CATCHMENT AREA TREATMENT PLAN

FOR

RENUKA DAM PROJECT IN SIRMAUR DISTRICT OF HIMACHAL PRADESH

Submitted to

HIMACHAL PRADESH POWER CORPORATION LTD.

Prepared By

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CATCHMENT AREA TREATMENT PLAN

1.1 INTRODUCTION

Land and water resources have optimum interaction and synergetic effect if developed in scientific and rational manner. In a larger sense land is represented by soil, which is usually susceptible to erosion due to various meteorological conditions such as total annual precipitation, snowfall, intensity of precipitation, wind velocity and directions, extent of vegetal cover and the topography of the catchment. The erosion of top soil from land reduces its fertility and the vegetation growth and increases sedimentation. Sedimentation of reservoir is a function of soil erosion rate of the river catchment area. It impinges upon the useful capacity of reservoir, water quality and the availability of water for its designated use as also life of various components of project using the water. Thus, no water resources scheme of medium and major classification can be successful by keeping in seclusion from it the most interactive gradient of nature i.e. land. Therefore, it becomes imperative to evolve a plan based on scientific approach to prevent soil erosion to the extent possible.

The study of erosion and sediment yield from catchments is of utmost importance as the deposition of sediment in reservoir reduces its capacity, thus affecting the water availability 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 important factor that adds to the sediment load, and which contributes to soil degradation is grazing pressure. A large number of cattle, sheep, and goats graze the pastures during summer season continuously for about six months. Due to this pressure, the productivity of these pastures is also declining further. 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 suitably address 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.

Watershed is the basic unit of a catchment. Watershed is a natural hydrological and geographic unit of specific spatial extent characterized by surface run-off confined to a defined course at a particular point. The boundary of the watershed is delineated by the line of water divide in a basin with reference to specific point drainage. The pre-requisite for a watershed management is the collection of multipronged data e.g., geology, geomorphology, topography, soil, landuse/landcover, climate, hydrology,

drainage pattern, etc. The catchment of the "Renuka Dam Project" consists of 13 micro watersheds. The multipronged 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 Treatment is presented here.

As a part of the EIA study for the proposed "Renuka Dam Project", a Catchment Area Treatment (CAT) plan for the free draining and directly draining catchment area (Figure 1.1) 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 of 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 reducing total sediment flow in the reservoir and flowing waters.

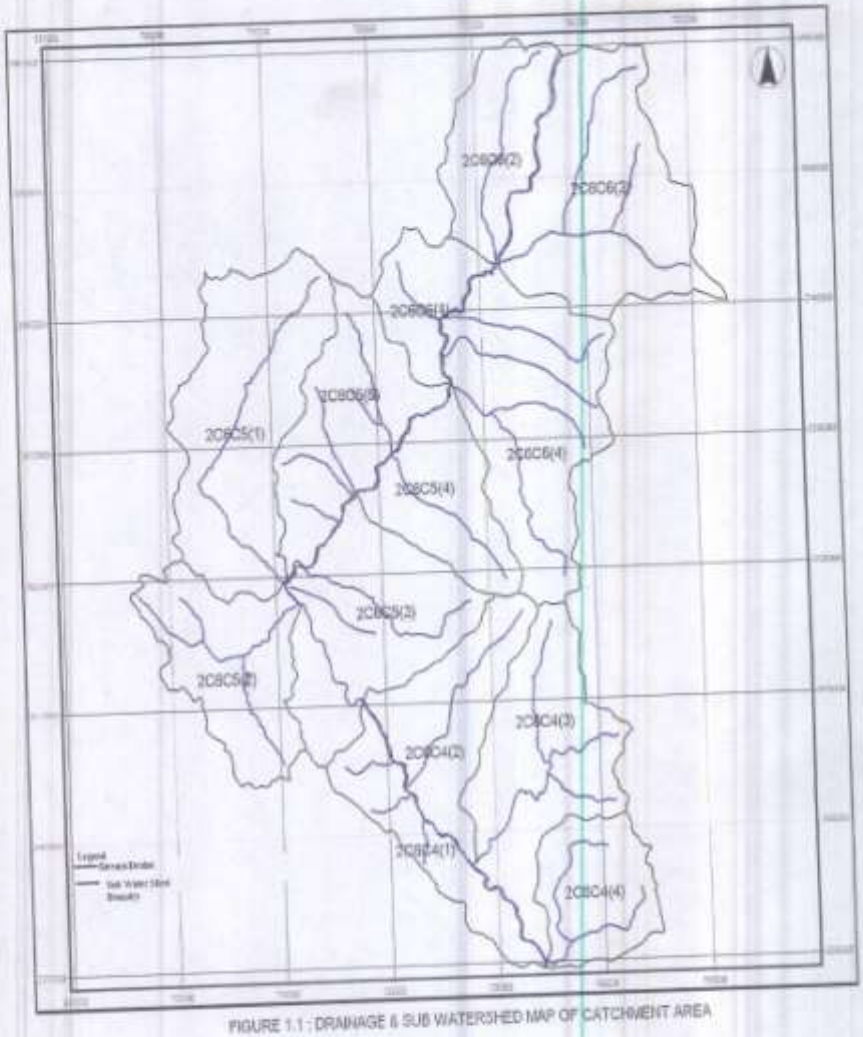

FIGURE 1.1 : DRAINAGE & SUB WATERSHED MAP OF CATCHMENT AREA

1.2 OBJECTIVES

Integrated watershed management is aimed at minimizing 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 the river and its tributaries.
2. Conservation of soil cover and to reduce 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 watersheds for treatment on the basis of 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. To meet the livelihood requirement of local people and broaden livelihood options.
8. Employment generation and community participation
9. Ecosystem conservation resulting from increased vegetal cover and water retaining properties of soil.

1.3 CATCHMENT AREA

The catchment area of river Giri and its tributaries upto the proposed dam site 1.5 km upstream of Dadahu town is 2175 sq km lying between EL 630 m to 3647 m above msl. The reservoir shall extend 24 km along river Giri and 3.5 km and 2.5 km inside Jogar ka Khala and Palar ka Khala, respectively. The present study is confined to an area of 2175 sq km, which is the free draining catchment as of now there is no river valley project upstream of the proposed dam project. There are three sanctuaries exists within Giri catchment viz. Churdhar, Chail and Renuka extending over 56.59 sq km, 110.04 sq km and 7.02 sq km, respectively.

As per nomenclature contained in Watershed Atlas of India, Edition 1990, the catchment area under study lies in Water Resources Region - 2; Basin 2C, Catchment 2C6; Sub catchment 2C6C watersheds 2C6C4 Palar and Jalal streams, 2C6C5 Ashni and 2C6C6 Upper Giri and Basri river falling partly in districts Solan, Simla and Sirmaur of Himachal Pradesh. Catchment Area Treatment Plan has been formulated for the free draining catchment. The Satellite data subset of IRS P6 (LISS-III, 2006) of the free draining catchment is presented in Figure 1.2.

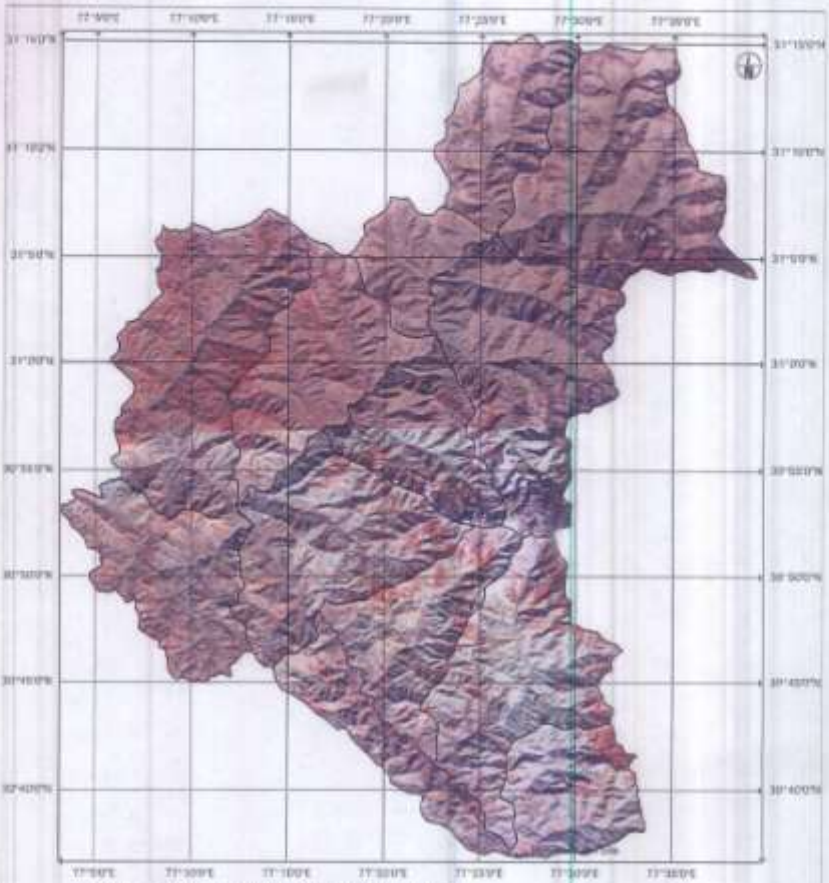

FIGURE 1.2 : SATELLITE IMAGERY OF CATCHMENT AREA
(IRS P6, LISS III SENSOR)

1.3.1 Basin Characteristics of River Giri

River Giri and its major tributaries viz. Ashni or Assan, Kawali, Basari Nadi, Banala Nadi, Chotti Nadi, Pervi Nadi, Nait ka Khala, Pallor ka Khala, Jogar ka Khala, and Jalal ka Khad constitute the river basin of river Giri. River Giri originates form Kupar Tibba within Chambi RF at an elevation (El) of 3360 m in mid Himalayas ranges and is a spring fed river. River Ashni which assimilates the drainage form Southern parts of Shimla and Solan hills originates from peak at El 2632 m located in Patgihar and confluences with river Giri near Yashwant nagar. Dense mixed jungle mainly pine lying under water works catchment RF and Nahar PF near Kufri constitute Shimla Municipal Catchment Forest in the Giri Catchment. Shimla waterworks catchment RF is maintained for water supply to Shimla town. River Basari, which confluences with river Giri at Neri, originates form Chambi R.F. at peak elevation of 3009 m above msl. Jalal ka Khad which brings substantial discharge meets river Giri d/s of Dadahu town. The basin is characterised by mountainous terrain with steep hill slopes. River Giri on its descend form Dadahu to its confluence with river Yamuna opposite Assan Barrage flows in a wider valley. Giri river owing to its low longitudinal gradent does not have major hydro power potential. Run-of-the-river (R-o-R) type of project are not feasible in this river owing to small regular flows and poor gradient. One R-o-R type project namely Giri-Bata (60 MW) project impounds water at Jataun Barrage which is 5 km. downstream of Dadahu township and release the water at Majri in Bata river via a power house located near Girinagar. Bata river joins River Yamuna at Bata Mandi about 2 km downstram of Paonta Sahib town.

Renuka dam project is conceived as a drinking water supply project for NCT Ddelhi storing the monsoon water and releasing the same about 23 cumecs during non-monsoon lean season period from month of September to June. Power generation of 40 MW is purely incidental.

1.3.2 Free Draining Catchment

The basin upto the proposed dam site 1.5 km. upstream of Dadahu bridge lies between Longitude 77°03'12" to 77°39'10" E and Latitude 30°36'51" to 31°15'23" N. The free draining catchment area of "Renuka Dam Project" measures 2175 sq km upto the proposed dam site.

The major tributaries participating in the free draining catchment of river Giri are spring fed hill torrents viz. Ashni, Kawali, Kiyar ka Khala, Chagaunti Gad, Chakred Khad Mangled Khala, Ghai Nala meeting the main river on its right bank and Basari, Banala, Arkat Khala, Chotti, Pervi, Nait ka Khala, Pallar and Jogar ka Khala meet it on the right bank.

The free draining catchment is divisible into three sub-water sheds having 13 micro watersheds. The aerial extents of which is shown in Table 1.1 and Figure 1.1.

1.3.2.1 Micro-watershed Parara [2C6C4(1)]

This micro-watershed, which constitutes 4.34% of the total catchment of river Giri at dam site is located on right bank of river Giri and has a geographical area of 94.40 sq km The predominant land use is under dense vegetation (45.21 sq km) followed by light vegetation (19.18 sq km). Dawan Ka Khala is the major drainage in this micro-watershed which has highest peak at EL 1956 m. above msl near Chabate.

1.3.2.2 Micro-watershed Nait Ka Khala [2C6C4(2)]

This micro-watershed, which constitutes 6.28% of the total catchment of river Giri at dam site is located on left bank of Giri and has a geographical area of 136.60 sq km The predominant land use is under dense vegetation (57.95 sq km) followed by agriculture and settlements (31.13 sq. k.). Nati ka Khala is the main drainage in the micro-watershed and has Jalta Ka Khala and Makra ka Khala as its tributaries. The heighest peak is near Tisari at El. 3381 m. above msl.

1.3.2.3 Micro -watershed Palar Ka Khala [2C6C4(3)]

This micro-watershed which constitutes 9.64% of the total catchment of river Giri at dam site in located on left bank of Giri and has a geographical area of 209.70 sq km The predominant land use is under dense vegetation (80.67 sq km) followed by agriculture and settlement (30.80 sq km). Palar Ka Khala is the major drainage in the micro-watershed which has highest peak 3544 m above msl at Uchehen Tibba in Churu RF.

1.3.2.4 Micro-watershed Jogar Ka Khala [2C6C4(4)]

This micro-watershed, which constitutes 5.00% of the total catchment of river Giri at dam site is located on right bank of Giri and has a geographical area of 108.87 sq km The presnominant land use is under dense vegetation (41.07 sq km) followed by agriculture and settlement (28.27 sq km). Jogar Ka Khala and Athal Ka Khala are the two main drainage in the micro-watershed. Situated in Ghaton RF Mandul at EL 2471 is the highest point of the micro-watershed.

1.3.2.5 Micro-watershed Ashni [2C6C5(1)]

This micro-watershed, which constitutes 12.15% of the total catchment of river Giri at dam site has a geological area of 264.32 sq km The predominant land use is under dense vegetation (146.96 sq km) followed by agriculture and settlement (41.92 sq km). The micro-watershed has Ashni or Assan river as the major river which meet Giri near Yashwantnagar. Ashni river drains areas like Solan, Kandaghat and Chail. Kyar Ka Khala, Shamri Nala, Gad Ki Nala, Katali Ka Nala are the tributaries of Ashni river. The micro-watershed also encompasses the famous waterworks catchment RF from which municipal water supply to Shimla town is being made. The highest point at El. 2632 m exists at Patgaihar R. F. in the sub-watershed.

1.3.2.6 Micro-watershed Kawali Nadi [2C6C5(2)

The micro-watershed which constitutes 7.40% of the total catchment of River Giri at dam site has a geological area of 161.08 sq km The predominant land use is dense vegetation (72.31 sq km) followed by light vegetation (42.86 sq km). Kawali Nadi which meets river Giri near Pothshal is the major drainage flowing in the micro-watershed. The highest point is at El. 1899 m. above msl and is near Bhur Singh Devta.

1.3.2.7 Micro-watershed Pervi Khala [2C6C5(3)]

The micro-watershed, which constitutes 9.67% of the total catchment of River Giri at dam site has a geographical area of 210.38 sq km The predominant land use under dense vegetation (98.21 sq km) followed by shrub/grass (37.49 sq km) Pervi Ka Khala is the major drainage which meets river Giri near Pathshal. Arkat Khala and Bagri Ka Khala are some of the important torrents in the sub-watershed, which has highest peak at El. 2962 m. above msl in Setabu RF.

1.3.2.8 Micro-watershed Bajhetu Ka Khala [2C6C5C4)]

The micro-watershed, which constitutes 5.67% of the total catchment of River Giri at dam site has geographical area of 123.28 sq km The predominant land area is under dense vegetation (73.03 sq km) followed by agriculture and settlement (24.24 sq km). Bajhetu Ka Khala, which originates from Julhasan Tibba at El 3394 m above msl is the main drainage which mets river Giri near Kaleyan, Khari Ka Khala is the other major torrent of the micro-watershed.

1.3.2.9 Micro-watershed Tir Mahasu [2C6C5(5)]

This micro-watershed, which constitutes 7.81% of the total catchment of river Giri at dam site has a geographical area of 169.71 sq km The predominant land use is under dense vegetation (72.06 sq km) followed by agricultures and settlement (49.30 sq km). Chakrad Khad which originates from Mahasu at El 2731 m above msl and Mangled Khala are the major drains in the micro-watershed.

