

Full Title of Project: - Construction of Adi Badri Dam on Somb Nadi and its piped link to Sarasvati Nadi and Sarasvati Reservoir

File No: - FP/HP/IRRIG/155846/2022

Date of Proposal: - 26.05.2022

CATCHMENT AREA TREATMENT (CAT) PLAN

Introduction

The study of erosion and sediment yield from catchment is of utmost importance as the deposition of sediment in reservoir reduces its capacity, thus affecting the water available for the designated use. The eroded sediment from catchment when deposited on streambeds and banks causes braiding of river reach. The removal of top fertile soil from catchment also adversely affects the agricultural production. Another crucial factor that adds to the sediment load and which contributes to soil degradation is grazing pressure. Many cattle, sheep, and goats graze the pastures continuously for about six months in a mountainous region.

The lack of proper vegetal cover is a factor to cause degradation and thereby results in severe run off/soil erosion, and subsequently premature siltation of the reservoir. Thus, a well-designed Catchment Area Treatment (CAT) Plan is essential to ameliorate the above-mentioned adverse cause and process of soil erosion. The catchment area treatment involves the understanding of the erosion characteristics of the terrain and suggesting remedial measures to reduce the erosion rate. For this reason, the catchment of the directly draining rivers, streams, tributaries, etc. are treated and the cost is included in the project cost.

The pre-requisite for a watershed management is the collection of multipronged data e.g., 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 forms the basis of the Action Plan for Catchment Area Treatment.

Catchment Area Treatment (CAT) plans for the free draining catchment area of the proposed project has been prepared for areas with high soil erosion intensity. The CAT Plan targets towards 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 holding capacity; and arresting total sediment flow in the reservoir and flowing waters.

Objectives

Integrated watershed management plan minimizes the sedimentation of reservoir. The main aim of the Catchment Area Treatment Plan is to rejuvenate various potential and degraded ecosystems in the catchment area for longevity of the reservoir storage capacity. For this purpose, the action plan has been prepared with the following objectives:

- 1 To facilitate the hydrological functioning of the catchment and to augment the quality of water of

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the river and its tributaries.

- 2 Conservation of soil cover and to arrest the soil erosion, floods and siltation of the river along with its tributaries and consequent reduction of siltation in the reservoir of the project.
- 3 Demarcation of the priority of watersheds for treatment based on soil erosion intensity in the catchment area.
- 4 Rehabilitation of degraded forest areas through afforestation and facilitating natural regeneration of plants.
- 5 Mitigation of landslide, landslip and rock falls.
- 6 Soil conservation through biological and engineering measures to reduce sediment load in river and tributaries, incidentally improving the quality of water.
- 7 Ecosystem conservation resulting from increased vegetal cover and water retaining properties of soil.
- 8 To meet the fuel and fodder requirements of local people.
- 9 Promotion of non-conventional energy device to reduce pressure on forest.
- 10 Employment generation through community participation and conservation.

Catchment Area

The catchment area of Somb Nadi upto the Adi Badri Dam project is about 29.50 Sq. Kms. Major portion of this catchment area is located in the Himachal Pradesh, while the rest in the Haryana State.

It is a small Catchment area, so rainfall over the catchment does not vary much from place to place. Bulk of the total annual rainfall occurs during the four monsoon months of June, July, August and September. The rock types met in the catchment area are Middle Shivaliks consists predominantly of sand stone of light grey colour which vary in thickness from 10 m to 20 m. They are coarse grained and grade from greywacke in lower portion and rkose in the higher portion. They are soft and friable because of lack of calcareous matter which occur in segregation rather than dissimilated throughout the mass as in lower Shivalik. Middle Shivalik fauna particularly the Dhok Pathan formation exhibit very close to Pontain affinities.

Free Draining Catchment

The catchment area of Somb Nadi upto the Adi Badri Dam project is about 29.50 Sq. Kms. which does not have any intercepted catchment. Since the catchment is not intercepted by any other major or medium water resource project on upstream, the Catchment Area Treatment Plan shall be formulated for entire catchment (29.50 sq. km)

The satellite imagery of the free draining catchment is presented in Figure 5.1, and the mosaic map of watershed location is shown in Figure 5.2.

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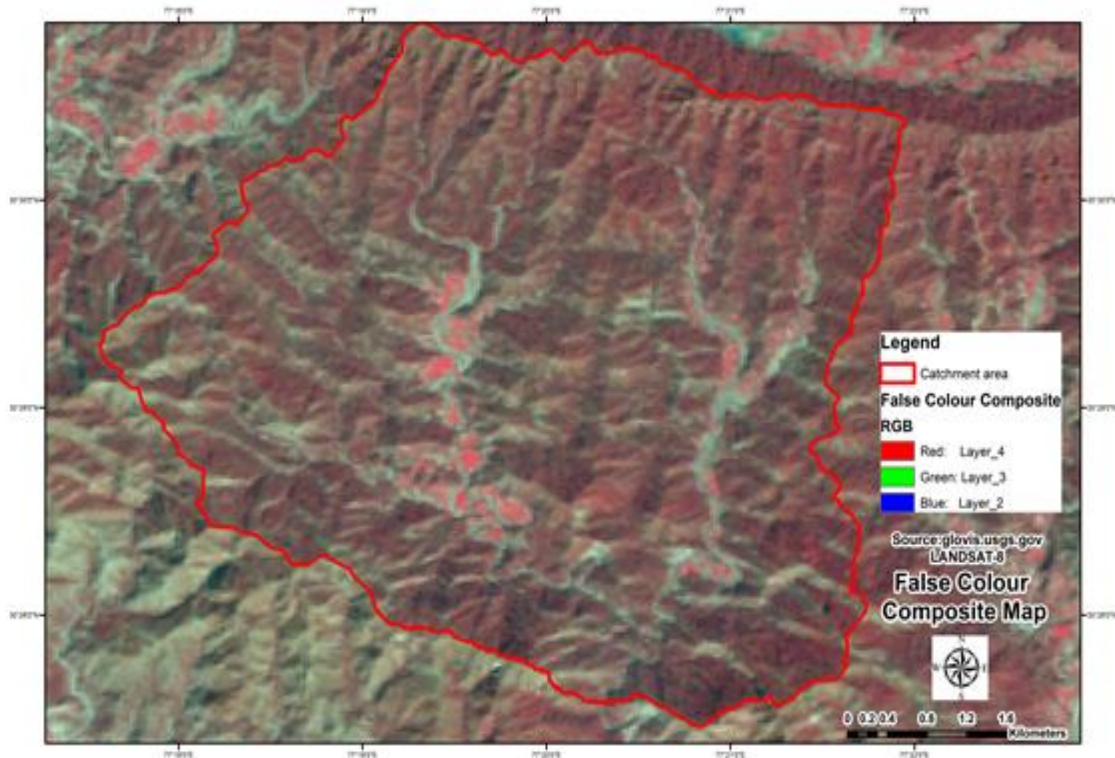


