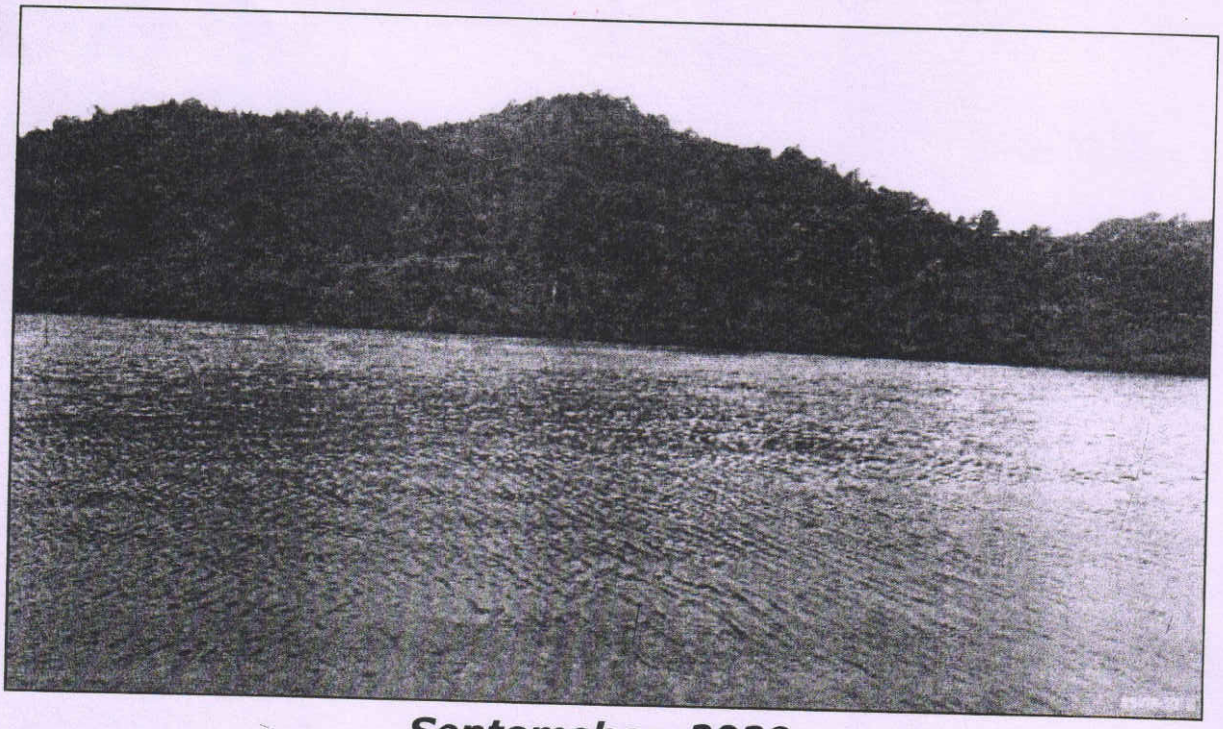
ENVIRONMENTAL MANAGEMENT PLAN
for
MENDHA IRRIGATION PROJECT
MADHYA PRADESH



Septemeber, 2020

Prepared for:

WATER RESOURCES DIVISION NO. II BETUL

WATER RESOURCES DEPARTMENT

MENDHA MEDIUM PROJECT

PROJECT AT A GLANCE

1 Introduction

The Preliminary investigation of the MENDHA MEDIUM PROJECT was started in the year 2005 with a view to construct storage reservoir across Tapti River to irrigate the area coming under Betul tehsil of Betul District. The MENDHA MEDIUM PROJECT was proposed to irrigate a Gross & Culturable Command Area of 7250 Ha and 5800 Ha respectively with annual irrigation of 5800 Ha at FRL-517.9 with a Gross Storage of 36.46 MCM.

2 Location

MENDHA MEDIUM PROJECT is located on the Tapti basin Sub Basin in Betul Tahsil of Betul district The proposed reservoir at Near Village Mendha is located at Latitude 21°45'3.82"N Longitude 77°48'17.16"Ewithin the Tapti basin Basin in Betul Tehsil of Betul District. The nature of the catchment is hilly and there are 39 Nos. upstream projects. Total catchment area of MENDHA MEDIUM PROJECT is 1380 Sq.Km.

3 Accessibility to Dam Site

The MENDHA MEDIUM PROJECT is located Near Village Mendha and is approachable from Betul at 47 km,.

4 Water Availability

Total Catchment area of,MENDHA MEDIUM PROJECT is 1380 Sq.Km and there are 39 proposed projects on the upstream of this project. The intercepted catchment area of U/S project is 951. Net Catchment Area of the Project is 429 Sq.Km.

The yield values for different depend abilities are shown below.

75% dependable yield	257.98 MCM
Net Yield @ site	36.57 MCM

5 Irrigation Planning

A culturable land of 5800 Ha is available on downstream of the proposed reservoir . The command on the downstream of the proposed reservoir is taken up as MENDHA MEDIUM PROJECT

The proposed CCA of 5800 Ha is irrigated by Pressure irrigation system . However, a single offtake on Dam is provided. In proposed command area, an area of 5800 Ha of land is proposed to be irrigated.

GCA	7250 Ha
CCA	5800 Ha
Rabi	5800 Ha
Intensity of Irrigation	100.00%

Top Bund Level	521.40 m
Max Water Level	519.40m
Full Reservoir Level	517.90 m
Lowest sill Level	498.80 m

6 The main components of the MENDHA MEDIUM PROJECT are

Earth Dam

An Earthen Dam of Maximum Height 18.825m and length (300 TO 675.92 M)m . The Earth Dam is designed as a Homogenous section. The required soil is available in the reservoir area in full with specified properties of C-φ and unit weights,

Spill chhnel

ogee spillway on right flank of earthen dam

a maximum height of 36.50 m above foundation is proposed.

Irrigation Sluice

No provision

Canal System

Maximum discharge required to be released into the canal is 2.262 cumecs As such including provision of 10% for future expansion, the pipesystem is deslgned to carry 2.262cumecs of discharge. The entire command area is proposed to be irrigated through hose pipe system. Bed level of the canal is kept at RL-498.8 m at commencement.

Rabi Crops such as Wheat, & Gram are predominantly cultivated in the command area, . As per the new guidelines the irrigation is designed for Rabi crops. The proposed CCA is 5800 Ha and the intensity of irrigation is 100%

7 On completion of the Project the following benefits can be derived.

- Annual Rabi irrigation of 5800 Ha
- Rise in sub-soil water level in the project Area
- Development of fisheries in the reservoir
- Employment to local labour largely tribes during construction period.

8 Recommendation

The scheme is proposed in tribal area with low standard of living. The percentage of submergence of Culturable land to the proposed irrigation is 2.66% which is well within the WRD norms. The scheme is recommended for implementation due to following reasons:

> MENDHA MEDIUM PROJECT is proposed across Tapti River with catchment area of 1380 Sq km

> No better storage site is available in the River
> The huge Culturable Command Area of about 5800 Ha spread over 15 villages mainly comprising small land holding famers will be benefitted
> The area has large population of tribes with very low standard of living

The government is also keen for developing the drought prone region, Hence the MENDHA MEDIUM PROJECT is recommended for sanction and construction at an earliest.

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SALIENT FEATURES

MENDHA MEDIUM PROJECT

SALIENT FEATURES

1	GENERAL			
	(a)	Name of the Project	:	MENDHA MEDIUM PROJECT
	(b)	Type of the Project	:	Irrigation
	(c)	Location	:	Near Village Mendha
	(d)	Latitude / Longitude	:	21°45'3.82"N / 77°48'17.16"E
	(e)	River Basin	:	Tapti basin
	(f)	Located on River	:	Tapti River
	(g)	Sub Basin	:	Tapti River sub basin
	(h)	Tehsil / District	:	Betul / Betul
2	HYDROLOGY			
	(a)	Catchment Area	:	1380.00 Sqkm
	(b)	Intercepted Catchment Area	:	951.00
	(c)	Net Catchment Area	:	429.00 Sqkm
	(d)	Rain Gauge Stations	:	Betul, Multai
	(e)	Period of Data Availability	:	20 Years.
	(i)	Available 75% Annual Yield at Dam Site		**257.98 MCM**
	(j)	Number of existing & proposed U/s Project	:	39
	(k)	Planned Utilization by the U/s project (Upto Ghogri T	:	221.41 MCM
	(l)	Net Yield At site	:	36.57 MCM
3	HYDROLOGY			
	(a)	Record of Observed Floods	:	Nil
	(b)	Type of Dam	:	Intermidiate
	(c)	Design Flood	:	Probable Maximum Flood
	(d)	Estimated SPF	:	19680.18 cumecs
	(e)	Flood Lift	:	1.50 m
4	SEDIMENT ESTIMATION			
	(a)	Sediment Rate	:	**(0.75 Acft/sqmile/Yr)**
	(b)	Net Catchment Area	:	429.00
	(c)	Sediment Inflow in Reservoir - 100 Years	:	498.8 Ha metre
	(d)	New Zero Elevation (With FRL517.9m) - 100 Yrs Sediment		498.80 m (used to fix Sill Level)
5	PRINCIPLE LEVELS			
	(a)	Lowest Sill Level (LSL)	:	498.80 m
	(b)	Minimum Draw Down Level (MDDL)	:	498.80 m
	(c)	Full Reservoir Level (FRL)	:	517.90 m
	(d)	Maximum Water Level (MWL)	:	519.400 m
	(e)	Top Bund Level (TBL)	:	521.40 m
	(f)	Dead Storage	:	2.35 MCM
	(g)	Gross Storage	:	36.46 MCM
	(h)	Live Storage	:	34.11 MCM
6	IRRIGATION			
	(a)	Gross Command Area	:	7250 Ha
	(b)	Culturable Command Area	:	5800 Ha
	(c)	Annual Irrigation Proposed	:	5800 Ha
	(d)	Existing Cropping Pattern		

Toposheet- 55G/14

		Rabi		
		Wheat Ordinary		2000 Ha
		Gram	:	1400 Ha
		Total	:	3400 Ha
	(e)	Proposed Cropping Pattern		
		Rabi		
		Wheat Hyd	:	3700 Ha
		Gram	:	2100 Ha
		Total	:	5800 Ha
	(f)	Intensity of Irrigation	:	100.00%
7	DOMESTIC WATER SUPPLY			
	(a)	Type of Demand	:	Domestic
	(b)	Villages Benefited	:	Betul, Bhainsdehi
	(c)	Size of Population served	:	Nil
	(d)	Quantum of water per capita (liter)	:	Nil
	(e)	Quantum of wate made available	:	13.15 MCM
8	UTILIZATION IN (Working Table)			
	(a)	Period of Study	:	1 years
	(b)	Net Yield at Site	:	36.57 MCM
	(c)	Average Annual water Utilized for Irrigation	:	19.00 MCM
	(d)	Average Annual Reservoir Evaporation	:	2.33 MCM
	(e)	Enviromental Release	:	1.96 MCM
	(f)	Drinking Water - Yearly	:	13.15 MCM 0.48
	(g)	Average annual Utilization	:	36.44 MCM
	(h)	No. of villages benefited	:	17
	(i)	Power Required		6.50 MW 6.68 MW
9	DAM DATA			
		Earth Dam		
	(a)	Type of Dam	:	Earthen Dam,
	(b)	(i) Length of Dam	:	380 M.
		(ii) Maximum height above GL	:	18.73 M.
		Spill Way		
	(c)	Type of Spillway		Flank Spillway
	(i)	Length of Spill Way	:	186.70 m (269) Need 2
	(ii)	No of Gates(including standby)	:	8 + 1
	(iii)	Deepest foundation Level	:	485.00 m
	(iv)	Crest Level	:	503.40 m
	(v)	Maximum Height above foundation	:	18.40 m
	(vi)	Peak flood Discharge	:	19680.18 Cumecs
	(vii)	Routed flood Discharge(Design Flood)	:	18696.17 Cumecs
	(d)	Non overflow Dam		
		(i) Length	:	40 + 15 = 55
		(ii) Maximum height above foundation	:	36.40 m
	(f)	Irrigation Sluice		
		(i) Location of Sluice	:	NA
10	CANAL			
	(a)	Length of Rising Main (RM - 1)	:	7.70 KM
	(b)	Length of Rising Main (RM - 2)	:	4.65 KM
	(c)	Head discharge Required	:	2.262 Cumecs
	(d)	Head discharge Designed	:	2.262 Cumecs

