WATER RESOURCE DEPARTMENT

GOVERENMENT OF MADHYA PRADESH

CATCHMENT AREA TREATMENT PLAN


PARKUL MEDIUM IRRIGATION PROJECT
At
Village: Bakswaha, Tehsil/District: Sagar (M.P.)

DAS INDIA

Prepared by

ENV Developmental Assistance Systems (India) Pvt. Ltd.

D-2247, Indira Nagar, Lucknow

QCI Serial No. 46

March, 2018

CONTENTS

LIST OF TABLES

Page No.

LIST OF FIGURES

LIST OF PHOTOS

CATCHMENT AREA TREATMENT

1.1 NEED FOR CATCHMENT AREA TREATMENT

It is a well-established fact that reservoirs formed by dams and barrages on rivers are subjected to sedimentation. The process of sedimentation embodies the sequential processes of erosion, entrainment, transportation, deposition and compaction of sediment. The study of erosion and sediment yield from a perticular catchment is important as the deposition of sediment in reservoir reduces its capacity, and thus affecting the water availability for the designated use as some capacity in the form of dead storage is to be kept free. The eroded sediment from catchment when deposited on streambeds and banks causes braiding of river reach. The removal of top fertile soil from catchment adversely affects the agricultural production. Another important factor that adds to the sediment load is due to grazing of animals. A large number of cattle, sheep, and goats graze the pastures which lead to loosening of soil that aggravates erosion. Thus, a well-designed Catchment Area Treatment (CAT) Plan is essential to ameliorate the above-mentioned adverse process of soil erosion.

Soil erosion may be defined as the detachment and transportation of soil. Water is the major agent responsible for this erosion. In many locations, winds, glaciers, etc. also cause soil erosion. In a hilly catchment area, as in the present case erosion due to water is a common phenomenon and the same has been studied as a part of the Catchment Area Treatment (CAT) Plan. The Catchment Area Treatment (CAT) plan highlights the management techniques to control erosion in the catchment area. Life span of a reservoir in case of a seasonal storage dams is greatly reduced due to erosion in the catchment area.

The catchment area treatment involves

- Understanding of the erosion characteristics of the terrain and
- Suggesting remedial measures to reduce the erosion rate.

In the present study `Silt Yield Index' (SYI), method has been used. In this method, the terrain is subdivided into various watersheds and the erodibility is determined on relative basis. SYI provides a comparative erodibility criteria of catchment (low, moderate, high, etc.) and do not provide the absolute silt yield. SYI method is widely used mainly because of the fact that it is easy to use and has lesser data requirement. Moreover, it can be applied to larger areas like sub-watersheds, etc.

It is a well-established fact that, all the reservoirs on rivers are subject to sedimentation. The erosion intensity in the catchment area.

sedimentation carried out by the river is mostly on account of erosion taking place in its catchments. To avoid excessive sedimentation, erosion in the catchments area treatment to vulnerable reaches.

The 71.88Sqkm catchment area of reservoir proposed for construction in Parkul Medium Irrigation Project consists of 15 sub-watersheds. The pre-requisite for a watershed management is the collection of multipronged data like geology, geomorphology, topography, soil, land use/ land cover, climate, hydrology, drainage pattern, etc. The multi-pronged data generated from various published sources and actual data collected from these watersheds on the above-mentioned parameters are the basis of the Action Plan for Catchment Area Treatment.

CAT plans for the Parkul catchment area of the proposed project has been prepared for areas with moderately soil erosion intensity, which targets toward overall improvement in the environmental conditions of the region. All the activities are aimed at treating the degraded and potential areas with severe soil erosion. The plan provides benefits due to biological and engineering measures and its utility in maintaining the ecosystem health. The plan with objectives addresses issues such as prevention of gully erosion, enhancing the forest cover for increasing soil binding capacity; and arresting total sediment flow in the reservoir and flowing waters. Although the proposed project is not expected to have any significant negative impacts on the environment, measures to minimize the entry of silt in to its reservoir and enhance its life as well as for conservation of the ecosystem will be taken while implementing the treatment plan.

1.1 Objectives

The main aim of the CAT is to rejuvenate various potential and degraded ecosystems in the catchment area. The action plan has been prepared for this purpose with the following objectives;

1. To facilitate the hydrological functioning of the catchment and to augment the quality of water of the river and its tributaries.
2. Conservation of soil cover and to arrest the soil erosion, floods and siltation of the river and its tributaries and consequent reduction of siltation in the reservoir of the project.
3. Demarcation of the priority of sub-watersheds of treatment on the basis of soil

4. Rehabilitation of degraded forest through afforestation.
5. Mitigation of landslide landslip and rock falls.
6. Soil conservation through biological and engineering measures to reduce sediment load in river and tributaries, thus improving the quality of water.
7. Ecosystem conservation resulting from increased vegetative cover and water retaining properties of soil.

1.2 Catchment Scenario and Drainage

The project envisages construction of storage reservoir across river Parkul to irrigate the area coming under Sagar tehsil of Sagar district. The Parkul project is located on the River Parkul, which is a sub tributary of Bewas River and it meets Ken River via Sonar in Ken basin and finally falls in river Ganga. The Parkul River originates near Pipraria village of Sagar District, Madhya Pradesh. The total length of the river lies in the State of Madhya Pradesh. The basin of Parkul (sub-basin of Ken basin) covers the areas of Sagar District of Madhya Pradesh. The area of the free-draining catchment of the Parkul irrigation project is about 71.88 sq km.

1.3 Geo-morphological Features of Parkul Catchment

1.3.1 Delineation of Parkul Catchment and its Sub-watersheds

In the present study, the watershed and the sub-watersheds are delineated utilizing Arc SWAT (Soil and Water Easement Tool). The Arc SWAT is a tool of GIS. Arc SWAT is graphical interface of SWAT, which delineates study territory into sub-basins and hydrologic reaction units utilizing the DEM's, land use or land cover, soil maps, slope maps. SWAT can be utilized to simulate a solitary watershed or an arrangement of numerous hydrologically associated watersheds. The Arc SWAT requires an information set that is Digital Elevation Model (DEM), which is made in Polyconic projection with determination and height in meter, having a horizontal grid basin of 20 arc seconds (around 1 km) The DEM is extracted from contours digitized from 1;50,000 scale toposheet and imported to the Arc GIS programming for delineation into sub-basins using watershed delineation tool. The watershed delineation carries out advance GIS capacity to help sectioning watershed into a several hydrologically associated sub-watersheds. The delineated catchment and its sub-watersheds

are presented in figure 1.1 Further, the sub-watersheds are represented by codes ranging from1 to 15. The area of each sub-watershed is given in Table 1.1

