GOVERNMENT OF MADHYA PRADESH

WATER RESOURCES DEPARTMENT

CATCHMENT AREA TREATMENT PLAN

of

SARKULA MEDIUM LIFT IRRIGATION PROJECT

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Prepared for:

Water Resources Division Shivpuri

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1 INTRODUCTION

1.1 General

The Sarkula Medium Lift Irrigation Project is proposed to be developed on Sarkula River in Shivpuri district in the state of Madhya Pradesh.

The project proposes construction of a 41.00 m high dam across Sarkula River near Pohari village to irrigate a total 6,500 ha of Culturable Command Area (CCA) in Pohari tehsil of Shivpuri District. Total 25 villages of Shivpuri district are to be benefitted by the implementation of proposed project. The creation of reservoir due to construction of dam will lead to submergence of 190 ha of forest land. The project is envisaged to have a live storage capacity of 24.086 MCM. Provision for dead storage is 4.69 MCM. Hence, gross storage is 28.776 MCM.

Scope of the present study is to prepare Catchment Area Treatment Plan for the catchment area of Sarkula Medium Lift Irrigation Project. Hence, the catchment area has been delineated from the source of Sarkula river to the dam site of Sarkula Medium Lift Irrigation Project. The project location map is enclosed as **Figure 1**.

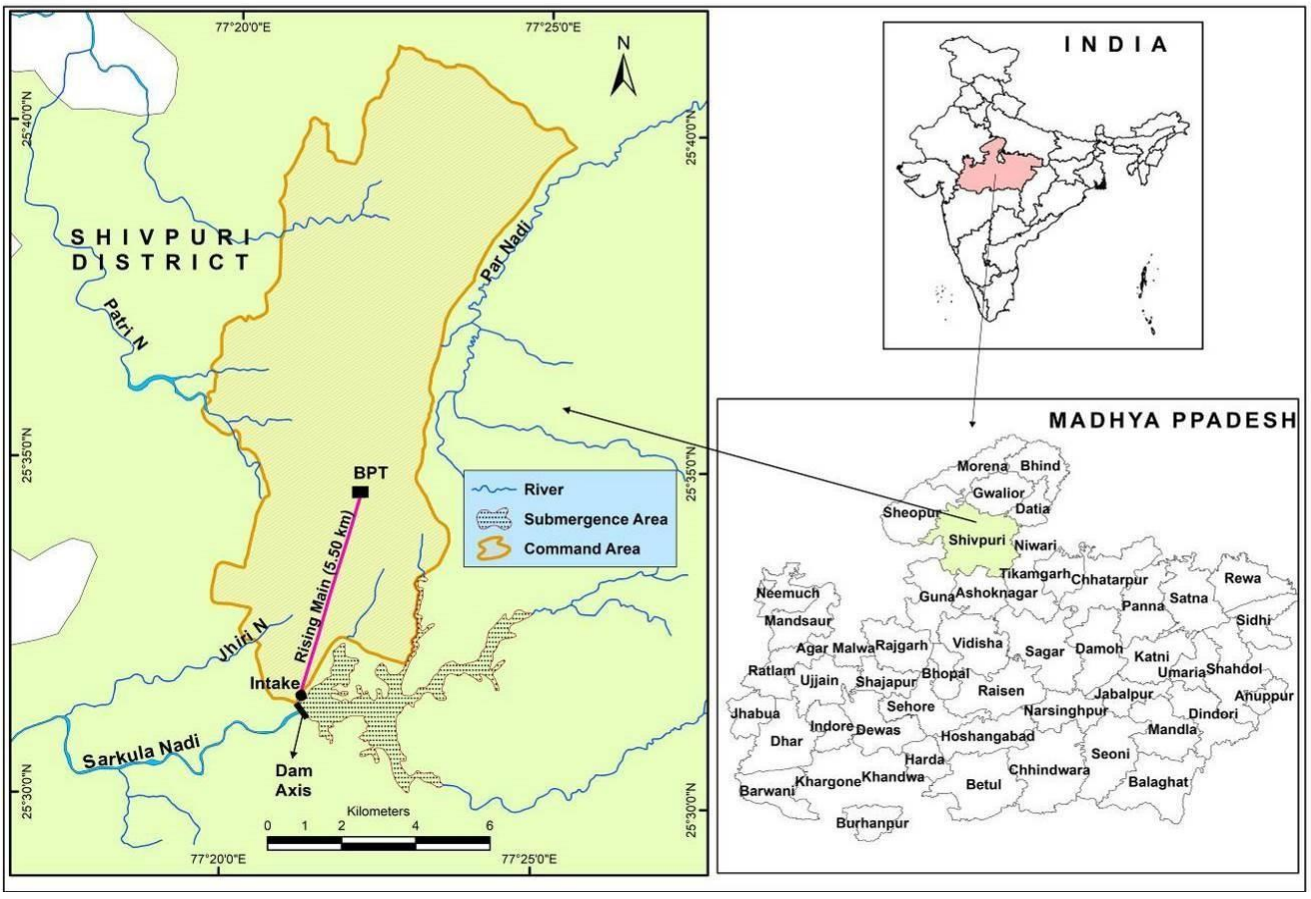

Figure 1: Location Map of Sarkula Medium Lift Irrigation Project

1.2Salient Features

The salient features of the proposed Sarkula Medium Lift Irrigation Project are given in **Table 1**. An Index map of the project is given at **Figure 2**.

Table 1: Salient Features of Sarkula Medium Lift Irrigation Project

1	**GENERAL DATA:-**			
	a.	District	:-	Shivpuri
	b.	Tehsil	:-	Pohari
	c.	River or River/ Nalla	:-	Sarkula
	d.	Location of Dam	:-	Near Village Pohari
	e.	Name of River/Basin	:-	Chambal Basin
	f.	Situation		
		Toposheet No.	:-	54 G/6
		Longitude	:-	77°21'22"
		Latitude		25°31'32"
2	**HYDROLOGICAL DATA:-**			
	a.	Name of the rainfall station	:-	Pohari
	b.	Average Monsoon rainfall	:-	767 mm
	c.	Monsoon Rainfall 75% dependable	:-	619.50 mm
	d.	Mean run-off	:-	35.46 mcum
	e.	75% dependable yield	:-	24.31 mcum
	f.	Flood	:-	3029 cumec
	g.	Moderated SPF Calculated	:-	2479 cumec
3	**RESERVOIR DATA:-**			
	a.	Catchment area	:-	131.25 sq km
	b.	Gross storage capacity	:-	28.776 MCM
	c.	Dead storage capacity	:-	4.69 MCM
	d.	Live Storage capacity	:-	24.086 MCM
	e.	Full Tank levels F.T.L.	:-	419.80 m
	f.	Max. water levels M.W.L.	:-	420.10 m
	g.	Top of bank level	:-	422.40 m
	h.	NZE	:-	387.55 m
	i.	NBL	:-	381.40 m
4	**DAM DATA:-**			
	a.	**Length of Dam**	:-	300 m
	b.	Masonry/Concrete Spill	:-	166 m
	c.	**Maximum height Of Dam**		
		Earthen / Masonry/Concrete	:-	28.50 M. / 41 m
	d.	**Top Width of Dam**		
		Earthen / Masonry/Concrete	:-	7.5 M./7.5 m
	e.	Type of waste weir	:-	Central Spillway
	f.	Maximum discharge of west weir	:-	2478 Cumec
4	**CANAL:-**			
	a.	Length of rising main		5.5 km
	b.	Village Benefited		25
	c.	Total Area in command		6500 ha
	d.	Power Required		2.41 MW
5		**COST:-**		
	a.	**Unit I - Head Works**		**Rs. 142.18 Cr.**
	b.	**Unit II - Canals**		**Rs. 84.44 Cr.**
		Total		**Rs. 226.62 Cr.**
		Cost per Ha.		**Rs. 3.49 Lakhs**
		B.C. Ratio		**1.96**

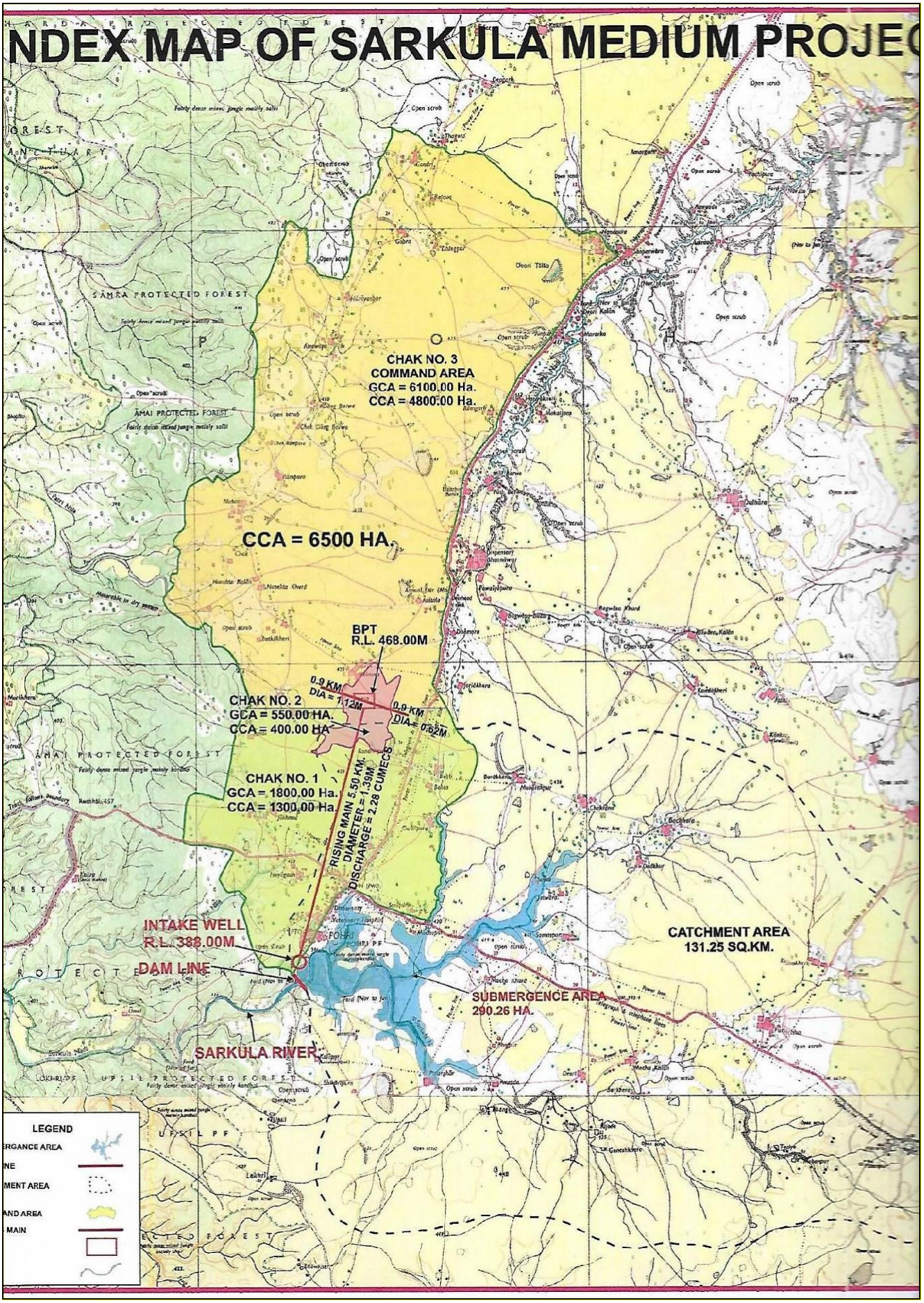

Figure 2: Index Map of Sarkula Medium Lift Irrigation Project

1.3Catchment Area

The catchment area of the project up to the proposed dam site is 131.25 km^2. The elevation of the catchment varies from about El. 380.0m to about El. 480.0m. Length of Sarkula river up to the proposed dam site is around 20.0 km. The catchment area map is shown in **Figure 3**.

