MAHAGENCO
Maharashtra State Power Generation Co. Ltd.
Maharashtra State Power Generation Co. Ltd.
Office of the Chief Engineer (Coal), Prakashgad, 3rd floor, Plot no. G-9,
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Email: cecoal@mahagenco.in

Ref: CE(Coal)/Coal & GP/CAT-SC Plan/373 Date:07.05.2020

To,
The Divisional Forest Officer (DFO)
Raigarh
Chattisgarh.

Sub: Submission of Catchment Area Treatment Plan and Soil Conservation Plan of Gare Palma Sector II coal mines Mand Raigarh, District Raigarh Chhattisgarh

Ref: DFO, Raigarh Letter No7361 dated 20.09.2019.

Sir,

This is with reference to your letter dated 20.09.2019, wherein you have advised Mahagenco to submit the Catchment Area Treatment Plan and Soil Conservation Plan of Gare Palma Sector II Coal Mine for processing the Forest Clearance application.

In view of the above, we are hereby submitting the requisite Catchment Area Treatment Plan and Soil Conservation Plan in six (6) set for your needful action and further approval.

Thanking You,

Yours sincerely,

Chief Engineer (Coal)
Maharashtra State Power Generation Company Limited

Enclosure:

1. Catchment Area Treatment Plan in six (6) set
2. Soil Conservation Plan in six (6) set

REPORT ON

CATCHMENT AREA TREATMENT PLAN

FOR

GARE PALMA SECTOR -II COAL MINE,

TEHSIL TAMNAR, DISTRICT RAIGARH, CHHATTISGARH

PROPONENT

MAHARASHTRA STATE POWER GENERATION COMPANY LTD

Prakashgad, Plot No. G-9 Prof Anant Kanerkar Marg, Bandra (E), Mumbai-400051 (MS)

PREPARED BY

SRUSHTI SEVA PRIVATE LIMITED

Harihar Niwas, Agresan Road, Near Adivasi Bhavan, Giripeth, Nagpur-440010, (Maharashtra)

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MARCH - 2020

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CATCHMENT AREA TREATMENT
OF GARE PALMA SECTOR –II COAL BLOCK

1.0 INTRODUCTION:

Background :

Maharashtra State Power Generation Company Limited (hereinafter referred to as MAHAGENCO) is a State owned Public Sector Unit of Government of Maharashtra engaged in power generation having its registered office situated Plot No. G-9, Prof Anant Kanekar Marg, Bandra (East), Mumbai. **Maharashtra State Power Generation Co Ltd**. has been incorporated under Indian Companies Act 1956 pursuant to decision of Govt. of Maharashtra to reorganize erstwhile **Maharashtra State Electricity Board** (herein after referred to as "MSEB"). The said reorganization of the MSEB has been done by Govt. of Maharashtra pursuant to Part XIII read with section 131 of The Electricity Act 2003. MAHAGENCO has been incorporated on 31.5.2005 with The Registrar of Companies, Maharashtra, Mumbai and has obtained Certificate of Commencement of Business on 15.09.2005. MAHAGENCO is engaged in the business of generation and supply of electricity and has been vested with generation assets, interest in property, rights and liabilities of MSEB.

MAHAGENCO has the highest overall generation capacity and the highest thermal installed capacity amongst all the state power generation utilities in India. In terms of installed capacity, it is the second highest generation company after NTPC. The company has a generation capacity of 13186 MW comprising of 9750 MW Thermal Power Plants, 2580 MW Hydel Power Plant, 672 MW Gas Turbine and 184 MWp Solar. The details of the power plants are given below.

Table 1.0 : Installed Capacity of MAHAGENCO Plants

Sr. No.	Power Station	Units & Size (MW)	Installed Capacity (MW)
A : Thermal Power Stations			
1	Koradi Units 6 To 10	2 x 210 + 3 x 660	2400
2	Nashik Units 3 To 5	3x210	630
3	Bhusawal Units 3 To 5	1x210 + 2x500	1210
4	Paras Units 3 & 4	2x250	500
5	Parli Units 6 to 8	3x250	750
6	Khaparkheda Units 1 To 5	4x210 + 1x500	1340

Sr. No.	Power Station	Units & Size (MW)	Installed Capacity (MW)
7	Chandrapur Units 3 To 9	2x210 + 5x500	2920
Total Installed Capacity of TPPs			9750
B : Gas Turbine Power Station			
	Uran Gas Turbine.	4x108	432
	W.H.R. Units 1&2	2x120	240
Total Installed Capacity of Gas-based Plants			672
C Hydro Power Stations			
	Koyna Hydro	St I&II- 4x70 + 4x80, St III- 4x80, St. IV- 4x250 & Koyna Dam Foot- 2x18	1956
	Small Hydropower projects		374
	Ghatghar Pump Storage	2x125	250
Total Installed Capacity of Hydel Plants			2580
D : Solar			184
Total Installed Capacity (A+B+C+D)			**13186**

The Project : The Gare Palma Sector II coal block has been allocated to Maharashtra State Power Generation Company Limited (MAHAGENCO) by Ministry of Coal, Govt. of India for end-use at its own plants in Maharashtra. The Gare Palma Sector II Coal Block spread over an area of 25.83 sq.km (2583.486 ha) is part of the Mand Raigarh Coalfield in Tamnar Tehsil of Raigarh District, Chhattisgarh. The mine lease area is located in the 14 villages of Bhalumura, Chitwahi, Dholnara, Dholesara, Gare, Jhinkabahal, Kunjemura, Libra, Murogaon, Pata, Radopali, Saraitola, Sarasmal, and Tihlirampur. The peak capacity of the mines will be 23.6 MTPA with both Opencast (22.0 MTPA) and Underground (1.6 MTPA) operations with a mine life of 69 years.