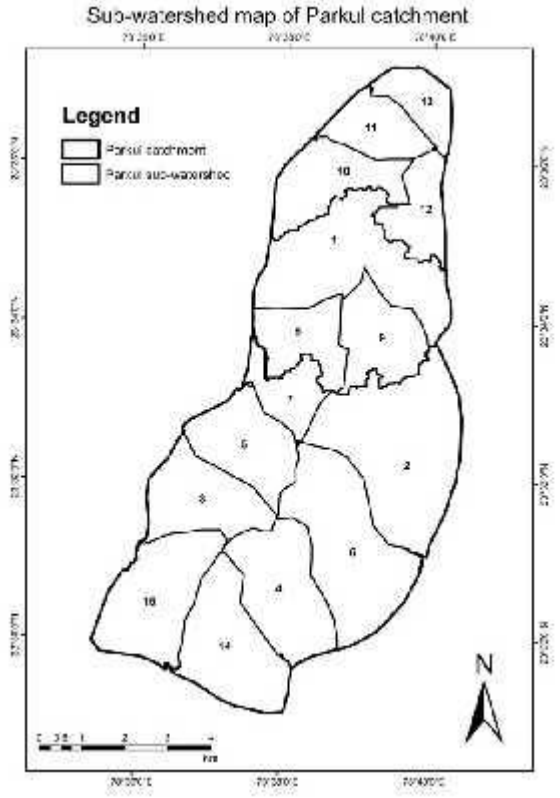

Figure 1.1: Catchment and sub-watersheds of proposed reservoir in Parkul irrigation project

Table 1.1: Characteristics of different sub-watersheds

S.No.	Sub-watershed Code	Area
1	1	8.364
2	2	8.918
3	3	4.28
4	4	5.5
5	5	4.45
6	6	8.27
7	7	1.88
8	8	3.23
9	9	3.707

10	10	3.94
11	11	2.4
12	12	2.65
13	13	1.88
14	14	5.7
15	15	6.68
Total		71.88

1.3.2 Topography

Catchment site possess mainly hilly terrain. At the project site, the stream flows in a valley having mean elevation of 549 m. The elevation of the study area varies from El. 532 m at barrage site to El. 697 m in the free draining catchment area. The topography of the free draining catchment is shown in Figure 1.2.

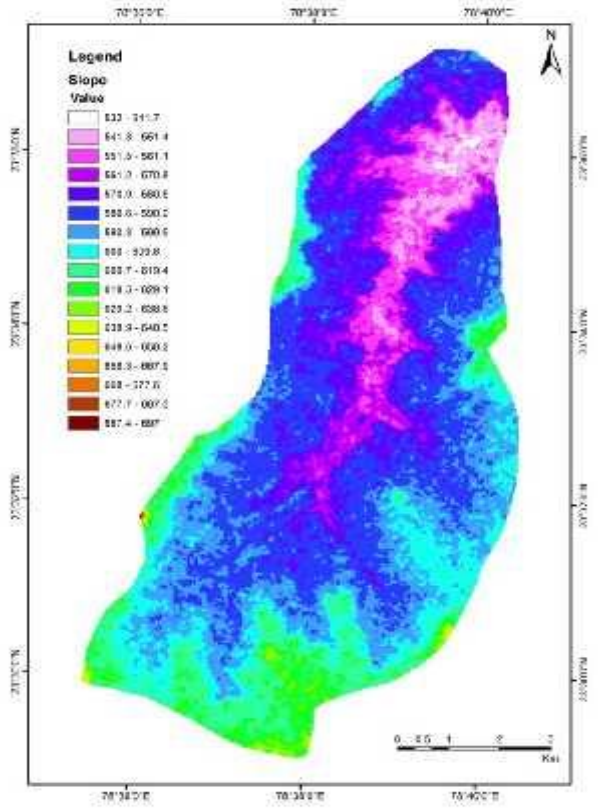

Figure 1.2: Slope map of the catchment

1.3.3 Soil Class and Soil Depth

Soil erosion in the Parkul catchment region is a major problem, which results in loss of soil fertility and increased sediment load in the rivers. Apparently, increase in sediment load has direct influences on the conditions of irrigation projects. Therefore, it is required to ensure proper maintenance and conservation of soil functions and its health.

The texture of the soil in the catchment is mostly Silty Loam. In the southern and central parts to the north of catchment area the soil is black, formed by decaying trap, and in the east it is reddish brown alluvium. The soil is quite fertile in terms of agricultural productivity. Soil class and soil depth types in the catchment were obtained from the Soil & Land Use Survey of India, Ministry of Agriculture of, GOI. This source has identified three soil series in the catchment area namely –

- clayey skeletal,
- fine and
- fine loamy to fine

The soil unit has deep soil at the lower elevation region, i.e mainly in the drainage network region. On moderately steepy sloping area near the ridges, the soil is very shallow to shallow. In-between region of the ridges and drainage is generally found shallow to moderately deep soil is generally found. (Figures 1.3)

