ratio between contour bund and gully plug	2:1
Therefore one acre treatment through contour bund and gully plug	1535
If a farmer lends money in the village, she/he can get 24 percent per year interest. If AKRSP keeps money in savings account it will get 6 percent interest per annum.	
For one acre treatment of SWC, farmer's contribution	Rs. 614
For one acre treatment of SWC AKRSP's contribution is	Rs. 912

Discount rate for farmer's contribution is 24% and for AKRSP's contribution is 6% weighted average discount rate is 13%.

Annexure 2

Calculation for silt deposition through gully plugs and contour bunds in one year

GULLY PLUGS

Volume of siltation :

Depth of siltation = 0.75 feet

Average depth of silted area $= \frac{0.75 + 0}{2} = 0.37$ feet

Slope = 6%

Average length of silted area $= \frac{100 \times \text{depth siltation}}{\text{slope}}$

i.e. $\frac{100 \times 0.75}{6} = 12.5$ feet

Width of gully plug = 82 feet

Average width of silted area $= \frac{82+2}{2} = 41$

Volume of silted area = average silted area x average width of silted area average x depth of silted area

= 12.5 x 41 x 0.37 = 1896 cubic feet (one cubic feet = 45.45 kg soil). Therefore 1896 cubic feet = 8618 kg (8.6 tons) soil deposition.

CONTOUR BUNDS

One acre = 43560 feet

Depth of siltation = 4" (0.3 feet)

Contour interval = 4.92 feet (1.5 meter)

Slope = 6%

Width of area of influence of Contour bund covering one acre of area with 6% Slope $= \frac{100 \times \text{contour interval}}{\text{slope}}$

$= \frac{100 \times 4.92}{6} = 81.9$ feet

Length of area of influence Contour bund, covering one acre of area

$= \frac{43560}{81.9} = 531$ feet

Width of silted area $= \frac{100 \times \text{depth}}{\text{slope}}$

$= \frac{100 \times 0.3}{6} = 5$ feet

Volume of siltation $= \frac{\text{Length of Contour bund x width of silted area x depth + 0}}{2}$

$= \frac{531 \times 5 \times 0.3 + 0}{2} = 398$ cubic feet

One cubic feet soil = 45.45 kg (100 pounds)

398 cubic feet soil = 180.90 kg = 18 tons.

EFFECTIVENESS OF CONTOUR BUNDS AND GULLY PLUGS AS TOOLS FORWATERSHED TREATMENT