The area is covered in the Survey of India Toposheet No. 64 N/8 & 12 (R.F. 1:50,000) and is bounded by the coordinates shown in table below.

Site Coordinates

Boundary Point	Latitude	Longitude
A	22° 08' 51.495" N	83° 26' 15. 580" E
B	22° 10' 05.178" N	83°26' 15.433" E
C	22° 10' 49.891" N	83° 27' 26.624" E

D	22° 09' 09.892" N	83°28' 57.871" E
E	22° 08' 03.774" N	83° 29' 49.271" E
F	22° 06' 24.215" N	83° 31' 12.632" E
G	22°07' 18.066" N	83° 29' 13.857" E
H	22°06' 50.059" N	83° 29' 15.318" E

The Raigarh - Sundargarh road is 9 km away in south east direction and Ambikapur Highway (SH-1) is 6 km in west direction from Phase-II site. The District headquarter is Raigarh which is aerially about 35km from the site and the nearest town is Tamnar at a distance of about 10 km to the south. The nearest railway station is also at Raigarh while the nearest airport is Raipur at a distance of 290 km in the south west direction. The inter-state boundary with Odisha is almost adjacent to the block on the eastern side, 10 km to the east. The details of the project site are given in Table below

Project Location

Sl.No.	Aspect	Description
1.	Project	Gare Palma Sector-II Coal Mine Project of 23.60 MTPA of MAHAGENCO, Raigarh District, Chhattisgarh over 2,583 Hectares of Land
2.	Location	
(i)	State	Chhattisgarh
(ii)	District	Raigarh
(iii)	Taluka	Tamnar
(iv)	Villages	Bhalumura, Chitwahi, Dholnara, Dholesara, Gare, Jhinkabahal, Kunjemura, Libra, Murogaon, Pata, Radopali, Saraitola, Sarasmal, Tihlirampur
(vi)	Latitude	22° 6' 24.215" N to 22° 10' 49.891" N
(vii)	Longitude	83° 26' 15.433" E to 83° 31' 12.632" E
3.	Distance	
(i)	Nearest Town	Tamnar, 10 km, S
(ii)	District Headquarters	Raigarh, 35 km, S
(iii)	Major Roads	Raigarh-Ambikapur Highway (SH-1), 6 km, W Raigarh-Gharghoda Road via Tamnar
(iv)	Railway Station	Raigarh, 35 km, S
(v)	Airport	Raipur, 290 km, SW

1.1 General

The Gare Palma-II Coal Block comprising total lease area of 25.83 km^2 has been allotted to Maharashtra State Power Generation Company Limited (MAHAGENCO) in the district of Raigarh of Chhattisgarh state. The location map is given in **Figure 1.1.** M/s Maharashtra State Power Generation Company Limited (MAHAGENCO) is in process of obtaining Environmental and Forest Clearance for Gare Palma-II Coal Block which requires Catchment Area Treatment Plan (CAT) and Soil Conservation Plan (SC). In context of above, the need for preparation of CAT & SC has been envisaged. Accordingly, M/s Srushti Seva Private Limited, Nagpur have been entrusted the Job vide Service Order no. HO/4500108857 dated 28.02.2020 with the following scope of work.

Figure 1.1 Location Map

1.2 Scope of Work:

I. Preparation of Catchment Area Treatment Plan and Soil Conservation Plan:

1. A Catchment area Treatment Plan in the immediate catchment of Kelo River is required to arrest silt and augment in-filtration of runoff water to improve the perennial water regime in the region for Gare Palma -II Coal Mine site.
2. Scope of study shall include Catchment area of Kelo for Gare Palma -II Coal Mine site.
3. Preparation of Climatic Water Balance of the study area.
4. Infiltration test on soil cove under study.
5. Preparation of detailed database on natural resources geological and geomorphological status, terrain conditions, soil type of catchment area & preparation of current management practices.
6. Obtaining satellite imagery and its interpretation with ground truth studies.
7. Integration of various terms land use, soil, slope, erodibility, topography & rainfall etc. using geographical information system (GIS).
8. Preparation of Digital Terrain model
9. Estimation of soil loss using silt yield index (SYI) method. Preparation of current management practices.
10. Preparation of current management practices.
11. Catchment area map.
12. Preparation of watershed management plan and catchment area Treatment measures to be taken.
13. Cost estimates.

1.3 Location of the Project:

The Gare Palma Sector–II Coal Block is located in Mand Raigarh Coalfield Thesil Tamnar in Raigarh District of Chhattisgarh State. The mine site is located at Tilhi Rampur, Kunjemura, Gare, Saraitola, Murogaon, Radopali, Pata, chitwahi, Dholnara, Jhinka Bahal, Dolesara, Bhalumura, Sarasmal and Libra village. The area is covered in the Survey of India Toposheet No. 64 N/8 & 12 (R.F.1:50,000)) and is bound by

Latitude: 22° 06’ 24.215” N to 22° 10’ 49.891” N

Longitude: 83° 26’ 15.433” E to 83° 31’ 12.632” E

The Gare palma is situated around 35 km towards north from Raigarh Township, which is also the nearest railway station on Mumbai-Howrah main line of SE Railway.