11	SUBMERGENCE DETAILS			
	(a)	Private Land		107.00 Ha
		(i) Irrigated Land	:	80.25 Ha
		(ii) Unirrigated Land	:	26.75 Ha
	(b)	Govt. Land		55.00 Ha
	(c)	Forest area	:	170.00 Ha
	(d)	Total submergence area	:	332.00 Ha.
	(e)	No. of Villages Affected	:	3 (Mendha, khapa, Borikas)
		No. of families to be displaced		290
12	ESTIMATE			
		Unit-1	:	**Rs 15805.55 Lakh**
		Unit-2	:	**Rs 11065.48 Lakh**
		Total Cost	:	**Rs 26871.03 Lakh**
		Cost Per Ha	:	**Rs. 4.63 Lakhs**
		B.C. Ratio	:	**1.59**

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CATCHMENT AREA TREATMENT PLAN

7.1 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 reduces 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 consist 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.

7.2 RIVER SYSTEM

The Tapti River, ancient original name Tapi River, is a river in central India. It is one of the major rivers of peninsular India with a length of around 724 km. The river originates in the Betul district from a place called Multai. It is one of only three rivers in peninsular India

that run from east to west - the others being the Narmada River and the Mahi River. It is the second largest westward draining inter-state river basin. It covers a large area in the State of Maharashtra besides areas in the states of Madhya Pradesh and Gujarat. The river drains an area of 65145 sq km out of which, 9804 sq km is in Madhya Pradesh, 51,504 sq km is in Maharashtra and the rest 3,837 sq km is in Gujarat.

For the first 282 Km., the river flows in Madhya Pradesh, out of which 54 Km form the common boundary with Maharashtra State. It flows for 228 Km in Maharashtra before entering Gujarat. Traversing a length of 214 Km in Gujarat, the river joins Arabian sea in Gulf of Cambay after flowing past the Surat city. The river receives several tributaries on both banks. There are 14 major tributaries having a length more than 50 Km. On the right bank 4 tributaries namely, the Vaki, the Gomai, the Arunavati and the Aner join the river. On the left bank, 10 important tributaries namely the Nesu, the Arunavati, the Buray, the Panjhra, the Bori, the Girna, the Vaghur, the Purna, the Mona and the Sipna drain into the main channel. The drainage system on the left bank of the river is therefore, more extensive as compared to the right bank area. The Purna and the Girna, the two important left bank tributaries together account for nearly 45 percent of the total catchment area of the river. The Purna is one of the principal tributaries of the river, starts in Betul district in Gawilgar hills of the Satpura range and mostly drains through three districts of Vidharbha namely Amravati, Akola and Buldhana. The Girna another Major tributary rises in the Western Ghats and drains Nasik and Jalgaon districts of Maharashtra.

7.3 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:

7.3.1 DEFINING STUDY AREA

Purpose of the study is preparation of CAT plan for the catchment of Mendha irrigation project. Since Parasdoh medium lift irrigation project is already under operation on river Tapti therefore, study area is defined as free draining catchment area of Mendha irrigation project. Free draining catchment area has been delineated as intercepting catchment area between the dam site of upstream Parasdoh medium lift irrigation project and dam site of proposed Mendha irrigation project.

The total free draining catchment area delineated for the Mendha irrigation project is **80488.65 ha**. Total length of river Tapti in the free draining catchment area is about **43 km**. Major right bank tributaries of river Tapti in the free draining catchment area are Ud Nala, Selgaon Nala, Dobidol Nala and Dalbori Nala. Major right bank tributaries of river Tapti in the free draining catchment area are Kolhaya Nala, Potpari Nadi and Bhal Nadi.

In order to plan watershed management and to formulate action plans it requires sub-watershed delineation, therefore, free draining catchment area was further delineated into sub-watersheds. For the delineation of sub-watershed, 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 free draining catchment area of Mendha irrigation project falls in 20 sub-watersheds. Out of these 20 sub-watersheds, 17 sub-watersheds falls completely within the free draining catchment area while 3 sub-watersheds fall partially within the free draining catchment area. The nomenclature of sub-watersheds has been assigned as follows: All drainage flowing into Arabian Sea except that of Indus drainage Region (5); Tapti Basin (5C); LB Ukai Dam to Purna Confluence Catchment (5C3); Tapti Sub-Catchment (5C3B); Tapti (5C3B7) & Tawa, Tapi, Ambara Watersheds (5C3B8) and 20 Sub-Watersheds. The detail of sub-watersheds delineated for the free draining catchment area is given below (**Figure 7.1 and Table 7.1**).

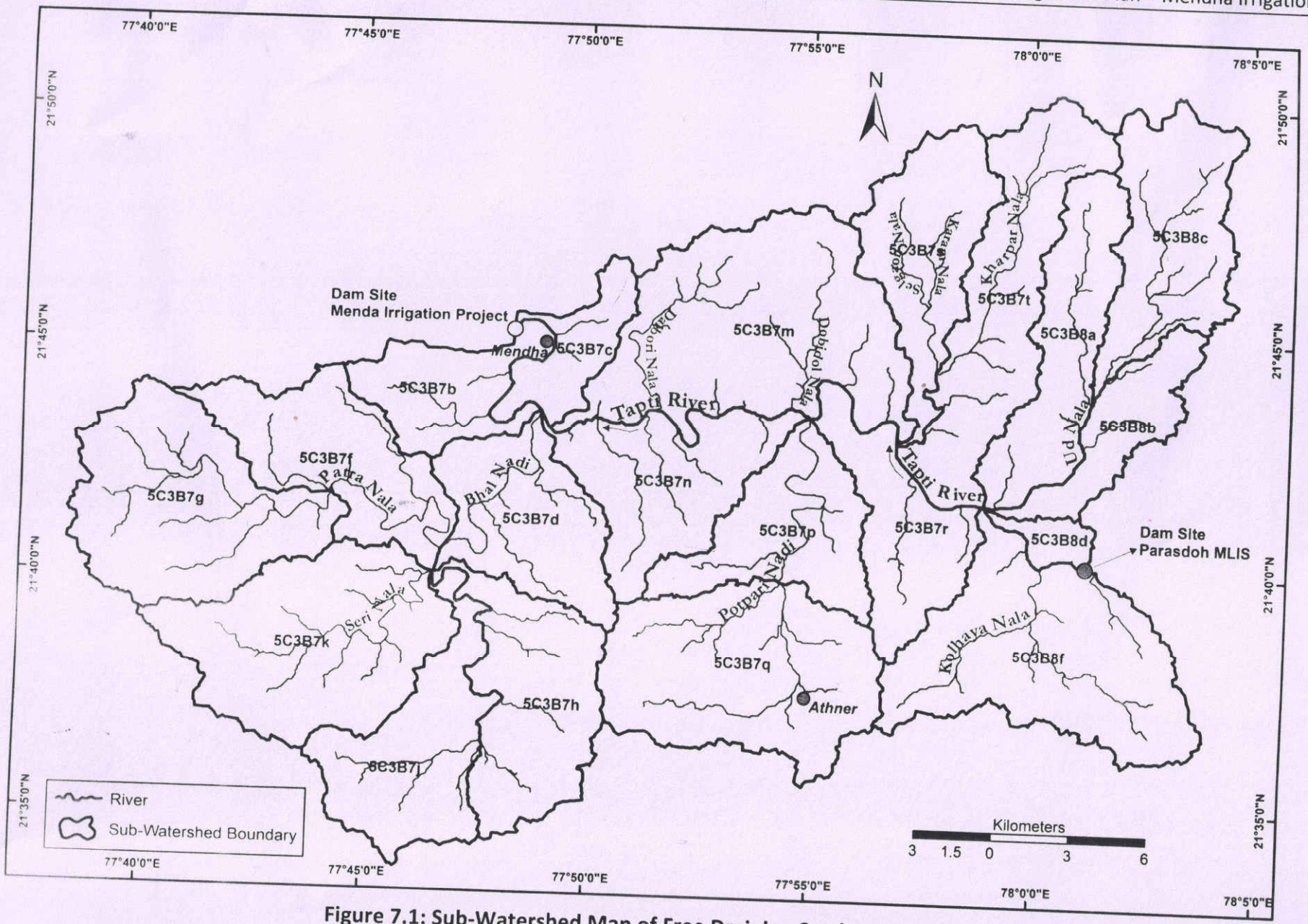

Figure 7.1: Sub-Watershed Map of Free Draining Catchment Area

Table 7.1: Names and Codes of Sub-Watersheds Delineated

S. No.	Water Resource Region	Basin	Catchment	Sub-Catchment	Watershed	Sub-Watershed Code	Sub-Watershed Area (ha)
1.	All drainage flowing into Arabian Sea except that of Indus drainage (5)	Tapti (5C)	LB Ukai Dam to Purna Confluence (5C3)	Tapti (5C3B)	Tapti (5C3B7)	5C3B7b	2295.46
2.						5C3B7c	1566.37
3.						5C3B7d	3547.45
4.						5C3B7f	3924.56
5.						5C3B7g	5806.27
6.						5C3B7h	4055.46
7.						5C3B7j	3797.09
8.						5C3B7k	6064.57
9.						5C3B7m	7801.33
10.						5C3B7n	3829.34
11.						5C3B7p	3381.44
12.						5C3B7q	6177.73
13.						5C3B7r	2980.36
14.						5C3B7s	3559.22
15.						5C3B7t	5124.46
16.					Tawa, Tapi, Ambara (5C3B8)	5C3B8a	3560.56
17.						5C3B8b	1989.79
18.						5C3B8c	4020.05
19.						5C3B8d	527.17
20.						5C3B8f	6479.97
	TOTAL						**80488.65**

7.3.2 DEFINING 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 land use/ land cover.

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

7.3.3 DATA 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 procured from the Tropical Rainfall Measuring Mission (TRMM) of NASA from their website https://pmm.nasa.gov/data-access/downloads/trmm. 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 has been used. For the preparation of land use/ land cover, map 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 partners has been used.

7.3.3.1 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 free draining catchment area, average rainfall of 10 years has been taken from the Tropical Rainfall Measuring Mission (TRMM) data (**Figure 7.2**). In the absence of site specific periodic data, TRMM data from the year 1998 to 2009 has been used for the calculation of R factor. As can be seen in the **Figure 7.2,** the free draining catchment area comprises of three average annual rainfall ranges i.e. 1000-2000 mm/year, 500-1000 mm/year and <500 mm/year. Similarly, free draining catchment area was divided into three zones and was assigned with X values 1500 mm, 750 mm and 250 mm for the average annual rainfall range of 1000-2000 mm/year, 500-1000 mm/year and <500 mm/year respectively. The R factors thus arrived are 176.5, 366.5 and 651.5 for the zones having average annual rainfall range of <500 mm/year, 500-1000 mm/year and 1000-2000 mm/year respectively and zones have been shown on map given at **Figure 7.3**.