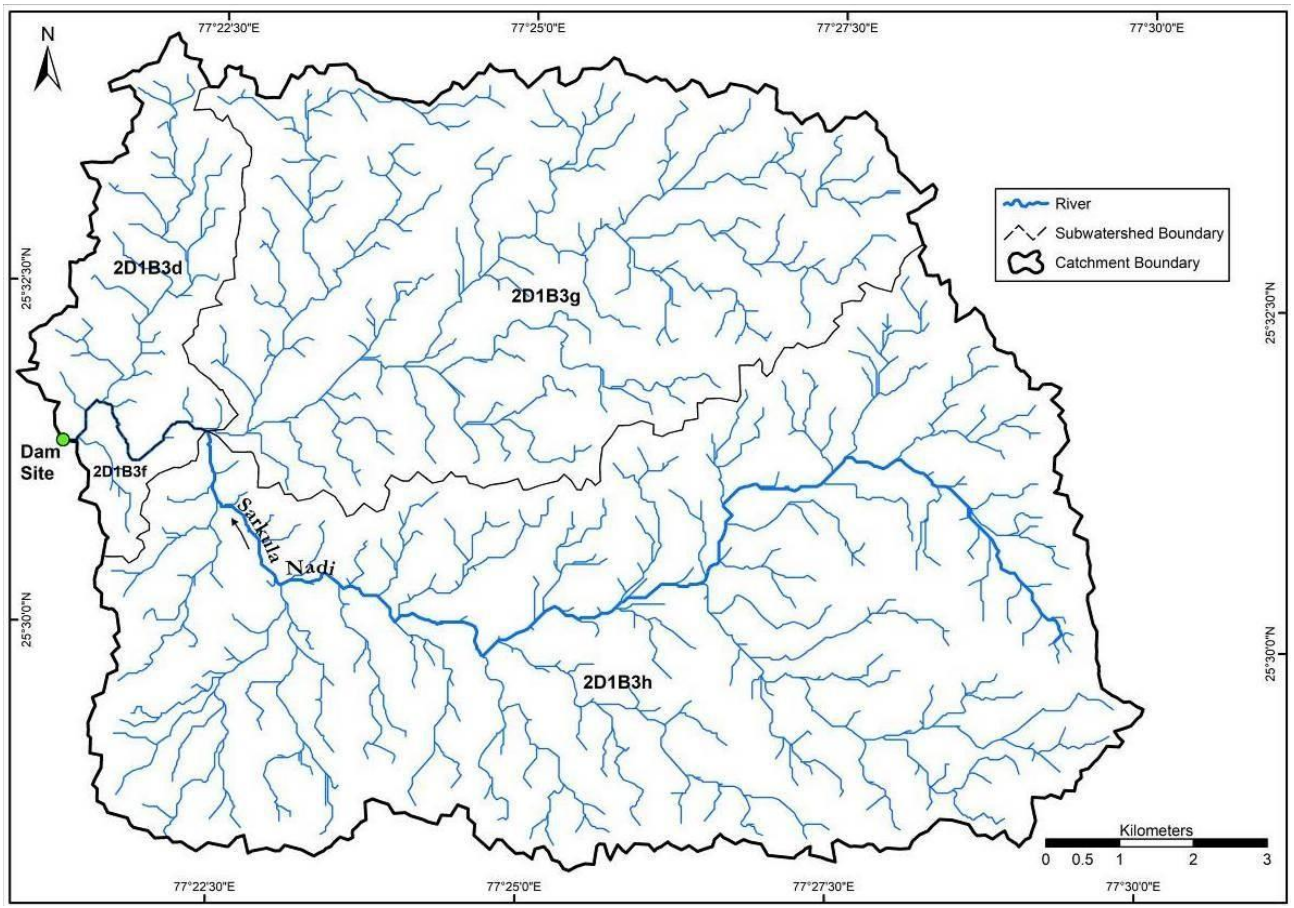

Figure 3: Drainage Map of Catchment Area showing Subwatersheds

2 NEED FOR CATCHMENT AREA TREATMENT

It is a well-established fact that reservoirs formed by dams on rivers are subjected to sedimentation. The process of sedimentation embodies the sequential processes of erosion, entrainment, transportation, deposition and compaction of sediment. The steady erosion and sediment in reservoir reduce its capacity, and 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 adversely affects the land productivity in the area. Thus, a well- designed Catchment Area Treatment (CAT) Plan is essential to ameliorate the above mentioned adverse effects of soil erosion. Soil erosion can be defined as detachment, transportation and deposition of soil particles from one place to other by means of transporting agent like air, water or animals. Soil erosion is mainly affected by rainfall intensity and runoff, slope gradient and length,

soil erodibility and vegetation cover (landuse pattern). Therefore, study of erosion and sediment yield from catchments are of great importance. Soil erosion leads to:

- loss in production potential
- reduction in infiltration rates
- reduction in water-holding capacity
- loss of nutrients
- increase in tillage operation costs
- reduction in water supply

To control the rate of soil erosion in the catchment, Catchment Area Treatment (CAT) is an ineluctable part. The CAT plan pertains to preparation of a management plan for treatment of erosion prone areas through adequate preventive measures. An effective CAT plan is a key factor to make the project eco-friendly and sustainable. Thus, a well-designed Catchment Area Treatment (CAT) Plan is essential to ameliorate the above mentioned adverse process of soil erosion. CAT plan essentially consists of following steps.

1. Calculation of soil erosion using Revised Universal Soil Loss Equation (RUSLE), combined with Remote Sensing (RS) and Geographic Information System (GIS) technologies.
2. Prioritizing the areas for treatment using Silt Yield Index (SYI).
3. Planning of suitable erosion control measures.
4. Cost estimation for CAT plan.

3 METHODOLOGY ADOPTED FOR THE STUDY

The various steps, covered in the study, are as follows:

- Defining study area
- Defining data requirement
- Data acquisition and preparation
- Output presentation

The above mentioned steps are briefly described in the following paragraphs:

3.1 Defining Study Area

As stated above, purpose of the study is preparation of CAT plan for the catchment of Sarkula Medium Lift Irrigation Project. Hence, study area is defined as catchment area of Sarkula Medium Lift Irrigation Project. In order to plan watershed management and to formulate action plans it requires subwatershed delineation, therefore, catchment area was further delineated

into subwatersheds. For the delineation of subwatershed, Watershed Atlas of India prepared by Soil and Land Use Survey of India (SLUSI) has been referred. Soil and Land Use Survey of India (SLUSI) has Watershed Atlas of India under digital environment using GIS and produced a Digital Watershed Atlas (DWA) where the delineation and codification of watersheds in the country has been undertaken in GIS environment. The delineation for DWS has been done in seven stages starting with Water Resource Regions and their subsequent division and subdivisions into Basins, Catchments, Sub-catchments, Watershed, Sub watershed and Micro-watersheds in decreasing size of the delineated hydrologic unit.

As per Watershed Atlas of India, the catchment area of Sarkula Medium Lift Irrigation Project falls in four subwatersheds. Of these four subwatersheds, two subwatersheds i.e. 2D1B3d and 2D1B3f falls partially while the other two
i.e. 2D1B3g and 2D1B3h falls completely within the catchment area. The detail of subwatersheds delineated for the catchment area is given below (refer **Table 2 and Figure 3**).

Table 2: Names and codes of Subwatersheds delineated for the Catchment Area

S. No.	Water Resource Region	Basin	Catchment	Sub-catchment	Watershed	Sub-watershed Code	Sub-watershed Area (ha)	Sub-watershed Area (%)
1.	2	2D	2D1	2D1B	2D1B3	2D1B3d	965.17	7.35
2.						2D1B3f	169.89	1.29
3.						2D1B3g	4381.80	33.39
4.						2D1B3h	7608.15	57.97
TOTAL							**13125.00**	**100**

3.2Defining Data Requirement

Soil loss has been calculated through RUSLE (Revised Universal Soil Loss Equation) model which is computed by the following equation:

Soil Loss (A) = R*K*LS*C*P

Wherein;

A = Soil loss (Tons/ha/year)

R is Rainfall & Runoff Erosivity Factor (MJ mm/ha^{-1}/h^{-1}/year^{-1}), which depends upon the annual average rainfall in mm. Data required for R factor is rainfall intensity.

K is Soil Erodibility Factor (Tons/ha/h/ha^{-1}/MJ^{-1}/mm^{-1}), which depends on the organic matter, texture permeability and profile structure of the soil. Also, it is a constant value for each soil type. Data required for K factor is soil type.

LS is Topographic Factor (dimensionless) which depends upon flow accumulation and steepness and length of slope in the area. Data required for LS factor is slope length and slope gradient.

C = Vegetation Cover and Crop Management Factor (dimensionless), which is the ratio of bare soil to vegetation and non- photosynthetic material. It is a constant value for each land use category. Data required for C factor is landuse/ landcover.

P is Conservation Supporting Practice Factor (dimensionless), which takes into account specific erosion control practices like contour bunding, bench terracing etc.

3.3Data Acquisition and Preparation

The base map of study area as already discussed was prepared from Survey of India Toposheets at 1:50000 scale. The data on various aspects was collected from different sources. The rainfall data in the Study area was sourced from the study 'Observed Rainfall Variability and Changes Over Madhya Pradesh State' carried out by India Meteorological Department. Soil map of the study area was prepared from soil map of Madhya Pradesh procured from Regional Centre of National Bureau of Soil Survey & Land Use Planning (NBSS&LUP), New Delhi.

For the preparation of DEM and preparation of Slope map, Shuttle Radar Topography Mission (SRTM) 3 Arc-Second Global Digital Terrain Elevation Data (DTED) data have been used. For the preparation of landuse/ landcover map, land use/landcover maps prepared by National Remote Sensing Centre (NRSC), Indian Space Research Organisation (ISRO) of Dept. of Space with Remote Sensing Applications Centre, MP Council of Science & Technology has been used.

3.3.1 Rainfall Erosivity (R) Factor

R factor is a function of the falling raindrop and rainfall intensity and is estimated as the product of the kinetic energy (E) of the raindrop and the maximum intensity of rainfall (I_{30}) over duration of 30 min in a storm. The erosivity of rain is calculated for each storm, and these values are summed up for each year.

In this study, the storm wise rainfall data were not available for the computation of rainfall erosivity factor (R); therefore, the relationship between seasonal value of R and average rainfall has been used. The rainfall erosivity factor has been defined as R = 81.5 + 0.38X, where, R is the average seasonal erosivity factor (MJ mm/ha^{-1}/h^{-1}/year^{-1}), and X is the annual average rainfall (mm).

For the estimation of rainfall erosivity in the catchment area, average rainfall of 30 years has been taken from the India Meteorological Department data. In the absence of site specific periodic data, India Meteorological Department data from the year 1989 to 2018 for Shivpuri district has been used for the calculation of R factor. As per the data, average annual rainfall in Shivpuri district ranges between 814-936 mm. The R factors thus arrived is 414.

3.3.2 Soil Erodibility (K) Factor

The K factor is an expression of the inherent erodibility of the soil or surface material at a particular site under standard experimental conditions. It is a function of the particle-size distribution, organic-matter content, structure, and permeability of the soil or surface material. Prior to deciding the K values, soil map for the area is prerequisite. Soil map procured from NBSS&LUP, Nagpur was digitized. Majority of the catchment area is covered by soil unit
468 (48.75%), which is characterised by deep, moderately well drained, calcareous, clayey soils on gently sloping plateau with moderate erosion. Soil map has been shown in **Figure 4**. The legend for soil unit classes is given in **Table 3**.