1.4 Location of Study Area :

The location of study area comprising catchment area related to mine and relevant drainage. Hereafter, this refers as study area. The study area have been considered based on the drainage entering into mine lease area, and the drainage intercepted by neighboring working coal mine. The area under study comprises 38.50 km^2. There are seven Micro Watersheds namely 1 to 7. The location of study area on toposheet with Micro Watershed is given in **Figure 1.2**.

1.5 Demography of Watershed:

There are 14 villages within the CAT Plan. The population and demographic profile of these villages are as follows given in **Table 1.1**

Table 1.1 Demographic Data

Source: (Census: 2011)

Village Name	Total Population	%	Male	Female
Bhalumura	490	3.63	228	262
Dholnara	512	3.79	243	269
Chitwahi	853	6.31	396	457
Dolesara	1326	9.82	644	682
Rodopali	752	5.57	374	378
Kunjemura	1364	10.10	689	675
Gare	828	6.13	412	416
Pata	1358	10.05	688	670
Mudagaon	553	4.09	270	283
Saraitola	653	4.83	320	333
Sarasmal	535	3.96	261	274
Tihli Rampur	1962	14.52	1051	911
Jhinku Bahal	905	6.70	494	411
Libara	1418	10.50	720	698
	13509	**100 %**		

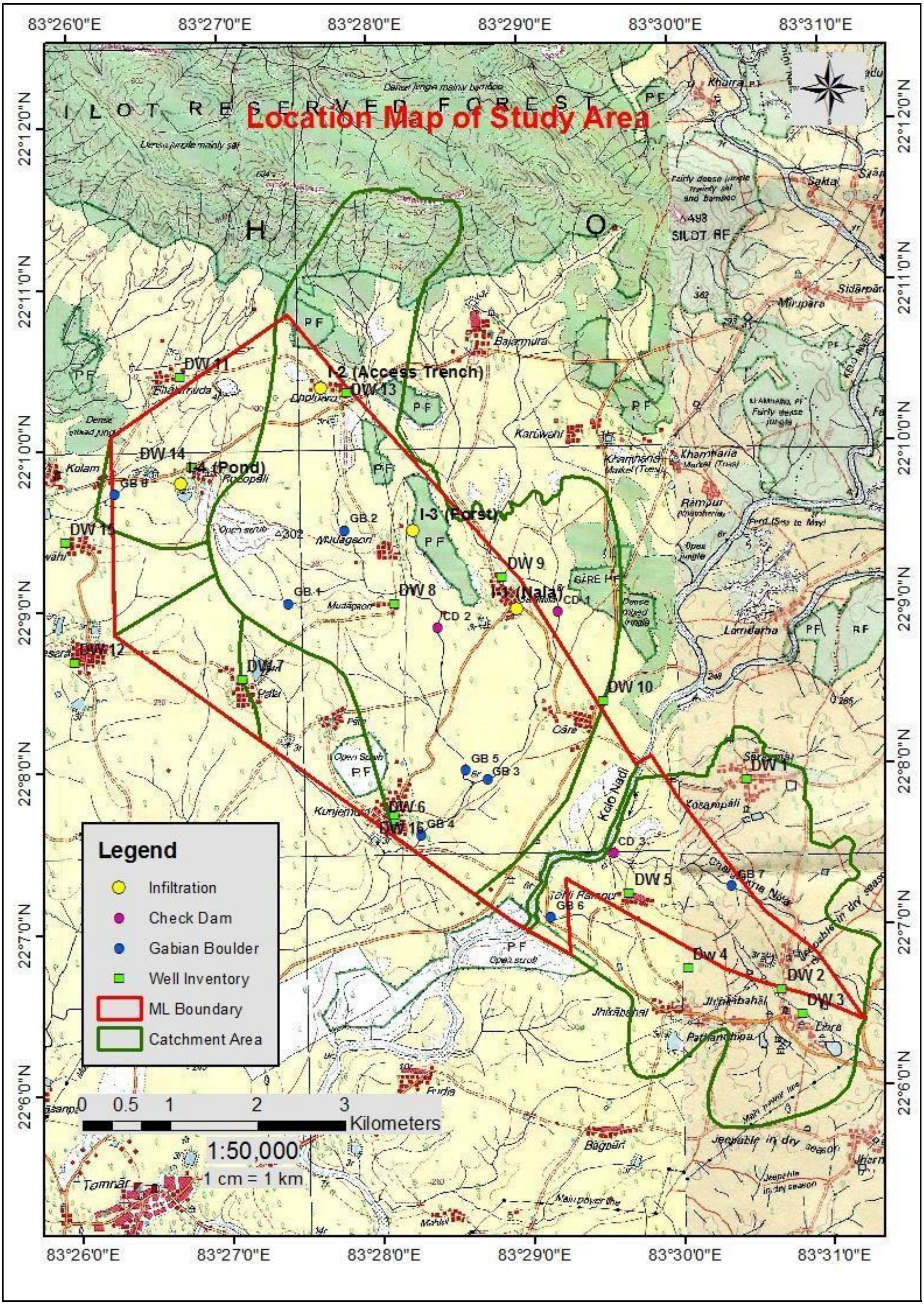


Figure 1.2 : Location on Toposheet

1.6 Need for Catchment Treatment Plan :

Catchment Area Treatment Plan is normally applicable for Hydroelectric and Irrigation Projects where impounding of water is proposed by construction of Barrage, Dam etc. This project is coal mining Project coming within catchment area of Kelo River. Besides this Kelo dam is situated downstream of this project. Prevention of siltation due to Mining in Kelo Dam, due to coal mining of this project, has to be given top most priority. The location of this mining project with reference to Kelo dam is depicted in **Figure 1.3.** It is well established fact that the reservoir are subject to sedimentation. The study of erosion and sediment yield from catchments is of the utmost importance in order to suggest proper mitigation measure to avoid deposition of sediment in Kelo reservoir. Sedimentation will reduces its capacity, and thus affecting the water availability for competing users. Properly designed Catchment Area Treatment Plan (CAT) is essential to ameliorate the above mentioned adverse process of soil erosion.