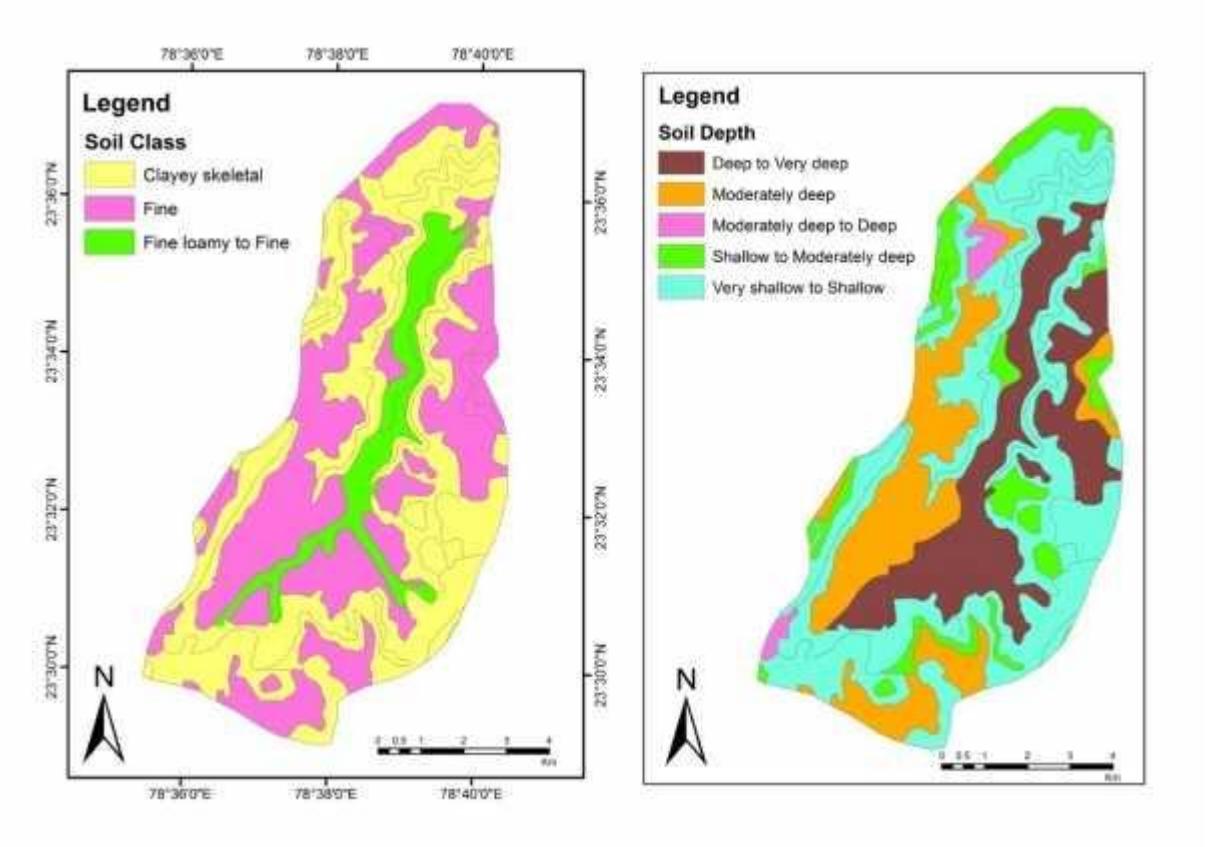

Figure 1.3: Soil Class and Soil Depth Map of Parkul Catchment Area

1.3.4 Land Use and Land Cover

A land use and land cover (LULC) thematic map depicts the land composition, using land cover classification technique which is one of the most common applications of remote sensing. Parkul catchment area depicts a LULC, predominantly with crop land and fallow land followed by scrubland, wasteland (which is mainly barren rocks) and water bodies. Landuse Land cover map on 1:50,000 scale of catchment area is derived using Landsat 8 geocoded data acquired on 20 Oct 2016. Digital image processing of the satellite data and the analysis of interpreted maps were using ERDAS Imagine 2014.

The distribution of the different LULC classes together with the irmapped areas is presented in Table **1.2**

Table **1.2**: LU Classes and their area (in km^2 and %) in the Parkul catchment area

S.No.	LULC Category	km^2	% area
1	Crop land	22.126	32.971
2	Water bodies	0.501	0.746
3	Fallow land	29.279	43.629

4	Scrubland	13.079	19.489
5	Wasteland	2.125	3.166

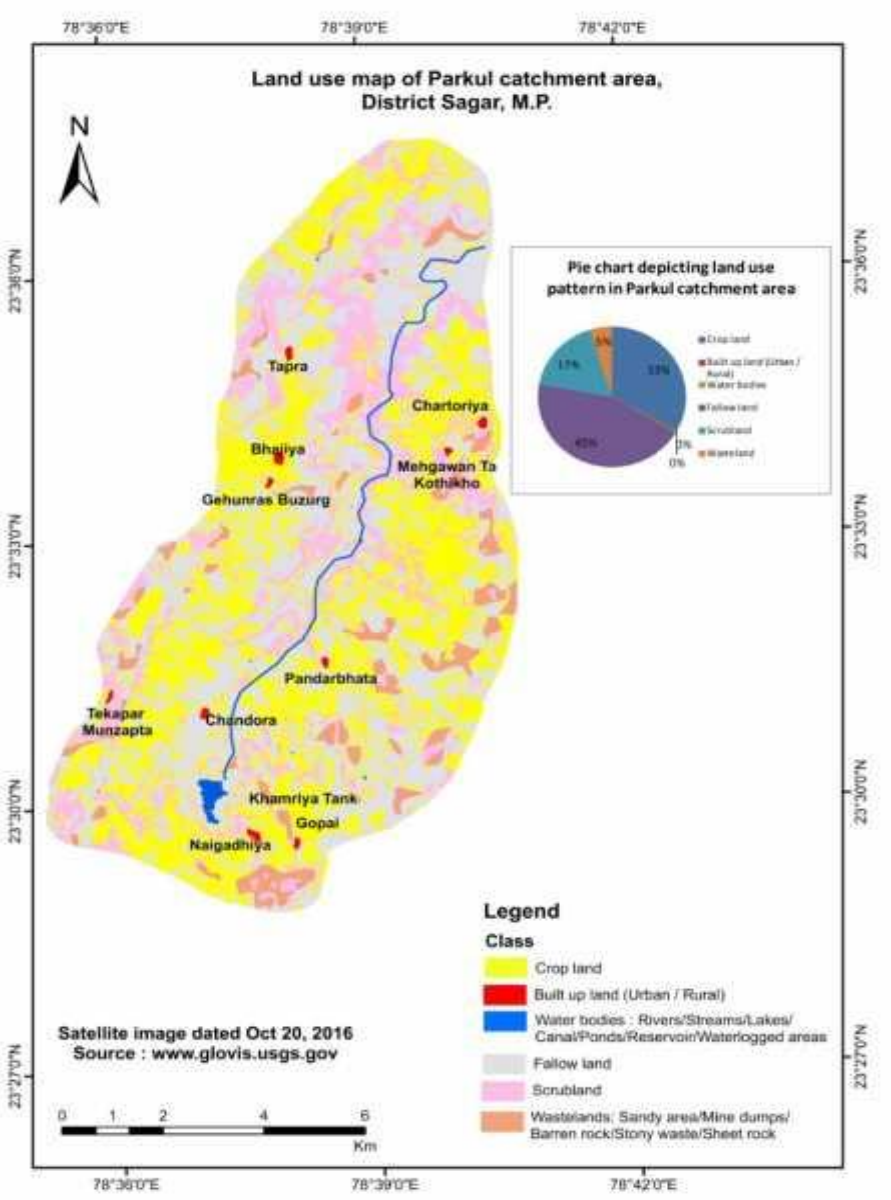

Fig 1.4: Land use land cover map of Parkul catchment area

1.3.5 Methodology Used For the Study

Superimposing topography, slope, soil and land use data/maps, a tentative estimation of erosion prone areas in the catchment have been made. The vulnerable and problematic areas were identified in different physiographic zones. These data sets were used for preparation of the thematic maps, calculation of sediment yield index and Erosion Intensity Units.