Table 3: Description of Soil Units in the Catchment Area

Soil Unit	Main Group	Sub Group	Area (ha)	Area (%)
452	**Fine-loamy, kaolinitic, hyperthermic, Typic Ustochrepts** Slightly deep, well drained, loamy soils on moderately sloping undulating plateau (slightly dissected) with severe erosion and moderately stony, *associated with:*	**Loamy, kaolinitic, hyperthermic, Lithic Ustorthents** Very shallow, somewhat excessively drained, loamy soils on gently sloping with severe erosion and moderately stony.	3206.51	24.43
463	**Fine, mixed, (Cal.), hyperthermic, Chromic Haplustrets** Deep, moderately well drained, calcareous, clayey soils on gently sloping intervening basin with severe erosion, *associated with:*	**Fine, mixed, hyperthermic, Vertic Ustochrepts** Slightly deep, moderately well drained, clayey soils on very gently sloping with moderate erosion.	3520.63	26.82
468	**Fine, mixed, (Cal.), hyperthermic, Typic Ustochrepts** Deep, moderately well drained, calcareous, clayey soils on gently sloping plateau with moderate erosion, *associated with:*	**Fine, mixed, (Cal.), hyperthermic, Vertic Ustochrepts** Deep, moderately well drained, calcareous, clayey soils on moderately sloping with moderate erosion.	6397.86	48.75
TOTAL			**13125.00**	**100**

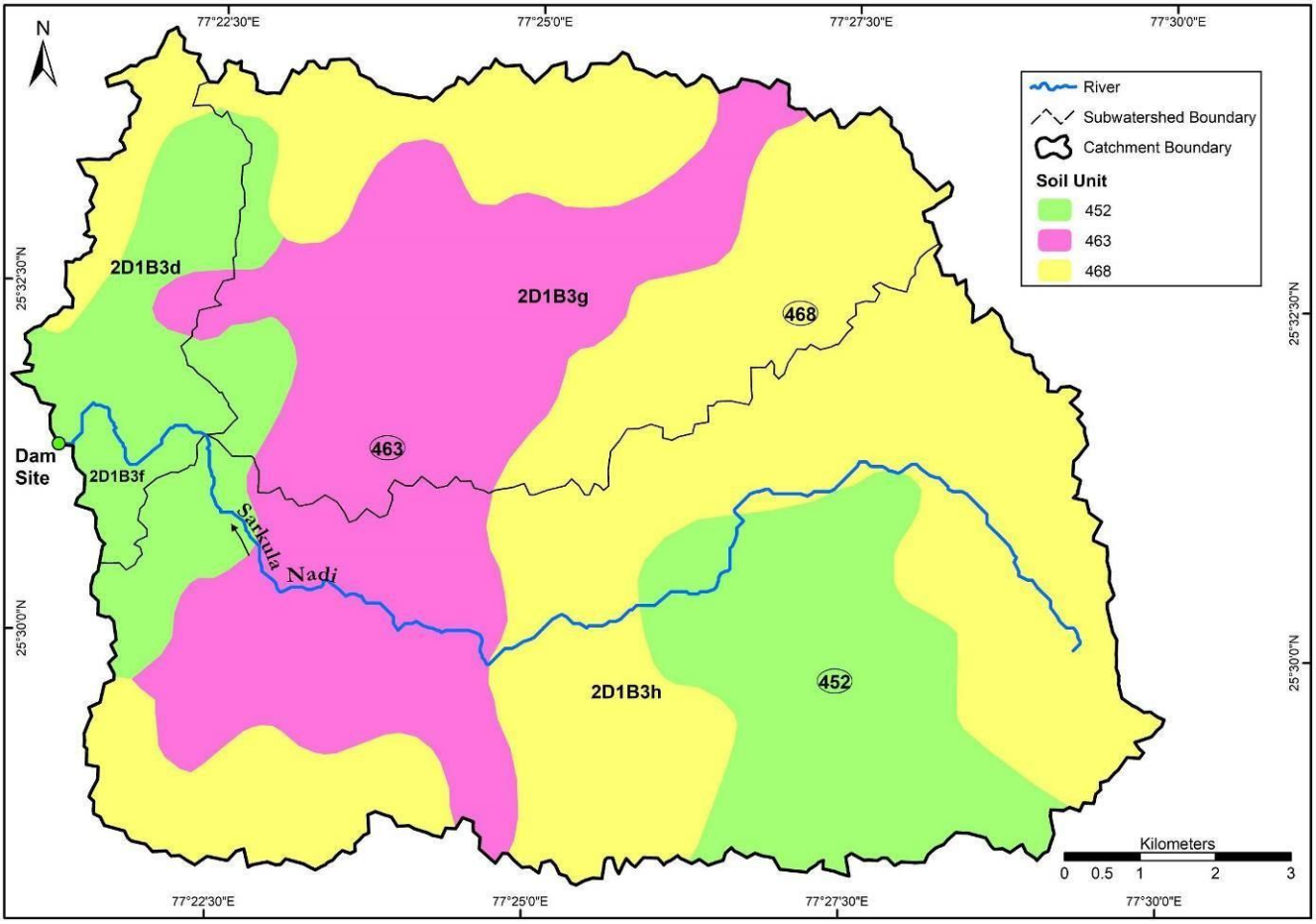

Figure 4: Soil Map of Catchment Area (For details of Soil Unit legend refer Table 3)

As per the soil map of the catchment area, the soil can be classified in two major categories. Deep with moderate erosion have low K values i.e. 0.25 because of high infiltration resulting in low runoff even though these particles are easily detached. Deep to slightly deep with severe erosion have high K value i.e. 0.35. Various classes of soil and the values of K are shown in **Figure 5** and given in **Table 4.**

Table 4: Soil Erodibility Factor for different soil types in the Catchment Area

S. No.	Soil Unit	Soil Type	Erosion Intensity	K Value
1	468	Deep	Moderate erosion	0.25
2	452, 463	Slightly deep to deep	Severe erosion	0.350

3.3.3 Topographic (LS) Factor

The LS factor is an expression of the effect of topography, specifically hill slope length and steepness, on rates of soil loss at a particular site. The value of 'LS' increases as hill slope length and steepness increase, under the assumption that runoff accumulates and accelerates in the down-slope direction. Digital Elevation Model (DEM) and Slope of a particular area is prerequisite for LS factor. As already discussed, SRTM data has been used for DEM and the sae DEM has been used for the preparation of slope map. The

slope map in degrees prepared for the catchment area is given at **Figure 6**. As can be seen from the figure, in the catchment area, the slope ranges from 0° to around 24°. The LS factor prepared for the catchment area is given at **Figure 7**.