Figure Error! No text of specified style in document..1: FCC of Catchment Area

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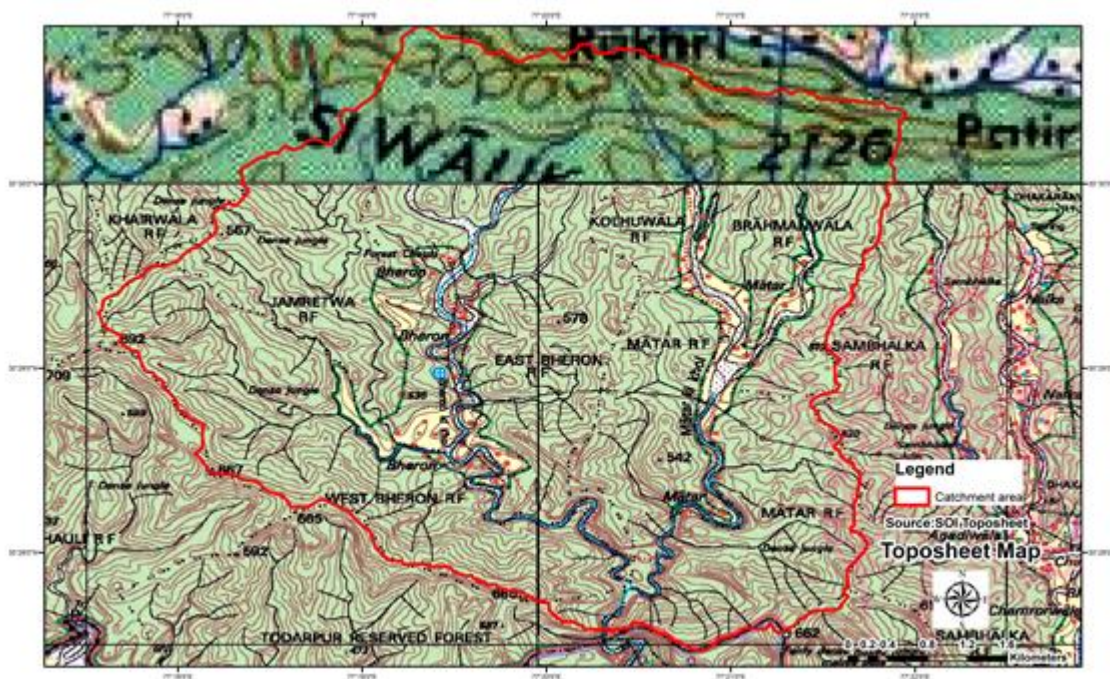


Figure Error! No text of specified style in document..2: Mosaic Map Showing Location of watersheds

Topography and Drainage

The topographic analysis of the project area comprises of sub- mountainous zone where middle Shivalik rocks are exposed in the shape of low hills. The project area lies in the Survey of India (SOI) topographic sheet 53F6 and 53F7. The altitude of the area varies from the lowest 318 m. In the Somb river bed to the highest 580 m. at the top of water divide. The topography sheet indicates that the Sarasvati river originates from the Shivalik hills. The source of river is underground water dipping from small hillock which is now snow fed. It contributes to its ephemeral character. The Adi Badri and its immediate surroundings are also drained by some other small first and second order tributaries which join the Somb river, a right bank tributary from Yamuna river. All the stream/ nallas/ gullies follow the local slope of the area. The drainage map of the catchment is shown in Figure 5.3.

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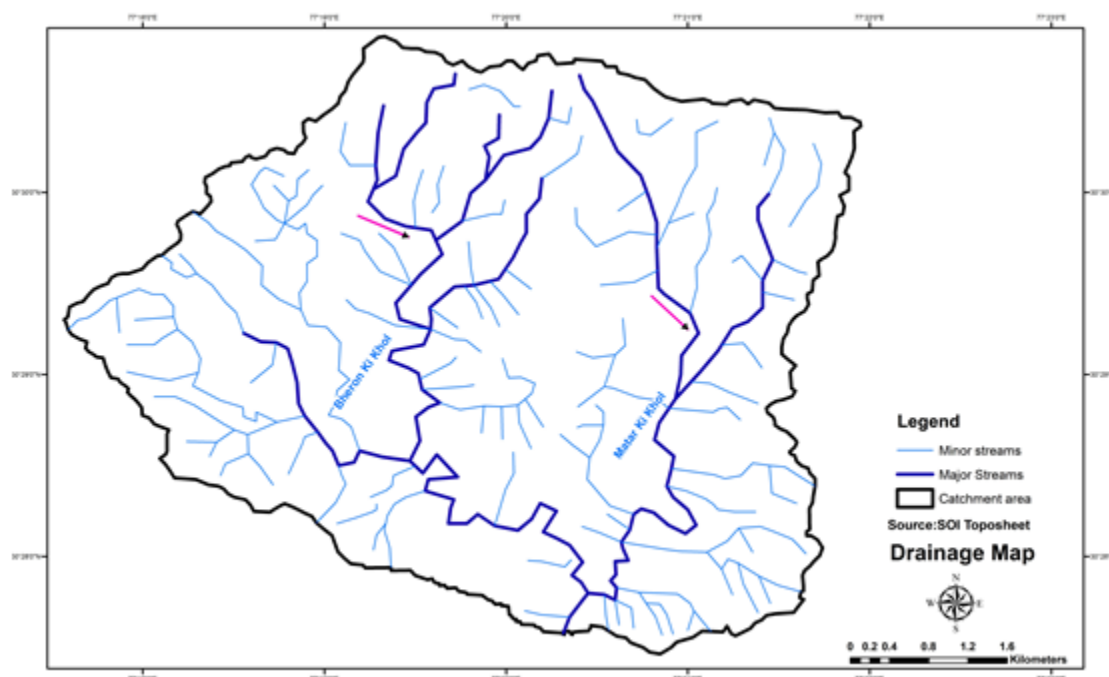


Figure Error! No text of specified style in document..3: Drainage map of the catchment.

Soil

The soil resource map of Himachal Pradesh and Haryana (NBSS Publication No 50) has been used in the present study. The soils of the catchment area belong to soil mapping unit 84, 89, 72, 66, 93 and 94. The soil belonging to soil mapping unit 94 are deep well drained, fine loamy soils on moderately sloping hill slope with loamy surface texture and moderate erosion and are associated with moderately deep well drained coarse loamy soils and moderate erosion. Taxonomically these are Dystric Eutrochrepts to Typic Udorthents and Eutrochrepts. The soil map is presented in Figure 5.4.