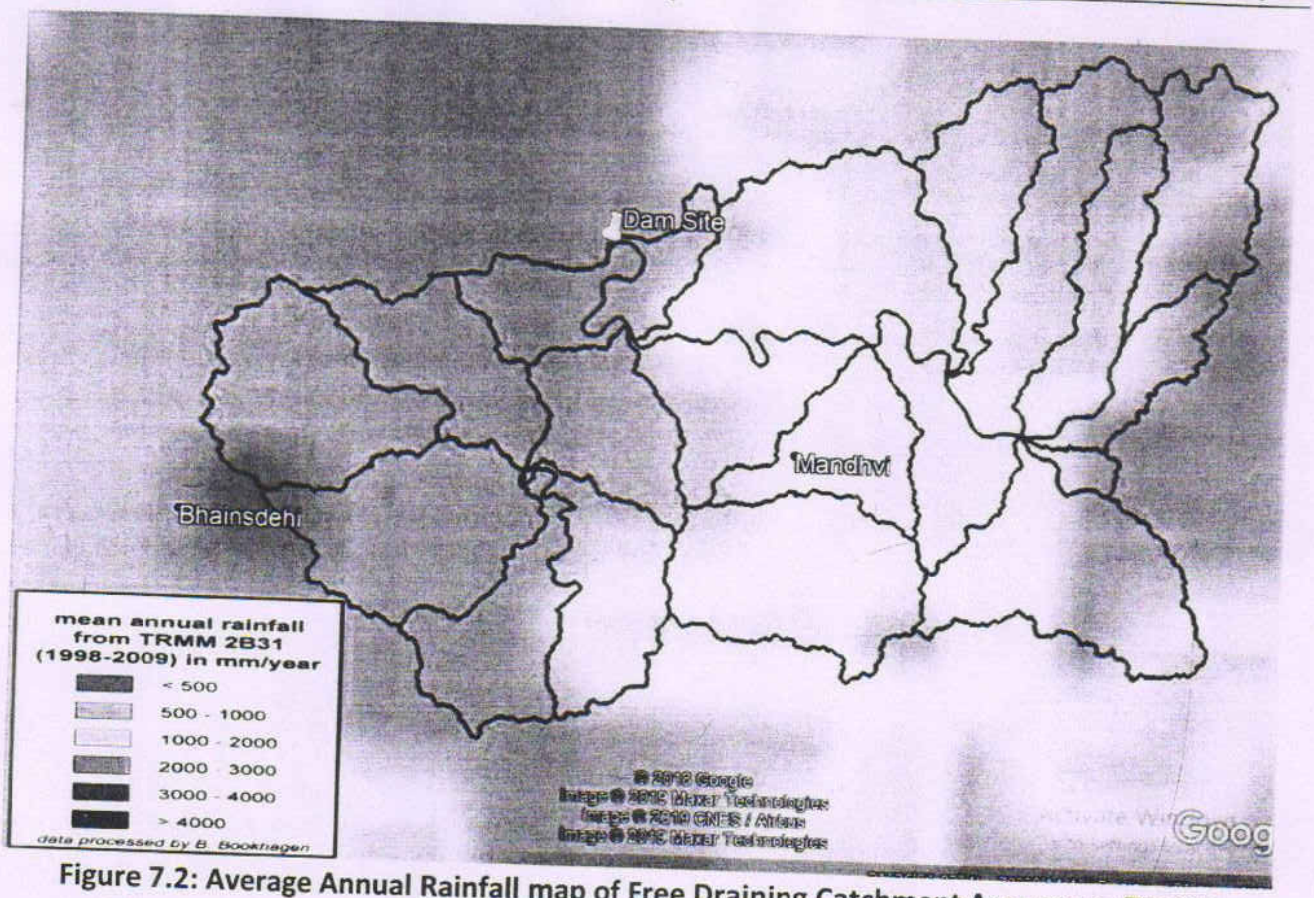

Figure 7.2: Average Annual Rainfall map of Free Draining Catchment Area as per TRMM

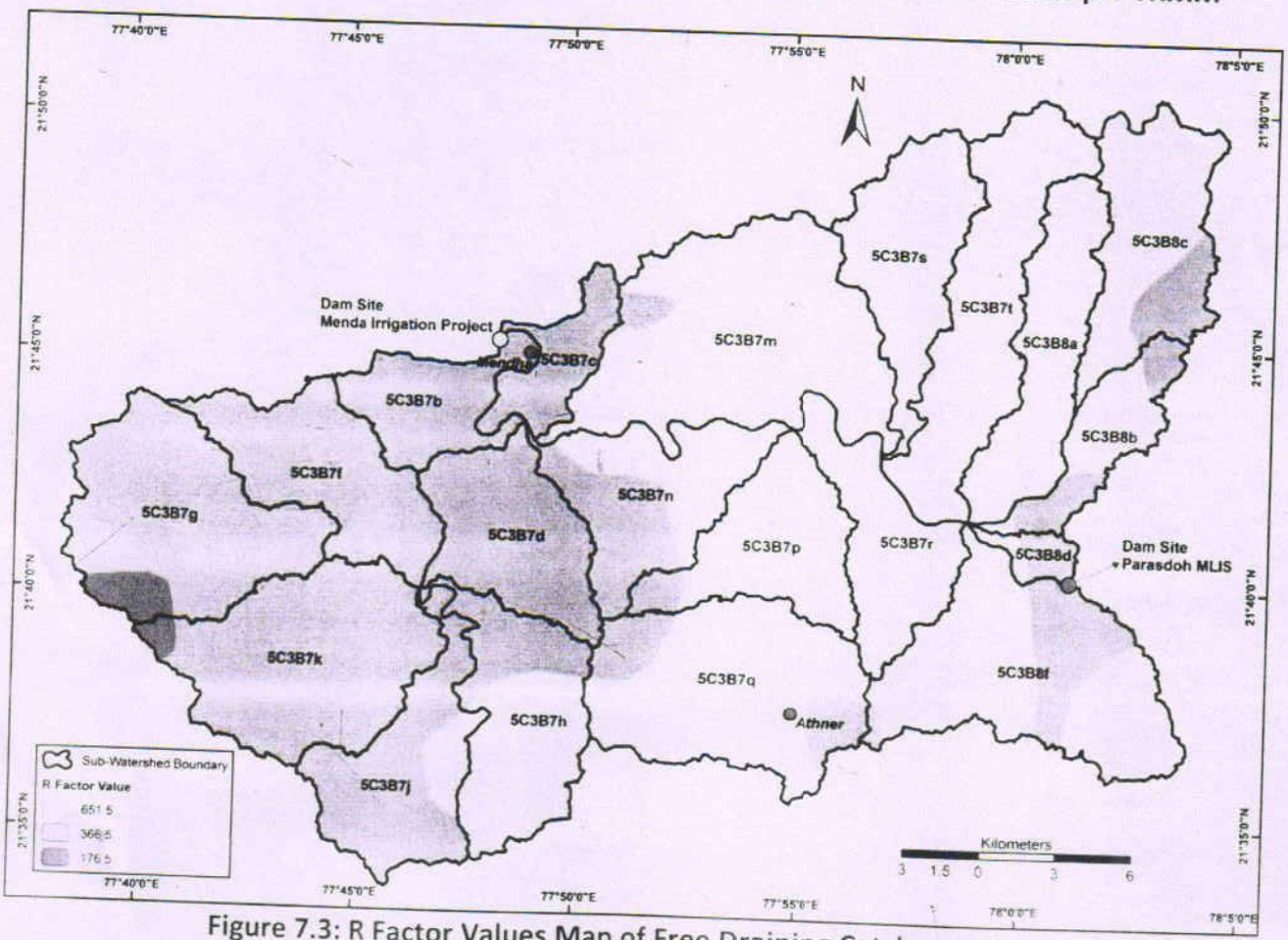

Figure 7.3: R Factor Values Map of Free Draining Catchment Area

7.3.3.2 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. The dominant soil unit is 68 (39.28%), which is characterised by deep, moderately well drained, clayey soils on gently sloping plateau with mounds with moderate erosion. Followed by, soil unit 66 (20.31%), which is characterised by deep, moderately well drained, clayey soils on gently sloping plateau with mounds with moderate erosion . Soil map has been shown in **Figure 7.4**. The legend for soil unit classes is given in **Table 7.2**.

Table 7.2: Description of Soil Units in the Free Draining Catchment Area

Soil Unit	Main Group	Sub Group	Area (ha)	Area (%)
	SOILS OF PLATEAU			
57	**Clayey, mixed, isohyperthermic, Typic Ustropepts** Shallow, well drained, clayey soils on gently sloping plateau with severe erosion and moderate stony *associated with*:	**Loamy-skeletal, mixed, isohyperthermic, Typic Ustorthents** Very shallow, somewhat excessively drained, loamy-skeletal soils on gently sloping plateau with severe erosion and slight stony.	4700.48	5.84
58	**Loamy, mixed, hyperthermic, Lithic Ustorthents** Very shallow, well drained, loamy soils on gently sloping plateau with moderate erosion *associated with*:	**Loamy-skeletal, mixed, isohyperthermic, Typic Ustorthents** Shallow, well drained, clayey soils on very gently sloping with moderate erosion.	9168.93	11.39
64	**Loamy, mixed, isohyperthermic, Lithic Ustorthents** Very Shallow, somewhat excessively drained, loamy soils on gently sloping plateau with severe erosion *associated with*:	**Loamy, mixed, isohyperthermic, Typic Ustropepts** Shallow, well drained, loamy soils on gently sloping with severe erosion and moderately stony	8915.79	11.08
	SOILS OF PLATEAU WITH MOUNDS			
66	**Fine, montmorillonitic, isohyperthermic, Vertic Ustropepts** Deep, moderately well drained, clayey soils on gently sloping plateau with mounds with moderate erosion, *associated with*:	**Fine, montmorillonitic, isohyperthermic, Typic Haplusterts** Deep, moderately well drained, clayey soils on gently sloping with moderate erosion.	16346.65	20.31
68	**Fine, montmorillonitic, isohyperthermic, Typic Ustropepts**	Loamy, mixed, isohyperthermic, Lithic	31618.73	39.28

Soil Unit	Main Group	Sub Group	Area (ha)	Area (%)
	Deep, moderately well drained, clayey soils on gently sloping plateau with mounds with moderate erosion, *associated with*:	**Ustorthents** Very shallow, somewhat excessively drained, loamy soils on gently sloping with severe erosion.		
69	**Fine, montmorillonitic, hyperthermic, Typic Haplusterts** Deep, moderately well drained, clayey soils on gently sloping plateau with mounds with moderate erosion, *associated with*:	**Fine, montmorillonitic, hyperthermic, Vertic Ustochrepts** Slightly deep, moderately well drained, clayey soils on gently sloping with moderate erosion.	9738.06	12.10
TOTAL			**80488.65**	**100**