1.3.2.10 Micro-watershed Theog [2C6C6(1)]

The micro-watershed which constitutes 3.39% of the total catchment of river Giri at dam site has a geographical area of 73.66 sq km The predominant land use is under agriculture and settlement (33.90 sq km) followed by dense vegetation (26.03 sq km) Ghui Nala, Patala Ka Khala and Lefe Ka Khala are some of the rivulets of the micro-watershed which has the highest point of El. 2527 m above msl near Bishong.

1.3.2.11 Micro-watershed Kyer Ka Khala [2C6C6(2)]

This sub-watershed which constitutes 5.46% of the total catchment of river Giri at dam site has a geographical area of 118.67 sq km The predominant land use is under dense forest (51.78 sq km) followed by agriculture and settlement (39.45 sq km). Kyar Ka Khala which meets river Giri near Bishog is the major hill rivulet following

in the micro-watershed which has the highest peak at El. 3187 m above msl near Janog in Hatu PF.

1.3.2.12 Micro-watershed Tharu [2C6C6(3)]

This micro-watershed which constitutes 11.69% of the total catchment of river Giri at dam site has a geographical area of 254.22 sq km The predominant land use is under dense vegetation (130.39 sq km) followed by agriculture and settlement (71.81 sq km). Chagaunti gad, Gartola Nala and Daran gad are major hill rivulets flowing in the area. Chagaunti gad meets with river Giri at a place near Maghali. Hatu dhar has the highest peak at El. 3138 m above msl in the micro-watershed.

1.3.2.13 Micro-watershed Bassari [2C6C6(4)]

This micro-watershed which constitutes 11.50% of the total catchment of river Giri at dam site has a geographical area of 250.11 sq km The predominant land use is under dense forest (134.66 sq km) followed by agricultue and settlement. River Giri originates in the form of Giri Nala from Kuppar Tibba in Chambi Kupar RF which is dense mixed jungle mainly pine. Chur at El 3647 m above msl is the highest peak in this micro-watershed and also in the catchment of River Giri.

Table 1.1: Hydrological Units

Giri Sub-catchment	Sub Water shed code and streams covered	Micro water shed code	Name of Micro water shed	Area (sq km)
Free draining catchment 2175 sq km	2C6C6 upper Giri and Basari Nadi	2C6C6 (1)	Theog	73.65
		2C6C6 (2)	Kiyar ka Khed	118.67
		2C6C6 (3)	Tharu	254.21
		2C6C6 (4)	Bassari river	250.12
	2C6C5 Ashni or Assan River	2C6C5 (1)	Ashni	264.33
		2C6C5 (2)	Kawali Nadi	161.08
		2C6C5 (3)	Pervi Khala	210.37
		2C6C5 (4)	Bajhetu ka khala	123.28
		2C6C5 (5)	Tir Mahasu	169.71
	2C6C4 Palar, Jogar Ka-Khath	2C6C4 (1)	Parara	94.39
		2C6C4 (2)	Nait ka khala	136.61
		2C6C4 (3)	Pallor ka khala	209.69
		2C6C4 (4)	Jogar ka khala	108.87
		Total		2174.98

Say 2175 sq km

1.4 TOPOGRAPHY

The project on river Giri lies in the hill district Sirmaur of Himachal Pradesh and physiographically the area is covered under Sub-Himalayas consisting of Shivalik ranges and quaternary sediment. The longitude of catchment area varies from 77°03'12" to 77°39'10"E and the latitude from 30°36'51" to 31°15'23" N.

Churdhar and Haripurdhar in the North-East and Saindhar etc. emanating from North-West of the main site of the dam area about 2 km away from Dadahu / Renukaji. Of these three mountainous ranges, Chrudhar has comparatively higher altitudes of about 3647 m. The average altitudes are generally around 3360 to 3647 m of these

mountains. The lowest altitude of 630 m is at the dam axis in the riverbed 1.5 km upstream of permanent bridge of Giri river at Dadahu. The location of Dadahu is 35 kms from Nahan, headquarters of district Sirmour (Himachal Pradesh). The valley is slightly narrow on upstream upto village Siyun, about 18 km away from Dam site and wider therefrom upto village Khairi 6 km. The profile of river Giri downstream dam axis is quite wider upto the confluence with Yamuna river 50 km from dam site. Both the bank spurs have very steep precipitous slopes right from the river banks to hilltops, interspersed with partly rocky portions, with the result that there is practically less habitation along the spurs. These slopes on higher reaches are supporting healthy forest of Deodar, Kail and Fir, and the slopes along the river banks contain Khair and Sheesham forests. The low lying area along the river is fairly populated and there are about 250 vilalges/hamlets. Besides the principle valley of Giri, Ashni and Basri river, there are numerous smaller streams cutting up the ground into numerous ridges and ravines. Elevation of free drainage catchment ranges from 630 m to 3647 m above msl (Figure 1.3a). The Aspect map is presented as Figure 1.3 and the digital elevation model of catchment area is shown in Figure 1.4.

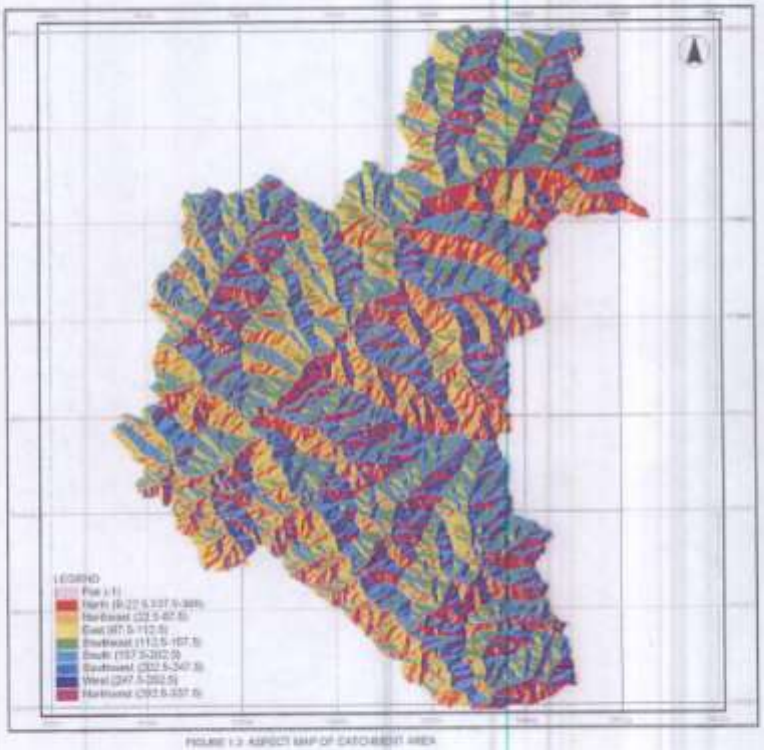

FIGURE 1.3 ASPECT MAP OF CATCHMENT AREA

Distance from Origin of Giri River(km)	Elevation(m)
0	3360
0.6	3200
1	3000
2.1	2800
3.7	2600
4.7	2400
7.3	2200
13.1	1720
14.1	1680
20.5	1480
25.5	1400
30	1280
36	1200
46.5	1080
56.3	1000
61.8	920
69	900
78	848
87	800
92	760
102	700
111	640
114	630
119	618
124	580
129	555
134	530
139	508
144	440
154	415

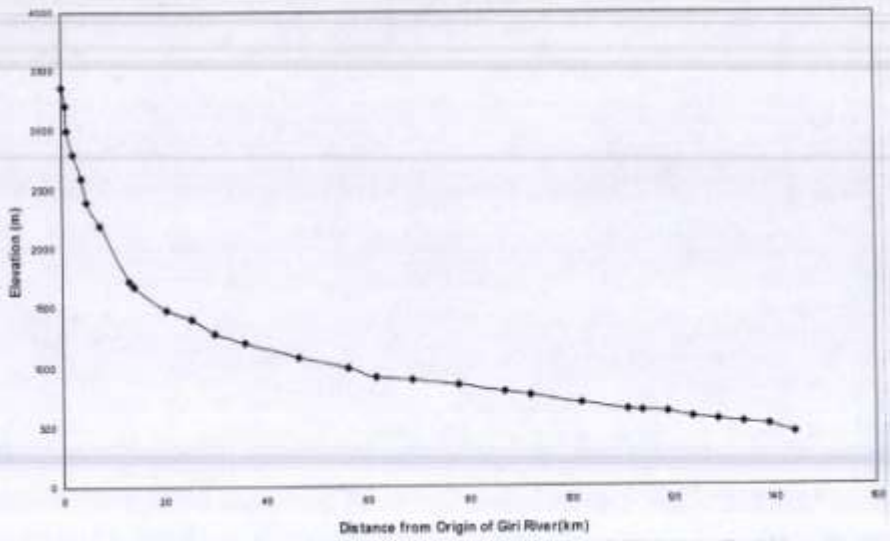

Figure 1.3a : Longitudinal Section of River Giri

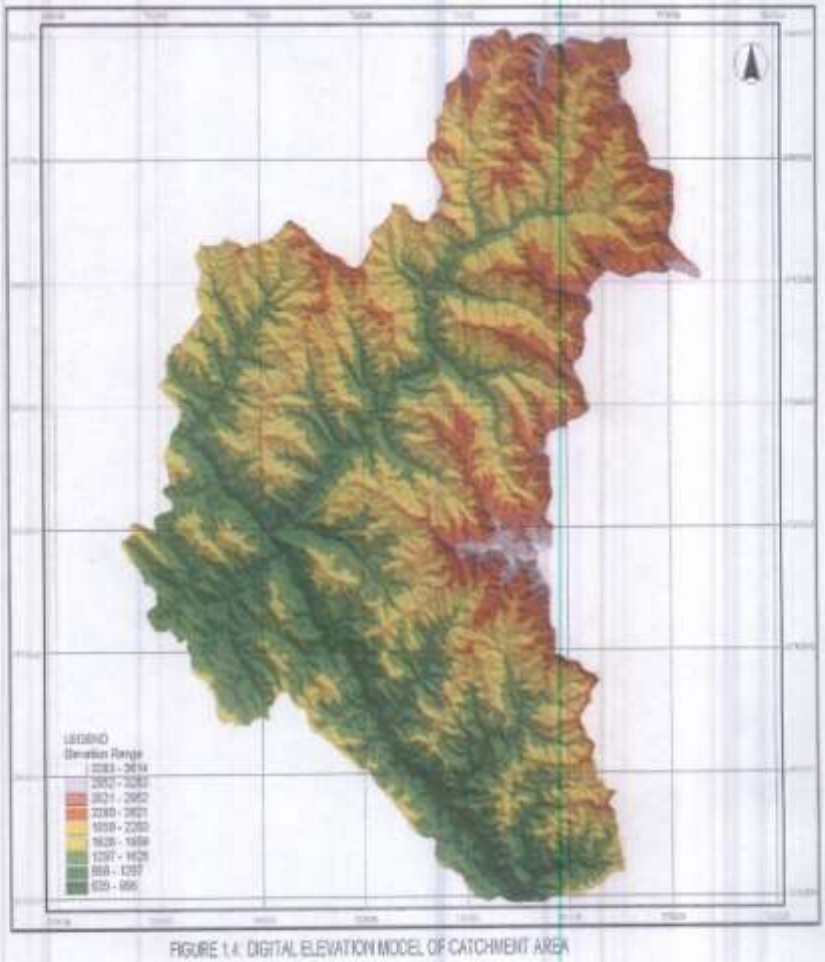

FIGURE 1.4: DIGITAL ELEVATION MODEL OF CATCHMENT AREA

1.5 SOIL

Physiography provides useful clues to understanding of soil types of the area. Runoff is another phenomenon controlled by physiography and slopes. The influence of slope on runoff is modified by soil properties and vegetation. Soil thickness, infiltration and permeability are the main characteristics of the soils that have bearing on runoff moderation. Thus, these parameters give qualitative prediction of the sediment yield from the different parts of catchment area.

The soil in the project area is derived from schist, shale and quartzite and is usually loamy or clayey loam. Rather poor and dry on southern aspects but of fair quality and moist elsewhere. The soil is generally fertile and porous. Based on a 3 Tier approach (Landform analysis, field survey and laboratory investigation), soil resources map of Himachal Pradesh has been prepared and used in present study. The soil map of free draining Catchment area is presented in Figure 1.5.

The soil has developed under unique environment of natural forest vegetation. The surface layer upto 15-20 cm is of reddish brown to yellowish colour, loamy with loose and un-decomposed organic matter and rich in humus at depths ranging from 15-50 cm.

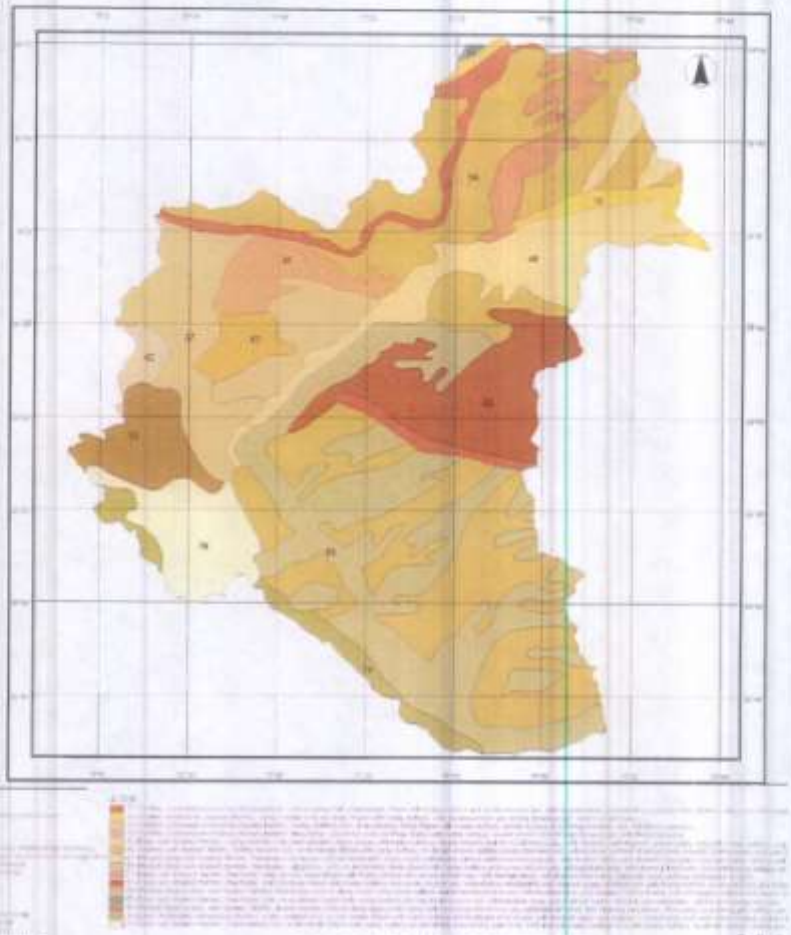

FIGURE 1.3: SOIL MAP OF CATCHMENT AREA

1.6 METHODOLOGY USED FOR THE STUDY

The Digital Satellite data of IRS P6 LISS-III (2006) acquired from NRSA was evaluated on ERDAS Imagine Software. The standard False Colour Composite (FCC) has been generated by assigning blue, green and red colors to visible green, visible red and near infrared bands respectively. Expressing image pixel addresses in terms of a map coordinate base is often referred to as geo-coding. As various thematic layers were to be overlaid for this project, all the layers were geo-referenced to real world coordinates. The 1:50,000 scale toposheets of the directly draining catchment area were used for the purpose of geo-referencing. A large number of Geodetic Control Points (GCPs) were selected for reasonably accurate geo- referencing/geo-coding. A map projection system (real world) was also defined.

Histogram of the scene under study has been generated to check the range of spectral values present in the scene. In order to use total grey level range and to optimize the contrast, the actual grey level ranges of three bands were linearly stretched independently. The zoomed images were studied wherever necessary. The interpretation key necessary for identifying different features has been developed systematically on the basis of image characteristics and associated elements viz. shape, size, shadow, pattern, color/tone, texture, association, location and available ground truth. Among these characteristics shape, size, shadow and pattern are basically dependent on the scale of the image whereas the color/tone and texture depends upon the brightness, contrast and resolution of the image. Various land units were identified, delineated and the map was validated.

Detailed field survey was conducted for study of soil characteristics, and erosion prone areas and landslides in the catchment area. The vulnerable and problematic areas were identified in different physiographic zones in the entire catchment area.