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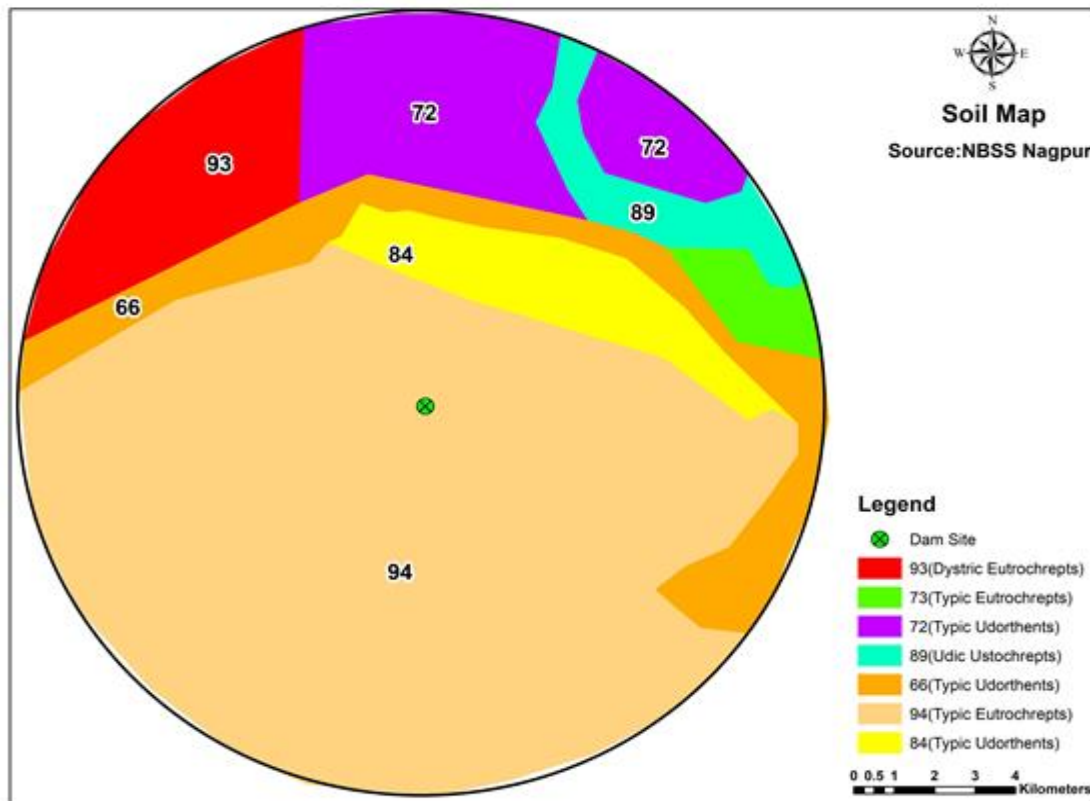


Figure Error! No text of specified style in document..4: Soil Map of the Catchment including study area

Land use

Land use-Land Cover Classification

Based on satellite data and toposheets, a land-use map has been prepared and verified in detail during ground surveys i.e. crosschecked with ground truths. The Land use/ Land-cover map of the catchment area is presented in Figure 5.5 and its details are presented in Table 5.2.

Land use Categories and Erosion

The erosion acts differently in different land-use types. It is important to understand the nature of erosion in a land-use class to further plan for treatment.

Agricultural Land

The catchment area is having 1.56 sq km agriculture land which is 5.29%

Settlement

There are some settlements in the catchment area which are 0.22% of total catchment area.

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Open Forest Land

Open forest covers about 9.09 sq. km area constituting 30.81% of the catchment

Dense Forest

Dense forest covers about 18.31 sq. km area constituting 62.07% of the catchment

River / Water body

Around 0.031 sq. km area constituting 0.11% of the catchment area is classified under water bodies.

Dry River Bed

Around 0.38 sq. km area constituting 1.29% of the catchment area is classified under Dry River Bed.

Table Error! No text of specified style in document..1: Land use Details in the Catchment

Class	Area(Sq Km)	%
Agricultural Land	1.56	5.29
Dry River Bed	0.38	1.29
Water body	0.031	0.11
Dense Forest	18.31	62.07
Open Forest	9.09	30.81
Settlement	0.13	0.44
Total	29.50	100

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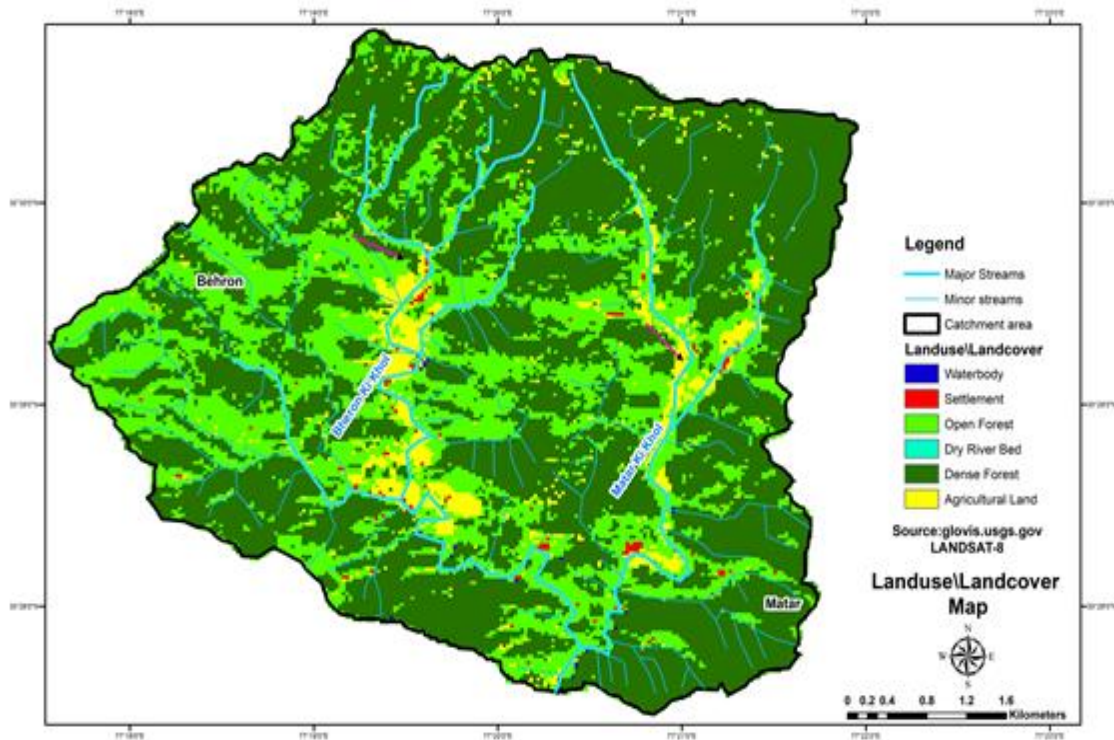


Figure Error! No text of specified style in document..5: Land use Map of Catchment Area

Slope

The slope of a watershed plays a key role in controlling the soil and water retention thereby affecting the land-use capability. The percentage of the slope in a watershed determines the soil erosion susceptibility and forms the basis for classifying different of the watershed into suitable classes for formulating effective soil erosion conservation measures. Broadly, the following slope classes and ranges (Table 5.3) as per norms of All India Soil and Land Use Survey were adopted to classify the slopes for the present study.

Table Error! No text of specified style in document..2: Slope Ranges of Catchment area

Sr. No	Slope Range (Degrees)	Description
1.	0-3.6	Very Gentle Slope
2.	3.6-7.6	Gentle Slope
3.	7.6-12.4	Moderate Slope
4.	12.4-18	Moderately Steep
5.	18-24	Steep
6.	Above 24	Very Steep

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The Slope map of the free draining catchment is presented in Figure 5.6 and slope details are as presented under Table 5.4. The data shows the slopes dominated by moderately steep sloping (31.02) to moderately sloping (27.24).