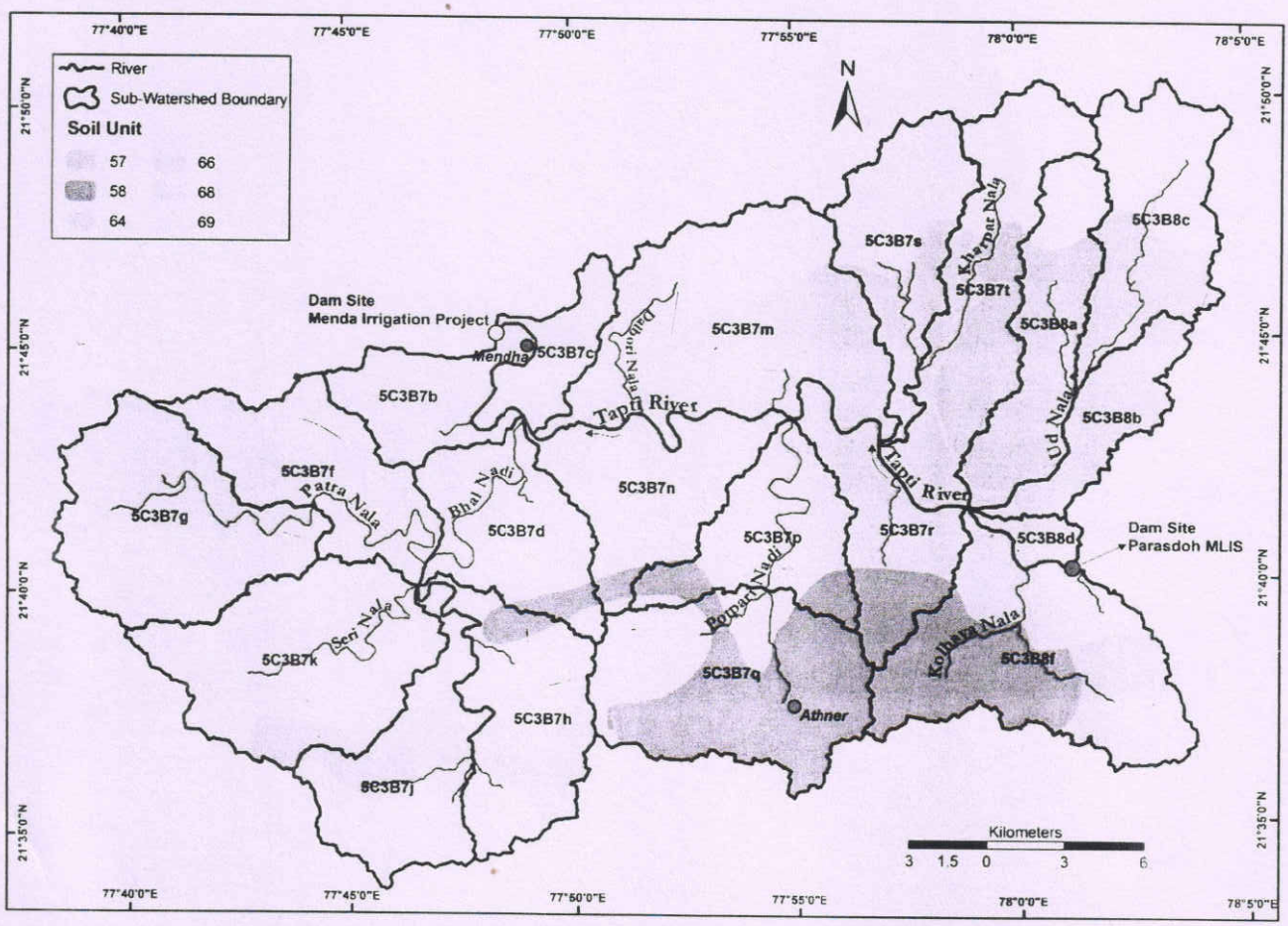

Figure 7.4: Soil Map of Free Draining Catchment Area (For details of Soil Unit legend refer Table 7.2)

As per the soil map of the free draining catchment area, the soil can be classified in three major categories. Deep with moderate erosion have moderate K value i.e. 0.15, because they are less susceptible to particle detachment and they produce runoff at moderate rates. Shallow to very shallow with moderate to severe erosion have slightly high K value i.e. 0.25. Very shallow with severe erosion have high K value i.e. 0.325. Various classes of soil and the values of K are shown in **Figure 7.5** and given in **Table** 7.3.

Table 7.3: Soil Erodibility Factor for different Soil Types

S. No.	Soil Unit	Soil Type	Erosion Intensity	K Value
1	64	Very Shallow	Severe	0.325
2	57, 58	Shallow to Very Shallow	Moderate to Severe	0.25
3	66, 68, 69	Deep	Moderate	0.15

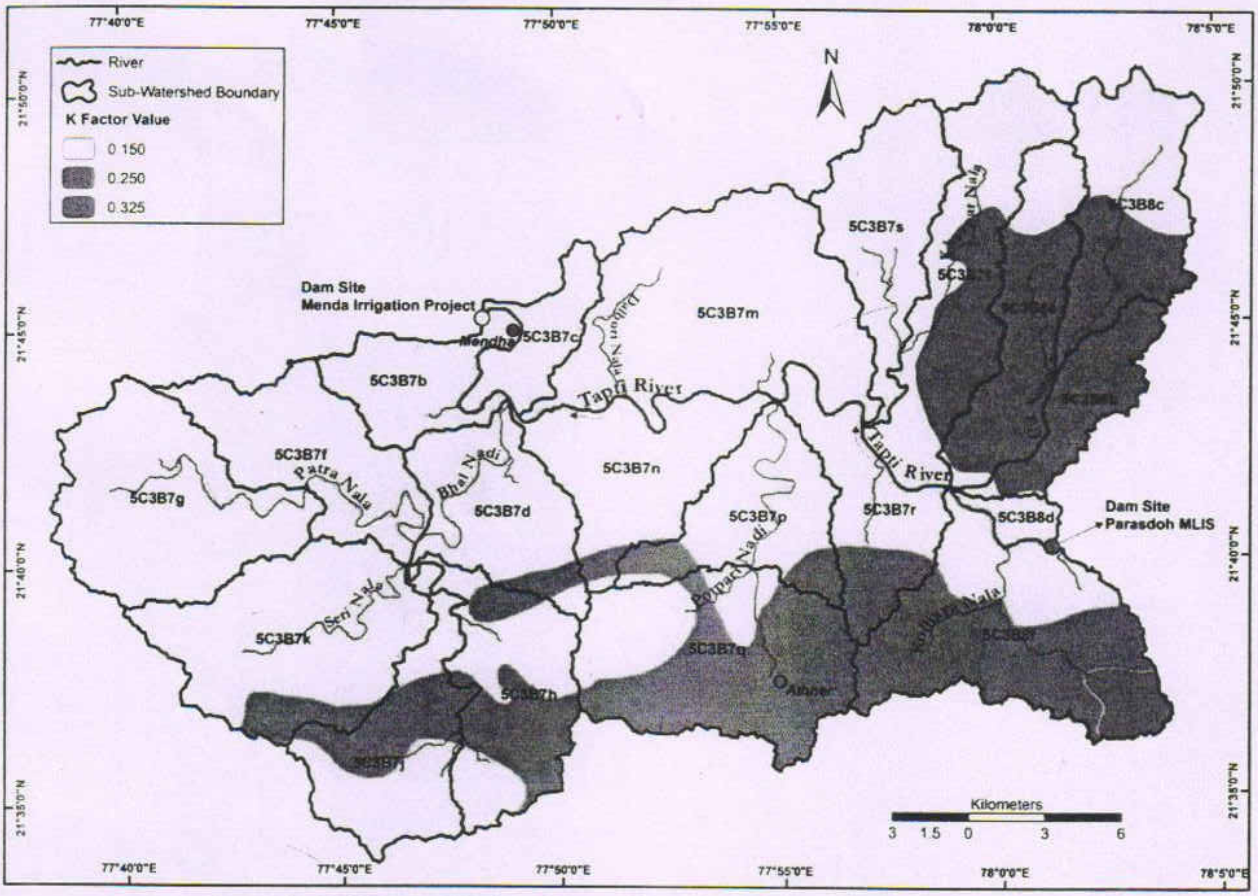

Figure 7.5: K Factor Value Map of Free Draining Catchment Area

7.3.3.3 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 free draining catchment area is given at **Figure 7.6**. In the free draining catchment area, the slope ranges from 0° to around 52°. The LS factor prepared for the free draining catchment area is given at **Figure 7.7**.