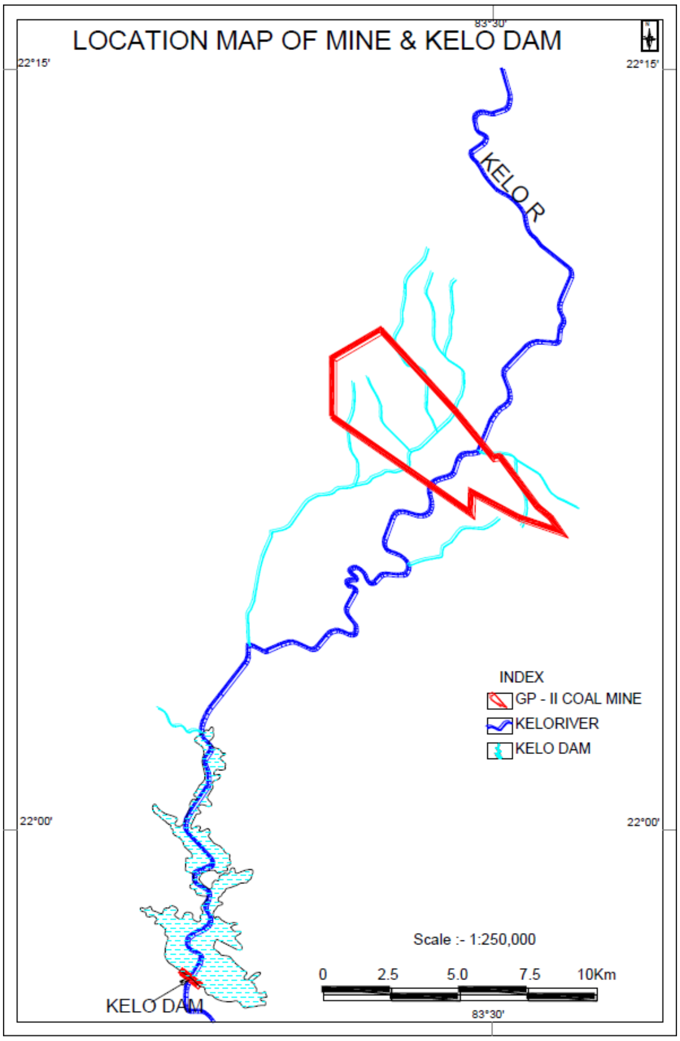


Figure 1.3 Location of Mine and Kelo Dam

1.6.1 Objective of Cat Plan

The objective of CAT Plan is to rejuvenate various potential and degraded ecosystems in the catchment area. The action plans have been prepared for this purpose with the following objectives.

1. To facilitated the hydrological functioning of the catchment and augment the quality of the Kelo River.
2. Conservation of soil cover and to arrest the soil erosion, flood and siltation of the river and its tributaries and consequent relation of siltation in the river of Kelo and its reservoir.
3. Demarcation of priority of sub watershed of treatment on the basis of soil erosion. intensity in the catchment area.
4. Soil conservation of through biological & engineering measures to reduce sediment load in river and tributaries, thus improving quality of water.
5. Increase vegetative cover and water retaining properties.

1.7 Modification of Nala /Garland drain

The Kelo River is passing through the block dividing East and West. Kelo river is flowing across the Coal Block towards south. The diversion of Kelo River is not proposed in mine plan due to natural topography, shape of the block and presence of other coal Block. The modifications of two nala passing through block are requirement as per Mine Plan. Modification of Nala to flow into Kelo River is shown in Figure 1.4

1.7.1 Modification of Nala –A (Located on west side of Kelo river) : It is proposed to construct a garland drain along the northern boundary line, within the block are, to join the into western side of Kelo river in the fifth year of mining. This is garland drain is passing through southern boundary of Gare IV/7 excavated coal block. It is expected that some of runoff generated over boundary area may contribute into this garland drain. The sediments during flood is to be considered in CAT Plan.

1.7.2 Modification of Karnala Nala (located on east side of the Kelo River) : The small catchment area (from 1st order drainage channels), previously lying over the eastern most part of the block on east of the Kelo river, has now been reformed by construction of the Urja Nagar colony by JPL. The area drainage has been modified and the diversion drain goes round the colony to hit a point on the northern boundary line of the block where some water drained from northern side also joins. The later part of the nala is proposed to be modified and aligned along the northern boundary of the block to join the Kelo River in the eastern side for safety of mining operations.