The data was generated on physiography, land-use/land-cover, lithology, geomorphological structure, drainage pattern, slope characteristics, landslides/slips, etc. These data sets were used for preparation of the thematic maps, calculation of sediment yield index and Erosion Intensity Units in the catchment area according to the following procedures:

1.6.1 Landuse – Landcover Classification

- Prior to ground truthing, the satellite data was classified using unsupervised classification technique. Further after collecting ground truth details maximum likelihood classification based supervised classification method was used with remote sensing image data.
- After the supervised classification procedure, a land-use map was prepared which the team at field verified, and any errors or omissions were identified.
- A reclassification of the land-use categories implementing the details and corrections was done. The reclassification output was used for the preparation of the final land-use classification map. This map after due verification was then composed and printed for different layers and purposes.
- The Landuse map of Study and Free draining Catchment area is presented in Figure 1.6. The Land-use Land-cover details for free-draining catchment and its sub watershed is presented in Table 1.2.

FIGURE 1.6 : LANDUSE CLASSIFICATION OF CATCHMENT AREA

Table 1.2: Land-use Land-cover Details

S. No.	MWS No.	Water Bodies	Barren Areas	Agricultural Land	Dense Vegetation	Light Vegetation	Shrubs/Grasses/Bushes	Snow Covered Areas	Settlement	Total (Area in Sq Km)	% of Total
1	2C6C4(1)	1.42	0.40	13.36	45.21	19.18	14.80	0.00	0.04	94.40	4.34
2	2C6C4(2)	1.33	0.40	30.28	57.95	22.51	23.29	0.00	0.85	136.60	6.28
3	2C6C4(3)	2.43	2.64	53.68	80.67	30.80	37.68	0.00	1.78	209.70	9.64
4	2C6C4(4)	1.13	1.12	27.54	41.07	15.49	21.19	0.00	1.33	108.87	5.00
5	2C6C5(1)	0.42	0.00	35.52	146.96	32.46	40.52	2.04	6.40	264.32	12.15
6	2C6C5(2)	0.84	0.00	17.82	72.31	42.86	27.22	0.00	0.03	161.08	7.40
7	2C6C5(3)	2.15	0.25	34.65	98.21	37.26	37.49	0.00	0.38	210.38	9.67
8	2C6C5(4)	0.20	0.51	20.97	73.03	8.52	14.90	1.89	3.27	123.28	5.67
9	2C6C5(5)	0.58	0.00	43.70	72.86	15.88	26.08	5.01	5.60	169.71	7.81
10	2C6C6(1)	0.00	0.00	26.11	26.03	1.24	11.16	1.33	7.79	73.66	3.39
11	2C6C6(2)	0.00	0.00	32.15	51.78	1.66	10.87	15.01	7.20	118.67	5.46
12	2C6C6(3)	0.00	0.00	56.46	130.39	4.04	24.23	21.74	15.35	254.22	11.69
13	2C6C6(4)	0.00	1.35	57.93	134.66	9.03	24.84	6.30	16.01	250.11	11.50
	Total	10.49	6.66	450.17	1031.11	240.94	314.28	55.32	66.03	2175.00	100.00
	% of Total	0.48	0.31	20.70	47.41	11.07	14.45	2.54	3.04	100	-

1.6.2 Slope Map Preparation

- Slope is a measure of change in the value of altitudes over distance, which can be expressed in degrees or as a percent. The first step in generation of slope map is to create surface using the elevation values stored in the form of contours or points. Surface is a representation of geographic information as a set of continuous data in which the map features are not spatially discrete, i.e., between any two locations, there are no clear or well defined breaks between possible values of the map feature. Models, built from regularly or irregularly spaced sample points on the surface can represent surfaces.

- Slope map of the catchment area was prepared using the elevation information for the area from contour heights. Toposheets of the scale 1:50,000 were collected for the entire directly draining catchment area. These toposheets were then manually pasted together to form a seamless mosaic of the area and the directly drained catchment boundary for the proposed "Renuka Dam Project" was marked on them.

- After marking the catchment area, all the contours on the toposheet were digitized. The output of the digitization procedure was the contours as well as points contours in form of x, y and z points (x, y location and z their elevation). All this information was in real world coordinates (latitude, longitude and elevation in meters above sea level).

- A Digital Terrain Model (DTM) of the area was then prepared, which was used to derive a slope map. The slope was divided in classes of slope percentages.

- The slope of a watershed plays an important 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 segments of the watershed into suitable capability classes for formulating suitable soil erosion conservation measures. Broadly the following slope classes and ranges as per norms of All India Soil and Land Use Survey (AISLUS) were adopted for the present study. The slope types are presented in Table 1.3.

Table 1.3: Slope Types

Slope Rank	Slope Range (%)	Description
1.	0-20	Very gentle slope
2.	20-35	Gentle slope
3.	35-50	Moderate slope
4.	50-80	Steep slope
5.	Above 80	Very steep slope

The slope map of the free draining catchment is presented in Figure 1.7. The slope details are as presented under Table 1.4.

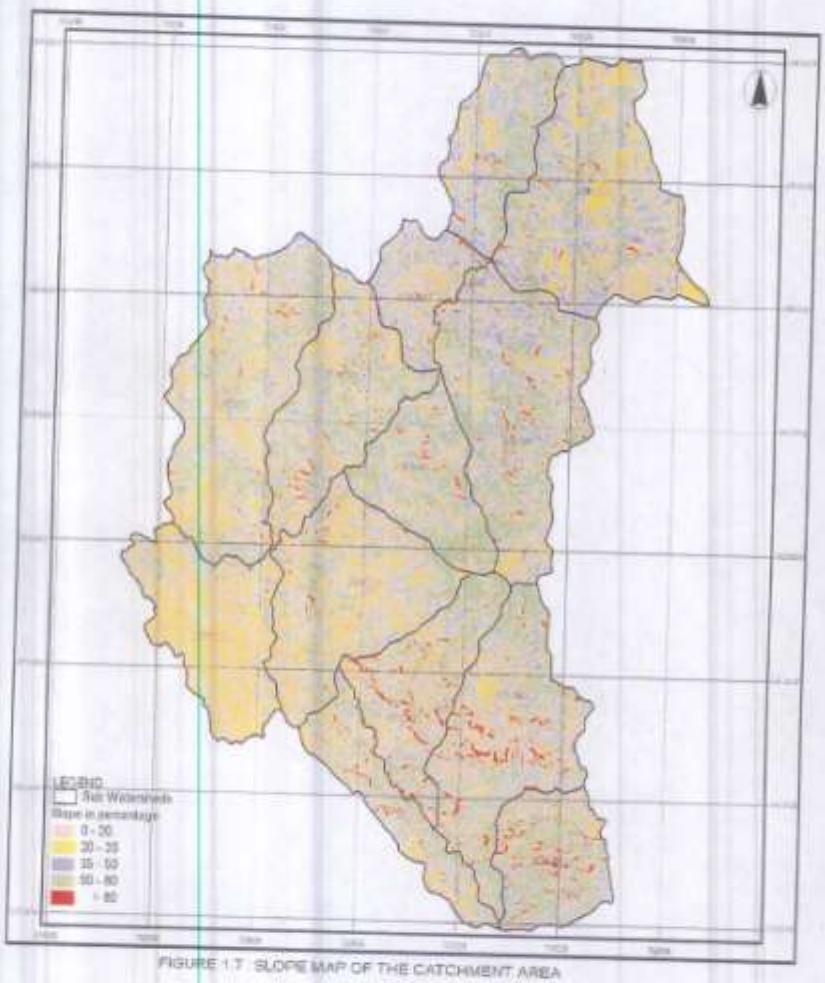

FIGURE 1.7 SLOPE MAP OF THE CATCHMENT AREA

Table 1.4: Slope

S. No.	MWS No.	Slope										Total (Area in Sq km)
		0-20%		20-35%		35-50%		50-80%		>80%		
		Area	%	Area	%	Area	%	Area	%	Area	%	
1	2C6C4(1)	9.47	10.03	16.85	17.85	24.13	25.56	39.84	42.20	4.12	4.36	94.40
2	2C6C4(2)	9.45	6.92	19.68	14.41	36.53	26.74	61.78	45.23	9.15	6.70	136.60
3	2C6C4(3)	10.23	4.88	31.77	15.15	63.18	30.13	90.57	43.19	13.95	6.65	209.70
4	2C6C4(4)	5.52	5.07	13.33	12.24	26.71	24.53	53.56	49.20	9.75	8.96	108.87
5	2C6C5(1)	22.97	8.69	61.01	23.08	88.42	33.45	86.83	38.85	5.10	1.93	264.32
6	2C6C5(2)	30.73	19.08	62.08	38.54	44.81	27.82	22.44	13.93	1.01	0.63	161.08
7	2C6C5(3)	19.06	9.06	51.08	24.28	69.95	33.26	66.57	31.54	3.91	1.86	210.38
8	2C6C5(4)	5.52	4.48	16.85	13.67	34.27	27.80	62.15	50.41	4.49	3.64	123.28
9	2C6C5(5)	11.08	6.53	30.96	18.24	52.51	30.94	69.05	40.69	6.11	3.60	169.71
10	2C6C8(1)	4.26	5.78	13.95	18.94	29.27	39.75	24.48	33.24	1.69	2.29	73.66
11	2C6C8(2)	4.28	3.61	18.41	15.51	43.55	36.70	49.24	41.49	3.19	2.69	118.67
12	2C6C8(3)	10.35	4.07	59.51	23.41	98.64	38.80	80.21	31.55	5.52	2.17	254.22
13	2C6C8(4)	9.89	3.92	36.14	14.45	80.01	31.99	113.55	45.40	10.60	4.24	250.11
Total		152.74	100.00	431.61	100.00	691.97	100.00	820.07	100.00	78.59	100.00	2175.00
% of Total Catchment		7.02		19.84		31.80		37.74		3.60		

1.6.3 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 by 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 (Department of Agriculture, Govt. of India) was followed in this study.

(i) Erosion Intensity and Delivery Ratio

- Determination of erosion intensity unit is primarily based upon the integrated information on soil characters, physiography, slope, landuse/land-cover, lithology and structure. This is achieved through superimposition 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 conducted during field work and published data, weightage and delivery ratio was assigned to each erosion intensity unit. The composite erosion intensity map was then superimposed on the drainage map with subwatershed boundaries to evolve Composite Erosion Intensity Unit (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 indicates 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 ratio 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 important factor responsible for delivery of the sediments) according to the following scheme. The delivery ratio criteria adopted for the study is presented in Table 1.5.

Table 1.5: Delivery Ratio (DR) Criteria Adopted for the Project
Nearest Stream Delivery Ratio (DR)

Sl. No.	Nearest Stream Distance (Km.)	Delivery Ratio
1.	0 - 0.9	1.00
2.	1.0 - 2.0	0.90
3.	2.1 - 5.0	0.80
4.	5.1 - 15.0	0.70
5.	15.1 - 30.0	0.50

(ii) Sediment Yield Index (SYI) and Prioritization of Sub-Watersheds

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

- The SYI is defined as the Yield per unit area and SYI value for hydrologic unit is obtained by taking the weightage arithmetic mean over the entire area of the hydrologic unit by using suitable empirical equation.

- Prioritization of sub-watersheds/ micro-watersheds within the vast catchments is based on the Silt Yield Indices (SYI) of the smaller units. The boundary values or range of SYI values for different priority categories are arrived at by studying the frequency distribution of SYI values and locating the suitable breaking points. 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
- Geomorphic factors comprising land forms, physiography, slope and drainage characteristics,
- Surface cover factors governing the flow hydraulics
- Management factors.

- The data on climatic factors were obtained for different locations in the catchment area from the meteorological stations whereas the field investigations were carried for estimating the other attributes.

- The various steps involved in the application of model are
  - Preparation of a framework of sub-watersheds through systematic delineation
  - Rapid reconnaissance surveys on 1:50,000 scale leading to the generation of a map indicating erosion-intensity mapping units.
  - 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.
  - Assignment of weightage values to various mapping units based on relative silt-yield potential.

- 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 = Σ (Ai x Wi x Di) x 100 / Aw, where i = 1 to n

Where,
Ai = Area of ith unit (EIMU)
Wi = Weightage value of i^{th} mapping unit
Di = Delivery ratio
n = No. of mapping units
Aw = Total area of sub-watershed

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

Sl. No.	Priority Category	SYI Range
1.	Very High	> 1300
2.	High	1200-1299
3.	Medium	1100-1199
4.	Low	1000-1099
5.	Very low	< 1000

(Refer pp 27-28 of AISLUS Bulletin-9)

Accordingly the sediment yield Index (SYI) was calculated for 13 micro-watersheds and were categorized into five erosion ranking classes i.e., very High, High, moderate, and low according to priorities. These prioritized watersheds would require treatment according to their priority ranking for soil conservation measures. The details are given in Table 1.6 and the prioritization of micro watershed is shown in Figure 1.8.

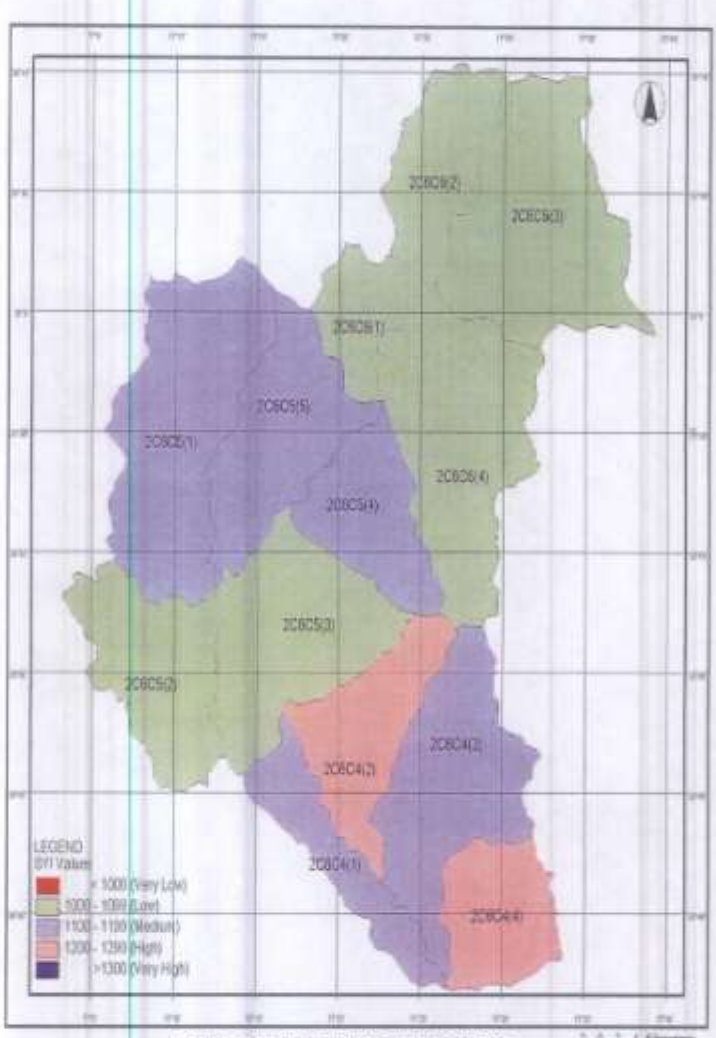

FIGURE 1.8 PRIORITIZATION OF SUB WATERSHEDS

Table 1.6: SYI and Priority Rating as per Erosion Intensity

MWS Code	Erosion Intensity Class	Area (Ha)	Weightage	Weightage X Area	DR	Gross Silt (ExF)	SYI	Priority	Area for CAT (Sq km)
A	B	C	D	E	F	G	H	I	J
2C6C4(1)	Negligible	1273	10	12730	1	12730	1175	Medium	
	Slight	2203	11	24233	0.9	21809.7			
	Moderate	3752	13	48776	0.9	43898.4			18.01
	Severe	1801	18	32418	0.8	25934.4			4.11
	V. Severe	411	20	8220	0.8	6576			**22.12**
	Total	**9440**							
2C6C4(2)	Negligible	1344	10	13440	1	13440	1258	High	
	Slight	2943	11	32373	1	32373			
	Moderate	5996	13	77948	0.9	70153.2			27.28
	Severe	2728	18	49104	0.9	44193.6			6.49
	V. Severe	649	20	12980	0.9	11682			**33.77**
	Total	**13660**							
2C6C4(3)	Negligible	1812	10	18120	1	18120	1128	Medium	
	Slight	5073	11	55803	0.9	50222.7			
	Moderate	9121	13	118573	0.8	94858.4			38.01
	Severe	3801	18	68418	0.8	54734.4			11.63
	V. Severe	1163	20	23260	0.8	18608			**49.64**
	Total	**20970**							
2C6C4(4)	Negligible	981	10	9810	1	9810	1208	High	
	Slight	2084	11	22924	0.9	20631.6			
	Moderate	4647	13	60411	0.8	48328.8			24.72
	Severe	2472	18	44496	0.9	40046.4			7.03
	V. Severe	703	20	14060	0.9	12654			**31.75**
	Total	**10887**							
2C6C5(1)	Negligible	4166	10	41660	0.9	37494	1125	Medium	
	Slight	8252	11	90772	0.9	81694.8			
	Moderate	10969	13	142597	0.9	128337.3			27
	Severe	2706	18	48708	0.9	43837.2			3.39
	V. Severe	339	20	6780	0.9	6102			**30.39**
	Total	**26432**							
2C6C5(2)	Negligible	4244	10	42440	0.9	38196	1014	Low	
	Slight	6692	11	73612	0.9	66250.8			
	Moderate	4275	13	55575	0.8	44460			
	Severe	763	18	13734	0.9	12360.6			1.34
	V. Severe	134	20	2680	0.8	2144			**1.34**
	Total	**16108**							
2C6C5(3)	Negligible	2911	10	29110	1	29110	1090	Low	
	Slight	6959	11	76549	0.9	68894.1			
	Moderate	8531	13	110903	0.8	88722.4			
	Severe	2214	18	39852	0.9	35866.8			4.23
	V. Severe	423	20	8460	0.8	6768			**4.23**
	Total	**21038**							