1.3.6 Soil Loss Using Silt Yield Index (SYI) Method

The Silt Yield Index Model (SYI), considering sedimentation as product of erosivity, erodibility and aerial extent was conceptualized in the All India Soil and Land Use Survey (AIS & LUS) as early as 1969 and has been in operational use since then to meet the requirements of prioritization of smaller hydrologic units within river valley project catchment areas. Methodology for the calculation of sediment yield index developed by All India Soil & Land Use Survey (Department of Agriculture, Govt. of India) was followed in this study. In this method, the terrain is subdivided into various watersheds and the erodibility is determined on relative basis. SYI provides a comparative erodibility criteria of catchment (low, moderate, high, etc.) and do not provide the absolute silt yield. SYI method is widely used mainly because of the fact that it is easy to use and has lesser data requirement.

(i) Erosion Intensity and Delivery Ratio

Determination of erosion intensity unit is primarily based upon the integrated information on soil characters, physiography, slope, land-use/land-cover, lithology and structure. This is achieved through super-imposition of different thematic map overlays. Based upon the field data collected during the field survey and published data, weightage value and delivery ratio were assigned to each erosion intensity unit. The composite map for delineating different erosion intensity units was prepared through superimposition of the maps showing soil types, slope and land-use/landcover.

This thematic mapping of erosion intensity for entire catchment was done using the overlay and union techniques. Based on ground truth verification conducted during fieldwork and published data, weightage and delivery ratio was assigned to each erosion intensity units. The composite erosion intensity map was then superimposed on the drainage map with sub-watershed boundaries to evolve CEIU (Composite erosion intensity unit) for individual sub-watershed. Each element of erosion intensity unit is assigned a weightage value. The cumulative weightage values of the erosion intensity units represent approximately the relative comparative erosion intensity within the watersheds. A basic factor of K=10 was used in determining the cumulative weightage values. The value of 10 indicated an equilibrium condition between erosion and deposition. Any value of K (10+X) is suggestive of erosion intensity in an ascending order whereas the value of K (10-X) is suggestive of deposition intensity in descending order.

(ii) Sediment Yield Index & Prioritization of Sub-Watersheds

The erosivity determinates are the climatic factors and soil and land attributes that have direct or reciprocal bearing on the units of the detached soil material. The relationship can be expressed as:

Soil erosivity = f (Climate, physiography, slope, soil parameters land use/land cover, soil management)

The Silt Yield Index (SYI) is defined as the Yield per unit area and SYI value for hydrologic unit is obtained by taking the weightage arithmetic mean of the products of the weightage value and delivery ratio over the entire area of the hydrologic unit by using suitable empirical equation. Prioritization of smaller hydrological units within the vast catchments is based on the SYI of the smaller units. The boundary values of range of SYI values for different priority categories are arrived at by studying the frequency distribution of SYI values and locating the suitable breaking point. The watershed/ sub-watersheds are subsequently rated into various categories corresponding to their respective SYI values. The application of SYI model for prioritization of sub-watersheds in the catchment areas involves the evaluation of:

- Climatic factors comprising total precipitation, its frequency and intensity
- Geomorphic factors comprising land forms, physiography, slope and drainage characteristics
- Surface cover factors governing the flow hydraulics
- Management factors.

The various steps involved in the application of model are:

- Preparation of a framework of sub-watershed through systematic delineation
- Rapid reconnaissance surveys on 1:50,000 scale leading to the generation of a map indicating erosion-intensity mapping units.
- Assignment of weightage values to various mapping units based on relative silt yield potential.
- Computing Silt Yield Index for individual watersheds/sub watersheds
- Grading of watersheds/sub-watersheds into very high, high medium, low and very low priority categories.

The area of each of the mapping units is computed and silt yield indices of individual sub-watersheds are calculated using the following equations:

$$\textbf{Sediment Yield Index (SYI)} = \sum \frac{(A_i \times W_i \times D_i)}{A_w} \times 100$$

Where,

i = 1 to n

Ai = Area of i_{th} mapping unit

Wi = Weightage assigned to i unit

Di = Delivery ratio assigned to i unit

Aw = Total area of the watershed

The model consists of two aspects, viz., delineation and codification of the catchment area into micro watershed level based on drainage map generated from 1:50000 scale Survey of India topographic map and generation of Erosion Intensity Map based on rapid traversing of the catchment.

For preparing CAT Plan of the Parkul catchment, the information of Erosion Intensity Map Area was obtained from All India Soil & Land Use Survey (Department of Agriculture, Govt. of India) (Refernce: Letter vide no. – T.8-4/2016-17/SLUSI/RC/219 dated 31 July 2017, attached as annexure 1). The area under different EIMU of Parkul catchment is presented in Table 1.3 and EIMU map is presented in Figure 1.5.

Table **1.3**: Area under different Erosion Intensity Mapping Units (EIMU) of Parkul Catchment

S.No.	Sub-watershed Code	Area (in Sq. Km)	Weightage	Delivery Ratio
1	A02	2.69	16	**0.56**
2	B01	0.78	19	0.61
3	B02	1.56	19	0.61
4	B04	1.24	18	0.6
5	B05	2.04	20	0.63
6	B07	6.06	19	0.63
7	B08	0.92	19	0.61
8	B09	16.18	21	0.65
9	B10	0.77	19	0.62
10	B12	6.78	19	0.61

11	B14	2.69	18	0.59
12	B15	1.15	17	0.59
13	B16	1.74	17	0.58
14	B17	13.27	15	0.55
15	B18	5.80	15	0.55
16	B19	4.05	14	0.54
17	B20	4.39	20	0.63
	Total	72.10		