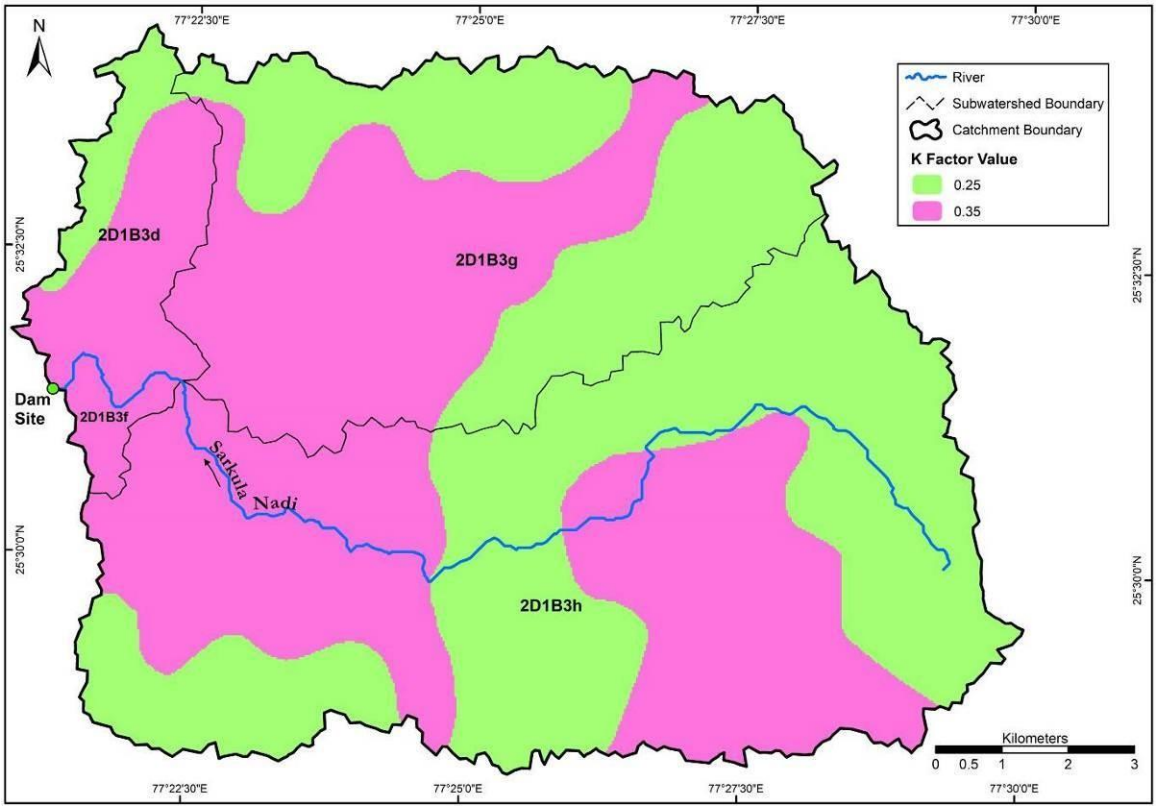

Figure 5: K Factor Value Map of Catchment Area

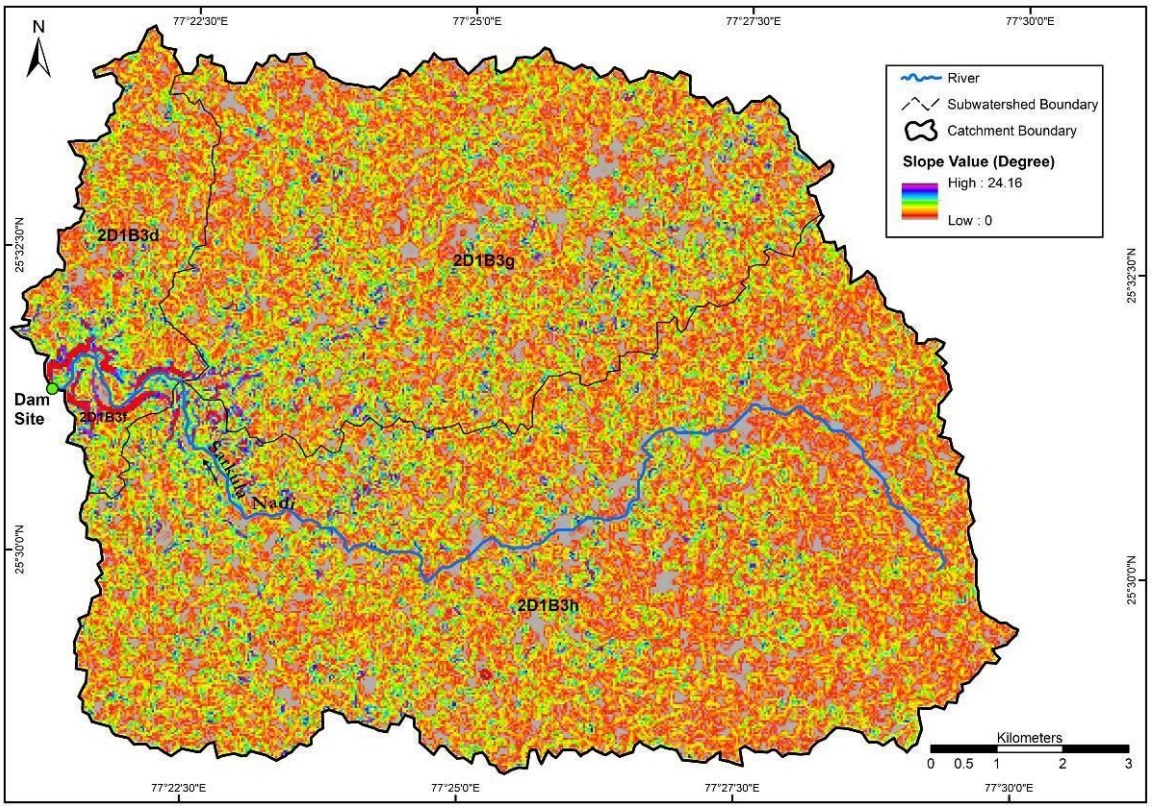

Figure 6: Slope Map of Catchment Area

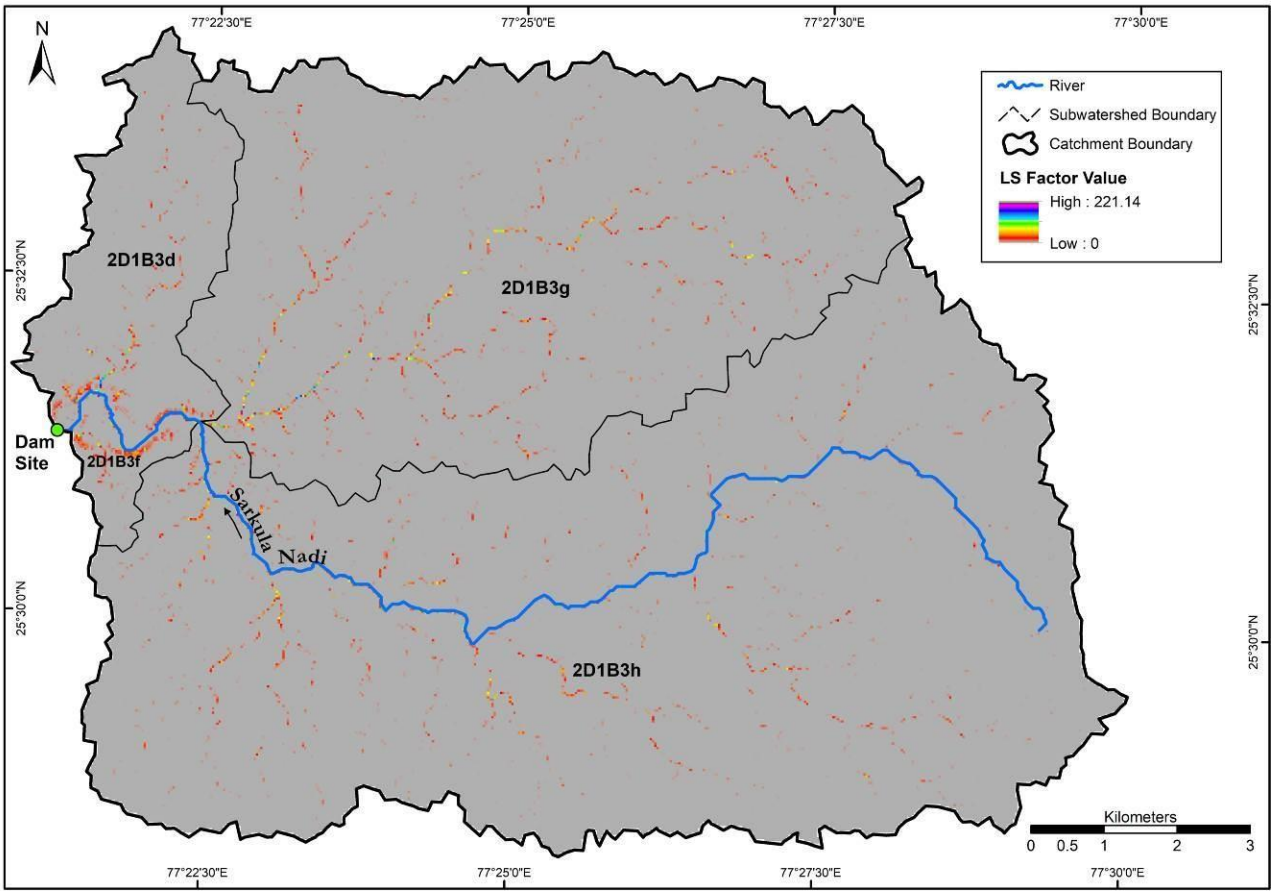

Figure 7: LS Factor Map of Catchment Area

3.3.4 Crop Management (C) Factor

The C factor is an expression of the effect of surface cover and roughness, soil biomass, and soil-disturbing activities on rates of soil loss at a particular site. The value of C decreases as surface cover and soil biomass increase, thus protecting the soil from rain splash and runoff. In the present study, the land use/land cover map prepared from Landsat Data has been used in the allocation of C factor for different land use classes.

For the present study, land use/landcover maps prepared by National Remote Sensing Centre (NRSC), Indian Space Research Organisation (ISRO) of Dept. of Space with Remote Sensing Applications Centre, MP Council of Science & Technology as partner; Google Earth has been used for the preparation of land use/ land cover maps.

The classified land use/ land cover map of the catchment area is shown as **Figure 8**. The land use/ land cover pattern of the catchment area as well as of subwatershed has been given in **Table 5**. As can be seen from the map and table, the land use/ land cover pattern can be classified into six classes, out of these six classes, agricultural land covers the maximum area i.e. around 81%. followed by scrub land i.e. around 14%. Deciduous forest, scrub forest, settlement and waterbody cover the rest 5% of the area.

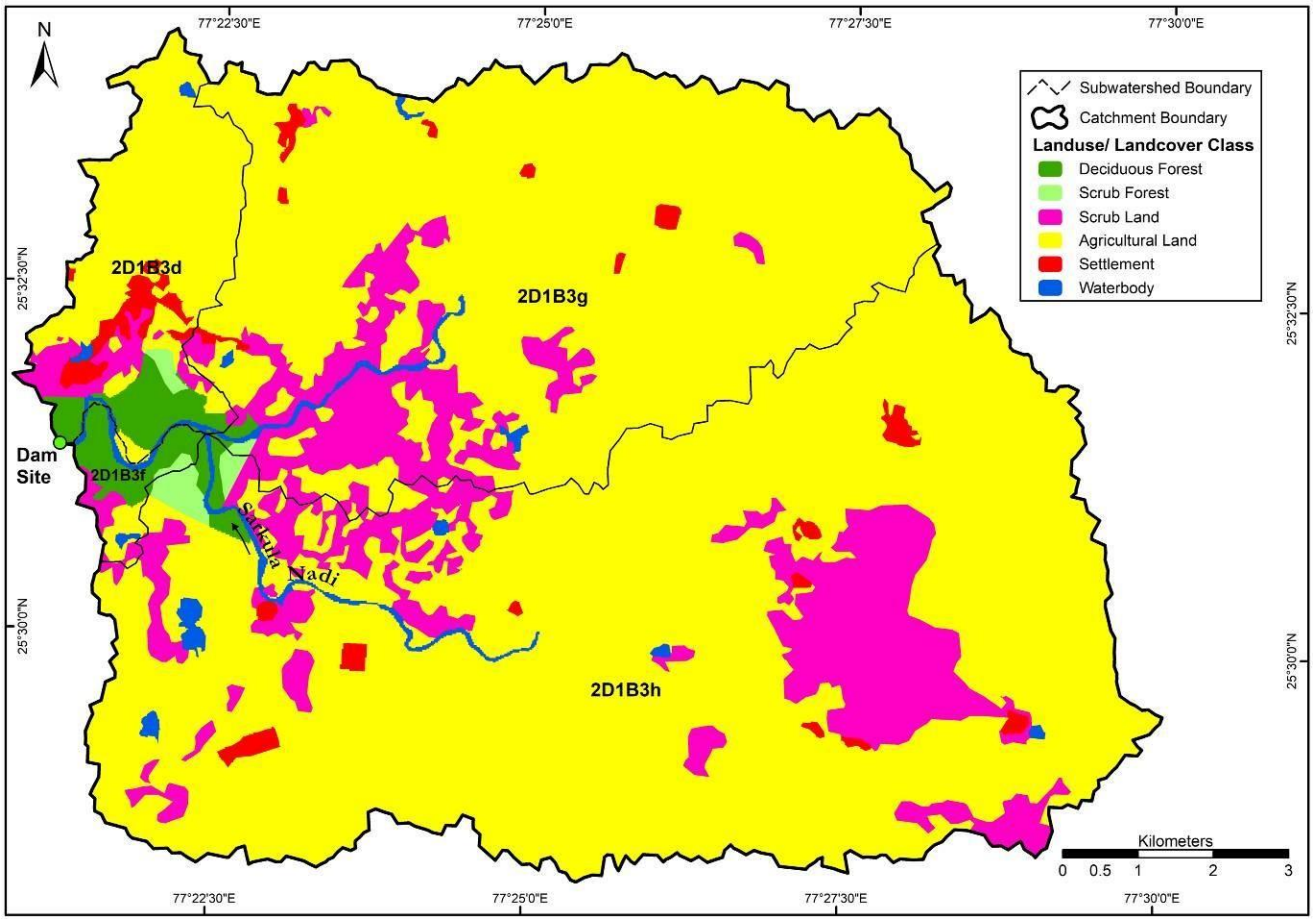

Figure 8: Landuse/ Landcover Map of Catchment Area

Table 5: Catchment Area falling under different Landuse/ Landcover Classes

S. No.	Landuse/ Landcover Class	Area (ha)	Area (%)
1	Deciduous Forest	254.01	1.94
2	Scrub Forest	75.25	0.57
3	Scrub Land	1803.30	13.74
4	Agricultural Land	10633.80	81.02
5	Settlement	200.68	1.53
6	Waterbody	157.96	1.20
	TOTAL	**13125.00**	**100**

Table 6 describes the cover management factors used in the model under different land use/land cover categories and the same is shown in the map of cover management factors given at **Figure 9**.

Table 6: Crop Management Factor used for the Catchment Area

S. No.	Land use/ Land cover Type	C Value
1	Deciduous Forest	0.05
2	Scrub Forest & Scrub Land	0.10
3	Agricultural Land	0.01
4	Settlement & Waterbody	0.00

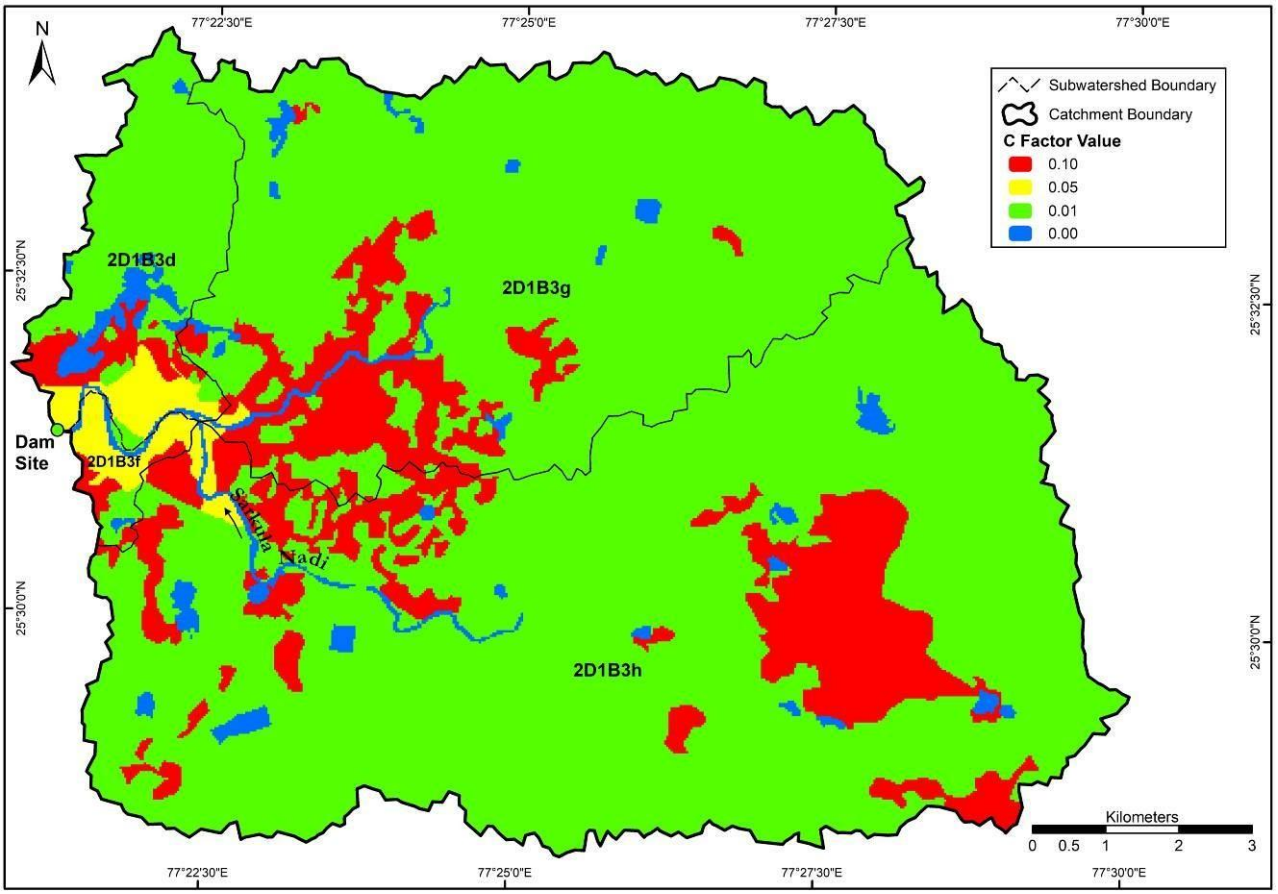

Figure 9: C Factor Value Map of Catchment Area

3.3.5 Conservation Support Practice (P) Factor

The P factor is an expression of the effects of supporting conservation practices, such as contouring, buffer strips of vegetation, and terracing, on soil loss at a particular site. It is the ratio of soil loss with specific support practice to the corresponding loss with up- or down-slope cultivation. In the present study, the P factor has been considered as 1.