2C6C5(4)	Negligible	1287	10	12870	1	12870			
	Slight	2566	11	28226	0.9	25403.4			
	Moderate	5965	13	77545	0.8	62036	1110	Medium	
	Severe	2271	18	40878	0.8	32702.4			22.71
	V. Severe	239	20	4780	0.8	3824			2.39
	Total	**12328**							**25.10**
2C6C5(5)	Negligible	2561	10	25610	1	25610			
	Slight	4239	11	46629	0.9	41966.1			
	Moderate	7485	13	97305	0.8	77844	1117	Medium	
	Severe	2376	18	42768	0.9	38491.2			23.76
	V. Severe	310	20	6200	0.9	5580			3.1
	Total	**16971**							**26.86**
2C6C6(1)	Negligible	1474	10	14740	1	14740			
	Slight	2137	11	23507	0.9	21156.3			
	Moderate	3212	13	41756	0.8	33404.8	1062	Low	
	Severe	480	18	8640	0.9	7776			
	V. Severe	63	20	1260	0.9	1134			0.63
	Total	**7366**							**0.63**
2C6C6(2)	Negligible	2791	10	27910	1	27910			
	Slight	2814	11	30954	0.9	27858.6			
	Moderate	4921	13	63973	0.8	51178.4	1084	Low	
	Severe	1265	18	22770	0.9	20493			
	V. Severe	76	20	1520	0.8	1216			0.76
	Total	**11867**							**0.76**
2C6C6(3)	Negligible	5507	10	55070	1	55070			
	Slight	7841	11	86251	0.9	77625.9			
	Moderate	9756	13	126828	0.8	101462.4	1053	Low	
	Severe	2190	18	39420	0.8	31536			
	V. Severe	128	20	2560	0.8	2048			1.28
	Total	**25422**							**1.28**
2C6C6(4)	Negligible	3606	10	36060	1	36060			
	Slight	5548	11	61028	0.9	54925.2			
	Moderate	11521	13	149773	0.8	119818.4	1095	Low	
	Severe	3881	18	69858	0.8	55886.4			
	V. Severe	456	20	9120	0.8	7296			4.56
	Total	**25012**							**4.56**

1.7 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. It is also known that agricultural activities, if faulty result in heavy loss of fertile soil. Second being open forest land in particular for obvious conservation reasons. Third is scrub or degraded land, which contributes heavily to the silt load and possibilities exists to bring this area under pastures and other plantation to meet the local demand of fuel, fodder and NTFP 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 forest land where in at few places soil conservation measures are required. For treatment of Giri river catchment, 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 1.7 below to further subdivide the area as per the erosion intensity classes. The Weightages for Landuse, Slope and Soil were summed to get the Erosion Intensity Classes.

Table 1.7 Erosion Intensity and Weightages

Erosion Intensity Class	Sum of Weightages
Very severe (E5)	12 to 14
Severe (E4)	9 to 11
Moderate (E3)	6 to 8
Low (E2)	4 to 5
Negligible (E1)	0 to 3

The area falling under severe and very severe erosion intensity categories in two micro-watersheds viz. 2C6C4(2) and 2C6C4(4) classified as high priority and for the rest of micro watershed (9 Nos.) the area under very severe erosion intensity only would be taken up for conservation treatment measures after excluding of such area which falls under rocky and inaccessible terrain where the treatment is not feasible. As a matter of fact, 53.07 sq km area has been proposed CAT plan. The vulnerability of catchment in terms of soil erosion intensity is presented in Figure 1.8 and the statistics is presented in Table 1.8.

Table 1.8: Erosion Intensity Categories in Sub-watersheds

Sl. No.	MWS Code	Erosion Intensity Class / Area in sq km					Total Area, Sq km
		Negligible	Slight	Moderate	Severe	v. Severe	
1.	2C6C4 (1)	12.73	22.03	37.52	18.01	4.11	94.40
2.	2C6C4 (2)	13.44	29.43	59.96	27.28	6.49	136.60
3.	2C6C4 (3)	18.12	50.73	91.21	38.01	11.63	209.70
4.	2C6C4 (4)	9.81	20.84	46.47	24.72	7.03	108.87
5.	2C6C5 (1)	41.66	82.52	109.69	27.06	3.39	264.32
6.	2C6C5 (2)	42.44	66.92	42.75	7.63	1.34	161.08
7.	2C6C5 (3)	29.11	69.59	85.31	22.14	4.23	210.38
8.	2C6C5 (4)	12.87	25.66	59.65	22.71	2.39	123.28
9.	2C6C5 (5)	25.61	42.39	74.85	23.76	3.10	169.71
10.	2C6C6 (1)	14.74	21.37	32.12	4.80	0.63	73.66
11.	2C6C6 (2)	27.91	28.14	49.21	12.65	0.76	118.67
12.	2C6C6 (3)	55.07	78.41	97.56	21.90	1.28	254.22
13.	2C6C6 (4)	36.05	55.48	115.21	38.81	4.56	250.11
	Total	**339.56**	**593.51**	**901.51**	**289.48**	**50.94**	**2175.00**
Percentage of Total Area		**15.61**	**27.29**	**41.45**	**13.31**	**2.34**	**100.00**

Considering the topographic factors, soil type, climate, land use / land cover in the catchment ara 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 along run. The proposed treatment is in addition to the ongoing conservation measures initiated under different projects, schemes and plans. In fact an integrated watershed development project viz. Mid Himalayan Watershed Development Project is being implemnted in Himachal Pradesh w.e.f. October 2005 with the assistance of the World Bank. The project area covers 598 panchayats of 42 development blaocks of 10 districts. Some of Giri catchment in Solan and Sirmaur districts is also covered under it.

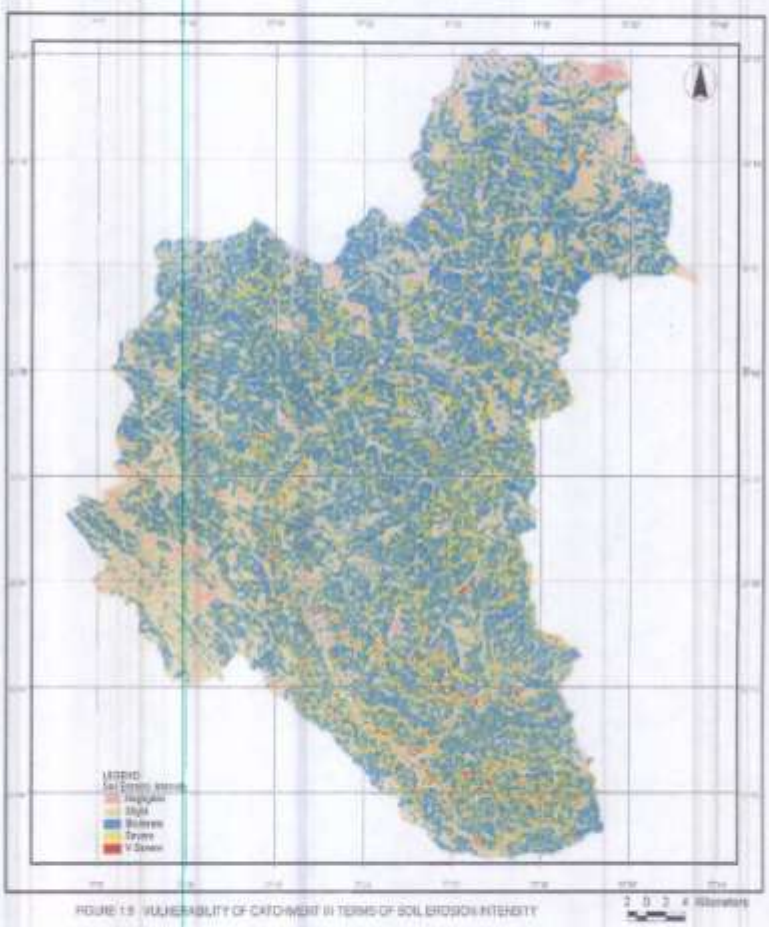

Figure 1.9: Vulnerability of Catchment in terms of soil erosion intensity

1.7.1 Erosion and Landuse

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

1.7.1.1 Agricultural Land and Settlement

Around 450.7 sq km (20.7%) and 66.03 sq km (3.0%) area of the free-draining catchment comes under agriculture and settlement category. In the free draining catchment of Renuka Dam Project, well-planned and developed terraces were seen. Almost 70% of the terraces are properly stabilized by using the stones which itself will manage to reduce the erosion. In general at places the sheet and rill type of soil erosion predominates with few gullies in early stage of its development. Very few measures are taken to conserve soil and tendency exists to interrupt the natural drainage due to faulty agricultural practices. Runoff often exceeds the safe velocity on long slope lengths. It is suggested to improve and alter the design of agricultural terraces, which mostly follow the faulty agricultural practices.

Agro-forestry practices and proposed to be introduced, Contour hedgerow technology of agricultural practice need to be followed. Temporary and semi permanent soil conservation structures like brushing dams, wiring woven dams, gabion check dams etc. are suggested.

1.7.1.2 Barren Areas

Under the waste land category only about 6.66 sq km area i.e. 0.3% of the free draining catchment is present. Waste land is characterized by highly degraded land surface and rock outcrops. Very little or no vegetation cover exists. Huge gullies, frequent land slips and high to extreme high erosion rates are other prominent features. Plantation with engineering measures is proposed for this land.

1.7.1.3 Shrubs / Bushes / Grasslands

Around 314.28 sq km area i.e. 14.45% of total catchment area is classified under this land-use category in the free draining catchment. These areas are characterized by highly degraded land surface. Very little and only seasonal vegetation cover exists. Huge gullies, frequent land slips and high to extreme high erosion rates are other prominent features. Well planned plantations followed by Stream bank protection works are suggested for such land-use category undergoing erosion. Silvi-pasture plantation and natural rejuvenation can also be done.

1.7.1.4 Light Vegetation

Light vegetation area has a spread of 240.94 sq km i.e. 11.07% of the area in the free draining Giri catchment. Forest crown density ranges from 0-40% or on average 20% crown density can be assumed to be present in the area. Soils have relatively good water holding capacity, humus and nutrients and have moderate to high erosion rates on steeper slopes. Therefore, rill erosion predominates which in due course leads to scrub lands formation with gullies. Plantation is suggested so as to increase the crown density by 20% in whole of the area.

1.7.1.5 Dense Vegetation

Dense vegetation covers about 1031.11 sq km i.e. 47.40% area of the free draining catchment. Forest crown density ranges above 40%. Soils are very good in water holding capacity, humus and nutrients with no erosion but due to steeper slopes small area requires soil conservation measures. Under this model only soil conservation measures have been proposed.

1.7.1.6 Water Bodies / Snow Cover Areas

Water bodies and snow cover areas approximately cover 10.49 sq km (0.48%) and 55.32 sq km (2.54%) area in the catchment of river Giri. Except for rocky and in accessible terrain where the snow well planted and stream bank protection works are suggested at vulnerable places in the water bodies besides reservoir rim treatment works.

1.7.2 Activities To Be Undertaken

1.7.2.1 Engineering Measure

- **Forest Wood Check dams and Retaining Walls**

Forest Wood check dams are useful in arresting further erosion of depressions, channels and gullies on the denuded landslides. In addition, retaining walls 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.

- **Bench Terracing**

The area under moderate to steep slopes would be subjected to bench terracing. The local people would be convinced to follow this type of terracing for comparatively better yield and with minimum threat to erosion. Moreover, in number of habitations in the catchment such practices are already visible. While making bench terraces, care will have to be taken not to disturb the topsoil by spreading earth from the lower terraces to higher terraces. The vertical intervals between terraces will not be more than 1.5 m and cutting depth may be kept at 50 cm. The minimum average width of the terrace would be kept from 4 to 5 m in order to enable usage of prolong hinge. The shoulder bunds of 30 x 15 cm would also be provided. Staggered channels will drain off the excess water from the terraces.

- **Gully Control –Check Dams**

Gullies are mainly formed on account of physiography, 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 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. Different types of check dams would be required for

different condition comprised of different materials depending upon the site conditions and the easy availability of material (stones) at local level and transport accessibility. The types of check dam recommended for treatment are:

- **Stream Bank Protection**

Stream bank erosion is caused by a 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 crates and vegetative spurs.

- **Contour Staggered Trenches**

Contour staggered trenches are mainly provided to trap the silt, reduce runoff and improve percolation. This is also done to prepare a fertile base for plantation.

- **Landslides Control**

Rainfall pattern of the area, water seepage coupled with geological formation results in landslides. Water plays an important role in triggering of landslides and mass wasting processes along with other factors such as slope and nature of soil/land-cover/land-use. However, most of the landslides are caused by human negligence. Road construction, overgrazing of hill slopes, felling of trees for timber, fuel, and fodder and upslope extension of cultivation are some of main causes of landslides. Critical alnd slide zones would be identified and treated with a mix of biological and engineering measures.

- **Catch-water Drains**

Among the most effective, practical and least expensive measures of landslide hazard management is the construction of catch-water drains for run-off and surface waters in the identified hazard-prone zone so that no or little water is able to infiltrate into the ground. All the streams and minor water courses would be diverted around the crown of the slide or the potentially hazardous area through catch water drains with a adequate gradient. The catch water drain when provided avoids the runoff to pass over such vulnerable areas and water is guided through these drains provided on foothill or along the katcha/pucca roads. The ground surface of threatened area is leveled out to eliminate all depressions where water can accumulate.

1.7.2.2 Biological Measures

- **Restoration of Degraded Areas**

In critically degraded areas, plantation of locally useful diverse and indigenous plant species such as timber plantation species, fodder species, conifers, fuel wood species, grasses, shrubs, legumes, medicinal and aromatic plants as listed in Annexure 9.1 would be undertaken. For raising plantation, nurseries would be developed over a total area of ha.

- **Afforestation**

This will include raising of multi-tier mixed vegetation of suitable local species including bio-fuel plants 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 some vegetation cover by way of timber plantation.

- **Fodder plantation**

To overcome the problem of scarce availability of the fodder, it is proposed to bring a substantial area under fodder plantation with suitable fast growing species.

- **Plantation of horticulture crops**

Under this treatment plan suitable horticultural crop species like, *Mangifera indica (Mango), Musa paradisiaca (Banana), Psidium guajava (Guava), Peach (Aadu) and* Citrus species shall be planted in select areas adjacent to the villages. These plants would be distributed to families residing in villages within the catchment with the objective of
supplementing their income.

- **Pasture Development**

As there are degraded patches of pastures in the area, this measure will be adopted to encourage development of new and healthy pasture areas for the use of cattle rearers. Under this treatment suitable species of grasses and tree fodder, and leguminous plant species shall be planted in the land area earmarked for this purpose.

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 equally important. It is recommended that some parts of the pastures should be closed for seeding purpose only.

- **Non-Timber Forest Plant (NTFP) Cultivation**

In keeping with Himachal Pradesh forestry sector Medical Plants Policy, 2006 and 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 also be undertaken. Thrust shall be made to organic cultivation of medicinal plants.