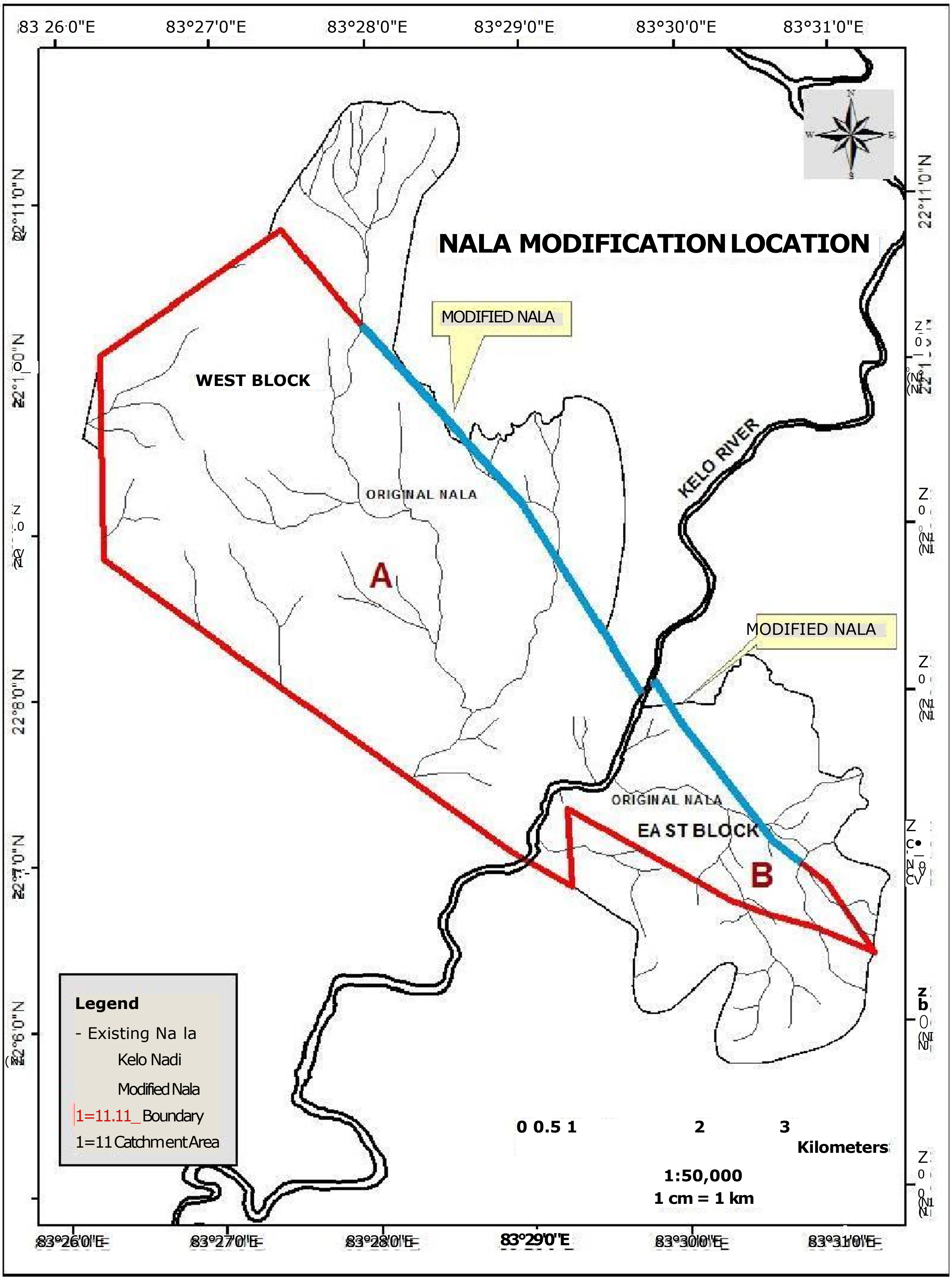


Figure 1.4 Alignment of Nala Modification

2.0 LAND USE PLAN:

2.1 Pre-mining Land use :

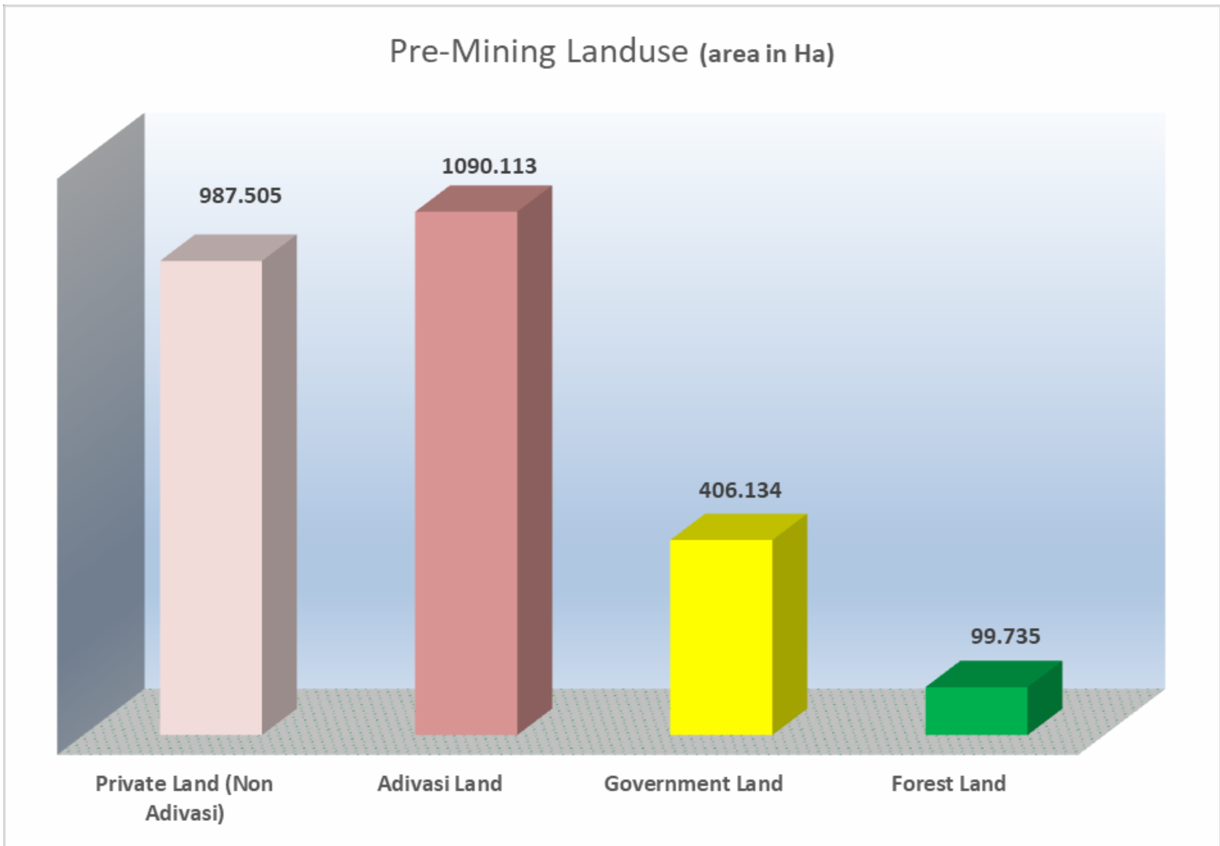
2.1.1 Total Mining Lease Area : Pre-mining Land Use Plan for Mine area is given below in **Table 2.1 & Figure 2.1.**