3.4 Output Presentation

A thematic map for soil loss of the catchment area has been prepared using RUSLE model mentioned in the above section. The catchment area was then demarcated into different soil erosion intensity mapping units or classes based upon the extent of soil loss (see **Table 7 & Figure 10**). The catchment area under different Erosion Intensity categories is given in **Table 7**. As can be seen from the figure and table, around 82% of the catchment area is prone to less than 1 tons/ha/annum soil erosion, i.e. under negligible erosion intensity category. Only 0.69% of its area is prone to Severe and Very Severe soil erosion.

Table 7: Area falling under different Erosion Intensity Categories

S. No.	Soil loss in tons/hectare/annum	Erosion Intensity Category	EIMU Code	Area (ha)	Area (%)
1	<1	Negligible	6	10734.81	81.79
2	1-5	Slight	6	1447.23	11.03
3	5-10	Very Low	5	351.54	2.68
4	10-20	Low	4	339.18	2.58
5	20-40	Moderate	3	161.87	1.23
6	40-80	Severe	2	61.04	0.47
7	>80	Very Severe	1	29.32	0.22
	Total			**13125.00**	**100**

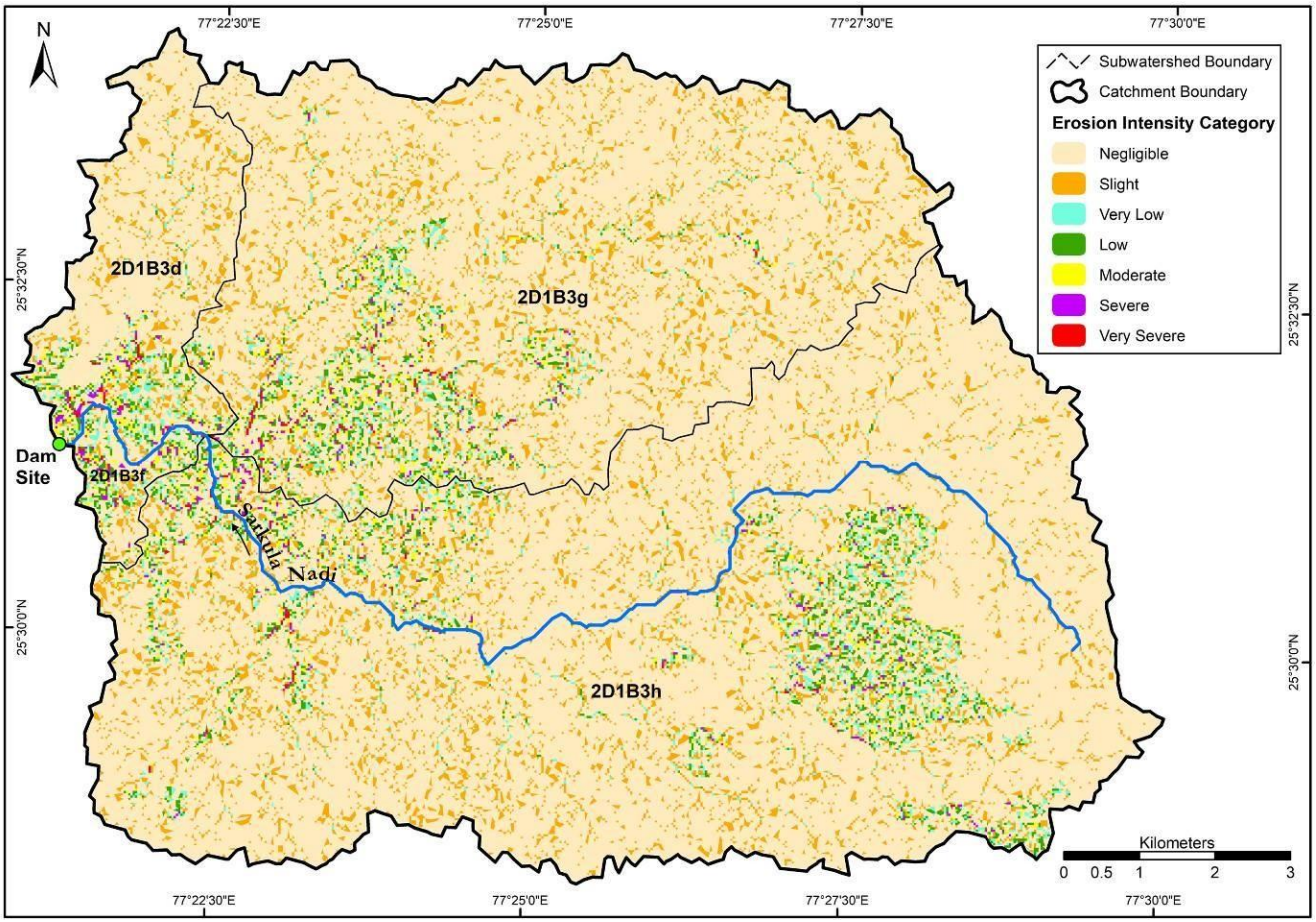

Figure 10: Erosion Intensity Map of Catchment Area

4 PRIORTIZATION OF SUBWATERSHEDS USING SILT YIELD INDEX (SYI) METHOD

`Silt Yield Index' (SYI), method has been used for prioritization of subwatersheds in the catchment for treatment. The Silt Yield Index (SYI) is defined as the Yield per unit area and SYI value for hydrologic unit is obtained by taking the weighted arithmetic mean over the entire area of the hydrologic unit by using suitable empirical equation. The Silt Yield Index Model (SYI) considers sedimentation as product of erosivity, morphometry and delivery ratio of a particular subwatershed and was conceptualized by Soil and Land Use Survey of India (SLUSI) as early as 1969 and has been operational since

then to meet the requirements of prioritization of smaller hydrologic units within river valley project catchment areas. Silt yield index (SYI) was calculated using following empirical formula:

$$SYI = \Sigma (Ai * Wi) * Di * 100 \text{ ; where } i = 1 \text{ to } n$$
$$Aw$$

where,

Ai = Area of ith unit (EIMU)
Wi = Weightage value of ith mapping unit
n = No. of mapping units
Aw = Total area of subwatershed.
Di = Delivery ratio

4.1 Erosion Intensity Mapping Unit

Erosion Intensity Mapping Units (EIMU) are demarcated and defined as per the soil erosion intensity map prepared above. Various EIMU categories, such as Very Severe, Severe, Moderate, Low, Very Low, and Negligible & Slight (clubbed together), were then used to calculate subwatershed-wise SYI. Erosion Intensity Mapping Units (EIMU) is a composite expression of physiography, land use, and conservation practices adopted. While computing soil erosion intensity in a catchment all the factors (physiography, land use, and conservation practices) are already taken into consideration. Therefore, EIMUs are assumed as per the soil erosion intensity in the subwatershed.

4.2 Weightage Value

Each erosion intensity unit is assigned a weightage value. When considered collectively, the weightage value represents approximately the comparative erosion intensity. A basic factor of K = 10 was used in determining the weightage values. The value of 10 indicates a static condition of equilibrium between erosion and deposition. Any addition to the factor K (10+X) is suggestive of erosion in ascending order whereas subtraction, i.e. (10-X) is indicative of deposition possibilities. The weightage value assigned to erosion mapping unit in a subwatershed ranges from 11-20.

4.3 Delivery Ratio

Delivery ratios were adjusted for each of the erosion intensity unit. The delivery ratio suggests the percentage of eroded material that finally finds entry into reservoir or river/ stream. Delivery ratios are assigned to all erosion intensity units depending upon their distance from the nearest stream. The criteria adopted for assigning the delivery ratio are as follows:

Nearest Stream	Delivery ratio
0 - 0.9 km	1.00

1.0 - 2.0 km	0.95
2.1 - 5.0 km	0.90
5.1 - 15.0 km	0.80
15.1 - 30.0 km	0.70

4.4 Silt Yield Index

The area of each of the mapping units is computed and silt yield indices of individual subwatersheds are calculated using the equations mentioned above. The SYI values for classification of various categories of erosion intensity rates are given in **Table 8**.

Table 8: Calculation of SYI in Subwatersheds in Catchment Area

Sub-watershed	EIMU	EIMU Area (EA) in ha	Weightage Factor (WF)	Silt Yield (SY) = EA * WF	Delivery Ratio (DR)	SYI = (SY*DR*100)/SA
2D1B3d	1	4.71	20	94.17	0.9	1121
	2	9.77	20	195.49		
	3	20.91	18	376.42		
	4	34.36	16	549.74		
	5	32.56	14	455.83		
	6	862.85	12	10354.23		
Total		965.17		12025.87		**1121**
2D1B3f	1	2.58	20	51.57	0.9	1215
	2	6.63	20	132.61		
	3	13.21	18	237.69		
	4	18.29	16	292.72		
	5	14.62	14	204.66		
	6	114.56	12	1374.75		
Total		169.89		2293.99		**1215**
2D1B3g	1	9.41	20	188.14	0.8	981
	2	17.10	20	342.00		
	3	51.86	18	933.40		
	4	100.70	16	1611.27		
	5	100.82	14	1411.45		
	6	4101.91	12	49222.95		
Total		4381.80		53709.21		**981**
2D1B3h	1	12.63	20	252.57	0.85	1042
	2	27.54	20	550.75		
	3	75.90	18	1366.13		
	4	185.83	16	2973.21		
	5	203.55	14	2849.66		
	6	7102.71	12	85232.56		
Total		7608.15		93224.87		**1042**

4.5 Prioritization of Subwatersheds

The subwatersheds are subsequently rated into various categories corresponding to their respective SYI values. The criteria followed for priority categorization of subwatersheds depending upon their SYI values is given

below and the priority classification of individual subwatershed is given in **Table 9** and **Figure 11**.