Table Error! No text of specified style in document..3: watershed Wise Areas Under Different Slope Classes

Slope Class	Area (Sq km)	%
0-2(Nearly level)	1.5	5.10
2-5(Very Gentle Sloping)	2.41	8.10
5-8(Gently Sloping)	1.25	4.25
8-15(Moderate Sloping)	8.04	27.24
15-30(Moderately Steep sloping)	9.12	31.02
30-50(Steep Sloping)	5.2	17.56
Above 50 (Very Steeplly Sloping)	1.98	6.73
Total	29.50	100

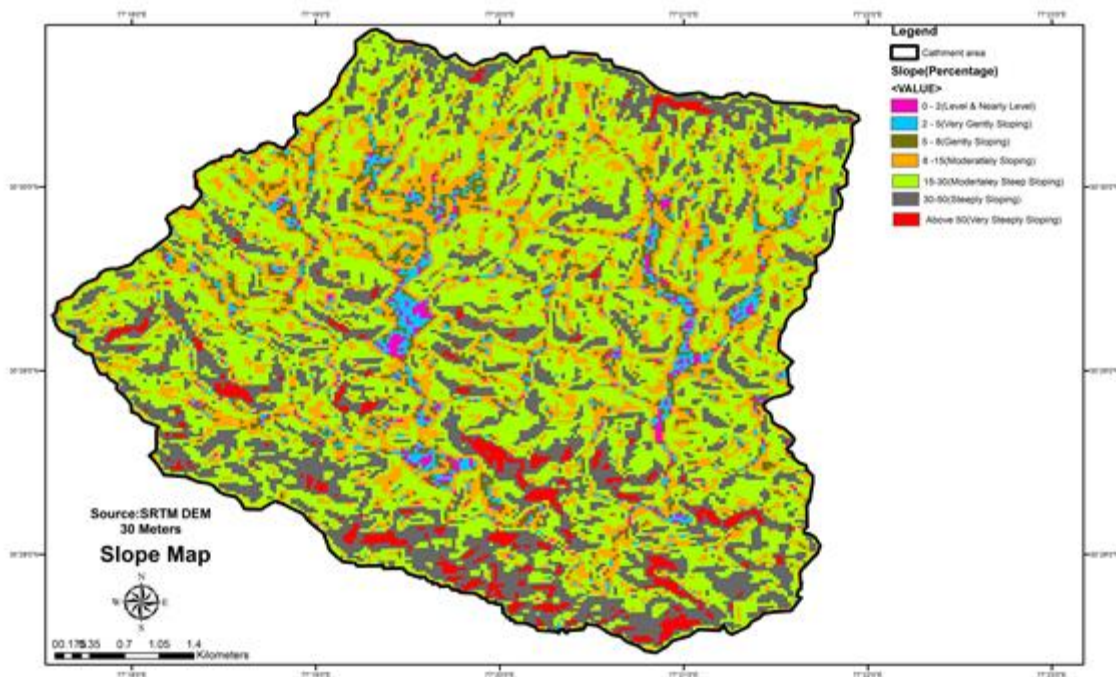


Figure Error! No text of specified style in document..6: Slope Map of Free Draining Catchment

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Methodology Used for the Study

Superimposing topography, slope, soil and land use data/maps, a tentative estimation of erosion prone areas and landslides area in the catchment were 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.

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 (AISLUS) 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 and Land Use Survey (Development of Agriculture, Govt. of India) was followed in this study.

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 ration 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/land-cover. 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 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.
- The delivery ratios were calculated for each composite erosion intensity unit. The delivery ration

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suggests the percentage of eroded material that finally finds entry into the reservoir or river/stream. Total area of different erosion intensity classes (composite erosion intensity unit) in each watershed was then calculated.

- The delivery ratio is generally governed by the type of material, soil erosion, relief length ratio, cover conditions, distance from the nearest stream, etc. However, in the present study the delivery ratios to the erosion intensity units were assigned upon their distance from the nearest stream (being the most crucial factor responsible for delivery of the sediments) per the following scheme. The delivery ratio criteria adopted for the study is presented in Table 5.5.

Table **Error! No text of specified style in document.**4: Delivery Ratio (DR) Criteria Adopted for the Project

Nearest Stream	Delivery Ratio (DR)
0-0.9 km	1.00
1.0-2.0 km	0.90
2.1-5.0 km	0.80
5.1-15.0 km	0.70
15.1-30.0 km	0.50

Sediment Yield Index and Prioritization of 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 watersheds /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

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- Geomorphic factors comprising land forms, physiography, slope and drainage characteristics
 - Surface cover factors governing the flow hydraulics
 - Management factors.
- The data on climatic factors can be obtained for various locations in the catchment area from the meteorological stations whereas the field investigations are required for estimating the other attributes.
 - 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:

Silt Yield Index

$$SYI = (A_i \times W_i \times D_i) \times 100/A_w; \quad \text{where } i = 1 \text{ to } n$$

Where

A_i = Area of i th (EIMU)

W_i = Weightage value of i th mapping unit

D_i = Delivery ratio

n = No. of mapping units

A_w = Total area of sub-watershed

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The SYI values for classification of various categories of erosion intensity rates were taken for the present study as:

	<u>Priority Category</u>	<u>SYI Values</u>
1.	Very High	>1300
2.	High	1200-1299
3.	Medium	1100-1199
4.	Low	1000-1099
5.	Very low	<1000

Accordingly, the sediment Yield Index has been calculated for sub-watersheds. The computation of SYI for watershed is presented in Table 5.6.

Table Error! No text of specified style in document..5: SYI and Priority Rating as per Erosion Intensity

Erosion intensity	Area* (ha)	Weightage	Area x weight-age	Delivery ratio	Gross silt yield	Sediment yield index	Priority
Severe	0	18	0	0.80	0	1137	Medium
Severe	58	16	928	0.85	789		
Moderate	311	14	4354	0.90	3919		
Slight	906	12	10872	0.90	9785		
	1275				14493		

Catchment Area Treatment Plan

It is known that there are mainly five categories of Land uses for which a proper treatment plan should be developed. First is the Agricultural Land as this activity can never be eliminated, because the faulty practice results in heavy loss of fertile soil. Second, being open forestland for obvious conservation reasons. Third is scrub or degraded land, which contributes heavily to the silt load and possibilities exist to bring this area under pastures and other plantation to meet the local demand of fuel and fodder and thus decreasing the biotic pressure on the forests and leading to environment friendly approach of sustainable development. The fourth and most important category is Barren land because with practically no vegetal cover, the area produces huge amount of silt load. The fifth is dense forestland

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where in a few places soil conservation measures are required. For treatment of catchment area, the areas that require treatment have been delineated from the Composite Erosion Intensity Unit Map. The sum of weightages was reclassified as per Table 5.7 below to further subdivide the area as per the erosion intensity classes. The weightages for Land use, Slope and Soil were summed to get the Erosion Intensity Classes.

Table Error! No text of specified style in document..6: Erosion Intensity and Weightages

Erosion Intensity Class	Sum of weightages
Very severe (E5)	12 to 14
Severe (E3)	9 to 11
Moderate (E3)	6 to 8
Slight (E2)	4 to 5
Negligible (E1)	0 to 3

After exclusion of rocks and inaccessible terrain, only those areas which fall under very severe and 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 area falling under very severe erosion intensity class shall be taken for treatment with biological and engineering measures under the CAT Plan.

Considering the topographic factors, soil type, climate, land-use/land-cover in the catchment area following engineering and biological measures have been proposed to be undertaken with the aim to check the soil erosion, prevent/check siltation of reservoir and to maintain its storage capacity in the long run.

The Erosion Intensity Map of the free draining catchment has been generated based on SYI data and is presented in Figure 5.6 and the statistics are presented in Table 5.8. As per SYI assessment, the sub-watershed has been prioritized as Medium and low.