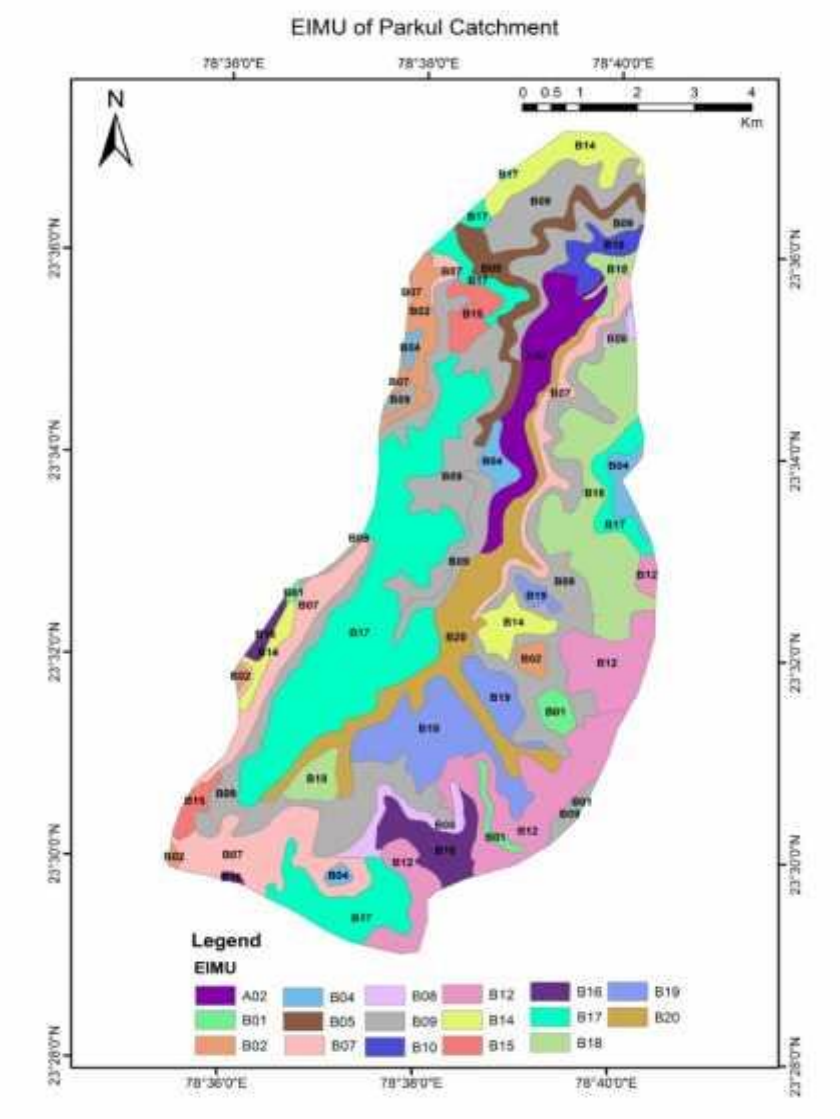

Figure 1.5: Erosion Intensity Mapping Units (EIMU) of Parkul Catchment

1.3.7 Grading of Sub-watersheds for Priority Fixation

The gradation and assignment of priority category to the micro-watersheds are based on the descending values of SYI values for deciding upon the boundaries of various priority categories namely, very high, high, medium, low and very low category, the following values ofSYI have been used as boundaries for various categories. Based on SYI various priority categories of sub-watersheds in Parkul catchment are given in Table 1.4

Table1.4: Based on SYI various priority categories of sub-watersheds in Parkul catchment

S. No.	Priority Category	SYI Values
1	Very high	1300 and above
2	High	1200 – 1299
3	Medium	1100 – 1199
4	Low	1000 – 1099
5	Very low	1000

The areas that require treatment have been delineated from the Composite Erosion Intensity Unit Map. The sum of weightages was reclassified as per the Table 1.5 to further subdivide the area as per the erosion intensity classes. The weightages for land use, slope & soil were summed to get the Erosion Intensity Classes.

Table 1.5: Legend for Erosion Intensity Unit (EIU) & Weightages

Erosion Intensity Classes	Slope Intensity	Landuse/ Landcover	Soil depth	Weightage/ DR Unit
None to slight erosion (a)	very gentle to gentle (1-5%) slope	single crop and multiple crop cultivation	deep to very deep	14/0.56
None to slight erosion to Moderate erosion (b)	gentle to moderate (3-10%) slope	single crop cultivation	moderately deep to deep	15/0.60
Moderate to severe	strong to moderately steep	single crop cultivation and	moderately deep	17/0.61

erosion (c)	(10-25%) slope	scrubland		
Severe erosion (d)	steep to very steep 25-50%	single crop cultivation, fallow land and scrubland	shallow to moderately deep	20/0.62
Very severe erosion (e)	very steep (>50%) slope	scrubland, wasteland	very shallow to shallow	21/0.63

1.3.8 Catchment Area Treatment Plan

In the Parkul catchment there are mainly four categories of land uses for which a proper treatment plan should be developed. First is the crop land as this activity can never be eliminated, because the faulty practice results in heavy loss of fertile soil. The second and most important category is fallow land because with practically no vegetal cover, the area produces huge amount of silt load. Third and fourth categories are the scrub land and wasteland, which contributes heavily to the silt load. Possibilities exist to bring this area under pastures and other plantation to meet the local demand of fuel and fodder. Considering the topographic factors, soil type, climate, land-use/land-cover in the catchment area, engineering and biological measures have been proposed to be undertake with the aim to check soil erosion, prevent/check siltation of reservoir and to maintain its storage capacity in long run. The Erosion Intensity Map of the catchment has been generated on the basis of SYI data and is presented in Tabl e 1.6 and pictorially represented in Figure 1.6.

Table **1.6**: Erosion Intensity Map of the Parkul catchment

Erosion Rate	Area (in Sq. Km)	Area (in %)
None to slight erosion	17.31	24.00
Slight erosion to Moderate erosion	5.80	8.04
Moderate erosion to Severe erosion	14.12	19.58
Severe erosion	13.30	18.44
Very severe erosion	21.57	29.91
Total Area	72.10	100

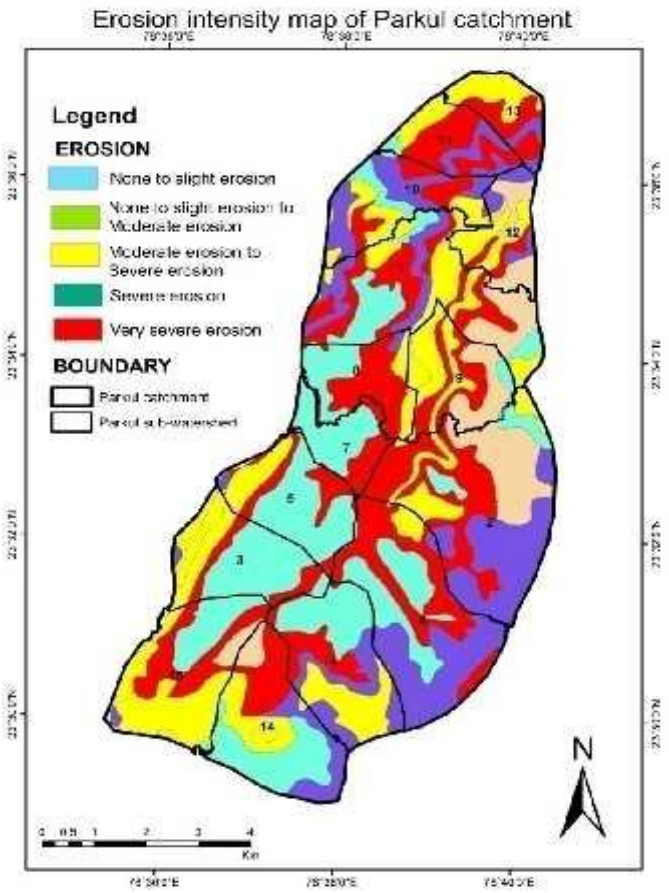

Figure 1.6: Erosion Intensity Map of Parkul Catchment Area

After exclusion of rocks and inaccessible terrain, only those areas which fall under severe erosion intensity category would be taken up for conservation treatment measures in very high priority category micro-watersheds, whereas in the rest of micro-watersheds belonging to other priority categories. The Sediment Yield Index has been calculated for each sub-watersheds and computation of SYI for each sub-watershed is presented in Table 1.7.