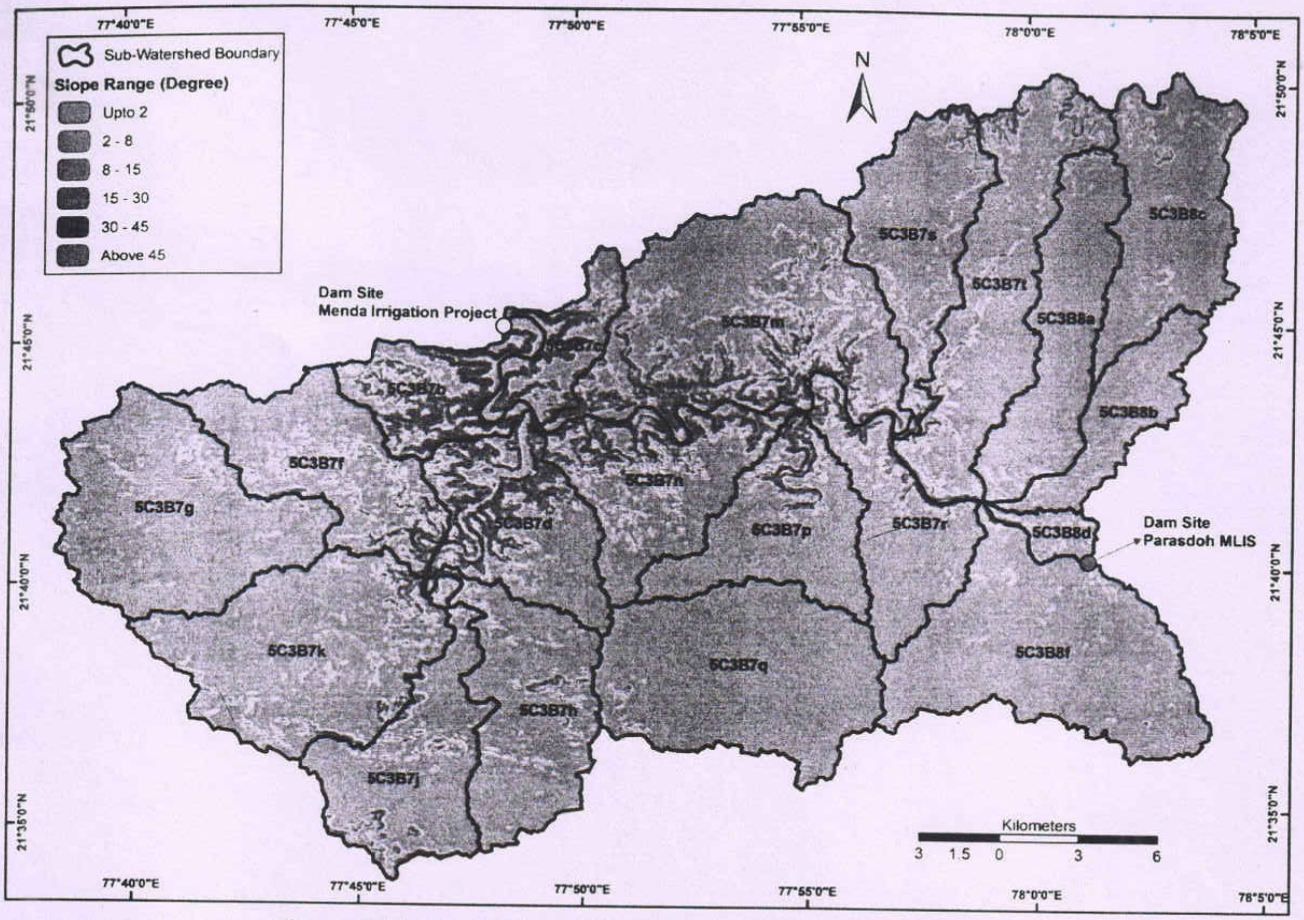

Figure 7.6: Slope Map of Free Draining Catchment Area

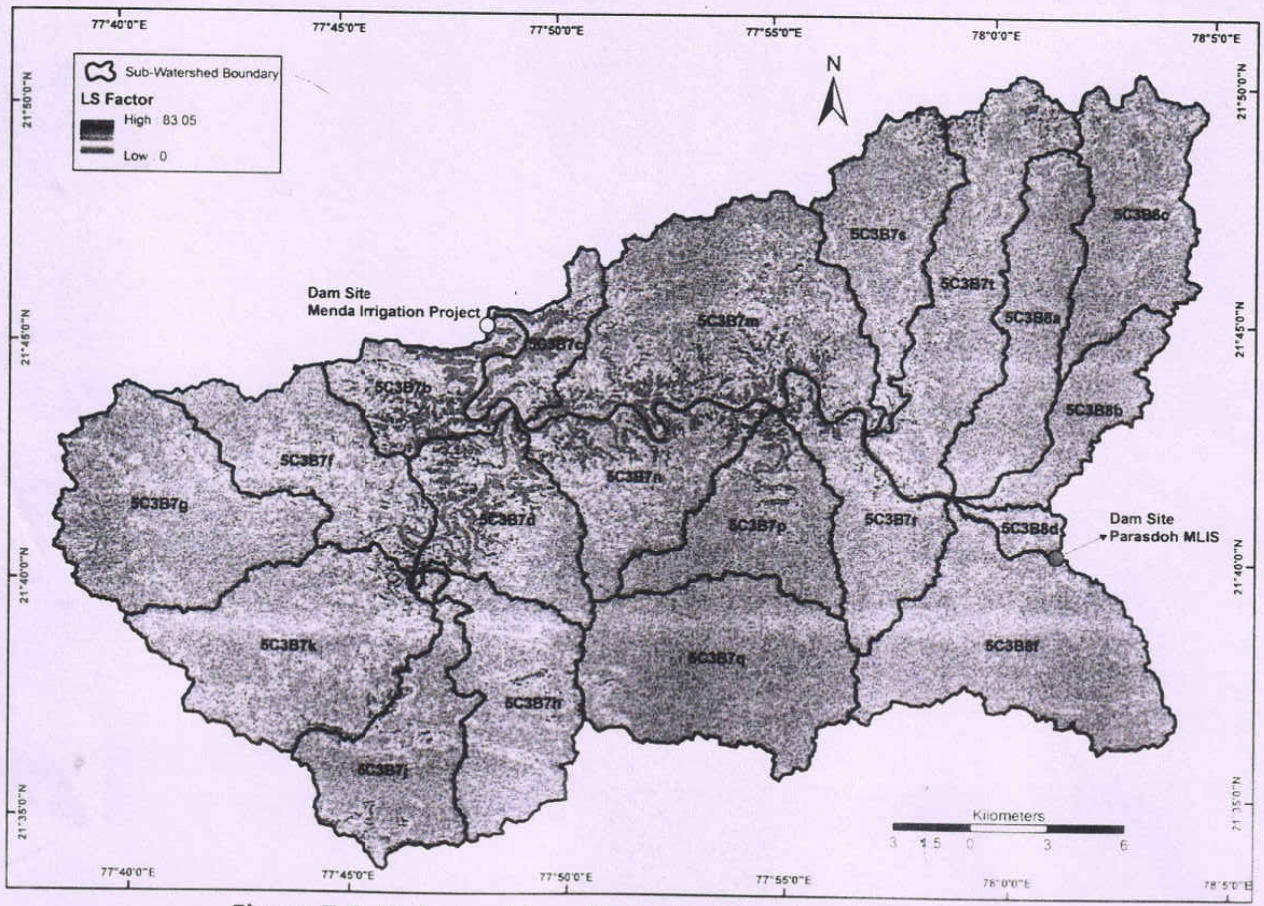

Figure 7.7: LS Factor Map of Free Draining Catchment Area

7.3.3.4 *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/land cover 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 and Google Earth was also referred.

The classified land use/ land cover map of the free draining catchment area is shown as **Figure 7.8**. The land use/ land cover pattern of the free draining catchment area has been given in **Table 7.4**. As can be seen from the map and table, the land use/ land cover pattern can be classified into five classes, out of these five classes, agricultural land covers the maximum area i.e. 84.39%, followed by scrub land, covering 10.49%. Rest all the other classes covers around 5%.

Table 7.4: Area falling under different land use/ land cover classes

Land use/ Land cover Classes	Area (ha)	Area (%)
Forest Land	1442.00	1.79
Scrub Land	8440.32	10.49
Agricultural Land	67925.35	84.39
Settlement	935.84	1.16
Waterbody	1745.14	2.17
Total	**80488.65**	**100**

Table 7.5 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 7.9**.

Table 7.5: Crop Management Factor

S. No.	Land use/ Land cover Type	C Value
1	Forest Land	0.03
2	Scrub Land	0.05
3	Agricultural Land	0.01
4	Settlement & Waterbody	0.00