1.8 TREATMENT OF INDIVIDUAL MICRO-WATERSHEDS

The area and type of treatment to be undertaken is based upon the stream drainage pattern, extent of forest cover, accessibility of the area, land-use, soil profile and slope. The areas with very severe erosion intensity having very steep slopes and which are inaccessible would be left alone for natural rejuvenation. In some of the micro-watersheds some areas under high erosion intensity category also have been earmarked for treatment owing to local condition and degradation factors. The details of micro-watershed-wise treatment measures are described below:

1.8.1 Micro-Watershed: Parara [2C6C4(1)]

This micro-watershed is located on right bank of Giri has an area of 94.40 sq km and is shown in Figure 1.10. The predominant land-use is under dense vegetation constituting about 45.21 sq km of the area followed by light vegetation (19.18 sq km), agriculture and settlements (13.40 sq km) shrubs/bushes (14.8 sq km) etc. The area requiring treatment under very high erosion category is about 4.11 sq km The central and eastern part of the MWS is under severe and very severe erosion intensity category. It is suggested that the areas under severe erosion intensity categories which

are mostly associated with light vegetation and agriculture area so the plantation of suitable species may be done in the former and in case of latter agriculture practices need to be corrected followed by planned plantation. The micro-watershed has 44% area above 50 degree slope.

The treatment measures suggested for this micro-watershed are:

		Area in Sq km
A. BIOLOGICAL MEASURES		
1.	Afforestation	0.40
2	Timber Plantation	0.20
3.	Fodder plantation	0.20
4.	Pasture development	0.18
5.	NTFP Cultivation	0.04
	Sub Total	**1.02**
B. ENGINEERING MEASURES		
1.	Stream bank protection	0.46
2.	Contour stagger trenching	0.20
3.	Gully control measures	0.33
4.	Landslide control	0.29
	Sub Total	**1.28**
	Grand Total	**2.30**

1.8.2 Micro-Watershed: Nait Ka Khala [2C6C4(2)]

This micro-watershed is located on left bank of Giri has an area of 136.60 sq km and is shown in **Fig: 1.11**. The predominant land-use is under Dense vegetation constituting about 57.95 sq km. of the area followed by Agriculture and Settlements (31.13 sq km), light vegetation (22.51 sq km), shrubs (23.29 sq km) etc. The area requiring treatment under very high and high erosion category is about 27.02 sq km and 6.49 sq km and is located in the south-western and also the southern parts of the micro watershed. The micro-watershed has 52% area above 50° slope. The treatment measures suggested for this micro-watershed are:

A	**BIOLOGICAL MEASURES**	**Area in Sq km**
1.	Afforestation	7.00
2	Timber Plantation	2.50
3.	Fodder plantation	2.50
4.	Pasture development	0.72
5.	NTFP Cultivation	0.66
	Sub Total	**13.38**
B.	**ENGINEERING MEASURES**	
1.	Stream bank protection	0.40
2.	Contour stagger trenching	0.25
3.	Gully control measures	1.53
4.	Landslide control	0.16
	Sub Total	**2.84**
	Grand Total	**16.22**

1.8.3 Micro-Watershed: Palar ka Khala [2C6C4(3)]

This micro-watershed is located on left bank of river Giri has an area of 209.70 sq km is shown in **Fig.: 1.12.** The predominant land-use is under Dense vegetation constituting about 80.67 sq km of the area followed by agriculture and settlement (55.46 sq km), shrubs / bushes (37.68 sq km) and light vegetation (30.80 sq km) etc. The area requiring treatment under very high erosion category is about 11.63 sq km ha and is mostly in south-western and north-west part of the micro-watershed associated with light vegetation and agriculture use class. The micro-watershed has 50% of the area above 50^0 slope. The treatment measures suggested for this sub-watershed are:

A.	**BIOLOGICAL MEASURES**	**Area in Sq km**
1.	Afforestation	1.64
2.	Timber Plantation	0.70
3.	Fodder plantation	0.70
4.	Pasture development	0.66
5.	NTFP Cultivation	0.20
	Sub Total	**3.90**
B.	**ENGINEERING MEASURES**	
1.	Stream bank protection	0.42
2.	Contour stagger trenching	0.20
3.	Gully control measures	1.00
4.	Landslide control	0.30
	Sub Total	**1.92**
	Grand Total	**5.82**

1.8.4 Micro-Watershed: Jogar ka Khala [2C6C4(4)

This micro-watershed is located on left bank of river Giri has an area of 108.87 sq km and is shown in Figure 1.13. The predominant land-use is under dense vegetation constituting about 41.07 sq km of the area followed by agriculture and settlement (28.27 sq km), shrubs / bushes (21.19 sq km), light vegetation (15.49 sq km) etc. The area requiring treatment under very high and high erosion category is about 24.72 and 7.03 sq km respectively mostly lying in south and central part of the micro-watershed, associated with areas belonging open and degraded forest land and agriculture land use classes. The micro-watershed has 58% of the area above 50^0 slope.

The treatment measures suggested for this micro-watershed are:

A.	BIOLOGICAL MEASURES	Area in Sq km
1.	Afforestation	5.27
2	Timber Plantation	2.34
3.	Fodder plantation	2.34
4.	Pasture development	1.20
5.	NTFP Cultivation	0.55
	Sub Total 11.70	

B.	ENGINEERING MEASURES	Area in Sq km
1.	Stream bank protection	1.50
2.	Contour stagger trenching	0.24
3.	Gully control measures	2.00
4.	Landslide control	0.60
	Sub Total 14.34	
	Grand Total 16.04	

1.8.5 Micro-Watershed: Ashni [2C6C5(1)]

This micro-watershed has an area of 264.32 sq km and is shown in Figure 1.14. The predominant land-use is under dense vegetation (146.96 sq km) followed by agriculture and settlement (41.92 sq km), shrubs / grasses (40.52 sq km), light vegetation (32.46 sq km) etc. The area requiring treatment under very severe erosion intensity category is about 3.39 sq km and is located in the northern and southern parts of micro-watershed which is largely associated with open forest and agriculture and settlements. Agriculture practice needs to be corrected followed by planned plantation. Gully control measures are required to stabilize terraces along first and second order drainages. The micro-watershed has 41% of the area above 50^0 slope. The treatment measures suggested for this micro-watershed are:

A. BIOLOGICAL MEASURES		Area in Sq km
1. Afforestation		0.58
2. Timber Plantation		0.23
3. Fodder plantation		0.23
4. Pasture development		0.23
5. NTFP Cultivation		0.10
	Sub Total	**1.38**

B. ENGINEERING MEASURES		Area in Sq km
1. Stream bank protection		0.22
2. Contour stagger trenching		0.05
3. Gully control measures		0.30
4. Landslide control		0.05
	Sub Total	**0.62**
	Grand Total	**2.00**

1.8.6 Micro-Watershed: Kawali Nadi [2C6C5(2)]

This micro-watershed has an area of 161.08 sq km and is shown in Figure 1.15. The predominant land-use is under dense vegetation (72.31 sq km)) followed by light vegetation (42.86 sq km), shrubs/bushes (27.22 sq km), agriculture and settlement (17.85 sq km) etc. The area requiring treatment under very severe erosion intensity category is about 1.34 sq km The erosion area is mostly concentrated in areas under light and dense vegetation and agricultural settlement land use class and is spread in NE and NW direction. The micro-watershed has 15% of the area above 50^0 slope. The treatment measures suggested for this micro-watershed are:

A.	**BIOLOGICAL MEASURES**	**Area in Sq km**
1.	Afforestation	0.39
2	Timber Plantation	0.09
3.	Fodder plantation	0.09
4.	Pasture development	0.06
5.	NTFP Cultivation	0.09
	Sub Total	**0.72**

B. ENGINEERING MEASURES		**Area in Sq km**
1.	Stream bank protection	0.14
2.	Contour stagger trenching	0.04
3.	Gully control measures	0.20
4.	Landslide control	0.04
	Sub Total	**0.42**
	Grand Total	**1.14**

1.8.7 Micro-Watershed: Pervi Khala [2C6C5(3)]

This micro-watershed has an area of 210.38 sq km and is shown in Figure 1.16. The predominant land-use is under dense vegetation (98.21 sq km) followed by shrub / grasses (37.49 sq km), light vegetation (37.26 sq km), agriculture and settlement (35.03 sq km) etc. The area requiring treatment under very severe erosion intensity category is about 4.23 sq km which is largely associated with light vegetation and agriculture and settlements. Agriculture practice needs to be corrected followed by planned plantation. Gully control measures are required to stabilize terraces along first and second order drainages. The micro-watershed has 33% of the area above 50^0 slope. The treatment measures suggested for this sub-watershed are:

A. BIOLOGICAL MEASURES		Area in Sq km
1.	Afforestation	0.60
2	Timber Plantation	0.25
3.	Fodder plantation	0.25
4.	Horticulture	0.24
5.	NTFP Cultivation	0.10
	Sub Total	**1.44**

B. ENGINEERING MEASURES		Area in Sq km
6.	Stream bank protection	0.26
7.	Contour stagger trenching	0.08
8.	Gully control measures	0.50
9.	Landslide control	0.05
	Sub Total	**0.89**
	Grand Total	**2.83**

1.8.8 Micro-Watershed: Bajhetu Ka Khala [2C6C5(4)]

This micro-watershed has an area of 123.28 sq km and is shown in Figure 1.17. The predominant land-use is under dense vegetation (73.03 sq km)) followed by agriculture and settlement (24.24 sq km), shrubs / grass (14.90 sq km), light vegetation (8.52 sq km) etc. The area requiring treatment under very severe erosion intensity category is about 2.39 sq km The erosion area is mostly concentrated in areas under light vegetation, barren land and agricultural settlement land use class and is spread in NE and NW direction. The micro-watershed has 54% of the area above 50^0 slope. The treatment measures suggested for this sub-watershed are:

A.	BIOLOGICAL MEASURES		Area in Sq km
1.	Afforestation		0.30
2	Timber Plantation		0.12
3.	Fodder plantation		0.12
4.	Horticulture		0.12
5.	NTFP Cultivation		0.06
		Sub Total	**0.72**

B.	ENGINEERING MEASURES		Area in Sq km
1.	Stream bank protection		0.15
2.	Contour stagger trenching		0.03
3.	Gully control measures		0.15
4.	Landslide control		0.05
		Sub Total	**0.38**
		Grand Total	**1.10**

1.8.9 Micro-Watershed: Tir Mahasu [2C6C5(5)]

This micro-watershed has an area of 169.71 sq km and is shown in Figure 1.18. The predominant land-use is under dense vegetation (72.86 sq km) followed by agriculture and settlement (49.30 sq km), shrubs/grasses (26.08 sq km), light vegetation (15.88 sq km) etc. The area requiring treatment under very severe erosion intensity category is about 3.10 sq km which is largely associated with light vegetation and agriculture and settlements. Agriculture practice needs to be corrected followed by planned plantation. Gully control measures are required to stabilize terraces along first and second order drainages. The micro-watershed has 44% of the area above 50^0 slope. The treatment measures suggested for this sub-watershed are:

A. BIOLOGICAL MEASURES		Area in Sq km
1.	Afforestation	7.22
2	Timber Plantation	1.80
3.	Fodder plantation	1.35
4.	Horticulture	0.78
5.	Pasture development	1.29
6.	NTFP Cultivation	0.45
	Sub Total	**12.89**

B. ENGINEERING MEASURES		Area in Sq km
6.	Stream bank protection	1.72
7.	Contour stagger trenching	0.86
8.	Gully control measures	4.30
9.	Bench terracing	0.86
10.	Landslide control	0.86
	Sub Total	**8.60**
	Grand Total	**21.49**

1.8.10 Micro-Watershed: Theog [2C6C6(1)]

This micro-watershed has an area of 73.66 sq km and is shown in Figure 1.19. The predominant land-use is under agriculture and settlement (33.90 sq km), dense vegetation (26.03 sq km), shrubs / grasses (11.16 sq km), light vegetation (1.24 sq km) etc. The area requiring treatment under very severe erosion intensity category is about 0.63 sq km The erosion area is mostly concentrated in areas under light vegetation, shrubs / bushes and agricultural settlement land use class and is spread in Central and NE being more predominant. The micro-watershed has 36% of the area above 50^0 slope. The treatment measures suggested for this sub-watershed are:

A.	**BIOLOGICAL MEASURES**		**Area in Sq km**
1.	Afforestation		0.24
2.	Timber Plantation		0.04
3.	Fodder plantation		0.04
4.	Pasture development		0.06
5.	NTFP Cultivation		0.04
		Sub Total	**0.42**

B.	**ENGINEERING MEASURES**		**Area in Sq km**
1.	Stream bank protection		0.07
2.	Contour stagger trenching		0.02
3.	Gully control measures		0.08
4.	Landslide control		0.04
		Sub Total	**0.21**
		Grand Total	**0.63**

1.8.11 Micro-Watershed: Kyar Ka Khala [2C6C6(2)]

This micro-watershed has an area of 118.67 sq km and is shown in Figure 1.20. The predominant land-use is under dense forest (51.78 sq km) followed by agriculture and settlement (39.45 sq km), shrubs/grasses (10.87 sq km), snow covered area (15.01 sq km) etc. The area requiring treatment under very severe and severe erosion intensity category is about 0.76 sq km and is predominant and is in South-West direction, which is largely associated with light vegetation and agriculture and settlements. Agriculture practice needs to be corrected followed by planned plantation. Gully control measures are required to stabilize terraces along first and second order drainages. The micro-watershed has 44% of the area above 50^0 slope. The treatment measures suggested for this sub-watershed are:

A. BIOLOGICAL MEASURES		Area in Sq km
1.	Afforestation	0.24
2	Timber Plantation	0.04
3.	Fodder plantation	0.04
4.	Pasture development	0.06
5.	NTFP Cultivation	0.04
	Sub Total	**0.42**

B. ENGINEERING MEASURES		Area in Sq km
1.	Stream bank protection	0.07
2.	Contour stagger trenching	0.02
3.	Gully control measures	0.08
4.	Landslide control	0.04
	Sub Total	**0.21**
	Grand Total	**0.63**

1.8.12 Micro-Watershed: Tharu [2C6C6(3)]

This micro-watershed has an area of 254.22 sq km and is shown in Figure 1.21. The predominant land-use is under dense vegetation (130.39 sq km) followed by agriculture and settlement (71.81 sq km), shrubs/grasses (24.23 sq km), snow covered (23.74 sq km) etc. The area requiring treatment under very severe erosion intensity category is about 1.28 sq km. The erosion area is mostly concentrated in areas under light vegetation, shrubs / bushes and agricultural settlement land use class and is spread in all direction, S and SW being more predominant. The micro-watershed has 34% of the area above 50° slope. The treatment measures suggested for this sub-watershed are:

A.	**BIOLOGICAL MEASURES**	**Area in Sq km**
1.	Afforestation	0.24
2.	Timber Plantation	0.12
3.	Fodder plantation	0.12
4.	Pasture development	0.06
5.	NTFP Cultivation	0.06
	Sub Total	**0.60**

B. ENGINEERING MEASURES		**Area in Sq km**
1.	Stream bank protection	0.09
2.	Contour stagger trenching	0.02
3.	Gully control measures	0.10
4.	Landslide control	0.03
	Sub Total	**0.24**
	Grand Total	**0.84**

1.8.13 Micro-Watershed: Bassari [2C6C6(4)]

This micro-watershed has an area of 250.11 sq km is shown in Figure 1.22. The predominant land-use is under dense forest (134.66 sq km) followed by agriculture and settlement (73.94 sq km), shrubs/grasses (24.84 sq km), light vegetation (9.03 sq km) etc. The area requiring treatment under very severe erosion intensity category is about 4.56 sq km and is located in central and southern direction, which is largely associated with light and dense vegetation and agriculture and settlements. Agriculture practice needs to be corrected followed by planned plantation. Gully control measures are required to stabilize terraces along first and second order drainages. The micro-watershed has 50% of the area above 50^0 slope. The treatment measures suggested for this micro-watershed are:

A. BIOLOGICAL MEASURES		Area in Sq km
1.	Afforestation	0.63
2.	Timber Plantation	0.25
3.	Fodder plantation	0.25
4.	Pasture development	0.24
5.	NTFP Cultivation	0.13
	Sub Total	**1.50**

B. ENGINEERING MEASURES		Area in Sq km
1.	Stream bank protection	0.41
2.	Contour stagger trenching	0.02
3.	Gully control measures	0.30
4.	Landslide control	0.05
	Sub Total	**0.78**
	Grand Total	**2.28**

1.9 Cost Analysis of Different Works Under Plan

1.9.1 Biological Measures

The cost analysis for per ha plantation @ 1500 plants / ha under afforestation, timber fodder NTFP plantation on the basis of norms fixed for arriving per hectare afforestation cost as suggested by Himachal Pradesh Forest Department Circular No. Ft 15-1790-2(D) Vol V (Norm) dated 19-06-2008 after incorporating labour and material rates. The cost per hectare of afforestation inclusive of maintenance and establishment and infrastructure works at Rs. 79500 / ha as shown in Table 1.9. The cost analysis of pasture development at 500 plants/ha is worked out in Table 1.10. The cost of horticulture development has been worked out on the basis of 500 plants/ha @ Rs. 50/- plant including maintenance for 5 years. The sub-watershed wise cost of all the works is shown in Table 1.11. The combined cost of all biological measures including maintenance works out as Rs. 2929.44 lacs.