Priority categories	SYI Values
Very high	> 1300
High	1200-1299
Medium	1100-1199
Low	1000-1099
Very Low	<1000

Table 9: Priority Number as per SYI Classification in Catchment Area

Subwatershed	SYI Value	Priority	Priority Number
2D1B3d	1121	Medium	2
2D1B3f	1215	High	1
2D1B3g	981	Very Low	4
2D1B3h	1042	Low	3

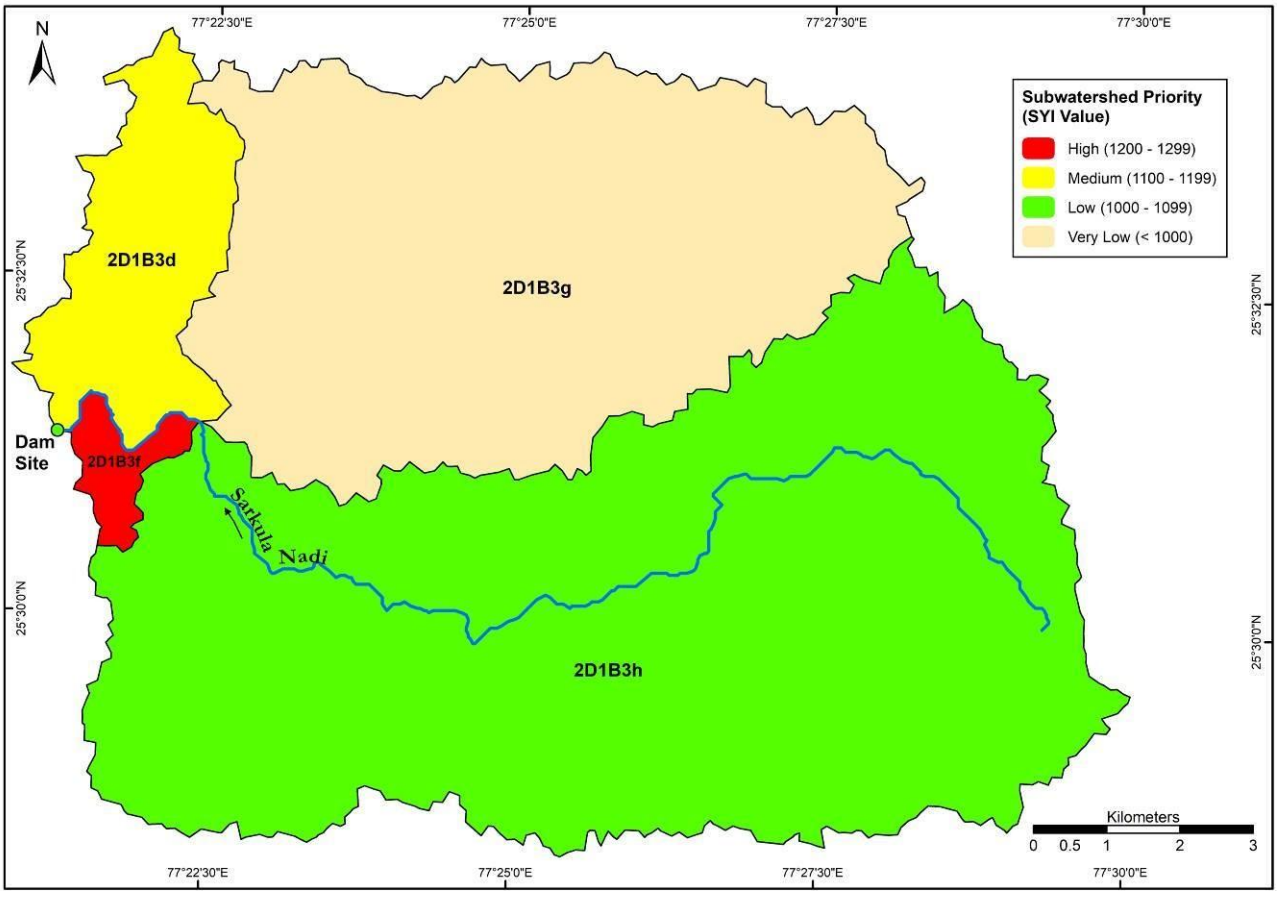

Figure 11: Subwatershed Priority Classification Map of Catchment Area

5 TREATMENT PLAN

5.1 Area to be taken up for treatment

Area under severe and very severe erosion intensity category in all the four subwatersheds will be taken up for treatment. To arrive at such an area, first of all area under severe and very severe erosion intensity category was

extracted for each subwatershed, which comes out to be **90.36 ha**. Thereafter, area under severe and very severe erosion intensity category falling inside proposed submergence area was excluded. The area under severe and very severe erosion intensity category falling outside proposed submergence area is
54.53 ha.

Lastly, area under severe and very severe erosion intensity category **(54.53)** falling under settlements, agricultural land and waterbody classes of land use/ land cover has been excluded as they are not being disturbed. The sub-watershed wise and land use/ land cover wise area thus arrived at and considered as treatable area is **49.88 ha** (or say **50 ha**) and is presented below in **Table 10**.

Table 10: Sub-Watershed wise treatable area under different Land use/ Land cover classes in Catchment Area

Subwatersheds	Sub-Watershed Wise Land use/ Land cover Classes Area (ha)			Total Area (ha)
	Deciduous Forest	Scrub Forest	Scrub Land	
2D1B3d	1.72	0.00	2.18	**3.90**
2D1B3f	0.45	0.00	0.65	**1.10**
2D1B3g	0.00	0.00	15.71	**15.71**
2D1B3h	0.14	0.87	28.17	**29.17**
Total	**2.31**	**0.87**	**46.71**	**49.88**

The period for implementing CAT plan interventions including maintenance has been taken as 8 years. It is proposed to prepare micro plans for sub-watersheds, establish administrative setup and implement other entry point activities in the first year itself. It is proposed to implement biological treatment measures in sub-watersheds falling under high and medium priority in the second year, followed by implementation of biological treatment measures in sub-watershed falling under low and very low priority in third year. Maintenance period will be subsequent 5 years, except for energy plantation where maintenance period will be subsequent 3 years. Since engineering measures provides immediate control of erosion therefore it is proposed to implement them in the second year itself for all the sub- watersheds.

5.2 Treatment Measures

Watershed management is the optimal use of soil and water resources within a given geographical area so as to enable sustainable production. It implies changes in land use, vegetative cover, and other structural and non-structural action that are taken in a watershed to achieve specific watershed

management objectives. The overall objectives of watershed management programme are to:

- increase infiltration into soil;
- control excessive runoff;
- manage & utilize runoff for useful purpose.

The basis of site selection for different engineering treatment measures under CAT are given in **Table 11**.

Table 11: Basis for Selection of Catchment Area Treatment Measures

Treatment measure	***Basis for selection***
Normal Afforestation	Area under severe and very severe erosion category falling under Scrub forest
Enrichment	Area under severe and very severe erosion category falling under Deciduous forest
Energy Plantation	Area under severe and very severe erosion category falling under Scrub land
Dry stone masonry Check Dams	In the streams of 3rd and 4th order
Gabion Check Dams	Wherever loose boulders are not stable in particular stretch of a stream

5.2.1 Biological Measures

The biological measures would comprise of:

- Normal Afforestation
- Enrichment
- Energy Plantation

5.2.1.1 Normal Afforestation

A well stocked forest is the best insurance against soil loss as well as for ecological rehabilitation. It is therefore proposed to increase the vegetation cover in the tract. For this, patches of scrub forest falling under severe and very severe erosion intensity category shall be brought under afforestation. The locality factors prevalent in the area such as fires, grazing etc. are fairly adverse to the establishment of plantations. Thus, special and intensive efforts are needed to ensure the success of afforestation work. Owing to the above enumeration factors, the plantation will require higher levels of maintenance also. This will include raising of multi-tier mixed vegetation of suitable local species. 1000 plants per hectare will be planted under this scheme. Planting will be done in pits. Earth work should be done well in advance. Plants should be healthy with strong stems. Planting should be done in June when the water supply starts. RCC fence posts with 4 strand barbed wire fencing, interlaced with thorny bushes will be done in the plantation areas. Further, it is assessed that it is essential to make provision for soil and moisture conservation measures in the areas proposed for afforestation.

Provision had been made for undertaking various necessary soil and moisture conservation measures in these areas. Provision is also made for five years maintenance of afforestation undertaken as part of the catchment area treatment. For providing the maintenance it is assumed that mortality for first year will be 25 per cent and will reduce to 20 per cent during second year and to 15 per cent during third, fourth and fifth year. The unit cost for afforestation including maintenance cost for five years is estimated to be **Rs 80,950** per ha consisting of Rs 56,000 for plantation and Rs 24,950 for maintenance for five years. The detailed break-up of item-wise cost for afforestation is furnished in **Annexure I**. The area to be brought under afforestation and its unit cost is given at **Table 12**.

5.2.1.2 Enrichment Plantation

Maintaining and enhancing existing forest cover reduces soil erosion to a great extent. It is therefore proposed to increase the vegetation cover of the existing forests. For this, patches of deciduous forest land falling under severe and very severe erosion intensity category shall be brought under enrichment plantation. 700 plants per hectare will be planted under this scheme. The plantation will be maintained for subsequent five years. RCC fence posts with 4 strand barbed wire fencing, interlaced with thorny bushes will be done in the plantation areas. The unit cost for enrichment plantation including maintenance cost for five years is estimated to be **Rs. 68,100** per ha consisting of Rs. 47,000 for plantation and Rs. 21,100 for maintenance for five years. The detailed break-up of item-wise cost for enrichment plantation is furnished in **Annexure I**. The area to be brought under enrichment plantation is given at **Table 12.**

5.2.1.3 Energy Plantation

Energy plantation scheme is essential for a continuous supply of fuel and fodder. It can be easily carried out and it is economical to carry out. Agricultural land will not be used for energy plantation, instead, fallow land falling under severe and very severe erosion intensity category will be used for energy plantation. 1000 plants per hectare will be planted under this scheme. The plantation will be maintained for subsequent three years. Wooden fence posts with 4 strand barbed wire fencing, interlaced with thorny bushes will be done in the plantation areas. The unit cost for energy plantation including maintenance cost for three years is estimated to be **Rs. 65,250** per ha consisting of Rs. 49,000 for plantation and Rs. 16,250 for maintenance for three years. The detailed break-up of item-wise cost for energy plantation is furnished in **Annexure I**. The area to be brought under energy plantation is given at **Table 12**.

5.2.2 Engineering Measures

The engineering treatment measures require less time to be put in place and can provide quick solutions. These would comprise mainly of Dry stone masonry check dams and Gabion check dams.

5.2.2.1 Dry Stone Masonry Check Dam

Dry stone masonry check dams can be made of boulder piled up across the streams if they are locally available. Such structures for damming a stream to refine the flow velocity and to control bank erosion are called dry stone masonry/ loose bolder check dams. The unit cost for dry stone masonry check dam is estimated to be **Rs. 22,300** per structure. The number of dry stone masonry check dams suggested is given at **Table 12.**

5.2.2.2 Gabion Check Dam

If dry stone masonry check dams are considered not to be stable in a particular reach of the stream, Gabion structure can be installed. The unit cost for gabion check dam is estimated to be **Rs. 46,875** per structure. The number of gabion check dams suggested is given at **Table 12.**

5.2.3 Summary of Treatment Measures

Subwatershed wise areas identified for treatment with different treatment measures is given in **Table 12.** The total cost required for the treatment of 50 ha by the means of different treatment measures is **Rs. 59.54 lakh.** The summary of treatment measures and their cost is given in **Table 13.**

Table 12: Sub-Watershed wise Summary of Treatment Measures

S. No.	Treatment Measures	Sub-Watershed				Total
		2D1B3d	2D1B3f	2D1B3g	2D1B3h	
1	Normal Afforestation (ha)	0	0	0	1	**1**
2	Enrichment Plantation (ha)	2	0	0	0	**2**
3	Energy Plantation (ha)	2	1	16	28	**47**
4	Dry stone Masonry Check Dams (No)	10	4	40	30	**84**
5	Gabion Check Dams (No)	2	1	8	6	**17**

Table 13: Summary of treatment measures and their cost for CAT Plan

Treatment Measures	Quantity	Unit Cost (Rs)*	Total Cost (Rs.)
Normal Afforestation (ha)	1	80,950	**80,950**
Enrichment Plantation (ha)	2	68,100	**1,36,200**
Energy Plantation (ha)	47	65,250	**30,66,750**
Dry stone Masonry Check Dams (No)	84	22,300	**18,73,200**
Gabion Check Dams (No)	17	46,875	**7,96,875**
TOTAL			**59,53,975**

Note*: Unit Cost has been taken as per the cost norms given in **Annexure I**

6 OTHER COMPONENTS OF CAT PLAN

Apart from the biological and engineering treatment measures in the catchment area there are other aspects of the CAT Plan to be addressed and their cost included in the overall cost estimate of the plan. The charges for operational support, forest protection, social mobilization, documentation and publication, monitoring and evaluation and providing environmental services are some of the integral ingredients which have to be considered and included while formulating the CAT plans.