Table 2.1
Pre-mining Land Use Plan in Mine Lease Area

(area in Ha)

Private Land (Non Adivasi)	Adivasi Land	Government Land				Forest Land	Total
		Chote Bade Jhad ki Jungle	Abadi	Others	Total		
987.505	1090.113	115.134	90.328	200.672	406.134	99.735	2583.487

Figure 2.1: Land Use in Mine Lease Area



2.1.2 Forest Land Schedule:

The catchment treatment plan (CAT Plan) is being prepared inclusive forest area of 76 km^2. The land schedule for purpose of CAT in respect of forest area is given below in **Table 2.2 & Figure 2.2.**

Table 2.2

Extent of CAT Area & Land Schedule

Sr. No.	Reserved	Percentage %
1	Dense Forest	0
2	Open Forest Land	16
3	Open Mixed Forest Land	84
4	**Total**	**100**

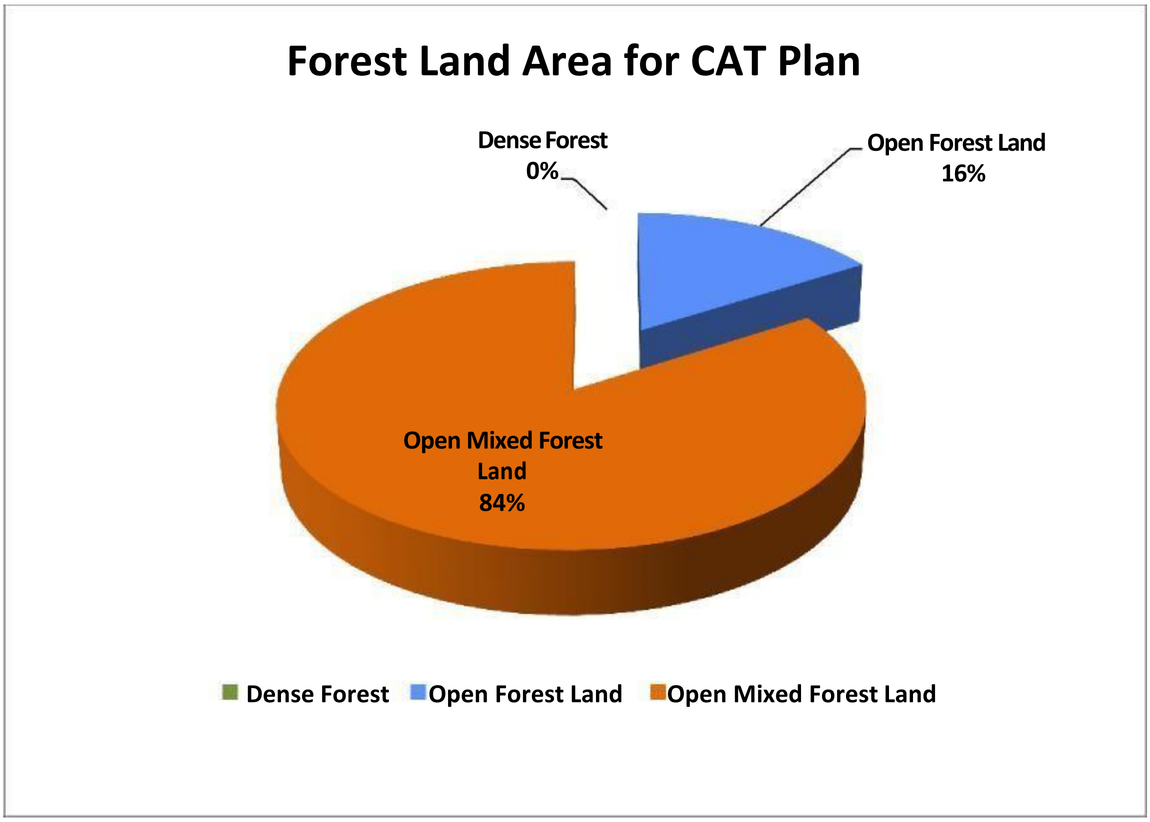


Figure 2.2: Extent of CAT Area & Land Schedule

2.2 Land use - Mining Plan:

The entire land coming within lease hold area of coal mine is 2583.48 ha will be utilized for mining and ancillary activities are given in **Table 2.3** respectively.