Table 5.7: Erosion Intensity Categories in Watersheds (sq. km)

Class	Area(Sq Km)
Slight erosion	17.73
Moderate Erosion	9.75
Severe Erosion	2.02
Total	29.50

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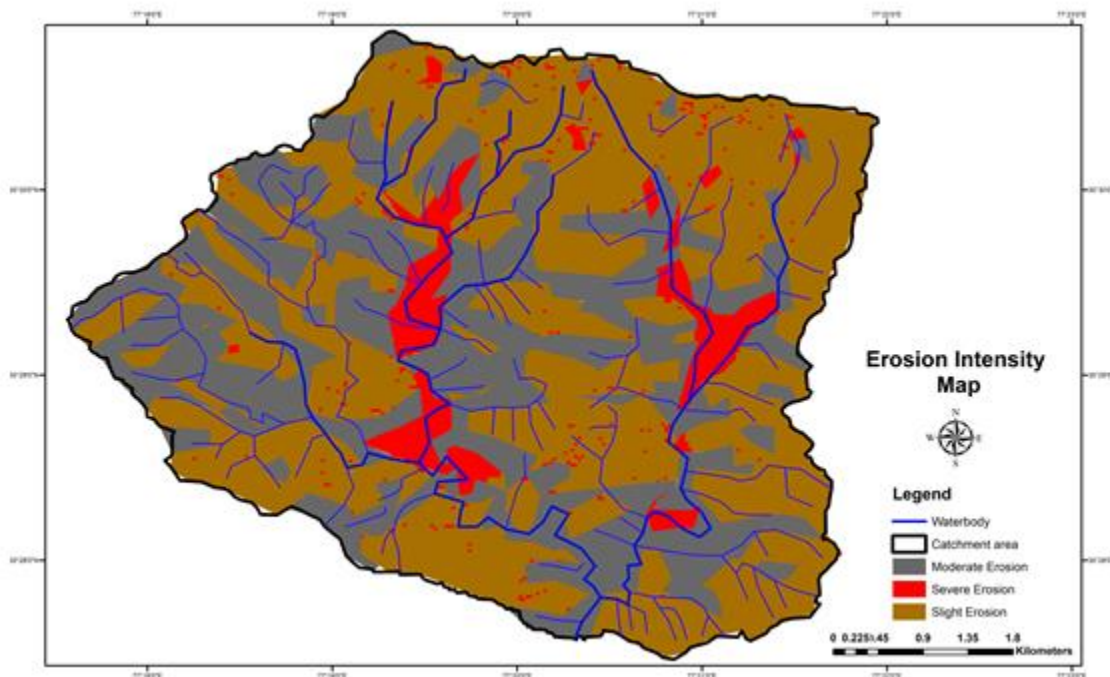


Figure Error! No text of specified style in document..7: Erosion Intensity Map of Free Draining Catchment Area

Treatment of Watershed

There are mainly five categories of land uses for which a proper treatment plan should be developed. First is the agricultural land, as this activity can never be eliminated. In addition, agriculture activities, if faulty, result in heavy loss of fertile soil. Second, is open forestland for conservation. Third, is scrub or degraded land, which contributes heavily to silt load. Possibilities exist to bring this area under pastures and plantation to meet local demand of fuel and fodder and thus decreasing the biotic pressure on the forests leading to environment friendly approach of sustainable development. The fourth and most important category is barren land because with practically no vegetal cover the area produces huge amount of silt load. The fifth is dense forestland where a few places soil conservation measures are required.

Areas falling under severe erosion intensity category would be taken up for conservation treatment measures. In the present case, an area of 58 ha has been proposed to be treated under the CAT plan. This area includes 50 ha area of catchment which shall be treated by biological measures and 8 ha area under hard engineering measures.

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Considering the topographic factors, soil type, climate, land-use/land-cover in the catchment area following measures have been proposed to be undertaken with aim to check soil erosion, prevent/check siltation of reservoir and to maintain its storage capacity in the long run.

Activities to be undertaken

Normal Afforestation

In critically degraded areas, plantation of locally useful diverse and indigenous plant species such as timber plantation species, fodder species, fuel wood species, grasses, shrubs and legumes, medicinal and aromatic plants would be undertaken. The forestation will include rising of multi-tier mixed vegetation of suitable local species in the steep and sensitive catchment areas of rivers/streams with the objective of keeping such areas under permanent vegetative cover. Furthermore, degraded areas would also be brought under vegetation cover. Suitable trees of economic value to local people shall be raised in the degraded forest areas near to villages with the objective of supplementing income of the villagers.

With a view to conserve and augment the state's rich medicinal plant resources in its natural habitat through adaptive and participatory management of the local people, cultivation of high priority medicinal plant species shall be undertaken. Thrust shall be given to organic cultivation of medicinal plants.

Effective fencing would also be provided for protection of saplings. Before any new area is taken up, eradication of weeds and unpalatable grass species is important. It is, therefore, recommended that some parts of the pasture should be closed for seeding purpose only.

Civil Structures

➤ Brush wood Check Dams and Retaining Walls

Brushes wood check dams are useful in arresting further erosion of depressions, channels, and gullies on the denuded landslides. In addition, retaining walls of stone masonry and RCC would be constructed to provide support at the base of threatened slopes.

➤ Slope Modification by Stepping or Terracing

The slope stability increases considerably by grading it. The construction of steps or terraces to reduce the slope gradient is one of the measures.

➤ Gully Control-Check Dams

Gullies are mainly formed because physiographic, soil type, and heavy biotic interference in an area. The scouring of streams at their peak flows and sediment-laden run-off cause gullies. The gullies would be required to be treated with engineering/mechanical as well as vegetative methods. Check dams would

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be constructed in some of the areas to promote growth of vegetation that will consequently lead to the stabilization of slopes/area and prevention of further deepening of gullies and erosion. Diverse types of check dams would be required for different conditions comprising of different materials depending upon the site conditions and the easy availability of material (stones) at local level and transport accessibility. Generally, brush wood check dams are recommended to control the erosion in the first order basin/streams in upper reaches and dry random stone masonry check dam shall be provided in the lower reaches where discharge is higher. In such stream where discharge and velocity of flow are still higher gabion structure shall be provided. Lower down the sub-watershed, i.e., in the third order drainage silt retention dams in the form of gabion structure shall be provided.

➤ Stream bank Protection

Stream bank erosion is caused by variety of reasons such as destruction of vegetative cover, mass movement on unstable bank slopes, undermining of top portion of lower bank by turbulent flow and sliding of slopes when saturated with water. The Stream Bank Protection would include wire crate boulder spurs in two to three tiers depending upon the high flood level of the streams.

➤ Contour Staggered Trenches

Contour staggered trenches are mainly provided to trap the silt and runoff. This is also done to prepare a fertile base for plantation, in moderately steep to very, very steep slopes.

Cost Analysis of Different Works under Biological Measures

Afforestation

Out of the total stock to be planted under afforestation, 20% species shall be tree species having medicinal values and 10% of fruit bearing wild species useful to wildlife shall also be planted. The cost analysis per hectare of afforestation with 1100 plants/ha, with five strands barbed wire fencing stretched across RCC fence posts inclusive of maintenance for five years has been worked out as Rs. 1.70 lakh/ ha as shown in Table-1.9. The rate analysis is as per minimum labor wages of Rs. 232/day with 10% annual enhancement. The cost of materials has been adopted as per prevalent market rates.

Plantation under normal afforestation component shall be carried through identified user groups in catchment area. Plantations will be maintained for five years.