Table 1.9: Per Ha Cost Norm for Model Plantation Works
(Under CAT / Compensatory Afforestation Works)
1500 plants per ha with RCC fence posts)

Sl. No.	Particulars of Work	Quantity	Rate	Amount for Non Tribal Area
	A. Fencing Work			
1	Survey and demarcation of plantation area including marking of sections, path and preparation of map	1 ha	68.25/ha	68.25
2	Preparation / purchase of RCC fence posts 2m long	60 Nos.	200/No.	12,000.00
3	Carriage of fence post upto 2 m long over distance 2 kms.	60 Nos.	454.60/Km	545.52
4				
5	Preparation / digging of holes 20-30 cm dia and 50 cm deep	60 Nos.	603.11/hundred	361.86
6	Fixing of posts including stuttling	60 Nos.	464.06/hundred	278.44
7	Carriage of B/wire over average distance of 2 km uphill	0.90 qtls	113.74/Qtl/Km	204.73
8	Stretching and fixing of barbed wire with U-staples in each strand (4 stands)	720 Rmt	3.15/Rmt	2268.00
9	Preparation of inspection path 60 cm wide	250 Rmt	7.25/Rmt	1812.50
10	Preparation of water retention mounds / trenches	LS	-	2000.00

Sl. No.	Particulars of Work	Quantity	Rate	Amount for Non Tribal Area
11	Interlacing of thorny bushes in B/wire obtained from planting site	180 Rmt	2.74/Rmt	493.20
	Total Fencing Works Cost			**20,032.50**
	B-Planting			
1	Digging of pits 45 cm x 45 cm x 45 cm (40% of total)	600 Nos	636.30/hundred	3817.80
2	Digging of pits 30 cm x 30 cm x 30 cm (60% of total)	900 Nos	318.23/hundred	2864.07
3	Filling of pits 45 cm x 45 cm x 45 cm	600 Nos	182.32/hundred	1093.92
4	Filling of pits 30 cm x 30 cm x 30 cm	900 Nos	127.23/hundred	1145.07
5	Carriage of naked root plants over distance 2 Km uphills (BL as well as conifers)	600 Nos	23.49/hundred/Km	281.88
6	Carriage of plants in P/bags over distance 2 km up hills	900 Nos	145.40/hundred.Km	2617.02
7	Planting of entire plants raised in P/bags	900 Nos	145.49/hundred	1313.91
8	Planting of naked root plants	600 Nos	122.66/hundred	735.96
9	Planting of grass tufts / preparation of strips including sowing in strips 100 m x 30 m x 5 cm for grass sowing along contour	500 strips	613.33/hundred	3066.65
	Total Planting Cost			**16,936.28**
	C-Material			
1	Cost of barbed wire	0.9 Qtl	7000 per Qtl	6,300.00
	Nursury Cost of Plants			
1	Naked root plants	600 Nos	6.0/plant	3,600.00
2	Polythene bags plants	900 Nos	8.0/plant	7,200.00
	Total Material Cost			**17,100.00**
	Grand Total (A + B + C)			**54,068.78**
	Or Say			**54,000.00**
	D. Maintenance Cost			
	1st year maintenance 30% mortality			
1	Re-digging of pits 45 cm x 45 cm x 45 cm	180 Nos	318.16/hundred	572.69
2	Re-digging of pits 30 cm x 30 cm x 30 cm	270 Nos	159.12/hundred	429.62
3	Filling of pits 45 cm x 45 cm x 45 cm	180 Nos	182.32/hundred	328.18
4	Filling of pits 30 cm x 30 cm x 30 cm	270 Nos	127.23/hundred	343.52
5	Planting of polythene bags plants	270 Nos.	145.49/hundred	392.82
6	Planting of naked root plants	180 Nos	122.66/hundred	220.79
7	Planting of grass tufts / preparation of strips including sowing in strips 100 m x 30 m x 5 cm for grass sowing	200 Nos	613.63/hundred	1227.26

Sl. No.	Particulars of Work	Quantity	Rate	Amount for Non Tribal Area
8	Carriage of polythene bags plants over a distance of 2 km uphill	270 Nos	145.40/hundred/km	785.16
9	Carriage of naked root plants over a distance of 2 km uphill	180 Nos	23.49/hundred/km	84.56
10	Nursery cost of plants in polythene bags	270 Nos	8.00/plant	2160.00
11	Nursery cost of naked root plant	180 Nos	6/plant	1080.00
12	Repair of fence	180 Rmt	1.18/Rmt	212.40
13	Repair of inspection path	L.S.	L. S.	700.00
14	Moisture conservation works	L.S.	L.S.	1000.00
	Total Maintenance Cost			**9537.14**
	Or Say			**9,500.00**
	2nd year maintenance 20% mortality			
1	Redigging of pits 45 cm x 45 cm x 45 cm	120 Nos	318.16/hundred	381.79
2	Redigging of pits 30 cm x 30 cm x 30 cm	180 Nos	159.12/hundred	286.42
3	Filling of pits 45 cm x 45 cm x 45 cm	120 Nos	182.32/hundred	218.78
4	Filling of pits 30 cm x 30 cm x 30 cm	180 Nos	127.23/hundred	229.01
5	Planting of polythene bags plants	192 Nos	145.49/hundred	279.34
6	Planting of naked root plants	108 Nos	122.66/hundred	132.47
7	Carriage of polythene bags plants over a distance of 2 km up hills	192 Nos	145.40/hundred	558.36
8	Carriage of naked root plants over a distance of 2 km up hills	108 Nos	23.49/hundred/km	50.74
9	Nursery cost of plants in polythen bags	192 Nos	8/plant	1536.00
10	Nursery cost of naked root plant	108 Nos	6.00/plant	648.00
11	Repair of fence	180 Rmt	1.18/Rmt	212.40
12	Repair of inspection path	L. S.		500.00
13	Moisture conservation works	L. S.	L. S.	800.00
	Total 2nd Year Maintenance Cost			**5833.31**
	Or Say			**5800.00**
	3rd Year maintenance 10% mortality			
1	Redigging of pits 45 cm x 45 cm x 45 cm	60 Nos.	318.16/hundred	191.16
2	Redigging of pits 30 cm x 30 cm x 30 cm	90 Nos	159.12/hundred	143.21
3	Filling of pits 45 cm x 45 cm x 45 cm	60 Nos.	182.32/hundred	109.39
4	Filling of pits 30 cm x 30 cm x 30 cm	90 Nos	127.23/hundred	114.51
5	Planting of polythene bags plants	90 Nos	145.49/hundred	130.94
6	Planting of naked root plants	60 Nos.	122.66/hundred	73.60
7	Carriage of polythene bags plants over a distance of 2 km up hills	90 Nos	23.49/hundred/Km	261.72

Sl. No.	Particulars of Work	Quantity	Rate	Amount for Non Tribal Area
8	Carriage of naked root plants over a distance of 2 km up hills	60 Nos.	23.49/hundred/Km	28.19
9	Nursery cost of plants in polythene bag	90 Nos	8/plant	720.00
10	Nursery cost of naked root plant	60 Nos.	6/plant	360.00
11	Repair of fence	200 Rmt	1.18/Rmt	236.00
12	Repair of inspection path	L. S.	-	400.00
13	Moisture conservation works	L. S.		800.00
	Total 3rd Year Maintenance Cost			**3568.72**
	Or Say			3600.00
	4th Year maintenance 10% mortality			
1	Redigging of pits 45 cm x 45 cm x 45 cm	60 Nos.	318.16/hundred	191.16
2	Redigging of pits 30 cm x 30 cm x 30 cm	90 Nos	159.12/hundred	143.21
3	Filling of pits 45 cm x 45 cm x 45 cm	60 Nos.	182.32/hundred	109.39
4	Filling of pits 30 cm x 30 cm x 30 cm	90 Nos	127.23/hundred	114.51
5	Planting of polythene bags plants	90 Nos	145.49/hundred	130.94
6	Planting of naked root plants	60 Nos.	122.66 /hundred	73.60
7	Carriage of polythene bags plants over a distance of 2 km up hills	90 Nos	145.40/hundred	261.72
8	Carrige of naked root plants over a distance of 2 km up hills	60 Nos.	23.49/hundred	218.19
9	Nursery cost of plant in polythene bag	90 Nos	8/plant	720.00
10	Nursery cost of naked root plant	60 Nos.	6/plant	360.00
11	Repair of fence	200 Rmt	1.18/Rmt	236.00
12	Repair of inspection path		L. S.	300.00
13	Moisture conservation works		L. S.	700.00
	Total 4th Year Maintenance Cost			**3368.72**
	Or Say			**3400.00**
	5th Year maintenance 10% mortality			
1	Redigging of pits 45 cm x 45 cm x 45 cm	60 Nos.	318.16	191.16
2	Redigging of pits 30 cm x 30 cm x 30 cm	90 Nos	159.12	143.21
3	Filling of pits 45 cm x 45 cm x 45 cm	60 Nos.	182.32	109.39
4	Filling of pits 30 cm x 30 cm x 30 cm	90 Nos	127.23	114.51
5	Planting of polythene bags plants	90 Nos	145.49	130.94
6	Planting of naked root plants	60 Nos.	122.66	73.60
7	Carriage of polythene bags plants over a distance of 2 km up hills	90 Nos	145.40	261.72
8	Carriage of naked root plants over a distance of 2 km up hills	60 Nos.	23.49	28.19

Sl. No.	Particulars of Work	Quantity	Rate	Amount for Non Tribal Area
9	Nursery cost of plants in polythene bag	90 Nos	8/plant	720.00
10	Nursery cost of naked root plant	60 Nos.	6/plant	360.00
11	Repair of fence	200 Rmt	1.18/Rmt	236.00
12	Repair of inspection path		L. S.	300.00
13	Repair of soil and moisture conservation works		L. S.	500.00
	Total 5th Year Maintenance Cost			**3168.72**
	Or Say			**3200.00**
	Abstract	**Amount (in Rs.)**		
	New plantation cost	54,000.00		
	I year maintenance cost	9,500.00		
	II year maintenance cost	5,800.00		
	III year maintenance cost	3,600.00		
	IV year maintenance cost	3,400.00		
	V year maintenance cost	3,200.00		-
	Grand Total	**79,500.00**		

Table 1.10: Cost Estimate For Pasture Development Per Ha

S. No.	Particulars of works	Quantity	Rate (Rs.)	Amount (Rs.)
1	Survey and demarcation of the selected area.	1 ha	68.25	68.25
2	Digging of pits 45m x 45m x 45m	500	6.36/hundred	3180.00
3	Preparation of patches for the sowing of legume appr. Size of 45 x 45 x 25 cm	500	327/hundred	1635.00
4	Lay out of pits	1 ha	113.72/ha	113.72
5	Carriage of plants in poly bags	500 Rmt.	145.40/hundred	727.00
6	Planting of plants raised in poly bags	500	145.99/hundred	729.00
7	Sowing of legume plants	500	176/hundred	880.00
8	Sowing of grass seeds in trenches	200 Rmt.	1.58/Rmt	316.00
9	Construction of brush wood fence	300 Rmt.	860/Rmt	2580.00
10	Live Hedge fencing with Ipomaea and Dodonaea viscose along bush wood fence	300 Rmt.	9.0/Rmt	2700.00
11	Cost of plants (Nursery – cost)	500	8.00/plant	4000.00
12	Cost of legume seed	10 Kg	200/Kg	2000.00
13	Cost of grass seed	10 Kg	300.00/Kg	3000.00
14	RCC post fencing cost	1 ha	20,000/ha	20,000.00
			Total	**41929.92**
	Maintenance cost for 5 years @			
	Rs. 2800 for first year,			**2,800.00**
	Rs. 1800 for second year,			**1,800.00**
	Rs. 1400 for third year and			**1,400.00**
	Rs. 1000 for every year thereafter upto 5th yrs			**2,000.00**
			Total	**8000.00**
			Grand Total	**49,929.92**
			Say Rs.	**50,000.00**

Table 1.11: Cost Estimate for Biological Measures

MWS	Afforestation / Timber / Fodder / NTFP		Pasture Development		Total Cost (Rs lacs) Col 3 + 5
	Area (ha)	Cost @ Rs 79500/ha (Rs lac)	Area	Cost @ Rs 50000/ha (Rs lac)	
1	2	3	4	5	6
2C6C4(1)	84	66.780	18	9.00	75.780
2C6C4(2)	1266	1006.470	72	36.00	1042.00
2C6C4(3)	324	257.58	66	33.00	290.58
2C6C4(4)	1050	834.75	120	60.00	894.75
2C6C5(1)	114	90.63	24	12.00	102.63
2C6C5(2)	66	52.47	06	3.00	55.47
2C6C5(3)	120	95.40	24	12.00	107.40
2C6C5(4)	60	47.70	12	06.00	53.70
2C6C5(5)	96	76.32	18	09.00	85.32
2C6C6(1)	36	28.62	06	03.00	31.62
2C6C6(2)	36	28.62	06	03.00	31.62
2C6C6(3)	54	42.93	06	03.00	45.93
2C6C6(4)	126	100.17	24	12.00	112.17
	3432	2728.44	402	201.00	2929.44

Summery of Cost

1 Afforestation/Timber/Fodder/NTFP Rs 2728.44 Lacs
2 Pasture Development Rs. 201.00 Lacs

Grand Total Rs. 2929.44 Lacs

1.9.2 Engineering Measures

The engineering measures are to be implemented to control the sediment yield and further degradation of the free draining catchments areas. Since the measures are to be carried out by construction of individual structures such as crate wires, check dams, contour stagger trenches, catch water drains etc., the number of such structures to be raised were calculated in the entire area and accordingly the financial provisions were provided. The analysis of rates is presented in Table 1.12 and micro watershed-wise details of work and cost are shown in Table 1.13.

Under engineering measures 1320 No. wire crate spurs, 1320 No. vegetative boulder spurs, 3460 No. DRSM check dams, 6920 No. brush wood check dams, 120 ha bench terracing, 750 ha contour staggered terracing and 18.00 km. catch water drains are proposed to be constructed at a cost of Rs. 1000.319 lacs.