Table 2.3
Landuse Cover of proposed Mine

Sr. no.	Landuse	At the end of 5th Year	At the end of 25th Year	At the end of OC mining 29th Year
1	Excavation	380.70	2272.42	2440.55
2	Backfill	0.00	1535.00	2248.77
3	Void	380.70	737.42	191.78
4	Surface dump	380.00	0.00	0.00
5	Bund	5.20	5.20	5.20
6	Green Belt	36.07	36.07	36.07
7	Top Soil Dump	60.00	00.00	0.00
8	Settling Pond	10.00	5.00	5.00
9	Road Diversion	30.30	30.30	30.30
10	Facilities (West)	50.94	50.94	50.94
11	Facilities (East)	68.54	0.00	0.00
12	Under Kelo River	15.42	15.42	15.42
13	Dismantling	0.00	0.00	0.00
14	Disturbed area	1017.17	2415.35	2583.48
15	Undisturbed	1566.31	168.13	0.00
	Total	**2583.48**	**2583.48**	**2583.48**

3.0 SATELLITE IMAGERY ANALYSIS:

3.1 Satellite Imagery:

This data is received from data set of sentinel – 2 on earth explorer-US 400 which provides global from 83 degree North, 56 degree South latitude 10 meter resolution, multispectral images every 10 days (2015-present). The sentinel mission consists of two satellites developed to supports vegetation land cover and environmental monitoring. The satellite imagery data is processed and the resultant map is placed at **Figure 3.1 & 3.2** respectively**.** Kelo River is clearly indicated in the Imagery.

3.2 Land use as per Satellite Imagery :

The land use of Catchment Treatment plan study area is categorized under following heads of land use pattern. The area in Km^2 has been rounded off in to Hector and given in **Table 3.1.**

Table 3.1
Land use

<table>
<tr><th colspan="2">Landuse type</th><th>Area in Km2</th><th>in Ha</th><th>%</th></tr>
<tr><td colspan="2">Waterbody</td><td>0.21</td><td>20</td><td>0.51</td></tr>
<tr><td colspan="2">Scrube</td><td>0.03</td><td>3</td><td>0.07</td></tr>
<tr><td colspan="2">Builtup</td><td>0.96</td><td>96</td><td>2.48</td></tr>
<tr><td rowspan="2">Forest</td><td>Mine Lease</td><td>0.75</td><td>75</td><td rowspan="2">12.59</td></tr>
<tr><td>Outside</td><td>4.05</td><td>405</td></tr>
<tr><td colspan="2">Agriculture</td><td>32.50</td><td>3247</td><td>84.35</td></tr>
<tr><td colspan="2">Total land</td><td>38.50</td><td>3850</td><td>100</td></tr>
</table>