The cost of works under normal afforestation component encompassing the free draining catchment area of the project has been assessed as Rs.85.00 lakh and is shown in Table-5.9.

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Table Error! No text of specified style in document..8: Per Ha. Cost Norms for Model Plantation Works

Sl.No.	Particular of Work	Quantity	Rate/Man days per unit	Total Man days	Total Amount
First year preparation year					
A. Labour Oriented Works					
1	Survey and demarcation of plantation area	1 ha	0.45 mandays /ha	0.45	104.40
2	Weeding of obnoxious weeds except lantana	1 ha	4 mandays/ha	4	928.00
3	Dag Belling with line for siting pits	1100	2.5 mandays/1000 no.	2.75	638.00
4	Digging pits 45x45x45 cm	1100	5 mandays/100 no.	55	12760.00
5	Filling pits with FYM mix with soil and Pesticides	1100	1.5 mandays/100 no.	16.5	3828.00
6	Preparation of Path	40m	30 mandays/km	7.2	1670.40
	Total Labour cost (A)				19928.8
B. Material Component					
1	Cost of FYM including carriage @ 10% of volume of pit i.e. $1100(0.45 \times 0.45 \times 0.45) \times 0.1$	10.03 m ³	1200 / m ³	0	12036
2	Providing fertile soil including carriage @ 10% of volume of pit i.e. $1100(0.45 \times 0.45 \times 0.45) \times 0.1$	10.03 m ³	500 Rs/m ³	0	5016
3	Applying cost of Neem Cake @ 30g/pit	33 Kg	55 Rs/ Kg	0	1815
4	Cost of plant	1210 No.	11 Rs/Plant	0	13310
5	Cost of Service Pipe	100 RM	55 Rs/m	0	5500
6	Proportionate cost for providing irrigation implements like tank, pipe fittings and electric motor etc.	1 job	L.S.	0	4200
7	Proportionate cost for providing chowkidar hut	1 job	L.S.	0	2000
	Total Material cost (B)				43877
C. Chain Link Fencing Work					
1(a)	Cost of 2m high RCC pole @ 2.5m c/c $(140 \times 1.1) / 2.5 = 62$	62	296.3/no.	0	18370.60
1(b)	<u>GST@18%</u>	Rs 18370.6	0.18	0	3306.70
2(a)	Cost of barbed wire in five strands $(141 \times 5) / 7 = 100$	100 Kg	90 Rs /kg	0	9000.00
2(b)	<u>GST@18%</u>	9000	0.18	0	1620.00

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Sl.No.	Particular of Work	Quantity	Rate/Man days per unit	Total Man days	Total Amount
3(a)	Cost of U-nails	10 Kg	90 Rs /kg	0	900.00
3(b)	GST@18%	900	0.18	0	162.00
4(a)	Cost of GI wire	3 Kg	100 Rs /kg	0	300.00
4(b)	GST@18%	300	0.18	0	54.00
5	Cost of labour for stretching and fixing barbed wire and other miscellaneous work	141	0.16 Man days / RM	6.56	1521.90
6	Excavation of pit for poles	62	2.5 mandays/100 No.	1.55	359.60
7	Cost of fixing poles in pit with PCC 1:3:6 mix	2.32 m3	3643/m3	0	8451.80
8	Erection of poles	62	Rs 80/ Pole	0	4960.00
	Total Fencing cost (C)				49006.60
	Total Cost First year				112812.40
Second Year - Plantation Work					
A. Labour Oriented Works					
1	Carriage of plant raised in nursery over a distance of 45 Km	1210 No.	170/100 No.	0	2057.00
2	Carriage of plants from road side to plantation site by manual labour up to 2 Km	1100	0.4Mandays/100 No	4.4	1122.00
3	Planting saplings in pits	1100	1.8 Man days/100 No	19.8	5049.00
4	Carrying out first weeding, nirai operations and application of fertilizer and pesticides including replacing of dead plants of previous year	1100	1.25 mandays/100 No.	13.75	3506.25
5	Carrying out second weeding, nirai operations and application of fertilizer and pesticides including replacing of dead plants of previous year	1100	1 mandays/100 No.	11	2805.00
6	Spraying pesticides and insecticides	1100	0.6 mandays/100 No.	6.6	1683.00
7	Applying Irrigation	1 job	L.S.	0	1600
8	Clearing of Fire lines	180 RM	2.25 mandays/Km	0.41	104.55
	Total Labour oriented Works cost (A)				17926.80
B. Material Component					
1	Cost of fertilizer (DAP/Urea) and Pesticides @ 40g and 10g / plant respectively	55 Kg	24 Rs/kg	0	1320
2	Cost of Diesel for Irrigation	1 Job	L.S.	0	1000
3	Contingency	1 Job	L.S.	0	200
	Total Material Component Cost				2520

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Sl.No.	Particular of Work	Quantity	Rate/Man days per unit	Total Man days	Total Amount
	(B)				
	Total Second Year				20446.80
Third Year - Maintenance					
A. Labour Oriented Works					
1	Repair of fencing	1 ha.	2 mandays/ha.	2	560.00
2	Cost of replacing of dead plants(10% mortality)	110	Rs 15 /No.	0	1650.00
3	Carriage of plant raised in nursery over a distance of 45 Km	110 No.	170/100 No.	0	187.00
4	Carriage of plants from road side to plantation site by manual labour upto 2 Km	110	0.4Mandays/100 No	0.44	123.20
5	Carrying out first weeding, nirai operations and application of fertilizer and pesticides including replacing of dead plants of previous year	1100	1.25 mandays/100 No.	13.75	3850.00
6	Carrying out second weeding, nirai operations and application of fertilizer and pesticides including replacing of dead plants of previous year	1100	1 mandays/100 No.	11	3080.00
7	Spraying pesticides and insecticides	1100	0.6 mandays/100 No.	6.6	1848.00
8	Applying Irrigation	1 job	L.S.	0	1600
9	Clearing of Fire lines	180 RM	2.25 mandays/Km	0.41	114.80
	Total Labour oriented Works cost (A)				13013.00
B. Material Component					
1	Cost of fertilizer (DAP/Urea) and Pesticides @ 40g and 10g / plant respectively	55 Kg	24 Rs/kg	0	1320.00
2	Cost of Diesel for Irrigation	1 Job	L.S.	0	1000.00
3	Contingency	1 Job	L.S.	0	200.00
	Total Material Component Cost (B)				2520.00
	Total Third Year				15533.00
Fourth Year - Second year of Maintenance					
A. Labour oriented works					
1	Carrying out first weeding, nirai operations and application of fertilizer and pesticides including replacing of dead plants of previous year	1100	1.25 mandays/100 No.	13.75	4235.00
2	Applying Irrigation	1 job	L.S.	0	1950.00