Table 1.7: SYI and Ranking for Sub-watersheds

Sub watershed code	Erosion intensity	Area* (Sq km))	Weightage	Area x weightage	Delivery ratio	Gross silt yield	Sediment yield index (SYI)
1	a	3.08	14	43.12	0.56	24.1472	
	b	2.48	15	37.2	0.6	22.32	
	c	0.82	17	13.94	0.61	8.5034	
	d	1.102	20	22.04	0.62	13.6648	
	e	0.882	21	18.522	0.63	11.66886	

	Total	8.364				80.30426	960.1179
2	a	1.218	14	17.052	0.56	9.54912	
	b	1.54	15	23.1	0.6	13.86	
	c	0.67	17	11.39	0.61	6.9479	
	d	2.93	20	58.6	0.62	36.332	
	e	2.56	21	53.76	0.63	33.8688	
	Total	8.918				100.5578	1127.583
3	a	1.05	14	14.7	0.56	8.232	
	b	0	15	0	0.6	0	
	c	0.16	17	2.72	0.61	1.6592	
	d	1.03	20	20.6	0.62	12.772	
	e	2.04	21	42.84	0.63	26.9892	
	Total	4.28				49.6524	1160.103
4	a	1.7	14	23.8	0.56	13.328	
	b	0	15	0	0.6	0	
	c	1.4	17	23.8	0.61	14.518	
	d	1.15	20	23	0.62	14.26	
	e	1.25	21	26.25	0.63	16.5375	
	Total	5.5				58.6435	1066.245
5	a	2.33	14	32.62	0.56	18.2672	
	b	0	15	0	0.6	0	
	c	0.73	17	12.41	0.61	7.5701	
	d	0.09	20	1.8	0.62	1.116	
	e	1.3	21	27.3	0.63	17.199	
	Total	4.45				44.1523	992.1865
6	a	1.9	14	26.6	0.56	14.896	
	b	0	15	0	0.6	0	
	c	0.37	17	6.29	0.61	3.8369	
	d	3.2	20	64	0.62	39.68	
	e	2.8	21	58.8	0.63	37.044	
	Total	8.27				95.4569	1154.255
7	a	1.04	14	14.56	0.56	8.1536	
	b		15	0	0.6	0	
	c		17	0	0.61	0	
	d		20	0	0.62	0	
	e	0.84	21	17.64	0.63	11.1132	
	Total	1.88				19.2668	1024.83
8	a	0.93	14	13.02	0.56	7.2912	
	b		15	0	0.6	0	
	c	0.48	17	8.16	0.61	4.9776	
	d	0.15	20	3	0.62	1.86	
	e	1.67	21	35.07	0.63	22.0941	
	Total	3.23				36.2229	1121.452
9	a	0.187	14	2.618	0.56	1.46608	

	b	1.05	15	15.75	0.6	9.45	
	c	1.35	17	22.95	0.61	13.9995	
	d	0	20	0	0.62	0	
	e	1.12	21	23.52	0.63	14.8176	
	Total	3.707				39.73318	1071.842
10	a	0.3	14	4.2	0.56	2.352	
	b		15	0	0.6	0	
	c	0.7	17	11.9	0.61	7.259	
	d	1.44	20	28.8	0.62	17.856	
	e	1.5	21	31.5	0.63	19.845	
	Total	3.94				47.312	1200.812
11	a	0	14	0	0.56	0	
	b	0	15	0	0.6	0	
	c	0.47	17	7.99	0.61	4.8739	
	d	0.73	20	14.6	0.62	9.052	
	e	1.2	21	25.2	0.63	15.876	
	Total	2.4				29.8019	1241.746
12	a	0	14	0	0.56	0	
	b	0.84	15	12.6	0.6	7.56	
	c	1.2	17	20.4	0.61	12.444	
	d	0.35	20	7	0.62	4.34	
	e	0.26	21	5.46	0.63	3.4398	
	Total	2.65				27.7838	1048.445
13	a		14	0	0.56	0	
	b		15	0	0.6	0	
	c	0.72	17	12.24	0.61	7.4664	
	d	0.28	20	5.6	0.62	3.472	
	e	0.88	21	18.48	0.63	11.6424	
	Total	1.88				22.5808	1201.106
14	a	1.6	14	22.4	0.56	12.544	
	b	0.22	15	3.3	0.6	1.98	
	c	1.7	17	28.9	0.61	17.629	
	d	0.92	20	18.4	0.62	11.408	
	e	1.26	21	26.46	0.63	16.6698	
	Total	5.7				60.2308	1056.681
15	a	1.27	14	17.78	0.56	9.9568	
	b	0.34	15	5.1	0.6	3.06	
	c	2.97	17	50.49	0.61	30.7989	
	d	0.08	20	1.6	0.62	0.992	
	e	1.52	21	31.92	0.63	20.1096	
	Total	6.18				64.9173	1050.442

Based on the Sediment Yield Index (SYI), sub-watersheds that require treatment measures were prioritized using the simple rule that the sub-watersheds with a higher SYI were ranked higher priority for treatment. The sub-watersheds would be treated on priority basis in the treatment scheme to be followed (Table 1.8). An index map giving physical targets of the treatment measures to be undertaken in different sub-watersheds according to their priority ranking for treatment was prepared.

Table 1.8: SYI & Ranking for Sub-watersheds

Sub watersheds code	Area	SYI	Ranking	Priority category
11	2.4	1241.75	1	High
13	1.88	1201.11	2	High
10	3.94	1200.81	3	High
3	4.28	1160.10	4	Medium
6	8.27	1154.26	5	Medium
2	8.918	1127.58	6	Medium
8	3.23	1121.45	7	Medium
9	3.707	1071.84	8	Low
4	5.5	1066.25	9	Low
14	5.7	1056.68	10	Low
15	6.18	1050.44	11	Low
12	2.65	1048.45	12	Low
7	1.88	1024.83	13	Low
5	4.45	992.19	14	Very low
1	8.364	960.12	15	Very low

Table-1.9: Erosion intensity categorization as per SYI classification

S.No.	Priority Category	Area (sq. km)	Percentage (%)

1	Very high	-	-
2	High	8.22	11.52
3	Medium	24.69	34.61
4	Low	25.61	35.90
5	Very low	12.81	17.95

1.3.9 Activities To Be Undertaken (Treatment Measures)

Details of treatment measures viz. engineering measures as well as biological measures to be undertaken are described in the following paragraphs.