Table 1.12 Cost Analysis For Engineering Structures

S. No		Quantity	Unit	Rate	Amount
1.	Dry Rubble Stone masonry (DRSM) Check Dam.				-
(a)	Excavation in foundation with 50% softrock and 50% E and B. 5m x 1.5 x 0.50	3.75	Cum	81.56	305.85
(b)	Labour changes for dry stone masonry with outer face stone dressed and 100 m lead. I – Step 5 x 1.5 x 1.25 9.38 II – Step 7 x 1.0 x 0.75 = 5.25 Wing Walls 2 x 2 x 0.6 x1.6 = 2.40 17.03	17.03	Cum	109.06	1857.29
©	Carriage of boulder by head load beyond initial 100 m lead up to 1 km by ponies @ Rs 285.15 x 0.8 x 1.25	17.03	Cum	285.15	4856.10
				Total	7019.24
				Add 3% Contingencies	**210.58**
				Grand Total Rs.	**7229.20**
				Say Rs.	**7230.00**
2	Wire Crate Check Dam				
(a)	Excavation in foundation with 50% Shale and 50% E and B – 6 x 2 x 1	12	Cum	81.56	978.72
(b)	Weaving of wire netting of G.I. Wire mesh size 15 cm x 15 cm. Foundation Step – 2 (6 x 2 + 6 x 1 + 2 x 1) = 40 m^2 I-Step – 2(6 x 1.9 + 6 x 1 + 2 x 1) = 38.8 m^2 II-Step – 2(6 x 1.8 + 6 x 0.8 + 2 x 0.8) = 34.4 m^2				

S. No		Quantity	Unit	Rate	Amount
	113.2 m^3	113.2		11.44	1295.00
(c)	Filling of boulder and hand packing in wire crates. Foundation 6.00 x 2.00 x 1.00 = 12.00 m^3 I – Step 6.0 x 1.9 x 1.0 = 11.40 m^3 II – Step 6.0 1.8 x 0.8 8.64 m^3 32.04 m^3	32.04	m^3	61.31	1964.37
(d)	Collection of boulder	32.04		74.50	2386.98
(e)	Carriage of boulder average lead 1 km by ponies	32.04	m^3	285.15	9136.21
(f)	Cost of GI wire	2.25	Qtl.	5000	11250.00
(g)	Carriage of G.I wire to an average lead of 5 km. by ponies.	2.25	Qtl.	48.60	98.10
				Total Rs.	**26130.66**
				Add 3% contingencies	**783.92**
				Grand Total Rs.	**26914.58**
				Say Rs.	**26920.00**
3.	Vegetative spur with loose boulder				
	a. Excavation foundation 5x2x1	10	m^3	81.56	407.80
	b. Cutting and preparation of vegetative post (17+17+5+5)	44	No	5.50	242.00
	c. Carriage of veg. Posts by manual labour average lead 2 km.	44	No.	9.35	411.40
	d. Digging of holes for vegetative post	44	No.	3.85	169.40
	e. Fixing of vegetative post	44	No.	2.95	129.80
	f. Cutting preparation of vegetative bracing	16	No.	5.93	94.88
	g. Fixing of bracing with post (5x4x2) + (2x4x2)	56	RM	6.00	336.00
	h. Stone pitching inside spur I-step 1x5x2x1 = 10.00 + II-step 1 x 5 x 1.5 x 3 = 22.50 = 32.50 m^3	32.50	Cum	61.31	1992.58
	i. Collection of boulder / stone	32.50	Cum	74.50	2421.25
	j. Carriage of boulder average lead 1 km by ponies	32.50	Cum	285.15	9267.38
				Total Rs.	**15472.49**
				Add 3% contingencies	**464.17**
				Grand Total Rs.	**15936.66**

S. No		Quantity	Unit	Rate	Amount
				Say Rs.	15940.00
4.	Bench terracing / ha excavation	172	Cum	81.56	14030.00
5.	Contour staggered trenches / ha excavation	100	Cum	81.56	8156.00
6.	Catch water drain / RM				
	Average dimension = 1m. x 0.5m. x 0.5m.				
	Excavation (1.5 + 0.75) x 0.75	0.84	Cum	81.56	68.51
	Labour charges for dry stone masonry	0.50	Cum	143.38	71.69
				Total Rs.	140.20
				Grand Total Rs.	140.00
7.	Double row brush wood check dam				
	a. Cutting of conversion of vegetative posts	40	No.	550.56 per %	220.22
	b. Carriage of vegetative posts to 5 km. distance @ Rs. 207.95 per hundred number per km.	40	No.	1159.25 per %	463.70
	c. Digging of holes for vegetative posts	40	No.	385.44 per %	154.18
	d. Fixing of vegetative posts	40	No.	295.94 per %	118.38
	e. Fixing of vegetative spurs double row	40	M	24.81	992.40
	f. Filling of gaps between rows of brush wood with the bundles of bushes and tied with rope of eulaliopsis binnata grass	1 job	L. S.	210.00	210.00
				Total Rs.	2158.88
				Say Rs.	2160.00

Table 1.13 Cost Estimate for Engineering Measures

	Wire Crate Spurs		Vegetative Boulder Spur		DRSM Check Dam		Brush Wood Check Dam		Contour Staggered Trenches		Catch Drains		
SWS	No.	Cost @ Rs. 26928/No.	No.	Cost @ Rs. 15940/No.	No.	Cost @ Rs. 7230/No.	No.	Cost @ Rs. 2160/No.	ha	Cost @ Rs.8156 ha	RM	Cost @ Rs. 140/-RM	Total Cost (Rs.)
2C6C4(1)	150	40.380	150	23.910	165	11.929	330	7.128	20	1.631	2000	2.800	87.778
2C6C4(2)	200	53.840	200	31.880	765	55.310	1530	33.048	25	2.039	2900	4.060	180.177
2C6C4(3)	144	38.765	144	22.954	500	36.150	1000	21.600	20	1.631	2000	2.800	123.900
2C6C4(4)	420	113.064	420	66.948	1000	72.300	2000	43.200	24	1.957	5700	7.980	305.449
2C6C5(1)	54	14.537	54	8.608	150	10.845	300	6.480	05	0.408	750	1.050	41.928
2C6C5(2)	36	9.691	36	5.738	100	7.230	200	4.320	04	0.326	500	0.700	28.005
2C6C5(3)	62	16.690	62	9.883	250	18.075	500	10.800	08	0.653	850	1.190	57.291
2C6C5(4)	44	11.845	44	7.013	75	5.423	150	3.240	03	0.245	550	0.770	28.536
2C6C5(5)	44	11.845	44	7.013	175	12.652	350	7.560	03	0.245	600	0.840	40.155
2C6C1(1)	25	6.730	25	3.985	40	2.892	80	1.728	02	0.163	300	0.420	15.918
2C6C1(2)	25	6.730	25	3.985	40	2.892	80	1.728	02	0.163	300	0.420	15.918
2C6C1(3)	30	8.076	30	4.783	50	3.615	100	2.160	02	0.163	300	0.420	19.217
2C6C1(4)	86	23.151	86	13.708	150	10.845	300	6.480	02	0.163	1250	1.750	56.097
	1320	355.344	1320	210.408	3460	250.158	6920	149.472	120	9.787	18000	25.200	1000.369

1.10 Treatment of Private Land

The silt contribution of private land holding is very significant. The agriculture land, if not developed properly and coupled with faulty agricultural practices like interrupting the natural drainage, contributes heavy soil erosion as compared to the other landuse categories like dense forest/open forest. Therefore, better land management shall help in reducing the sediment flow besides increasing the land productivity by way of arresting the loss of soil cover and increased soil moisture content. Therefore, it is proposed to provide treatment to private holdings for development of horticulture, agriculture and private pasture development. Some parts of the free draining Catchment area falling under all have such development potential. An area of 720 ha and 600 ha have been earmarked to be undertaken for horticulture development and private pasture development respectively under this plan as a joint venture with the owners of the land with their share of the cost being the cost of fencing and maintenance. The cost of works proposed under this head work out to Rs. 569.838 lakh and is shown in Table 1.14.

Table 1.14: Cost of private land treatment

S.No	Particular	Quantity	Unit	Rate	Amount (Rs Lacs)
(A)	Biological Measures				
(1)	Horticulture Development	720	ha	25000	180.00
(2)	Private Pasture Development	600	ha	25000	150.00
	Sub Total (A)				29.77
(B)	Engineering Measures				
	DRSM check dams.	1125	No.	7920	89.10
	Bench Terracing	900	ha	14030	126.270
	Contour staggered Terracing	300	ha	8156	24.468
	Sub Total (B)				239.838
	Grand Total (A) + (B)				569.838

1.11 COST OF OTHER COMPONENTS OF CAT PLAN

Apart from the Forestry works and the 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 plan. The eco-restoration works, livelihood support works, social mobilization, documentation and publication, monitoring and evaluation are some of 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 and the Forest Department of Himachal Pradesh.

1.11.1 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 circle for which the executing agency shall need necessary infrastructure support. Accordingly provision has been made for purchase of office equipments and inspection vehicle 9 Bolaro and 8 cars with O & M charges for 6 years. Besides these for facilitating stay of inspecting officers at site, provision for construction of 6 new inspection house one each at Rajgarh, Nahan, Shimla and Theog and two at Renuka has been made at Rs. twenty lacs each. In addition to this provision for repair and upgradation of ten number rest house, at Rs. five lacs each has also been provided. For improvement / repair of mule path / bridle path, foot paths in the catchment area a slump sum provision of Rs. 50 lacs has also been earmarked. The cost estimate is presented in Table-1.15.

Table 1.15: Cost Estimate for Support Infrastructure

S.No	Particular	Quantity	Unit	Rate	Amount
(A)	Office Equipments				
1	Purchase of Pentium 4 PC Complete with accessories and Laser printer 36 for range offices and 24 for division and circle offices	60	No	0.50	30.00
2	Purchase of X-erox Machine	12	No	2.00	24.00
3	Purchase of Fax Machine	12	No	0.15	1.80
4	Purchase of inspection vehicles	17	No.	7.00	119.00
5	O & M Charges for vehicles @ Rs 0.6 lacs/year for 6 years	17 x 6	No.	0.6/year	61.20
6	Construction of new inspection houses	6	No.	20.00	120.00
7	Repair and upgradation of existing R/H	10	No.	5.00	50.00
8	Repair of mule / bridle / foot path	L. S.	-	-	50.00
					456.00

1.11.2 Fuel Wood Saving Devices

In order to reduce the pressure in the forest particularly for fuel wood exerted by villagers living near forest areas under the catchment who are totally dependent upon the fuel wood for cooking purpose some alternate source of energy is to be planned. It is proposed to provide pressure cookers solar cookers and LPG gas connection with cylinder at 100% subsidized cost to BPL families and also 50% subsidy for APL families At the outset this provision is being made for 4000 number of BPL families and also 4000 No. APL families who are residing in the area falling under micro watersheds 2C6C4(1), 2C6C4(2), 2C6C4(3) and 2C6C4(4). Beneficiary preference shall be given to project affected families. Any saving may be utilized for providing benefit to

people of other micro-watersheds on the similar basis. For repair of devices trainire should be imported to ITI certificate holders who will also be provided with seed money. The cost debitable on this count is shown in Table-1.16.

1.11.3 Training and Extension Programme

There is a need to keep local people in center stage in programme implementation so that they can play an active role in the implementation of the CAT plan by associating with the development work in their areas and carry the work in a scientific manner. For this purpose people have to be trained in respect of different measures especially for agriculture lands under the CAT with special thrust to the local technique making use of indigenous material without deteriorating the ecology. The technique of river-training work needs to be explained properly so that desired results are achieved. For this purpose training programme has to be carried out at each of micro-watersheds headquarters for which a provision @ 1.5% of the cost of engineering and biological work is being made to the tune of Rs. 67.00 lacs.

Table-1.16: Cost of Fuel Wood Saving Devices

Sl. No.	Particular	Quantity	Unit	Rate	Amount (Rs. Lacs)
1.	LPG gas connection with 1 cylinder for BPL families	4000	No	3000	120.00
2.	LPG gas connection with 1 cylinder for APL families	4000	No	1500	60.00
3.	Solar cookers	4000	No	1800	72.00
4.	Pressure cookers	4000	No	800	32.00
5.	Training and seed money	L.S.	No		16.00
					300.00

1.11.4 Provision for Formulation of Micro Plans

Based on the ground truth reality in each of the Village Forest Development Committee or Society falling under the different sub-watersheds, comprehensive micro plan for execution of the work has to be prepared as per norms. For this purpose a provision at 2% of the cost of biological and engineering measure, amounting to Rs. 90.00 lacs is being made.

1.11.5 Provision for Proper Documentation

Emphasis should be laid on the visual publicity of the work proposed under the plan and work carried out on annual basis so that transparency is maintained and the proper documentation of the work is also carried out for future reference and testing the efficacy of the work in due course of time. On this count a provision @ 1% of the cost of biological and engineering measures

amounting to Rs. 45.00 lacs is being made. The documentation would inter alia include implementation report, progress reports, photography, videography etc. Publication for public awareness would be made and distributed to concerned panchayat and Village Forest Development Committees / Societies.

1.11.6 Gender Support

By far the women folk are more industrious than man in the hills. There is a need to keep them in center stage in programme implementation so that they can play an active role in the preservation of ecology as well as the socio-economic development of the area. Proper training with respect to work related to NTFP cultivation, animal husbandry, gardening and farm works etc. shall be imparted for which a provision @ 1% of the cost of biological and engineering measures amounting to Rs. 45.00 lacs.

1.11.7 Funds for Educational Activities related to Medicinal Plant Sector

In keeping with the provision under para 4.6.2 of Himachal Pradesh Forestry Sector medicinal Plants Policy, 2006, a provision of Rs. 20.00 lacs is being earmarked for various conservation and educational activities related to medicinal plant sector.

1.11.8 Monitoring of Silt

The Success of implementation of a CAT Plan can be fathomed by the increase in vegetal cover over hill slopes and the enhancement in forest canopy. Various engineering and biological measures have been aimed at treating the degraded and potential areas of severe to very severe soil erosion by increasing the soil holding capacity and thus reducing the sediment flow in the flowing water. Therefore, for recording soil and silt data at regular interval one small laboratory / observatory each shall be established at prominent locations in different streams where the regular discharges of the streams shall also be monitored. For establishing these a provision @ Rs. 20.00 lacs per site for 8 sites amounting Rs. 160 lacs is being made.

1.11.9 Development of Eco-Tourism

The trekking routes with camping facilities can help to boost eco-tourism in the area. Concept of "Homesteads" can be promoted. Such host families who are enterprising and having reasonable traditional accommodation in the village en-route to good eco-treks can accommodate tourists on payment basis. Some financial support to rural people can boost the activity. Involvement of local youths can fetch them self employment avenues by providing services like guides, porters and making arrangement for boarding

and lodging of eco-tourists. Thus poor families can get wage earning by porter or other small works. Eco-tourism societies can be formulated under the overall control of the special purpose vehicle (SPY) for anchoring the eco-tourism activities. There is a lot of scope for eco-tourists for beholding the nature in its wild virgin and pristine glory and catching the everlasting enthralling moments in their mind while enjoying and learning the nature. In keeping with the Revised Policy on Development of Eco-tourism in Himachal Pradesh, 2005, and guideline issued by the Forest Deptt, H.P., vide letter No. Ft-48-124/94 (FCA), one percent of the CAT plan should be earmarked for eco-tourism purposes. However, a provision of Rs 75.00 lacs is being made on this count as it seems to be meaningful and purposeful for establishing a certain asset.

1.11.10 Provision for Floristic Surrey

Though adequate provision of Rs 20 lacs & 15 lacs have already been provided in environment monitoring plan for ecosystem monitoring including environmental studies respectively during construction and post constructional stage, yet a provision of Rs 11.0 lacs is being made for carrying out floristic survey of the area after complete of implementation CAT plan i.e. immediately after the fifth year of maintenance.

1.11.11 Eco- Force

The concept of Eco-Task Force (ETF) scheme was initiated by the Ministry of Defence in 1980 with a view to involve ex-service men in afforestation and eco-development schemes in for flung and difficult places to under take restoration of degraded eco-systems through afforestation, soil conservation and water resource management techniques. Under the scheme the establishment and operational expenditure on Eco-Task Force or Eco-Battalion raised by the Ministry of Defence is reimbursed by Ministry while the input such as sapling, fencing etc. as also the professional and managerial guidance is provided by the concerned State Forest Departments.

The state of Himachal Pradesh has also raised 133 Infantry Battalion TA (Ecological) in March 2006 with sole purpose of generation of employment opportunities for ex-servicemen of the state though afforestation and soil conservation work. The Eco- Battalion is engaged in Satluj basin in the task of rim plantation in Tatapani area of Karsog Forest Division. There are a number of on-going and proposed HEP in Satluj basin whose CAT plan are either being implemented or being formulated. In the light of the fact that the state has already mooted a proposal for raising two more Eco-Battalions one each for Ravi and Beas catchment financial resources are to be pooled to support the existing Batallion and the two more Batallions to be raised. Therefore, with a view to pool in resources to support ETF, a provision at 5% of cost of

biological and engineering measures amounting to Rs 225.00 lacs is being made on this account in the CAT Plan.

1.11.12Provision for Monitoring and Evaluation

In keeping with broad guide lines for preparing and implementation of CAT plans, issued by the Forest Depurtment, Himachal Pradesh, vide letter Ft. 48-124 / 94 (FCA, a provision towards monitoring and evaluation activities @ 5% has to be earmarked on this count. Therefore, a provision if Rs 225.00 lac is being made on this count.

1.11.13Provision for providing Environmental Services

In Keeping with the guide lines issued in this direction, a provision @ 10% of the cost of works under CAT shall have to be earmarked on this count. Therefore a provision of Rs 450 lacs is being made under this sub-head. The scheme has been conceived as drinking water supply scheme. Thus the concerted efforts shall be required for mainly water environment. The most of villages near the reservoir and also near other major streams forming parts of catchment have no sewage treatment plants, which shall have to be provided from this head. Besides this due to ownership limitation of private land near reservoir the activities leading to erosion of soil can not be controlled easily albeit the problem can be addressed through by adopting incentive schemes. Besides this the people shall be motivated to desist from tree felling, excessive grazing and digging and setting fire in private land besides forest.