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Sl.No.	Particular of Work	Quantity	Rate/Man days per unit	Total Man days	Total Amount
3	Watch and ward	1 job	L.S.	0	3000.00
	Total Labour oriented Works cost (A)				9185.00
B. Material Component					
1	Cost of Diesel for Irrigation	1 Job	L.S.	0	1100.00
2	Contingency	1 Job	L.S.	0	200.00
	Total Material Component (B)				1300.00
	Total Fourth Year				10485.00
Fifth Year - Third year of Maintenance					
A. Labour oriented works					
1	Fencing repair	1 ha.	2 mandays/ha.	2	678.00
2	Watch and ward	1 job	L.S.	0	3300.00
	Total Labour oriented Works cost (A)				3978.00
B. Material Component					
1	Contingency	1 Job	L.S.	0	220.00
	Total Material Component Cost (B)				220.00
	Total Fifth Year				4198.00
Sixth Year - Fourth year of Maintenance					
A. Labour oriented works					
1	Watch and ward	1 job	L.S.	0	3600
	Total Labour oriented Works cost (A)				3600
B. Material Component					
1	Contingency	1 Job	L.S.	0	240
	Total Material Component Cost (B)				240
	Total Sixth Year				3840
Seventh Year - Fifth year of Maintenance					
A. Labour oriented works					
1	Watch and ward	1 job	L.S.	0	2100
	Total Labour oriented Works cost (A)				2100
B. Material Component					
1	Contingency	1 Job	L.S.	0	300
	Total Material Component (B)				300
	Total Seventh Year				2400
Abstract of Cost of Plantation and Maintenance					
First year-preparation					112812.40
Second Year-Plantation					20446.80
Third year-First year of Maintenance					15533.00
Fourth year-Second year of Maintenance					10485.00
Fifth year-Third year of Maintenance					4198.00
Sixth year-Fourth year of Maintenance					3840.00
Seventh year-Fifth year of Maintenance					2400.00
Total Cost					169715.20

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Sl.No.	Particular of Work	Quantity	Rate/Man days per unit	Total Man days	Total Amount
					Say Rs 1.70 Lakh/ha.

Table Error! No text of specified style in document..9: Cost Estimate for Afforestation Measures

watershed	Area under Afforestation (Ha.)	Cost @ Rs. 1.70lakh/- ha. (Rs. in lakh)
Saraswati Catchment	50	85

COST ANALYSIS OF DIFFERENT WORKS UNDER SOIL AND WATER CONSERVATION MEASURES

Cost Analysis of Vegetative Structure, Civil Structures for Land Slide and Stream Bank Stabilization and Moisture Retention Operations

These structures are to be constructed as landslide control and stream bank stabilization over visually active slides and eroded banks of the main river and its tributaries falling under "Severe" erosion intensity areas to control the sediment flow and further degradation of the free draining catchment areas. Since these measures are to be carried out by construction of individual structure such as wire crate spurs, check dams, contour staggered trenches, catch water drains, retaining walls etc. on site specific basis, the cost of each of such structure must be analyzed on the basis of dimensions adopted. The analysis of rates of such structures is presented in Table 5.11.

Table Error! No text of specified style in document..10: Cost Analyses of Structures

S. No.	Item	Quantity	Unit	Rate	Amount
1.	Dry Rubble Stone masonry (DRSM) Check Dam				
(a)	Excavation in foundation with 50% soft rock and 50% E and B involving peak and jumper work in 5.60 m x 1.80 m x 0.50 m = 5.04 cubic meter	5.04	Cum	224.88	1133.39
(b)	Collection of boulder				
	I-Step 5 x 1.5 x 1.25 = 9.38				
	II – Step 7 x 1.0 x 0.75 = 5.25	23.52	Cum	175.25	4121.88
	Wing Walls 2 x 3.75x 0.6 x 1.5 = 6.75 Total 21.38 x1.1= 23.52				
(c)	Carriage of boulder by manually beyond initial 100 m lead up to 1 km	21.38	Cum	561.00	11994.18
(d)	Labour charges for dry stone masonry with outer face stone dressed and 100 m lead.	21.38	Cum	277.50	5932.95
				Total	23182.40
				Add 3% Contingencies	695.47
				Grand Total Rs.	23877.87
				Say Rs.	24000.00

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S. No.	Item	Quantity	Unit	Rate	Amount
2.	Wire Crate Check Dam				
(a)	Excavation in foundation with 50% soft rock and 50% E and B involving peak and jumper work in 6.60 m x 2.30 m x 0.50 m = 7.59 cubic meter	7.59	Cum	224.88	1706.84
(b)	Collection of boulder				
	Foundation Step - 6.0 x 2.0 x 1.0 m = 12 cubic meters				
	I- Step - 6.0 m x 1.9m x 1.0m = 11.40 cubic meter	35.24	Cum	175.25	6175.81
	II- Step – 6.0 m x 1.8m x 0.8 m = 8.64 cubic meter				
	Total requirement of boulder = 32.04 x 1.1 = 35.24 cubic meter				
(c)	Carriage of boulder manually average lead 1 km	32.04	M ³	561.00	17974.44
(d)	Weaving of wire netting of GI wire mesh size 15 cm x 15 cm				
	Foundation Step-2(6x2+6x1+2x1) = 40 m ²	113.2	M ²	21.75	2462.10
	I- Step-2(6x1.9+6x1+2x1) = 38.8 m ²				
	II- Step- 2(6x1.8 + 6x0.8 + 2x0.8) = 34.4 m ²				
	Total = 113.2 m ²				
(e)	Filling of boulder and hand packing in wire crates	32.04	M ³	144.25	4621.77
(f)	Cost of GI wire	2.25	Qtl	8000	18000.00
(g)	Carriage of GI wire manually to an average lead of 1 km	2.25	Qtl	83.50	187.88
Total Rs.					51128.84
Add 3% Contingencies					1533.86
Grand Total Rs.					52662.70
Say Rs.					52700
3.	RR Dry stone masonry / RM Average dimension = 5 m long, 2m high and side slope 1:4				
a.	Excavation in foundation with 50% soft rock and 50% E and B 5 x 1.10 x 0.3 = 1.65	1.65	Cum	224.88	371.05
b.	RR stone masonry dry 5 x (1.10 + 0.60 / 2) x 2.0 = 8.5 cum	8.5	Cum	277.50	2358.75
Total					2729.80
Add 3% Contingencies					81.89
Grand Total					2811.69
Or say					2800.00
Total					15725.00
4.	Contour staggered trenches ,0.45mx0.45m / R.M.	1	R.M	31.79	31.79
Say					32.00

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Abstract of Works under Civil Structures

The Break-up of works under different sub-watersheds in respect of vegetative structure, civil structures for land slide and stream bank stabilization and moisture retention operations with their costs is shown in Table-5.12.

Table.11: Abstract of Works under Civil Structures

DRSM check dam @ Rs. 0.24 lakh each		Wire Crate Check Dam @ Rs. 0.527 lakh each		Contour Staggered Trenches@Rs32/m		Total Cost (Rs. lakh)
Number	Cost	Number	Cost	Meter	Cost	
35	8.40	7	3.69	2400	0.77	21.39

Cost of Other Components of CAT Plan

Apart from the forestry works and drainage line treatment in the catchment area there are other aspects of the CAT Plan to be addressed and their cost included in the overall cost estimate of the plan. The eco-restoration works, documentation and publication, monitoring and evaluation and providing environmental services are some of the integral ingredients, which have to be considered and included while formulating the CAT plans.

Implementation of Support Infrastructure Cost

In order to execute the catchment area treatment plan, the forest department would be requested to establish a catchment area treatment cell for which the executing agency shall need necessary infrastructure support. Accordingly, provisions have been made for purchase of office equipment. The cost of works proposed under the head works out to Rs. 1.50 lakh and is shown in Table-5.13.