1.3.9.1 Engineering Measures

Gully Control: The gully(s) would be treated with the help of engineering/ mechanical as well as vegetative methods. Check dams would be constructed in some of the areas to promote growth of vegetation that will consequently lead to the stabilisation of the slopes/area and prevention of further deepening of gully(s) and erosion. For controlling the gully(s), the erosive velocities are reduced by flattening out the steep gradient of the gully. This is achieved by constructing a series of check which transform the longitudinal gradient into a series of steps with low risers and long flat treads. Different types of check dams would be required for different conditions comprising different materials depending upon the site conditions and the easy availability of material at local level.

The following types are recommended for this area:

a. Brushwood checkdam

b. DRSM (Dry Rubble Stone Masonry) - Check dams with stones

c. Contour Bunding

d. Slope modification by Stepping/Bench Terracing

In addition to the vegetative measures used for stabilisation of gullys, temporary or permanent mechanical measures will be used as supplementary measures to prevent the washing away of young plantations by large volume of runoff. The gullys get stabilised over a period of time with the establishment and growth of vegetation cover. With the passage of

time mechanical structures weaken and vegetative measures get strengthened. For engineering measures following types of checkdams are suggested.

A. Brushwood check dams

The main advantage of brushwood check dams is that they are quick and easy to construct and are inexpensive as they are constructed by using readily available materials at the site. In brushwood check dams, small branches preferably of coppicing species are fixed in two parallel rows across the gully or nala and packed with brushwood between the rows of these vertical stakes. The vertical stakes are tied down with wires or fastened with sticks across the top. The important consideration in erecting brushwood check dams is to pack the brushwood as tightly as possible and to secure it firmly. This type of check dam is generally constructed over small gully or at the starting stretch of gully. A number of brushwood check dams/ vegetative spurs would be constructed to check gully erosion, stream bank protection and slope stabilization works.

B. Dry Rubble Stone Masonry (DRSM) check dams

The site where DRSM check dams are to be constructed is cleared and the sides are sloped 1:1. The bed of gully is excavated for foundation to a uniform depth of 0.45 m to 0.60 m and dry stones are packed from that level. Over the foundation, DRSM super structure of check dam is constructed. The stones are dressed and properly set in with wedges and chips. The width of check dam at the base should be approximately equal to maximum height and successive courses are narrower so the section is roughly a trapezium. It is common to find upstream face of check dams vertical with all slopes on the downstream face but while there is sound engineering reason for this in case of large check dams but it is not of any consequence in small gully control dams. In the centre of the dam portion sufficient waterway is allowed to discharge the maximum run off. The dry stone work should go up to 0.30m to 0.60m in the stable portion of the gully side to prevent end-cutting. Sufficient apron is provided to prevent scouring of the structure. The thickness of the apron packing would be about 0.45 m and gully sides above the apron have to be protected with packing to a height of at least 0.30 m above the anticipated maximum water level to prevent side scour being formed by the falling water. For gully control measures, DRSM check dams would be constructed.

C. Contour Bunding

Contour bunding is one of the simple methods of soil and water conservation. It plays an important role in soil and water conservation in the field with medium slope. Along bunds trees which fix nitrogen into the soil are planted with grass along the bunds. Contour bonding helps in soil and water conservation. When there is rainfall, contour bund acts as a barrier to the water flow and checks the velocity. This reduces chances of soil erosion. When water starts flowing along the fields, bund becomes obstruction for it. Due to the obstruction, velocity reduces and water percolates behind the bunds. This allows infiltration of water into the soil. The affected area will be taken for contour bunding.

D. Slope modification by Stepping/ Bench Terracing

Bench terracing is one of the most popular mechanical soil conservation practices adopted by farmers in India and other many countries. It is constructed in the form of step like fields along contours by half cutting and half filling and would result in the conversion of the original slope into levelled fields. Thus, hazards of erosion are eliminated and manure and fertilisers applied are retained in the levelled fields. The sloping fields in the valley need to be bench terraced by cutting and filling with the later supported by retaining stone wall. While making bench terraces, care will be taken not to disturb the top soil by spreading earth from the lower terraces to higher terraces. The vertical intervals between the terraces will not be more than 1.5 m and cutting depth would be kept at 50 cm. The minimum average width of the terrace would be 4 to 5 m to enable the usage of prolong hinge. The shoulder bunds of 30 x 15 cm would also be provided. The excess water from the terraces will be drained off by staggered channels. The affected area will be taken for stepping / bench terracing..

1.3.9.2 Biological Measures/Preventive Measures

The Biological Measures/Preventive Measures suggested are:

A. Afforestation

B. Assisted Natural Regeneration (ANR)

C. Pasture Development

D. Nursery development

It is always better to undertake preventive measures than to mitigate the factors that ultimately lead to soil erosion. Such preventive measures will indirectly help to conserve soil in the long run, keeping in view the importance of integrating eco-restoration strategy with

socio-economic needs of the local community wherein both ecology and economics are developed. The preventive measures that are suggested for the project area have been discussed below.

A. Afforestation

In the upland region like this project area, the trees and vegetation cover play an important role in the conservation of soil and ecology. Afforestation programme would be taken up in such areas that contain large patches of barren grassy slopes and are generally devoid of trees and are honey-combed by cultivation. In critically degraded areas, plantation of locally useful, diverse and indigenous plant species such *as Tectona grandis, Terminalia tomentosa, Acacia nilotica, Lagerstroemia parviflora, Terminalia arjuna, Diospyros, Madhuca latifolia, Ficus religiosa, Alianthus excelsa, Albezzia lebbeck, Albizzia procera, Pterocarpus marsupium, Sterculia urens, Prosopis juliflora, Tamarindus indica, Moringa pterygosperma, Emblica officinalis, Azadirachta indica etc.* would be selected after considering altitude, aspect, biotic pressures, soil depth, moisture, etc. As there is great pressure of cattle grazing, non fodder/fuel wood species would also be planted in suitable proportion in between the fodder species. Afforestation measures would be taken up under CAT plan to cover various areas under afforestation in different sub-watersheds.

B. Assisted Natural Regeneration in Existing Forest

In some of the forest areas, conditions are conducive to natural regeneration provided some sort of assistance is provided. Such areas shall be taken up under this component. The areas shall be closed to exclude biotic interference. Scrub land floor will be cleared of slash; debris and felling refuse to afford a clean seedbed to the falling seed. At certain places some soil raking may also have to be done to facilitate germination of seeds. Where natural regeneration is found deficient, it will be supplemented by artificial planting. Patch sowing in suitable areas may also be done. Bush cutting & cleaning operations are done depending on necessity. Up to 800 plant or patches per hectare will be planted /sown to hasten the process of regeneration in the area uniformly. A amount of Rs. 4.0 Lakhs should be allocated after analysing need base assessment for CAT with the consultation of forest dept., to compensate the loss of biodiversity due to submergence.