1.12 INSTITUTIONAL MECHANISM

1.12.1 Role of Project Proponent

The forest department would implement the Catchment Area Treatment plan. The joint inspection group would be formalized which would include officers from State Forest Department and Officials from the Environment Group at HPPCL. The management will have liaison with the forest officials as far as the financial disbursement is concerned. The soil conservation and afforestation program would evolve employment opportunities. Thus, people's participation should be encouraged and would involve mobilization of manpower for such activities. Experts and professionals competent enough in operationalizing the plan need to be consulted from time to time.

1.12.2 CAT Implementation

Environmental officer or Manager (Environment) of project proponent would coordinate with forest department for the implementation of the proposed Plan. The Environment officer would evaluate/monitor financial aspects at Site Office. The modalities of financial disbursement every quarter in a year need to be taken care of. The implementing agency shall have to submit completion certificate in the light of guidelines fixed by CAMPA. The

implementation of CAT Plan should have enough flexibility and should be subject to changes as per requirements and periodic gains. A monitoring committee as per the MOEF guidelines such as Renuka CAT plan Society with its headquarter at Shimla should be instituted for the project for administrative guidance and smooth realization of targets.

1.12.3 Project Monitoring and Reporting Procedures

Meetings would be held every three months to resolve logistic problems in plan implementation. A Joint committee would be formed with the Environmental Cell of Himachal Pradesh Power Corporation Ltd (HPPCL) and State Forest Departments team members to ensure the implementation and monitoring of the CAT works and reviews the progress from time to time. Quarterly progress reports and completion certificates would be submitted to HPPCL, for evaluation and disbursement of finance. In addition, the work done should be published through public awareness campaigns. Visual and print media need to be used to embark on maximum benefit by direct and indirect beneficiaries. Such efforts would resolve conflicts which otherwise are potential sources for project gestation.

1.13 SUMMARY OF COST OF WORKS

The cost of all the works proposed in the CAT plan is enumerated in **Table 1.17**. Year-wise Tentative Break-up of Engineering and Biological Measures and other components under CAT plan is shown in **Table 1.18**.

Table 1.17: Cost Estimate of CAT Plan

S.No.	Particulars	Amount (Rs. Lacs)
1	Treatment Works Under free draining catchment.	
a)	Biological Measures	2929.440
b)	Engineering Measures.	1000.369
2	Treatment Works under private land	
a)	Biological Measures	330.000
b)	Engineering Measures.	239.838
	Sub Total (1) + (2)	**4499.647**
	Say	**4500.000**
3	Implementation of Support Infrastructure Cost	456.00
4	Fuel wood saving devices.	300.00
5	Training and Extension Programme	67.00
6	Preparation of Micro Plans	90.00
7	Documentstion	45.00
8	Gender Support	45.00

S.No.	Particulars	Amount (Rs. Lacs)
9	Funds for Educational Activities related to Medicinal Plant Sector	20.00
10	Monitoring of silt	150.00
11	Development of Eco-tourism	75.00
12	Provision for floristic survey	11.00
13	Support for Eco-task force	225.00
14	Provision for Monitoring and Evaluation Activities	225.00
15	Provision for providing Environmental Services.	450.00
16	Escalation @ 10% per annum for 4 years on cost of treatment works i.e. on Rs 105.715 lacs	841.253
	Grand Total	7500.253
	Say	7500.00

Table 1.18 : Year-Wise tentative break up of Engineering and Biological Measures and other Components under CAT Plan.

Sl.No.	Particular	0 Year		1-Year		II - Year		III- Year		IV- Year		V- Year	
		P	F	P	F	P	F	P	F	P	F	P	F
(I)	Biological Measures.												
(A)	Advance works.												
(i)	3432 ha afforestation/timbre/fodder/NTFP @ Rs 2,000/ha.	572	114.4	572	114.4	572	114.4	572	114.4	572	114.4	572	114.4
(ii)	402 ha Pausture Development @ 20,000/ha	67	13.4	67	13.4	67	13.4	67	13.4	67	13.4	67	13.4
(B)	Plantation works.	-	-	-	-	-	-	-	-	-	-	-	-
(i)	3432 ha Afforestation/timbre/fodder/NTFP @Rs 34,000/ha.	-	-	572	194.48	572	194.48	572	194.48	572	194.48	572	194.48
(ii)	402 ha Pasture @ Rs 22,000/ha	-	-	67	14.74	67	14.74	67	14.74	67	14.74	67	14.74
©	Maintenance.	-	-	-	-	-	-	-	-	-	-	-	-
(i)	3432 ha Afforestation/timber/fodder/NTFP	-	-	-	-	-	-	-	-	-	-	-	-
	I - Year @ 9500/ha	-	-	-	-	572	54.34	572	54.34	572	54.34	572	54.34
	II - Year @ 5800/ha	-	-	-	-	-	-	572	33.176	572	33.176	572	33.176
	III - Year @ 3600/ha	-	-	-	-	-	-	-		572	20.592	572	20.592
	IV - Year @ 3400/ha	-	-	-	-	-	-	-				572	19.448
	V - Year @ 3200/ha	-	-	-	-	-	-	-					

(ii)	402 ha Pasture Development												
	I - Year @ 2800/ha	-	-	-	-	67	1.876	67	1.876	67	1.876	67	1.876
	II - Year @ 1800/ha	-	-	-	-	-	-	67	1.206	67	1.206	67	1.206
	III - Year @ 1400/ha	-	-	-	-	-	-	-	-	67	0.938	67	0.938
	IV - Year @ 1000/ha	-	-	-	-	-	-	-	-	-	-	67	0.67
	V - Year @ 1000/ha	-	-	-	-	-	-	-	-	-	-	-	-
	Total Biological I (A + B + C)	-	127.8	-	337.02		393.236		427.618		449.148		469.266
II	Engineerinmg Measures												
(i)	1320 No Wire Crate Spur @ Rs 26920/No.	-	-	264	71.0688	264	71.0688	264	71.0688	264	71.0688	264	71.0688
(ii)	1320 No Vegetative Boulder Spur @ Rs 15940/No	-	-	264	42.0816	264	42.0816	264	42.0816	264	42.0816	264	42.0816
(iii)	3460 No DRSM @ Rs 7230/No	-	-	692	50.0316	692	50.0316	692	50.0316	692	50.0316	692	50.0316
(iv)	6920 No Brush wood check dam @ Rs 2160/No	-	-	1384	29.8944	1384	29.8944	1384	29.8944	1384	29.8944	1384	29.8944
(v)	120 ha Contour Staggered Rrench @ 8156/	-	-	24	1.9574	24	1.9574	24	1.9574	24	1.9574	24	1.9574
(vi)	18000 m catch drain @ Rs 140/RM	-	-	3600	5.04	3600	5.04	3600	5.04	3600	5.04	3600	5.04
	Total Engineering Measures	-	-	-	200.074		200.0738		200.0738		200.0738		200.0738
III	Private Land Treatment	-	-	-	-	-	-	-	-	-	-	-	-
(A)	Biological Measures.	-	-	-	-	-	-	-	-	-	-	-	-

(i)	720 ha Worticulture Dev. @ Rs 25000/ha	-	-	144	36	144	36	144	36	144	36	144	36
(ii)	600 ha Pasture Dev. @ Rs 25000/ha	-	-	120	30	120	30	120	30	120	30	120	30
	Total Biological III A (i + ii)	-	-	-	66		66		66		66		66
(B)	Engineering Measure.												
(i)	1125 No DRSM check dam @ Rs 7920/No	-	-	225	17.82	225	17.82	225	17.82	225	17.82	225	17.82
(ii)	900 ha Bench Terracing @ Rs 14030/ha	-	-	180	25.254	180	25.254	180	25.254	180	25.254	180	25.254
(iii)	300 ha Contour Staggered Terracing @ 8156/ha	-	-	60	4.8936	60	4.8936	60	4.8936	60	4.8936	60	4.8936
	Total Engineering Measures B (i + ii + iii)	-	-		47.9676	-	47.9676	-	47.9676	-	47.9676	-	47.9676
	Total Private Land Treatment III (A + B)	-	-		113.968	-	113.9676	-	113.9676	-	113.9676	-	113.9676
	Ground Total of I + II + III	-	127.8		651.061	-	707.2774	-	741.6594	-	763.1894	-	783.3074
(iv)	Implementation of Support infortructure	-	50		100	-	100	-	100	-	23	-	23
(v)	Fuel Wood Savinh Devices	-	-		100	-	100	-	100	-	-	-	-
(vi)	Training & Extension Programme	-	-		33.5	-	33.5	-	-	-	-	-	-
(vii)	Preparation on of Micro Plans	-	45		22.5	-	22.5	-	-	-	-	-	-
(viii)	Documentation	-	-	-	-	-	9	-	9	-	9	-	9
(ix)	Gender Support	-	-	-	15	-	15	-	15	-	-	-	-
(x)	Funds for Educational Activities	-	-	-	-	-	10	-	10	-	-	-	-
(xi)	Monitoring of Silt	-	-	-	-	-	30	-	30	-	30	-	10

(xii)	Development of Eco-tourism	-	-	-	-	-	40	-	35	-	-	-	-
(xiii)	Floristic Survey	-	-	-	-	-		-	-	-	-	-	-
(xiv)	Support for Eco-task force	-	-	-	-	-	45	-	45	-	45	-	45
(xv)	Monitoring and Evaluation	-	-	-	-	-		-	45	-	45	-	45
(xvi)	Providing Environmental Services	-	-	-	90	-	90	-	90	-	90	-	45
(xvii)	Escalation	-	-	-	-	-	260.472	-	210.97	-	159.054	-	105.631
	Total IV to XVII	-	45		361		755.472		689.47		401.154		282.631
	Grand Total I to XVII	-	222.8		1012.06		1462.7494		1431.6294		1164.243		1065.938

Sl.No.	Particular	VI- Year		VII- Year		VIII_ Year		IX- Year		X- Year		XI- Year		Total	
		P	F	P	F	P	F	P	F	P	F	P	F	P	F
(I)	Biological Measures.														
(A)	Advance works.														
(i)	3432 ha afforestation/timbre/fodder/NTFP @ Rs 2,000/ha.	-	-	-	-	-	-	-	-	-	-	-	-	3432	686.4
(ii)	402 ha Pausture Development @ 20,000/ha	-	-	-	-	-	-	-	-	-	-	-	-	402	80.4
(B)	Plantation works.	-	-	-	-	-	-	-	-	-	-	-	-		
(i)	3432 ha Afforestation/timbre/fodder/NTFP @Rs 34,000/ha.	572	194.48	-	-	-	-	-	-	-	-	-	-	3432	1166.88
(ii)	402 ha Pasture @ Rs 22,000/ha	67	14.74	-	-	-	-	-	-	-	-	-	-	402	88.44
©	Maintenance.	-	-	-	-	-	-	-	-	-	-	-	-		
(i)	3432 ha Afforestation/timber/fodder/NTFP	-	-	-	-	-	-	-	-	-	-	-	-		
	I - Year @ 9500/ha	572	54.34	572	54.34	-	-	-	-	-	-	-	-	3432	326.04
	II - Year @ 5800/ha	572	33.176	572	33.176	572	33.176	-	-	-	-	-	-	3432	199.056
	III - Year @ 3600/ha	572	20.592	572	20.592	572	20.592	572	20.592	-	-	-	-	3432	123.552
	IV - Year @ 3400/ha	572	19.448	572	19.448	572	19.448	572	19.448	572	19.448	-	-	3432	116.688
	V - Year @ 3200/ha	572	18.304	572	18.304	572	18.304	572	18.304	572	18.304	572	18.304	3432	109.824

(ii)	402 ha Pasture Development														
	I - Year @ 2800/ha	67	1.876	67	1.876	-	-	-	-	-	-	-	-	402	11.256
	II - Year @ 1800/ha	67	1.206	67	1.206	67	1.206	-	-	-	-	-	-	402	7.236
	III - Year @ 1400/ha	67	0.938	67	0.938	67	0.938	67	0.938	-	-	-	-	402	5.628
	IV - Year @ 1000/ha	67	0.67	67	0.67	67	0.67	67	0.67	67	0.67	-	-	402	4.02
	V - Year @ 1000/ha	67	0.67	67	0.67	67	0.67	67	0.67	67	0.67	67	0.67	402	4.02
	Total Biological I (A + B + C)		360.44		151.22		95.004		60.622		39.092		18.974		2929.44
II	Engineering Measures														
(i)	1320 No Wire Crate Spur @ Rs 26920/No.	-	-	-	-	-	-	-	-	-	-	-	-	1320	355.344
(ii)	1320 No Vegetative Boulder Spur @ Rs 15940/No	-	-	-	-	-	-	-	-	-	-	-	-	1320	210.408
(iii)	3460 No DRSM @ Rs 7230/No	-	-	-	-	-	-	-	-	-	-	-	-	3460	250.158
(iv)	6920 No Brush wood check dam @ Rs 2160/No	-	-	-	-	-	-	-	-	-	-	-	-	6920	149.472
(v)	120 ha Contour Staggered Rrench @ 8156/.	-	-	-	-	-	-	-	-	-	-	-	-	120	9.787
(vi)	18000 m catch drain @ Rs 140/RM	-	-	-	-	-	-	-	-	-	-	-	-	18000	25.2
	Total Engineering Measures	-	-	-	-	-	-	-	-	-	-	-	-		1000.37
III	Private Land Treatment	-	-	-	-	-	-	-	-	-	-	-	-		
(A)	Biological Measures.	-	-	-	-	-	-	-	-	-	-	-	-		

(i)	720 ha Worticulture Dev. @ Rs 25000/ha	-	-	-	-	-	-	-	-	-	-	-	-	720	180
(ii)	600 ha Paustre Dev. @ Rs 25000/ha	-	-	-	-	-	-	-	-	-	-	-	-	600	150
	Total Biological III A (i + ii)	-	-	-	-	-	-	-	-	-	-	-	-		3.3
(B)	Engineering Measure.														
(i)	1125 No DRSM check dam @ Rs 7920/No	-	-	-	-	-	-	-	-	-	-	-	-	1125	89.1
(ii)	900 ha Bench Terracing @ Rs 14030/ha	-	-	-	-	-	-	-	-	-	-	-	-	900	126.27
(iii)	300 ha Contour Staggered Terracing @ 8156/ha	-	-	-	-	-	-	-	-	-	-	-	-	300	24.468
	Total Engineering Measures B (i + ii + iii)	-	-	-	-	-	-	-	-	-	-	-	-	-	239.838
	Total Private Land Treatment III (A + B)	-	-	-	-	-	-	-	-	-	-	-	-	-	569.838
	Ground Total of I + II + III	-	360.44		151.22		95.004		60.622		39.092		18.974	-	4499.65
(iv)	Implementation of Support infortructure	-	10		10		10		10		10		10	-	
(v)	Fuel Wood Savinh Devices	-	-	-	-	-	-	-	-	-	-	-	-	-	300
(vi)	Training & Extension Programme	-	-	-	-	-	-	-	-	-	-	-	-	-	67
(vii)	Preparation on of Micro Plans	-	-	-	-	-	-	-	-	-	-	-	-	-	90
(viii)	Documentation	-	9	-	-	-	-	-	-	-	-	-	-	-	45
(ix)	Gender Support	-	-	-	-	-	-	-	-	-	-	-	-	-	45
(x)	Funds for Educational Activities	-	-	-	-	-	-	-	-	-	-	-	-	-	20
(xi)	Monitoring of Silt	-	10		10		10		10		10				150

(xii)	Development of Eco-tourism	-	-	-	-	-	-	-	-	-	-	-	-	-	75
(xiii)	Floristic Survey	-	5.5	-	5.5	-	-	-	-	-	-	-	-	-	11
(xiv)	Support for Eco-task force	-	45	-		-	-	-	-	-	-	-	-	-	225
(xv)	Monitoring and Evaluation	-	45	-	45	-	-	-	-	-	-	-	-	-	225
(xvi)	Providing Environmental Services	-	45	-		-	-	-	-	-	-	-	-	-	450
(xvii)	Escalation	-	580.799	-	25.569	-	14.983	-	8.333	-	4.089	-	1.353	-	841.253
	Total IV to XVII		220.299		96.307		34.983		28.333		24.089		11.353		3000.25
	Grand Total I to XVII		580.739		247.29		129.987		89.005		63.181		30.327		7499.9