Table Error! No text of specified style in document..12: Cost Estimate for Support Infrastructure

S. No.	Particular	Quantity	Unit	Rate (Rs. Lakh)	Amount (Rs. Lakh)
1	Purchase of Computers complete with accessories and Laser printer	1	No.	1.00	1.00
2	Purchase of Fax Machine	1	No.	0.10	0.10
3	Purchase of GPS and Survey instruments	LS	-	-	0.40

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S. No.	Particular	Quantity	Unit	Rate (Rs. Lakh)	Amount (Rs. Lakh)
	Total				1.50

Provision for Micro Plans

Based on the ground truth reality in each of the village forest department committee or society under different sub-watersheds, comprehensive micro plan for execution of the work must be prepared as per norms. The micro plan for each beats of sub-watershed shall be prepared in consultation with the members of concerned VFDCs with due regards to the environmental functions and productive potential of the forests and their carrying capacity. For this purpose, a provision of Rs. 0.50 lakh is being made.

Provision for Proper Documentation

Emphasis should be laid on the publicity of the work proposed under the plan and work carried out on annual basis so that transparency is maintained and proper documentation of the work is carried out for future reference, and testing the efficacy of the work in due course of time. On this count, a provision of Rs. 0.50 lakh is proposed. The documentation would inter alia include implementation report, progress reports, photography, videography etc. Publication of the work done may be distributed to concerned panchayat and village Forest Development Committees/Societies for wider dissemination.

Provision for Monitoring and Evaluation

The success of implementation of a CAT Plan can be fathomed by increase in vegetal cover on hill slopes and the enhancement. Various engineering and biological measures have been aimed at treating degraded and potential areas of severe to very severe soil erosion by increasing soil holding capacity and thus reducing sediment flow in the water. Therefore, for recording soil and silt data at regular intervals one small laboratory/observatory shall be established at dam site, where the regular discharges of the streams and silt samples shall be monitored twice a day for ten years.

A close watch on annual basis shall be maintained in respect of such areas where habitat improvement works have been carried out to verify the work executed on site itself and also to ascertain the rate of survival of plants and / or any damage to the new work. For monitoring of works under forestry operation, the use of remote sensing technique by using digital satellite imagery of IRS P6 LISS-VI with high resolution should be made obligatory. The monitoring through satellite scene should be done before commencement of works under CAT plan and in a block of two years after completion of CAT plan. The work of monitoring of various works under the CAT plan should be entrusted to an external

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agency which has long experience of carrying out similar work on land use data and evaluating environment impact.

A provision of Rs. 1.50 lakhs being made for monitoring and evaluation activities including the expenditure likely to be incurred on conducting meetings / seminar / workshops at the head quarter and outside. This will include payments made to the non-official members of the monitoring evaluation committee on accounts of their expenditure on traveling and boarding etc. The payment to the external agencies shall also be met out from this part.

Provision for Providing Environmental Services

A provision of Rs.3.00 lakhs being made under this sub-head for carrying out such works, which enhance the environmental status and reduce the adverse impact on the environment and ecology. Funds for identified and approved activities for Payment for Environmental Services have also been provided under this component. The scheme inter-alia includes construction of contour trenches, incentives for fire protection on private as well as on government land/forests, provision of funds for live hedge fence on land and Payment for Environmental Services as per approved Forest Department activities and norms.

Fire management and control plan expenditure for the catchment area will be done under the PES Component. For success and survival of bioengineering plantations, protection against the fire will also be very important. In general protection against forest fire hazards and incidents following indicative action points are proposed to manage and control fire in the catchment area;

- To prevent and tackle fire incidences awareness campaign against the fire hazards and involvement of local people in controlling and prevention of fire incidences to be ensured.
- Identification of sensitive hot spots on past record and accordingly increased patrolling by deploying of appropriate manpower during fire-season.
- Maintenance of fire-lines as per the Working Plan.
- Winter control burning to be ensured as per the Working Plan.
- Strengthening of communication network to ensure timely and immediate response to tackle fire incidences.
- Enforcing fire rules and regulations especially during the fire season.
- Need based fire equipment be purchase and to be kept at appropriate places.
- Fire watchtowers and fire huts to house equipment and manpower during fire season be constructed based on requirement after getting approval from the Conservator of Forests.

Necessary veterinary assistance by providing medicines and other support to maintain hygiene and health of the animal stock based on the suggestions of local veterinary office will be provided at pre-identified sites along with time schedule to be worked out as per the migration period/ time. The cost

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of medicines and other assistance based on realistic assessment and inputs from Veterinary Office/ Department will be charged to PES.

Provision for Forest Protection

The need for rigorous watch and ward of the forest covered under the catchment area becomes more imperative in view of proposed new plantation under the CAT plan and due to increased human activity in the form of labour, who shall be engaged for forestry works. Thus, fire protection measures including construction and maintenance of fire lines, construction of check-posts, watch towers must be

undertaken. Besides these construction / repair of forest, boundary pillars shall also be carried out. The forest staff shall have to be properly equipped with modern utility gadgets like walky-talky, GPS and fire-fighting equipment's. For these a provision of Rs. 1.00 lacs is being earmarked.

INSTITUTIONAL MECHANISM

Role of Project Proponent

The Forest department would implement the Catchment Area Treatment Plan. A joint inspection group is suggested that would include officers drawn from State Forest Department and officials from the Environment Cell of state Water Resources Department. The management will have liaison with the forest officials. As far as the financial disbursement to undertake activity, involvement of various stake holders and collaborative public participation should be encouraged to have transparency in the system.

CAT Implementation

The designated Environmental Officer of state Water Resources Department would coordinate with the forest department for the implementation of the proposed Plan. The Environment Officer would evaluate/monitor financial aspects. The modalities of financial disbursement need to be worked out. The implementing agency shall submit completion certificate in the light of guidelines fixed by the state Forest Department. The implementation of CAT Plan should have enough flexibility and should be subject to changes as per requirements of specific ecosystem and periodic gains.

Project Monitoring and Reporting Procedures

Meetings would be held every three months to resolve problems arising in plan implementation. A Joint committee may be formed with the Environment Cell of Project Proponent and State Forest Department; the team members must ensure implementation and monitoring of the CAT works and review the progress from time to time. Quarterly progress reports and completion certificates would be submitted to Project Proponent for evaluation and disbursement of finance. In addition, the work done should be published through public awareness campaigns. Visual and print media may be used. Such efforts would resolve conflicts which otherwise are potential sources for project delays.

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SUMMARY OF COST OF WORKS

The cost of all works proposed in the CAT plan is enumerated in Table-5.14.

Table **Error! No text of specified style in document..13**: Cost Estimate of CAT Plan

S. No.	Particulars	Amount (Rs. In Lac)
1.	Habitat treatment works under free draining catchment	
(a)	afforestation (50 ha @ Rs. 170000/ ha)	85.00
	Sub- total (1)	85.00
2.	Soil and water conservation measures	
(a)	DSRM check dam (45 no. @Rs 24000/ha each)	10.80
(b)	Wire crate check dam (10 no. @ Rs 52700/each)	5.27
(c)	Contour staggered trenches (2.90km @Rs 32/km)	0.93
	Sub- total (2)	17.00
3	Other Components of CAT Plan	
(a)	Implementation of Support Infrastructure Cost	1.50
(b)	Provision for Micro Plan	0.50
(c)	Documentation	0.50
(d)	Provision for Monitoring and Evaluation Activities	1.50
(e)	Provision for providing Environmental Services	3.00
(f)	Forest Protection	1.00
	Sub- total (3)	8.00
	Grand Total.	110.00