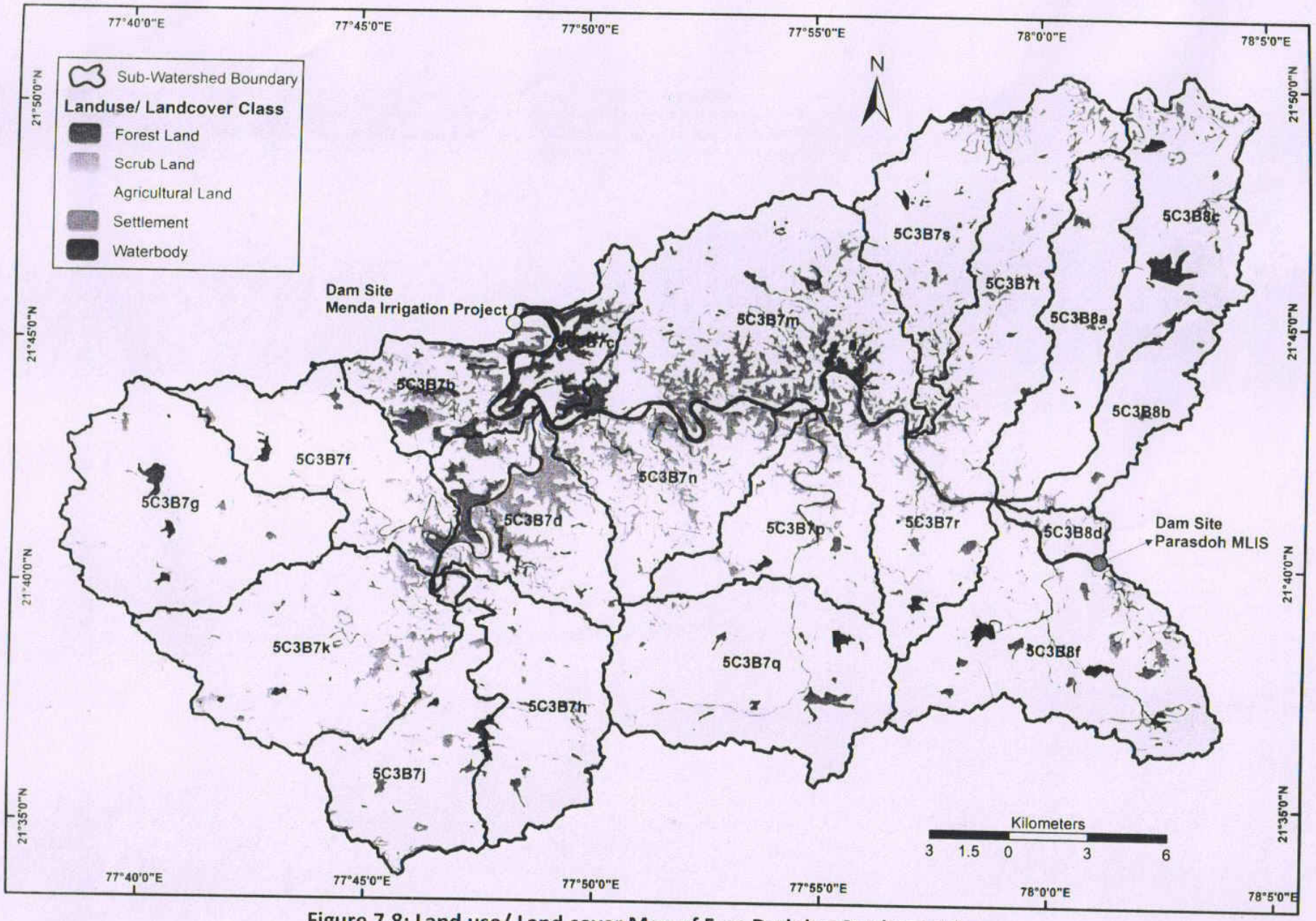

Figure 7.8: Land use/ Land cover Map of Free Draining Catchment Area

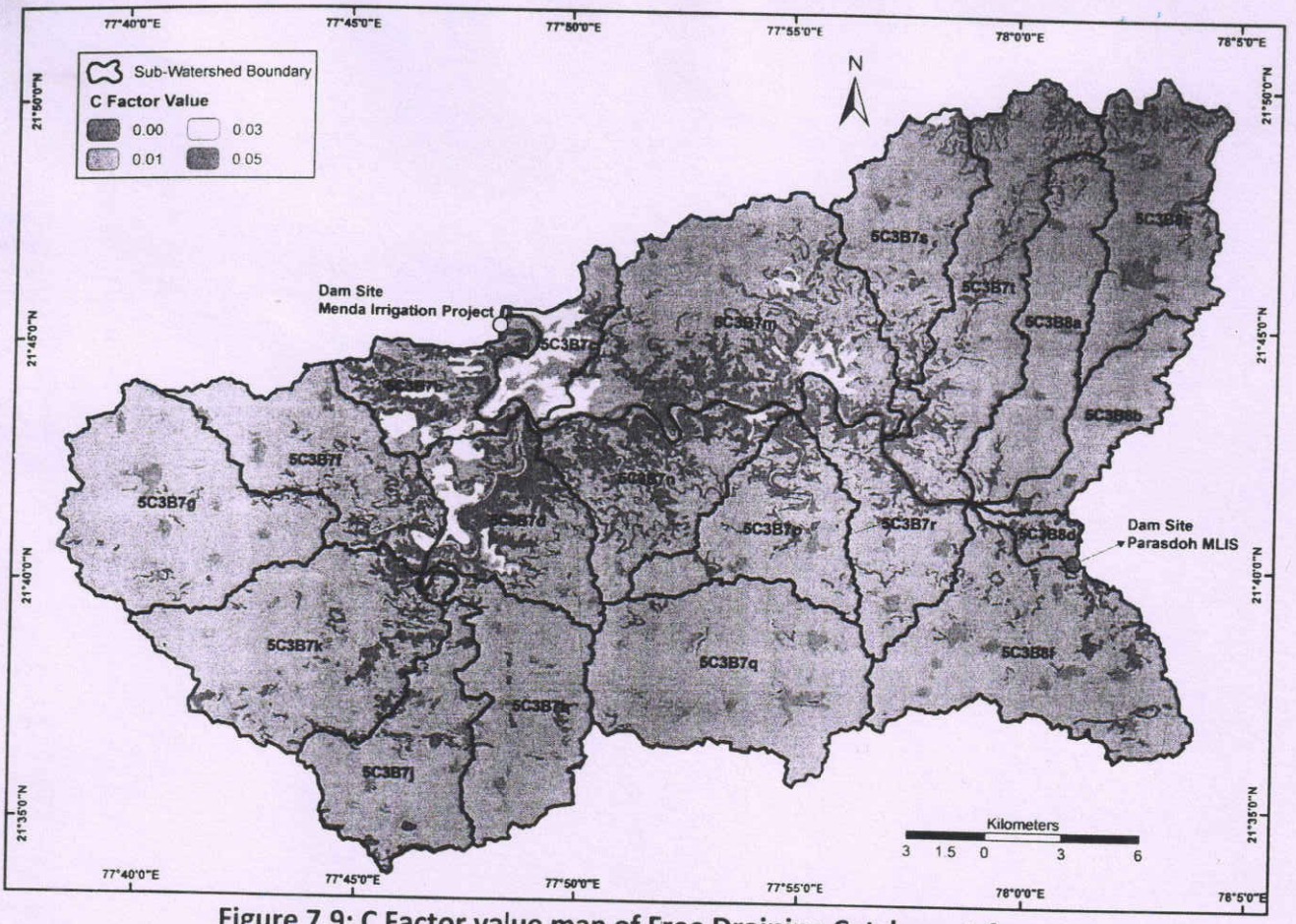

Figure 7.9: C Factor value map of Free Draining Catchment Area

7.3.3.5 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.

7.3.4 OUTPUT PRESENTATION

A thematic map for soil loss of the free draining catchment area has been prepared using RUSLE model mentioned in the above section. The free draining catchment area was then demarcated into different soil erosion intensity mapping units or classes based upon the extent of soil loss (see **Table 7.6 & Figure 7.10**). The free draining catchment area under different Erosion Intensity categories is given in **Table 7.7**. As can be seen from the figure and table, around 53% of the free draining catchment area is prone to less than 1 tons/ha/annum soil erosion, i.e. under negligible erosion intensity category. Almost negligible i.e. 0.14% of its area is prone to Severe and Very Severe soil erosion.

Table 7.6: Soil Loss Range and Erosion Intensity Categories

S. No.	Soil loss in tons/hectare/annum	Erosion Intensity Category
1	<1	Negligible
2	1-5	Slight
3	5-10	Very Low

4	10-20	Low
5	20-40	Moderate
6	40-80	Severe
7	>80	Very Severe
	Total	

Table 7.7: Area falling under different Erosion Intensity Categories

Erosion Intensity Category	Area (ha)	Area (%)
Negligible	64107.16	79.65
Slight	9441.27	11.73
Very Low	2117.82	2.63
Low	2193.55	2.73
Moderate	1798.42	2.23
Severe	710.76	0.88
Very Severe	119.66	0.15
Total	**80488.65**	**100**

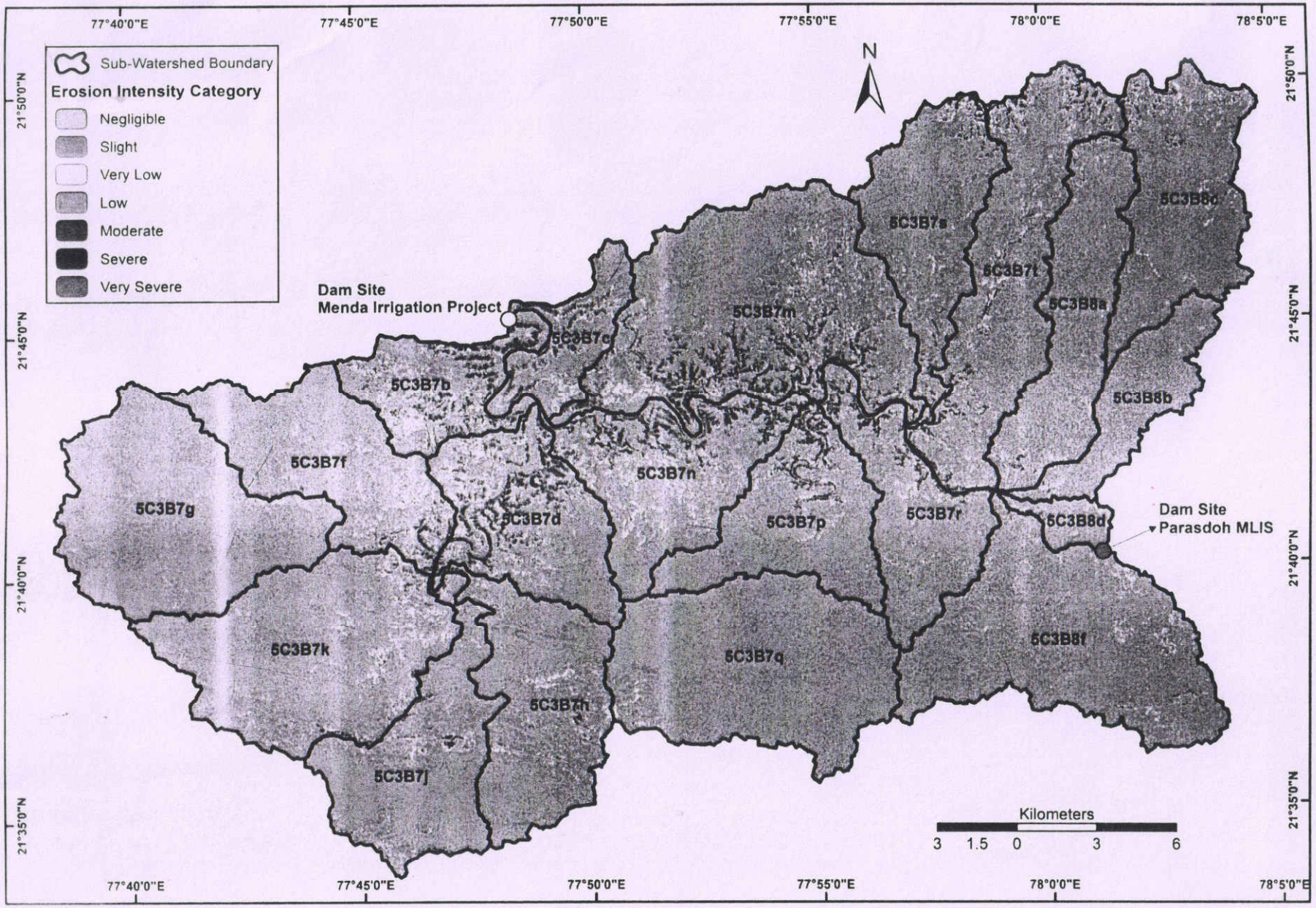

Figure 7.10: Erosion Intensity Map of Free Draining Catchment Area

7.4 PRIORTIZATION OF WATERSHEDS USING SILT YIELD INDEX (SYI) METHOD

`Silt Yield Index' (SYI), method has been used for prioritization of watersheds 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 watershed 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:

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

where,

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

7.4.1 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 sub-watershed 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 sub-watershed.

7.4.2 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 sub-watershed ranges from 11-20.

7.4.3 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:

Sub-Watershed	EIMU	EIMU Area (hectare) (EA)	Weightage factor (WF)	Silt Yield (SY) = EA * (WF)	Delivery Ratio (DR)	SYI = (SY*DR*100)/SA
Total		**5806.27**		**69759.65**		**961**
5C3B7h	1	0.46	20	9.19	0.85	1032
	2	7.79	20	155.83		
	3	28.25	18	508.46		
	4	36.06	16	576.89		
	5	91.69	14	1283.67		
	6	3891.22	12	46694.61		
Total		**4055.46**		**49228.65**		**1032**
5C3B7j	1	0.55	20	11.03	0.85	1036
	2	9.18	20	183.51		
	3	41.04	18	738.75		
	4	69.38	16	1110.05		
	5	63.53	14	889.36		
	6	3613.42	12	43360.99		
Total		**3797.09**		**46293.69**		**1036**
5C3B7k	1	0.00	20	0.00	0.8	973
	2	6.34	20	126.73		
	3	40.02	18	720.34		
	4	99.69	16	1595.03		
	5	134.83	14	1887.57		
	6	5783.70	12	69404.38		
Total		**6064.57**		**73734.05**		**973**
5C3B7m	1	39.11	20	782.23	0.9	1158
	2	206.09	20	4121.74		
	3	419.23	18	7546.16		
	4	394.71	16	6315.29		
	5	335.55	14	4697.71		
	6	6406.64	12	76879.73		
Total		**7801.33**		**100342.85**		**1158**
5C3B7n	1	27.29	20	545.83	0.9	1168
	2	131.75	20	2634.98		
	3	213.37	18	3840.73		
	4	198.63	16	3178.07		
	5	190.12	14	2661.73		
	6	3068.17	12	36818.08		
Total		**3829.34**		**49679.41**		**1168**
5C3B7p	1	13.04	20	260.74	0.85	1056
	2	54.78	20	1095.58		
	3	83.17	18	1497.05		
	4	63.05	16	1008.77		
	5	65.32	14	914.42		
	6	3102.09	12	37225.13		
Total		**3381.44**		**42001.68**		**1056**
5C3B7q	1	0.00	20	0.00	0.85	1021
	2	0.64	20	12.87		
	3	3.22	18	57.90		
	4	5.97	16	95.55		
	5	28.62	14	400.74		

Sub-Watershed	EIMU	EIMU Area (hectare) (EA)	Weightage factor (WF)	Silt Yield (SY) = EA * (WF)	Delivery Ratio (DR)	SYI = (SY*DR*100)/SA
	6	6139.27	12	73671.30		
Total		**6177.73**		**74238.36**		**1021**
5C3B7r	1	12.18	20	243.64	0.9	1123
	2	50.76	20	1015.19		
	3	81.19	18	1461.35		
	4	76.17	16	1218.73		
	5	71.70	14	1003.84		
	6	2688.36	12	32260.34		
Total		**2980.36**		**37203.09**		**1123**
5C3B7s	1	2.02	20	40.44	0.9	1105
	2	17.84	20	356.71		
	3	60.93	18	1096.67		
	4	71.26	16	1140.14		
	5	81.91	14	1146.71		
	6	3325.27	12	39903.24		
Total		**3559.22**		**43683.91**		**1105**
5C3B7t	1	9.56	20	191.27	0.9	1123
	2	55.10	20	1102.05		
	3	148.27	18	2668.84		
	4	166.11	16	2657.69		
	5	183.74	14	2572.39		
	6	4561.68	12	54740.14		
Total		**5124.46**		**63932.39**		**1123**
5C3B8a	1	0.06	20	1.18	0.9	1090
	2	3.87	20	77.46		
	3	19.84	18	357.11		
	4	31.96	16	511.32		
	5	63.26	14	885.66		
	6	3441.57	12	41298.79		
Total		**3560.56**		**43131.51**		**1090**
5C3B8b	1	0.00	20	0.00	0.9	1086
	2	0.37	20	7.36		
	3	2.88	18	51.76		
	4	10.09	16	161.51		
	5	30.75	14	430.43		
	6	1945.71	12	23348.50		
Total		**1989.79**		**23999.56**		**1086**
5C3B8c	1	0.09	20	1.84	0.85	1036
	2	4.70	20	94.08		
	3	38.17	18	687.06		
	4	75.55	16	1208.76		
	5	95.27	14	1333.80		
	6	3806.27	12	45675.20		
Total		**4020.05**		**49000.75**		**1036**
5C3B8d	1	0.00	20	0.00	0.9	1102
	2	1.47	20	29.44		
	3	3.97	18	71.42		
	4	11.81	16	189.04		

Sub-Watershed	EIMU	EIMU Area (hectare) (EA)	Weightage factor (WF)	Silt Yield (SY) = EA * (WF)	Delivery Ratio (DR)	SYI = (SY*DR*100)/SA
	5	22.05	14	308.73		
	6	487.86	12	5854.35		
Total		**527.17**		**6452.98**		**1102**
5C3B8f	1	0.37	20	7.36	0.9	1087
	2	3.14	20	62.72		
	3	17.26	18	310.73		
	4	49.83	16	797.28		
	5	92.73	14	1298.29		
	6	6316.64	12	75799.63		
Total		**6479.97**		**78276.00**		**1087**

7.4.5 PRIORITIZATION OF SUB-WATERSHEDS

The sub-watersheds are subsequently rated into various categories corresponding to their respective SYI values. The criteria followed for priority categorization of sub-watersheds depending upon their SYI values is given below and the priority classification of individual sub-watershed is given in **Table 7.9** and **Figure 7.11**.