6.1 Administrative Charges

For an efficient management of forest resources, it is essential that operational support to the Forest Department is adequately developed. Similarly, in remote localities there are no places for shelter for the staff, people and trekkers. Therefore, a budgetary provision of **Rs 2.98 lakh** has been kept for this component.

6.2 Provision for Micro Planning

The year-wise areas requiring treatment measures have been suggested but have not been marked. The spatial location of specific treatment to be carried out in the catchment area would require extensive detailing during the implementation of CAT and a provision for micro-planning has been made in the total CAT financial allocation. For this purpose, a provision of **Rs 1.19 lakh** is being made.

6.3 Monitoring & Evaluation

Monitoring and evaluation will be undertaken as a part of project management. A process of self-evaluation at specified intervals of time will ensure the field level verification of suggested treatment measures and efficacy of the CAT plan.

The year-wise areas requiring treatment measures have been suggested but have not been marked. The spatial location of specific treatment to be carried out in the catchment area would require extensive detailing during the implementation of CAT and a provision for micro-planning has been made in the total CAT financial allocation. Thereafter, annual work plan would be prepared well in advance after undertaking initial ground surveys during micro-planning, specifying physical and financial targets, sites, locations and beneficiaries of each component of the project activity. Month-wise work schedule of various items of each component for the financial year would also be prepared in advance and its timely implementation would be ensured. Monthly progress report on all activities would be submitted by the Range

Officers to Divisional Forest Officer. The monitoring committee shall be constituted at the project level for this purpose which too would monitor on a regular basis the quality and quantity of works being carried out under the CAT plan area. A provision of **Rs 1.79 lakh** has been made for this component.

6.4 Contingencies

A provision of **Rs 5.95 lakh** has been kept under this component for some leeway to adjust any unforeseen expenditure.

7 COST ESTIMATE

The estimated cost of implementation of CAT plan including monitoring and evaluation is **Rs. 71.45 lakh** and is given at **Table 14**. The phasing of physical and financial targets is given in **Table 15.**

Table 14: Estimated Cost of CAT Plan Implementation

S. No.	Item	Rate (Rs)	Unit	Target	
				Physical	Financial (Rs)
I	**Biological Measures**				
1	Normal Afforestation		ha		
	i) Creation	56,000		1	56,000.00
	ii) Maintenance for 5 years	24,950		1	24,950.00
2	Enrichment		ha		
	i) Creation	47,000		2	94,000.00
	ii) Maintenance for 5 years	21,100		2	42,200.00
3	Energy Plantation		ha		
	i) Creation	49,000		47	2,303,000.00
	ii) Maintenance for 3 years	16,250		47	763,750.00
	Sub Total I (1+2+3)				**3,283,900.00**
II	**Engineering Measures**				
4	Check Dams (DRSM)	22,300	No	84	1,873,200.00
5	Gabion Check Dams	46,875	No	17	796,875.00
	Sub Total II (4+5)				**2,670,075.00**
A	**Treatment Cost (Sub Total I + II)**				**5,953,975.00**
III	**Administrative Measures**				
6	Administrative Charges @5% of Total				297,698.75
7	Micro planning @2% of Treatment Cost				119,079.50
8	Monitoring & Evaluation Cost @3% of Treatment Cost				178,619.25
9	Contingencies @10% of Treatment Cost				595,397.50
B	**Sub Total III**				**1,190,795.00**
	Total CAT Plan Cost (A + B)				**7,144,770.00**

Table 15: Year Wise Physical & Financial Targets of Treatment Measures for CAT Plan

S. No.	Year Wise Treatment Plan	Year - 1 (2020-21)		Year - 2 (2021-22)		Year - 3 (2022-23)		Year - 4 (2023-24)		Year - 5 (2024-25)		Year – 6 (2025-26)		Year - 7 (2026-27)		Year - 8 (2027-28)		Total	
		Phy.	Fin. (Rs)	Phy.	Fin. (Rs)	Phy.	Fin. (Rs)	Phy.	Fin. (Rs)	Phy.	Fin. (Rs)	Phy.	Fin. (Rs)	Phy.	Fin. (Rs)	Phy.	Fin. (Rs)	Phy.	Fin. (Rs)
I	**Biological Measures (ha)**																		
1	**Normal Afforestation**					1	56,000											**1**	**56,000**
	1st Year maintenance							1	6,400									**1**	**6,400**
	2nd Year maintenance									1	5,500							**1**	**5,500**
	3rd Year maintenance											1	4,350					**1**	**4,350**
	4th Year maintenance													1	4,350			**1**	**4,350**
	5th Year maintenance															1	4,350	**1**	**4,350**
2	**Enrichment Plantation**			2	94,000													**2**	**94,000**
	1st Year maintenance					2	10,000											**2**	**10,000**
	2nd Year maintenance							2	8,800									**2**	**8,800**
	3rd Year maintenance									2	7,800							**2**	**7,800**
	4th Year maintenance											2	7,800					**2**	**7,800**
	5th Year maintenance													2	7,800			**2**	**7,800**
3	**Energy Plantation**			3	147,000	44	2,156,000											**47**	**2,303,000**
	1st Year maintenance					3	19,200	44	281,600									**47**	**300,800**
	2nd Year maintenance							3	16,500	44	242,000							**47**	**258,500**
	3rd Year maintenance									3	13,050	44	191,400					**47**	**204,450**
	Sub Total I			**5**	**241,000**	**50**	**2,241,200**	**50**	**313,300**	**50**	**268,350**	**47**	**203,550**	**3**	**12,150**	**1**	**4,350**		**3,283,900**
II	**Soil & Water Conservation Measures**																		
4	Dry Stone Masonry Check Dams (Nos)			84	1,873,200													**84**	**1,873,200**
5	Gabion Check Dams (Nos)			17	796,875													**17**	**796,875**
	Sub Total II				**2,670,075**														**2,670,075**
A	**Total (I and II)**				**2,911,075**		**2,241,200**		**313,300**		**268,350**		**203,550**		**12,150**		**4,350**		**5,953,975**
III	**ADMINISTRATIVE MEASURES**																		
6	Administrative Charges @5% of Total		148,849		148,849														**297,699**
7	Micro planning @2% of Treatment Cost		119,080																**119,080**
8	Monitoring & Evaluation Cost @3% of Treatment Cost				87,332		67,236		9,399		8,051		6,107		365		131		**178,619**
9	Contingencies @10% of Treatment Cost				291,108		224,120		31,330		26,835		20,355		1,215		435		**595,398**
B	**Sub Total III**		**267,929**		**527,289**		**291,356**		**40,729**		**34,886**		**26,462**		**1,580**		**566**		**1,190,795**
	Total (A and B)		**267,929**		**3,438,364**		**2,532,556**		**354,029**		**303,236**		**230,012**		**13,730**		**4,916**		**7,144,770**

ANNEXURE I

1. Per Hectare Cost Norm for Normal Afforestation

S. No.	Particulars of Work	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	Survey & demarcation and preparation of map	ha.	1	450	450.00
2	Bush cutting in the plantation site	ha.	1	750	750.00
3	Interlacing of thorny bushes in B/wire	Rmt	180	3	540.00
4	Preparation of inspection path 60 cm wide	Rmt	150	15	2250.00
5	Layout of Pits	ha.	1	500	500.00
6	Digging of pits 45x45x45 cm (40% of total)	00	4	1200	4800.00
7	Digging of pits 30x30x30 cm(60% of total)	00	6	900	5400.00
8	Filling of pits 45x45x45 cm (40% of total)	00	4	200	800.00
9	Filling of pits 30x30x30 cm (60% of total)	00	6	150	900.00
10	Carriage of naked roots plants over a distance of 0.5 km up hill	00	2	100	200.00
11	Carriage of plants in P/bags over a distance of 0.5 km up hill	00	3	150	450.00
12	Planting of entire Plants raised in P/bags	00	6	300	1800.00
13	Planting of naked root plants	00	4	200	800.00
14	Nursery cost of Plants	Nos	1000	9	9000.00
	Total				**28640.00**
15	Soil & moisture conservation works (25% of initial planting cost)		25%		7160.00
16	Add cost of RCC fence post and B/Wire			LS	20000.00
	Grand Total				**55800.00**
	Or Say				**56000.00**
I	**1st Year Maintenance - 25% Mortality**				
1	Re-digging of Pits 45x45x45 cm	00	1	600	600.00
2	Re-digging of Pits 30x30x30 cm	00	1.5	450	675.00
3	Filling of pits 45x45x45 cm	00	1	100	100.00
4	Filling of pits 30x30x30 cm	00	1.5	75	112.50
5	Planting of P/bags plants	00	1.5	300	450.00
6	Planting of naked root plants	00	1.0	200	200.00
7	Carriage of plants in P/bags over a distance of 0.5 km up hill	00	0.8	150	112.50
8	Carriage of naked roots plants over a distance of 0.5 km up hill	00	0.5	100	50.00
9	Nursery cost of Plants	No.	250	9	2250.00
10	Repair of fence	Rmt	180	2	360.00
11	Repair of Inspection path	LS			500.00
12	Repair of soil and moisture conservation works	LS			1000.00
	Total I				**6410.00**
	Or Say				**6400.00**
II	**2nd Year Maintenance - 20% Mortality**				
1	Re-digging of Pits 45x45x45 cm	00	0.8	600	480.00
2	Re-digging of Pits 30x30x30 cm	00	1.2	450	540.00
3	Filling of pits 45x45x45 cm	00	0.8	100	80.00
4	Filling of pits 30x30x30 cm	00	1.2	75	90.00
5	Planting of P/bags plants	00	1.2	300	360.00
6	Planting of naked root plants	00	0.8	200	160.00
7	Carriage of plants in P/bags over a distance of 0.5 km up hill	00	0.6	150	90.00
8	Carriage of naked roots plants over a distance of 0.5 km up hill	00	0.4	100	40.00
9	Nursery cost of Plants	No.	200	9	1800.00
10	Repair of fence	Rmt	180	2	360.00
11	Repair of Inspection path	LS			500.00
12	Repair of soil and moisture conservation works	LS			1000.00
	Total I				**5500.00**
	Or Say				**5500.00**

S. No.	Particulars of Work	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
III	**3rd Year Maintenance - 15% Mortality**				
1	Re-digging of Pits 45x45x45 cm	00	0.6	600	360.00
2	Re-digging of Pits 30x30x30 cm	00	0.9	450	405.00
3	Filling of pits 45x45x45 cm	00	0.6	100	60.00
4	Filling of pits 30x30x30 cm	00	0.9	75	67.50
5	Planting of P/bags plants	00	0.9	300	270.00
6	Planting of naked root plants	00	0.6	200	120.00
7	Carriage of plants in P/bags over a distance of 0.5 km up hill	00	0.5	150	67.50
8	Carriage of naked roots plants over a distance of 0.5 km up hill	00	0.3	100	30.00
9	Nursery cost of Plants	No.	120	9	1080.00
10	Repair of fence	Rmt	200	2	400.00
11	Repair of Inspection path	LS			500.00
12	Repair of soil and moisture conservation works	LS			1000.00
	Total I				**4360.00**
	Or Say				**4350.00**
IV	**4th Year Maintenance - 15% Mortality**				
1	Re-digging of Pits 45x45x45 cm	00	0.6	600	360.00
2	Re-digging of Pits 30x30x30 cm	00	0.9	450	405.00
3	Filling of pits 45x45x45 cm	00	0.6	100	60.00
4	Filling of pits 30x30x30 cm	00	0.9	75	67.50
5	Planting of P/bags plants	00	0.9	300	270.00
6	Planting of naked root plants	00	0.6	200	120.00
7	Carriage of plants in P/bags over a distance of 0.5 km up hill	00	0.5	150	67.50
8	Carriage of naked roots plants over a distance of 0.5 km up hill	00	0.3	100	30.00
9	Nursery cost of Plants	No.	120	9	1080.00
10	Repair of fence	Rmt	200	2	400.00
11	Repair of Inspection path	LS			500.00
12	Repair of soil and moisture conservation works	LS			1000.00
	Total I				**4360.00**
	Or Say				**4350.00**
V	**5thYear Maintenance - 15% Mortality**				
1	Re-digging of Pits 45x45x45 cm	00	0.6	600	360.00
2	Re-digging of Pits 30x30x30 cm	00	0.9	450	405.00
3	Filling of pits 45x45x45 cm	00	0.6	100	60.00
4	Filling of pits 30x30x30 cm	00	0.9	75	67.50
5	Planting of P/bags plants	00	0.9	300	270.00
6	Planting of naked root plants	00	0.6	200	120.00
7	Carriage of plants in P/bags over a distance of 0.5 km up hill	00	0.5	150	67.50
8	Carriage of naked roots plants over a distance of 0.5 km up hill	00	0.3	100	30.00
9	Nursery cost of Plants	No.	120	9	1080.00
10	Repair of fence	Rmt	200	2	400.00
11	Repair of Inspection path	LS			500.00
12	Repair of soil and moisture conservation works	LS			1000.00
	Total I				**4360.00**
	Or Say				**4350.00**
	Total Maintenance Cost				**24,950.00**
	GRAND TOTAL	**ha.**	**1**		**80,950.00**