C. Grazing Land/ Pasture Improvement

The livestock owned by the local communities exert significant pressure on the natural

habitats. In order to improve the grazing areas/pastures and to make these sustainable, the degraded areas, particularly among community lands will be taken up for trreatment unde

silvi-pastoral model. A significant amount should be allocated after analysing need base assessment for CAT with the consultation of forest dept., to compensate the loss of biodiversity due to submergence.

D. Nursery Development

Proper development of nursery and allied services, like drip irrigation or micro-irrigation, will be crucial for successful execution of CAT plan. It will be important to prepare a stock of plant material for the supply of saplings for afforestation programme and various other activities. Main nursery may be developed near dam site, proposed colony areas, preferably along the road side for easy accessibility. The nurseries may be developed around colony area because of its proximity to both the upstream and downstream part of the CAT plan area as it lies in the middle of catchment. Besides, this area possesses necessary infrastructure and various raw materials for nursery development can be easily made available. In addition, provision will also be made for two green-houses/polies & net house for maintaining plant saplings. Development of nursery and greenhouses should be managed in consultation with forest department and the budget of 10 Lakhs has been alloted for nursery development Development of nursery will start from the zero years and will continue for 5 years with its maintenance. During initial stage, some plants/saplings may be procured for forest nurseries.

1.3.9.3 Cost of Other Components of CAT Plan

Apart from the forestry works and the drainage line treatment in the catchment there are other aspects of the CAT plan to be addressed and their cost to be included in the overall plan. The eco-restoration works, livelihood support works, socio-mobilization, documentation and publication, monitoring and evaluation are some the integral ingredients which have to be considered and included while formulating the CAT plans as per suggestions made from time to time by the MOEF.

1.3.9.4 Administrative Set Up

The CAT plan involves intensive and highly technical operations, which require expertise of technical personnel. It is therefore, recommended that the existing Department of Watershed Development will look after all the works to be carried out under the CAT plan including plantation and maintenance as all the areas to be covered under CAT plan fall under this divisions. However, temporary staff may be engaged for this purpose during the project implementation period.

1.3.9.5 Establishment Works Related To Area Development

There is urgent need to reduce the dependency of local population on the forest and other natural resources which are under severe pressure. The establishment works related to area development is suggested and should be carried out through Community Welfare Committees (CWC) of local villages in catchment area of Parkul. This should include the following measures, which would help in rejuvenating the ecosystems and in reducing the soil erosion in the region.

1. Establishment of a committee for plantation
2. Avenue plantation using fuel wood trees with suitable fencing in the villages.
3. Technical and financial support for using alternate energy sources such as non-conventional energy (solar heating) to reduce pressure on the forest (tree cutting) for fuel wood.
4. Maintenance of hygiene in the villages.
5. Establishment of training, awareness programmes, etc. for water conservation and harvesting in the villages, Soil conservation measures in village areas,

Improvement in agricultural and horticultural practices, etc.

6. Establishing a rural technology support programmes.
7. Awareness programmes for conservation of wildlife and natural resources.

1.3.10 Eco-Restoration

There is urgent need to reduce the dependency of local population on the natural resources which are under severe pressure. The eco-restoration works and other activities related to income generation are suggested and should be carried out through Community Welfare Committees of local villages. These should include the following measures, which would help in rejuvenating the ecosystems and in reducing the soil erosion in the region.

1. Plantation in the degraded patches of community/civil/ forest land.
2. Water conservation and harvesting in the villages.
3. Soil conservation measures in village areas.
4. Improvement in agricultural and horticultural practices.
5. Rural technology support programmes.
6. Awareness programmes for conservation of wildlife and natural resources.
7. Promotion of income generating schemes like ecotourism.

1.3.11 Monitoring and Evaluation

Monitoring and evaluation will be developed as a part of the project management. Thus, a process of self-evaluation at specific interval of time will ensure the field worthiness and efficacy of the CAT plan. Annual work plan for each sub-watershed would be prepared well in advance specifying physical and financial targets, sites, locations and beneficiaries of each component of the project activity. Month-wise work scheme of various items of each component for the financial year would also be prepared in advance and its timely implementation would be ensured. Monthly progress report on all activities would be submitted by the Project In-charge of Department of Watershed Development to Divisional Watershed Development Officer for its subsequent submission to the project authorities and Department of Land Resources, GoI. The monitoring committee appointed for this purpose would also monitor the quality and quantity of works carried out in the area on a regular basis. Installation of silt recording station upstream of barrage site on Parkul catchment is suggested to monitor the silt load and impact on soil conservation measures.

1.3.11.1 Cost Estimate of CAT Plan

The total estimated cost of catchment area treatment plan to be spent over a period of five years has been planned as Rs. 27.50 lakhs. The details of cost estimates and physical work schedule as well as phasing of expenditure shall be done in consultation of WRD and Forest department are given as follows in Tables 1.10. All the costs towards the administration during the implementation work have been included in the cost estimates of CAT.

Table 1.10: Component-wise cost Estimate for Catchment Area Treatment Plan

Sl. No	Item of Work		Unit	Qty.	Rate (Rs)	Amount (Rs.)
A	**ENGINEERING MEASURES**					
1	Gully control					
	a	Brushwood check dams	Nos.	5	2000	100000
	b	DRSM check dams	Nos.	4	26500	100000
	c	Mulching	ha	1	10000	10000

	d	Contour bunding	ha	12	7000	84000
2	Bench terracing		ha	4	21500	86000
	Sub-Total (1+2)					380,000
	Add 5% for maintenance of structures					19000
	Sub-total (A)					399,000
B	**BIOLOGICAL MEASURES**					
1	Afforestation					
		Creation	ha	3	60,000	180,000
		Maintenance for 3year		3	28000	84000
2	Assisted natural regeneration in existing scrubland/wasteland					
		Creation	ha	3	25000	75000
		Maintenance for 3 year		3	13500	40500
3	Pasture development					
		Creation	ha	5	30000	150000
		Maintenance		5	5000	25000
4	Nurseries					10000
5	Wire/Barbed fencing for 5 year					500,000
	Sub-total (B)					1064500
	Total (A+B)					14,63500
C	**Micro-planning @ 5% of (A+B)**					73175
D	**Eco-restoration**					10,000,00
E	**Establishment Cost @ 7%**					102445
F	**Contingency @ 5%**					73175
G	**Monitoring and evaluation cost@3%**					43905
	GRAND TOTAL (A TO G)					27,56200

Part of catchment Area of Parkul River

Submergence area of Parkul Dam Reservoir

Parkul River near the Bakswaha Village