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

Table 7.9: Priority Number as per SYI Classification

S. No.	Sub-Watershed	SYI	Priority	Priority Number
1	5C3B7b	1198	Medium	1
2	5C3B7n	1168	Medium	1
3	5C3B7c	1167	Medium	1
4	5C3B7m	1158	Medium	1
5	5C3B7r	1123	Medium	1
6	5C3B7t	1123	Medium	1
7	5C3B7d	1113	Medium	1
8	5C3B7s	1105	Medium	1
9	5C3B8d	1102	Medium	1
10	5C3B8a	1090	Low	2
11	5C3B8f	1087	Low	2
12	5C3B8b	1086	Low	2
13	5C3B7p	1056	Low	2
14	5C3B7j	1036	Low	2
15	5C3B8c	1036	Low	2
16	5C3B7h	1032	Low	2
17	5C3B7q	1021	Low	2
18	5C3B7f	979	Very Low	3
19	5C3B7k	973	Very Low	3
20	5C3B7g	961	Very Low	3

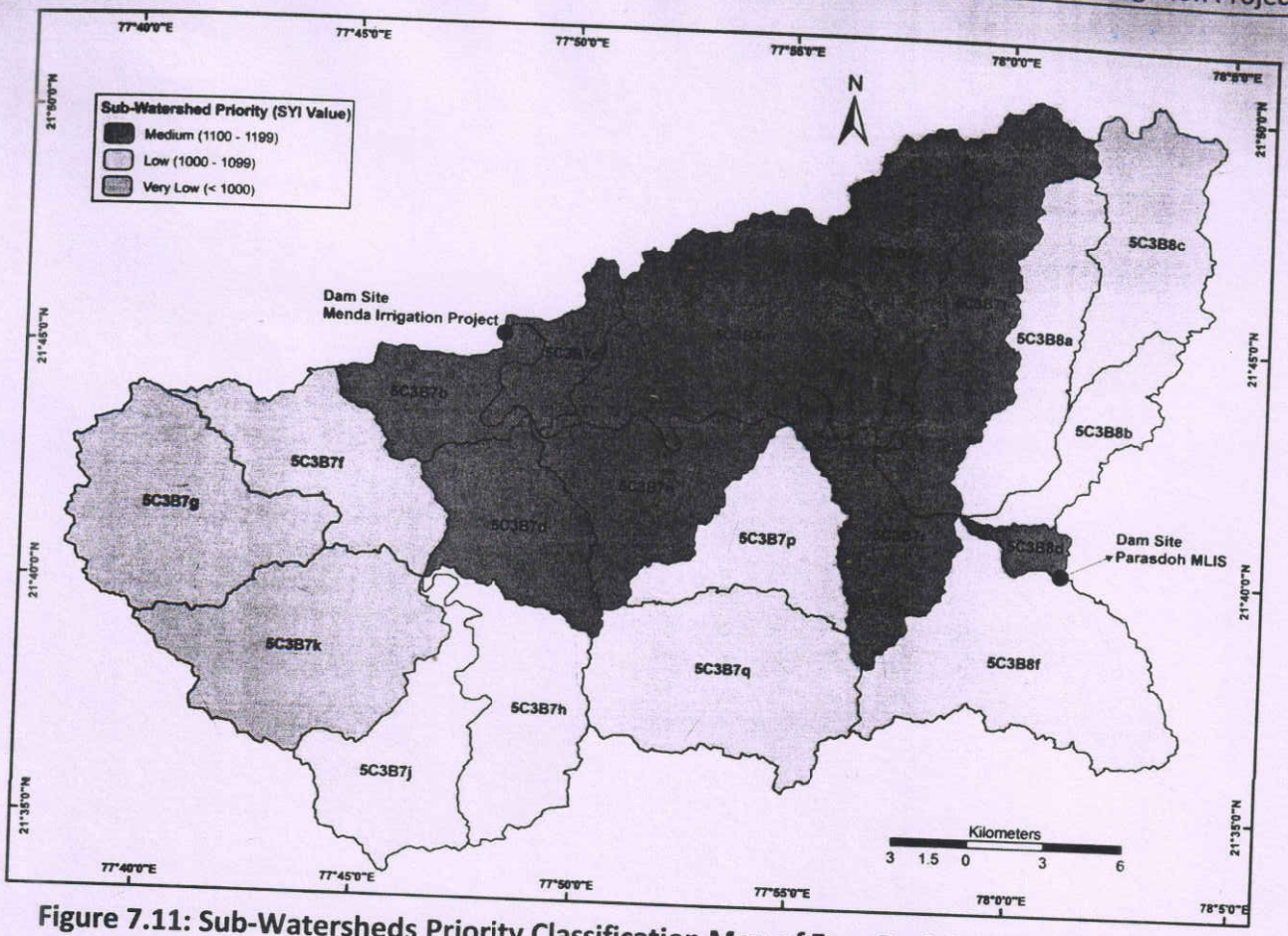

Figure 7.11: Sub-Watersheds Priority Classification Map of Free Draining Catchment Area

7.5 TREATMENT PLAN

7.5.1 AREA TO BE TAKEN UP FOR TREATMENT

Area under severe and very severe erosion intensity category in all the 20 sub-watersheds 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 sub-watershed, which comes out to be **830.42 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 **806.84 ha**.

Lastly, area under severe and very severe erosion intensity category **(806.84 ha)** falling under settlements and waterbody classes of land use/ land cover have 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 **798.15 ha (or say 798 ha)** and is presented below in **Table 7.10.** Out of the total 798 ha to be treated, it is proposed to treat **186** ha by biological measures and the rest **612** ha by engineering measures.

Table 7.10: Sub-Watershed wise treatable area under different Land use/ Land cover classes in Free Draining Catchment Area

Sub-Watersheds	Sub-Watershed Wise Land use/ Land cover Classes Area (ha)			Total Area (ha)
	Forest Land	Scrub Land	Agricultural Land	
5C3B7b	3.40	50.91	1.40	**55.71**
5C3B7c	14.70	1.45	0.13	**16.28**

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

7.4.4 SILT YIELD INDEX

The area of each of the mapping units is computed and silt yield indices of individual sub-watersheds are calculated using the equations mentioned above. The SYI values for classification of various categories of erosion intensity rates are given in **Table 7.8**.

Table 7.8: Calculation of SYI in Sub-Watersheds

Sub-Watershed	EIMU	EIMU Area (hectare) (EA)	Weightage factor (WF)	Silt Yield (SY) = EA * (WF)	Delivery Ratio (DR)	SYI = (SY*DR*100)/SA
5C3B7b	1	7.51	20	150.30	0.9	1198
	2	59.12	20	1182.48		
	3	195.87	18	3525.58		
	4	245.19	16	3922.99		
	5	163.62	14	2290.66		
	6	1624.15	12	19489.80		
Total		**2295.46**		**30561.82**		**1198**
5C3B7c	1	0.55	20	11.04	0.9	1167
	2	16.11	20	322.29		
	3	86.18	18	1551.24		
	4	164.59	16	2633.51		
	5	101.34	14	1418.75		
	6	1197.59	12	14371.04		
Total		**1566.37**		**20307.86**		**1167**
5C3B7d	1	6.30	20	126.08	0.85	1113
	2	70.41	20	1408.24		
	3	262.52	18	4725.38		
	4	323.05	16	5168.81		
	5	191.60	14	2682.37		
	6	2693.57	12	32322.80		
Total		**3547.45**		**46433.67**		**1113**
5C3B7f	1	0.55	20	11.03	0.8	979
	2	11.30	20	225.99		
	3	51.65	18	929.70		
	4	90.98	16	1455.65		
	5	91.17	14	1276.41		
	6	3678.91	12	44146.88		
Total		**3924.56**		**48045.66**		**979**
5C3B7g	1	0.00	20	0.00	0.8	961
	2	0.00	20	0.00		
	3	1.41	18	25.36		
	4	9.48	16	151.75		
	5	19.02	14	266.29		
	6	5776.35	12	69316.25		

Treatment measure	*Basis for selection*
	Agricultural 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

7.5.2.1 Biological Measures

The biological measures would comprise of:

- Enrichment
- Assisted Natural Regeneration
- Energy Plantation

7.5.2.1.1 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 forest land falling under severe and very severe erosion intensity category shall be brought under enrichment plantation. 800 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. 72,560** per ha consisting of Rs. 50,000 for plantation and Rs. 22,560 for maintenance for five years. The detailed break-up of item-wise cost for energy plantation is furnished in **Annexure III**. The area to be brought under enrichment plantation is given at **Table 7.12.**

7.5.2.1.2 Assisted Natural Regeneration

In scrub land, conditions are conducive to natural regeneration provided some sort of assistance is provided. Such area shall be taken up under this component. The areas shall be closed to reduce biotic interference. Ground surface will be cleared of slash, debris and felling refuse to afford a clean seed bed to the falling seed. At certain places some soil raking may also have to be done to facilitate germination of seeds. Where natural regeneration is found deficient. It will be supplemented by artificial planting. Patch sowing in suitable areas may also be done. 250 plants per hectare will be planted under this scheme. The plantation will be maintained for subsequent five 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 assisted natural regeneration including maintenance cost for five years is estimated to be **Rs. 39,240** per ha consisting of Rs. 25,700 for plantation and Rs. 13,540 for maintenance for five years. The detailed break-up of item-wise cost for assisted natural regeneration is furnished in **Annexure III**. The area to be brought under assisted natural regeneration is given at **Table 7.12**.

7.5.2.1.3 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 and scrub land falling under severe and very severe erosion intensity category will be used for energy plantation. 1100 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. 69,560** per ha consisting of Rs. 51,900 for plantation and Rs. 17,660 for maintenance for three years. The detailed break-up of item-wise cost for energy plantation is furnished in **Annexure III**. The area to be brought under energy plantation is given at **Table 7.12**.