2. Per Hectare Cost Norm for Enrichment

S. No.	Particulars of Work	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	Survey & demarcation and preparation of map	ha.	1	450	450.00
2	Bush cutting in the plantation site	ha.	1	750	750.00
3	Interlacing of thorny bushes in B/wire	Rmt	180	3	540.00
4	Preparation of inspection path 60 cm wide	Rmt	150	15	2250.00
5	Layout of Pits	ha.	1	500	500.00
6	Digging of pits 45x45x45 cm (40% of total)	00	2.8	1200	3360.00
7	Digging of pits 30x30x30 cm(60% of total)	00	4.2	900	3780.00
8	Filling of pits 45x45x45 cm (40% of total)	00	2.8	200	560.00
9	Filling of pits 30x30x30 cm (60% of total)	00	4.2	150	630.00
10	Carriage of naked roots plants over a distance of 0.5 km up hill	00	1.5	100	150.00
11	Carriage of plants in P/bags over a distance of 0.5 km up hill	00	2	150	300.00
12	Planting of entire Plants raised in P/bags	00	4.2	300	1260.00
13	Planting of naked root plants	00	2.8	200	560.00
14	Nursery cost of Plants	Nos	700	9	6300.00
	Total				**21390.00**
15	Soil & moisture conservation works (25% of initial planting cost)		25%		5347.50
16	Add cost of RCC fence post and B/Wire			LS	20000.00
	Grand Total				**46737.50**
	Or Say				**47000.00**
I	**1st Year Maintenance - 25% Mortality**				
1	Re-digging of Pits 45x45x45 cm	00	0.7	600	420.00
2	Re-digging of Pits 30x30x30 cm	00	1.05	450	472.50
3	Filling of pits 45x45x45 cm	00	0.7	100	70.00
4	Filling of pits 30x30x30 cm	00	1.05	75	78.75
5	Planting of P/bags plants	00	1.1	300	315.00
6	Planting of naked root plants	00	0.7	200	140.00
7	Carriage of plants in P/bags over a distance of 0.5 km up hill	00	0.5	150	75.00
8	Carriage of naked roots plants over a distance of 0.5 km up hill	00	0.4	100	37.50
9	Nursery cost of Plants	No.	175	9	1575.00
10	Repair of fence	Rmt	180	2	360.00
11	Repair of Inspection path	LS			500.00
12	Repair of soil and moisture conservation works	LS			1000.00
	Total I				**5043.75**
	Or Say				**5000.00**
II	**2nd Year Maintenance - 20% Mortality**				
1	Re-digging of Pits 45x45x45 cm	00	0.6	600	336.00
2	Re-digging of Pits 30x30x30 cm	00	0.8	450	378.00
3	Filling of pits 45x45x45 cm	00	0.6	100	56.00
4	Filling of pits 30x30x30 cm	00	0.8	75	63.00
5	Planting of P/bags plants	00	0.84	300	252.00
6	Planting of naked root plants	00	0.56	200	112.00
7	Carriage of plants in P/bags over a distance of 0.5 km up hill	00	0.4	150	60.00
8	Carriage of naked roots plants over a distance of 0.5 km up hill	00	0.3	100	30.00
9	Nursery cost of Plants	No.	140	9	1260.00
10	Repair of fence	Rmt	180	2	360.00
11	Repair of Inspection path	LS			500.00
12	Repair of soil and moisture conservation works	LS			1000.00
	Total I				**4407.00**
	Or Say				**4400.00**
III	**3rd Year Maintenance - 15% Mortality**				
1	Re-digging of Pits 45x45x45 cm	00	0.4	600	252.00
2	Re-digging of Pits 30x30x30 cm	00	0.6	450	283.50

S. No.	Particulars of Work	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
3	Filling of pits 45x45x45 cm	00	0.4	100	42.00
4	Filling of pits 30x30x30 cm	00	0.6	75	47.25
5	Planting of P/bags plants	00	0.6	300	189.00
6	Planting of naked root plants	00	0.4	200	84.00
7	Carriage of plants in P/bags over a distance of 0.5 km up hill	00	0.3	150	45.00
8	Carriage of naked roots plants over a distance of 0.5 km up hill	00	0.2	100	22.50
9	Nursery cost of Plants	No.	120	9	1080.00
10	Repair of fence	Rmt	200	2	400.00
11	Repair of Inspection path	LS			500.00
12	Repair of soil and moisture conservation works	LS			1000.00
	Total I				**3945.25**
	Or Say				**3900.00**
IV	**4th Year Maintenance - 15% Mortality**				
1	Re-digging of Pits 45x45x45 cm	00	0.4	600	252.00
2	Re-digging of Pits 30x30x30 cm	00	0.6	450	283.50
3	Filling of pits 45x45x45 cm	00	0.4	100	42.00
4	Filling of pits 30x30x30 cm	00	0.6	75	47.25
5	Planting of P/bags plants	00	0.6	300	189.00
6	Planting of naked root plants	00	0.4	200	84.00
7	Carriage of plants in P/bags over a distance of 0.5 km up hill	00	0.3	150	45.00
8	Carriage of naked roots plants over a distance of 0.5 km up hill	00	0.2	100	22.50
9	Nursery cost of Plants	No.	120	9	1080.00
10	Repair of fence	Rmt	200	2	400.00
11	Repair of Inspection path	LS			500.00
12	Repair of soil and moisture conservation works	LS			1000.00
	Total I				**3945.25**
	Or Say				**3900.00**
V	**5thYear Maintenance - 15% Mortality**				
1	Re-digging of Pits 45x45x45 cm	00	0.4	600	252.00
2	Re-digging of Pits 30x30x30 cm	00	0.6	450	283.50
3	Filling of pits 45x45x45 cm	00	0.4	100	42.00
4	Filling of pits 30x30x30 cm	00	0.6	75	47.25
5	Planting of P/bags plants	00	0.6	300	189.00
6	Planting of naked root plants	00	0.4	200	84.00
7	Carriage of plants in P/bags over a distance of 0.5 km up hill	00	0.3	150	45.00
8	Carriage of naked roots plants over a distance of 0.5 km up hill	00	0.2	100	22.50
9	Nursery cost of Plants	No.	120	9	1080.00
10	Repair of fence	Rmt	200	2	400.00
11	Repair of Inspection path	LS			500.00
12	Repair of soil and moisture conservation works	LS			1000.00
	Total I				**3945.25**
	Or Say				**3900.00**
	Total Maintenance Cost				**21,100.00**
	GRAND TOTAL	**ha.**	**1**		**68,100.00**

3. Per Hectare Cost Norm for Energy Plantation

S. No.	Particulars of Work	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	Survey & demarcation and preparation of map	ha.	1	450	450.00
2	Bush cutting in the plantation site	ha.	1	750	750.00
3	Interlacing of thorny bushes in B/wire	Rmt	180	3	540.00
4	Preparation of inspection path 60 cm wide	Rmt	150	15	2,250.00
5	Layout of Pits	ha.	1	500	500.00
6	Digging of pits 45x45x45 cm (40% of total)	“00	4	1200	4800.00
7	Digging of pits 30x30x30 cm(60% of total)	“00	6	900	5400.00
8	Filling of pits 45x45x45 cm (40% of total)	“00	4	200	800.00
9	Filling of pits 30x30x30 cm (60% of total)	“00	6	150	900.00
10	Carriage of naked roots plants over a distance of 2 km up hill	“00	2	100	200.00
11	Carriage of plants in P/bags over a distance of 2 km up hill	“00	3	150	450.00
12	Planting of entire Plants raised in P/bags	“00	6	300	1800.00
13	Planting of naked root plants	“00	4	200	800.00
14	Nursery cost of Plants	Nos	1000	9	9000.00
	Total				**28640.00**
15	Soil & moisture conservation works (25% of initial planting cost)		25%		7160.00
16	Add cost of RCC fence post and B/Wire			LS	13000.00
	Total Plantation Cost				**48800.00**
	Or Say				**49000.00**
	Maintenance				
I	**1st Year - 25% Mortality**				
1	Re-digging of Pits 45x45x45 cm	“00	1	600	600.00
2	Re-digging of Pits 30x30x30 cm	“00	1.5	450	675.00
3	Filling of pits 45x45x45 cm	“00	1	100	100.00
4	Filling of pits 30x30x30 cm	“00	1.5	75	112.50
5	Planting of P/bags plants	“00	1.5	300	450.00
6	Planting of naked root plants	“00	1.0	200	200.00
7	Carriage of plants in P/bags over a distance of 2 km up hill	“00	0.8	150	112.50
8	Carriage of naked roots plants over a distance of 2 km up hill	“00	0.5	100	50.00
9	Nursery cost of Plants	No.	250	9	2250.00
10	Repair of fence	Rmt	180	2	360.00
11	Repair of Inspection path	LS			500.00
12	Repair of soil and moisture conservation works	LS			1000.00
	Total I				**6410.00**
	Or Say				**6400.00**
II	**2nd Year - 20% Mortality**				
1	Re-digging of Pits 45x45x45 cm	“00	0.8	600	480.00
2	Re-digging of Pits 30x30x30 cm	“00	1.2	450	540.00
3	Filling of pits 45x45x45 cm	“00	0.8	100	80.00
4	Filling of pits 30x30x30 cm	“00	1.2	75	90.00
5	Planting of P/bags plants	“00	1.2	300	360.00
6	Planting of naked root plants	“00	0.8	200	160.00
7	Carriage of plants in P/bags over a distance of 2 km up hill	“00	0.6	150	90.00
8	Carriage of naked roots plants over a distance of 2 km up hill	“00	0.4	100	40.00
9	Nursery cost of Plants	No.	200	9	1800.00
10	Repair of fence	Rmt	180	2	360.00
11	Repair of Inspection path	LS			500.00
12	Repair of soil and moisture conservation works	LS			1000.00
	Total II				**5500.00**
	Or Say				**5500.00**
III	**3rd Year - 15% Mortality**				
1	Re-digging of Pits 45x45x45 cm	“00	0.6	600	360.00

S. No.	Particulars of Work	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
2	Re-digging of Pits 30x30x30 cm	"00	0.9	450	405.00
3	Filling of pits 45x45x45 cm	"00	0.6	100	60.00
4	Filling of pits 30x30x30 cm	"00	0.9	75	67.50
5	Planting of P/bags plants	"00	0.9	300	270.00
6	Planting of naked root plants	"00	0.6	200	120.00
7	Carriage of plants in P/bags over a distance of 2 km up hill	"00	0.5	150	67.50
8	Carriage of naked roots plants over a distance of 2 km up hill	"00	0.3	100	30.00
9	Nursery cost of Plants	No.	120	9	1080.00
10	Repair of fence	Rmt	200	2	400.00
11	Repair of Inspection path	LS			1000.00
12	Repair of soil and moisture conservation works	LS			**4360.00**
	Total III				**4350.00**
	Or Say				
	Total Maintenance Cost				**16,250.00**
	GRAND TOTAL	**Ha.**	**1**		**65,250.00**

Sub Divisional Officer
W.R. Sub Division No. 2
Shivpuri (M.P.)

O.P. GUPTA
Executive Engineer
Water Resources
Division Shivpuri (M.P.)