7.5.2.2 Engineering Measures

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

7.5.2.2.1 Staggered Contour Trenches

To improve soil & moisture regime in the area, Staggered trenches of size 1x0.3x0.3m are prescribed in the area. The detailed break-up of item-wise cost is furnished in **Annexure III**. The area to be brought under staggered contour trenches and its unit cost is given at **Table 7.12**.

7.5.2.2.2 Dry Stone Masonry Check Dam

Dry stone masonry check dams can be made of boulder piled up across the gulley and along the banks if they are locally available. Such structures for damming a gulley or a stream to refine the flow velocity and to control bank erosion are called dry stone masonry/ loose bolder check dams. The detailed break-up of item-wise cost is furnished in **Annexure III**. The number of dry stone masonry check dams suggested is given at **Table 7.12.**

7.5.2.2.3 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. This is not very much encouraged therefore with proper judgment about the site conditions these structures may be installed. The detailed break-up of item-wise cost is furnished in **Annexure III**. The number of gabion check dams suggested is given at **Table 7.12.**

7.5.2.2.4 Summary of Treatment Measures

Sub-Watershed wise areas identified for treatment with different treatment measures is given in **Table 7.12.** The total cost required for the treatment of 322 ha by the means of different treatment measures is **Rs. 300.74 lakh.** The summary of treatment measures and their cost is given in **Table 7.13.**

Table 7.12: Sub-Watershed wise Summary of Treatment Measures

S. No.	Sub-Watershed	Enrichment Plantation (ha)	Assisted Natural Regeneration (ha)	Energy Plantation (ha)	Staggered Contour Trenches (No)	Dry stone Masonry Check Dams (No)	Gabion Check Dams (No)
1	5C3B7b	3	6	4	1	22	10
2	5C3B7c	12	0	0	0	1	0
3	5C3B7d	3	6	6	1	26	15
4	5C3B7f	0	1	1	0	6	3
5	5C3B7g	0	0	0	0	0	0
6	5C3B7h	0	0	1	1	4	2
7	5C3B7j	0	1	1	0	5	3
8	5C3B7k	0	0	1	0	4	2
9	5C3B7m	16	28	12	7	62	30
10	5C3B7n	4	18	10	3	45	20
11	5C3B7p	0	12	5	2	30	10
12	5C3B7q	0	0	0	0	0	0
13	5C3B7r	0	12	5	2	25	10
14	5C3B7s	0	2	2	1	10	5
15	5C3B7t	0	9	5	5	10	10
16	5C3B8a	0	0	0	0	2	1
17	5C3B8b	0	0	0	0	0	0
18	5C3B8c	0	0	0	0	3	1
19	5C3B8d	0	0	0	0	1	0
20	5C3B8f	0	0	0	0	2	1
	Total	**38**	**95**	**53**	**23**	**258**	**123**

Table 7.13: Summary of treatment measures and their cost for CAT Plan

Treatment Measures	Quantity	Unit Cost (Rs)*	Total Cost (Rs.)
Enrichment Plantation (ha)	38	72,560	**27,57,280**
Assisted Natural Regeneration (ha)	95	39,240	**37,27,800**
Energy Plantation (ha)	53	69,560	**36,86,680**
Staggered Contour Trenches (Nos)	23	21,850	**5,02,550**
Dry Stone Masonry Check Dams (Nos)	258	22,500	**58,05,000**
Gabion Check Dams (Nos)	123	29,500	**36,28,500**
TOTAL			**2,01,07,810**

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

7.5.3 DEVELOPMENT OF NURSERIES

Nursery is defined as an area where plants are raised for eventual planting out in the forest area or elsewhere selected for afforestation in field. Nursery should preferably be rectangular or square in shape with well laid out beds, separated by main paths, around the fence and within the Nursery for the movement of small machinery, wheel barrows, etc. Nursery should be properly fenced; 5 to 7 strands barbed wire (with criss-cross barbed wire), with distance of strands closer below the ground and gradually increasing upwards. It should have gate for day to day labour movements. Nursery should have Mali's quarter, tool shade, store, and labour shed, with in nursery or just adjoining it for constant

supervision and better success of the nursery. Water supply should have assured from perennial water sources/ springs/ streams throughout the year.

Some of the important points for nursery raising are:-
Nature of Nursery (Permanent or Temporary), Choice of site (Preferably Northern Aspect), Lay-out of nursery (Flat or Terraced), Dimensions of beds, Soil Preparations, Level & Edging, Inoculation with mycorrhiza (if required), Inputs in the soil (Forest Manure/ Farm Yard Manure), Pre-germination (Treatment), Method of Sowing (Line/ Broadcasting), Quality of Seed, Time of Sowing (Pre Monsoon/ Post Monsoon), Protection/ Covering the seed against birds & Rodents, Shading, Protection from Frost, Protection from rain & hail, Types of shade (Polythene/ Brush wood/ Grass), Hardening off (Permeability/ Texture of soil), Watering and damping off (Drainage/ Aeration), Weeding & soil working, Herbicides for the nursery Hoeing/ weeding etc.

A provision of **Rs. 10.00 lakh** has been made for establishment of a new nursery and **Rs. 4.00 lakh** as maintenance cost for 4 subsequent years.

7.5.4 SILT MONITORING

For regular monitoring of silt load coming from nalas, one Silt Monitoring site have been suggested. This would ensure monitoring efficacy of implementation various treatments measures suggested as in CAT plan. Monitoring would be undertaken for a period of six years. A lumpsum cost **Rs. 6.00 lakh** for establishment of monitoring site and **Rs. 3.00 lakh** as running and maintenance cost for silt observation has been made in the present CAT plan.

7.6 OTHER COMPONENTS OF CAT PLAN

Apart from the biological and engineering treatment measures in the free draining 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.

7.6.1 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 11.20 lakh** has been kept for this component.

7.6.2 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 free draining 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 4.48 lakh** is being made.

7.6.3 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 free draining 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 6.72 lakh** has been made for this component.

7.6.4 CONTINGENCIES

A provision of **Rs 22.41 lakh** has been kept under this component for some leeway to adjust any unforeseen expenditure.

7.7 COST ESTIMATE

The estimated cost of implementation of CAT plan is **Rs. 268.89 lakh** and is given at **Table 7.14**. Year wise phasing of physical and financial outlay has been given in **Table 7.15**.

Table 7.14: Estimated Cost of CAT Plan Implementation

S. No.	Item	Rate (Rs)	Unit	Target	
				Physical	Financial (Rs)
I	**Biological Measures**				
1	Enrichment		ha		
	i) Creation	50,000		36	19,00,000.00
	ii) Maintenance for 5 years	22,560		36	8,57,280.00
2	Assisted Natural Regeneration		ha		
	i) Creation	25,700		76	24,41,500.00
	ii) Maintenance for 5 years	13,540		76	12,86,300.00
3	Energy Plantation		ha		
	i) Creation	51,900		97	27,50,700.00
	ii) Maintenance for 3 years	17,660		97	9,35,980.00
4	Nursery Development				
	i) Creation	LS			10,00,000.00
	ii) Maintenance for 4 years	LS			4,00,000.00

S. No.	Item	Rate (Rs)	Unit	Target	
				Physical	Financial (Rs)
	Sub Total I (1+2+3+4)				**1,15,71,760.00**
II	**Engineering Measures**				
5	Staggered Contour Trenches	21,850	ha	23	5,02,550.00
6	Check Dams (DRSM)	22,500	No	258	58,05,000.00
7	Gabion Check Dams	29,500	No	123	36,28,500.00
8	Silt Monitoring				9,00,000.00
	Sub Total II (5+6+7+8)				**1,08,36,050.00**
A	**Treatment Cost (Sub Total I + II)**				**2,24,07,810.00**
III	**Administrative Measures**				
9	Administrative Charges @5% of Total				11,20,390.50
10	Micro planning @2% of Treatment Cost				4,48,156.20
11	Monitoring & Evaluation Cost @3% of Treatment Cost				6,72,234.30
12	Contingencies @10% of Treatment Cost				22,40,781.00
B	**Sub Total III**				**44,81,562.00**
	Total CAT Plan Cost (A + B)				**2,68,89,372.00**

Table 7.15: Year Wise Phasing of Physical and Financial Targets

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	**Afforestation Measures (ha)**																		
1	**Enrichment Plantation**			38	19,00,000														
	1st Year maintenance					38	2,09,380											38	19,00,000
	2nd Year maintenance							38	1,81,640									38	2,09,380
	3rd Year maintenance									38	1,55,420							38	1,81,640
	4th Year maintenance											38	1,55,420					38	1,55,420
	5th Year maintenance													38	1,55,420			38	1,55,420
2	**Assisted Natural Regeneration**			81	20,81,700	14	3,59,800											95	24,41,500
	1st Year maintenance					81	2,43,000	14	42,000									95	2,85,000
	2nd Year maintenance							81	2,24,370	14	38,780							95	2,63,150
	3rd Year maintenance									81	2,09,790	14	36,260					95	2,46,050
	4th Year maintenance											81	2,09,790	14	36,260			95	2,46,050
	5th Year maintenance													81	2,09,790	14	36,260	81	2,46,050
3	**Energy Plantation**			44	22,83,600	9	4,67,100											53	27,50,700
	1st Year maintenance					44	3,02,720	9	61,920									53	3,64,640
	2nd Year maintenance							44	2,58,280	9	52,830							53	3,11,110
	3rd Year maintenance									44	2,16,040	9	44,190					53	2,60,230
4	**New Nursery and 4 Year Maintenance**	1	10,00,000		1,00,000		1,00,000		1,00,000		1,00,000								14,00,000
	Sub Total I		**10,00,000**	**163**	**63,65,300**	**186**	**16,82,000**	**186**	**8,68,210**	**186**	**7,72,860**	**142**	**4,45,660**	**133**	**4,01,470**	**14**	**36,260**		**1,15,71,760**
II	**Soil & Water Conservation Measures**																		
5	Staggered Natural Regeneration (ha)			20	4,37,000	3	65,550											23	5,02,550
6	Dry Stone Masonry Check Dams (Nos)			202	45,45,000	56	12,60,000											258	58,05,000
7	Gabion Check Dams (Nos)			100	29,50,000	23	6,78,500											123	36,28,500
8	Silt Monitoring		6,00,000		50,000		50,000		50,000		50,000		50,000		50,000				9,00,000
	Sub Total II		**6,00,000**		**79,82,000**		**20,54,050**		**50,000**		**50,000**		**50,000**		**50,000**				**1,08,36,050**
A	**Total (I and II)**		**16,00,000**		**1,43,47,300**		**37,36,050**		**9,18,210**		**8,22,860**		**4,95,660**		**4,51,470**		**36,260**		**2,24,07,810**
III	**ADMINISTRATIVE MEASURES**																		
9	Administrative Charges @5% of Tota		5,60,195		5,60,195														11,20,391
10	Micro planning @2% of Treatment Cost		4,48,156																4,48,156
11	Monitoring & Evaluation Cost @3% of Treatment Cost		48,000		4,30,419		1,12,082		27,546		24,686		14,870		13,544		1,088		6,72,234
12	Contingencies @10% of Treatment Cost		1,60,000		14,34,730		3,73,605		91,821		82,286		49,566		45,147		3,626		22,40,781
B	**Sub Total III**		**12,16,351**		**24,25,344**		**4,85,687**		**1,19,367**		**1,06,972**		**64,436**		**58,691**		**4,714**		**44,81,562**
	Total (A and B)		28,16,351		1,67,72,644		42,21,737		10,37,577		9,29,832		5,60,096		5,10,161		40,974		2,68,89,372