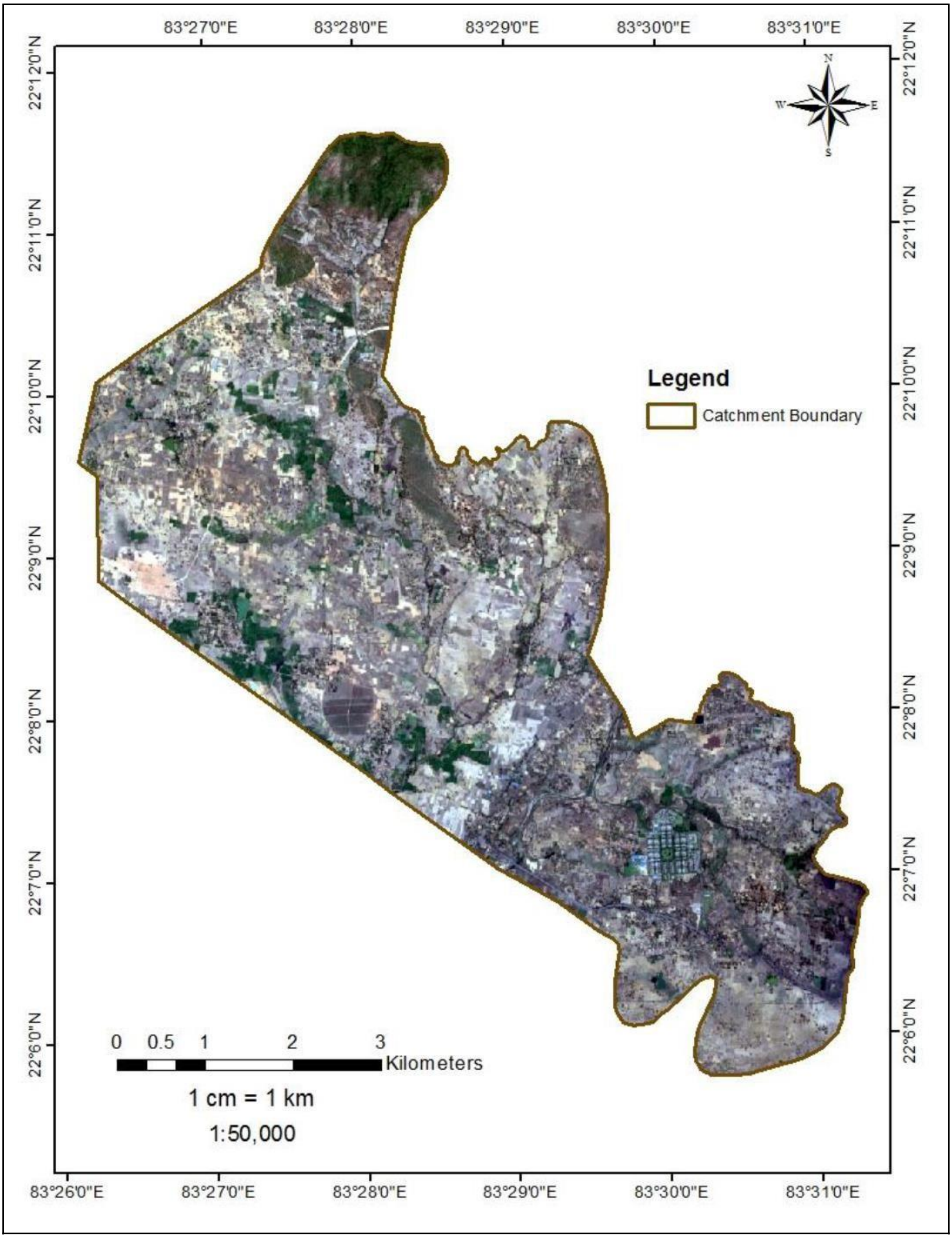


Figure 3.1 Satellite imagery

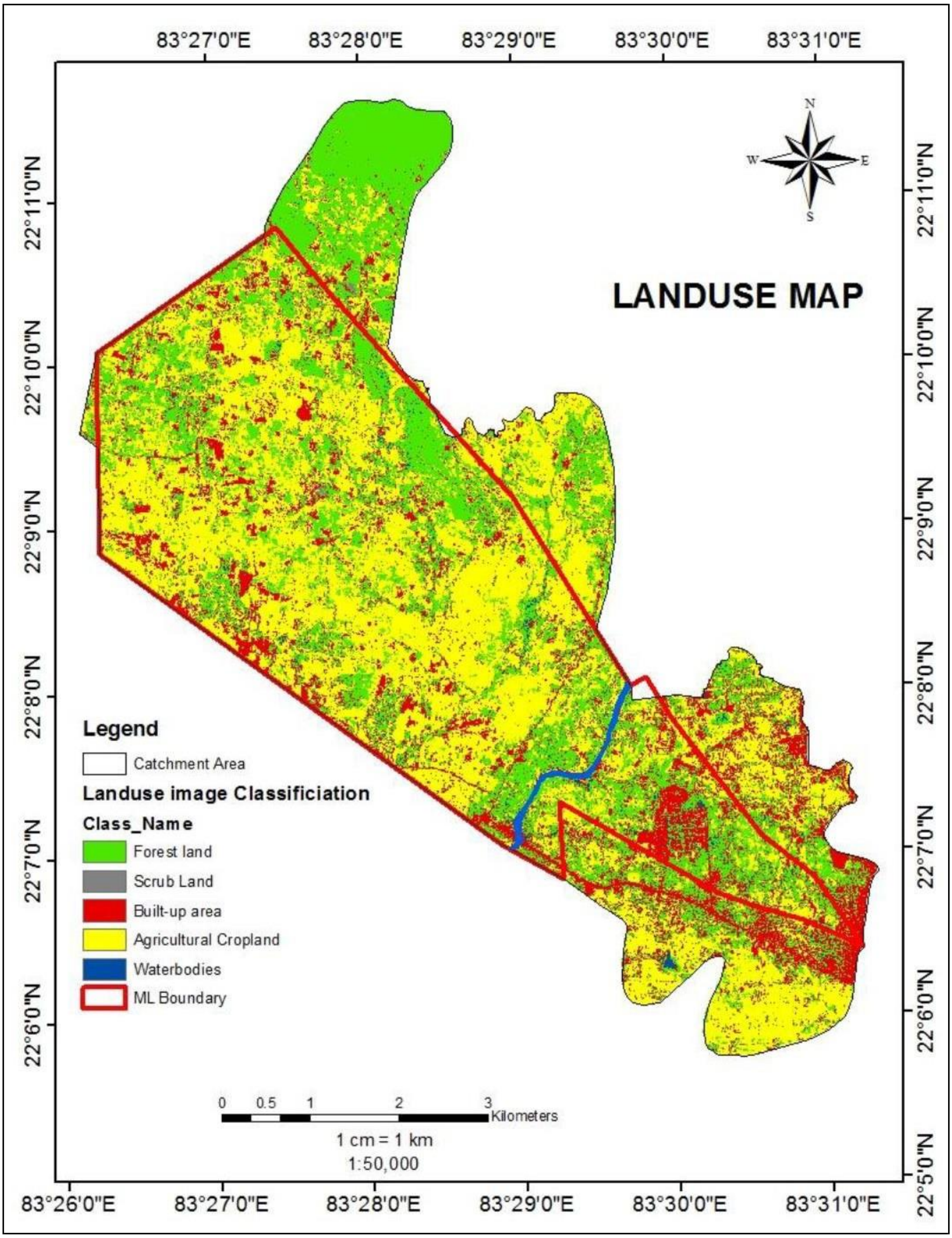


Figure 3.2 Landuse map by satellite imagery

3.3 Digital Elevation Model (DEM):

The area under study is plain having rolling topography with occasional undulating feature, except a hillock in the north outside, Mine Lease area. The highest elevation is 640 m amsl in the North while lowest 246 m amsl around Kelo River. The Digital Elevation Model (DEM) of Catchment Area Treatment (CAT) Plan is prepared by GIS tool and the same is reproduced in **Figure 3.3.**

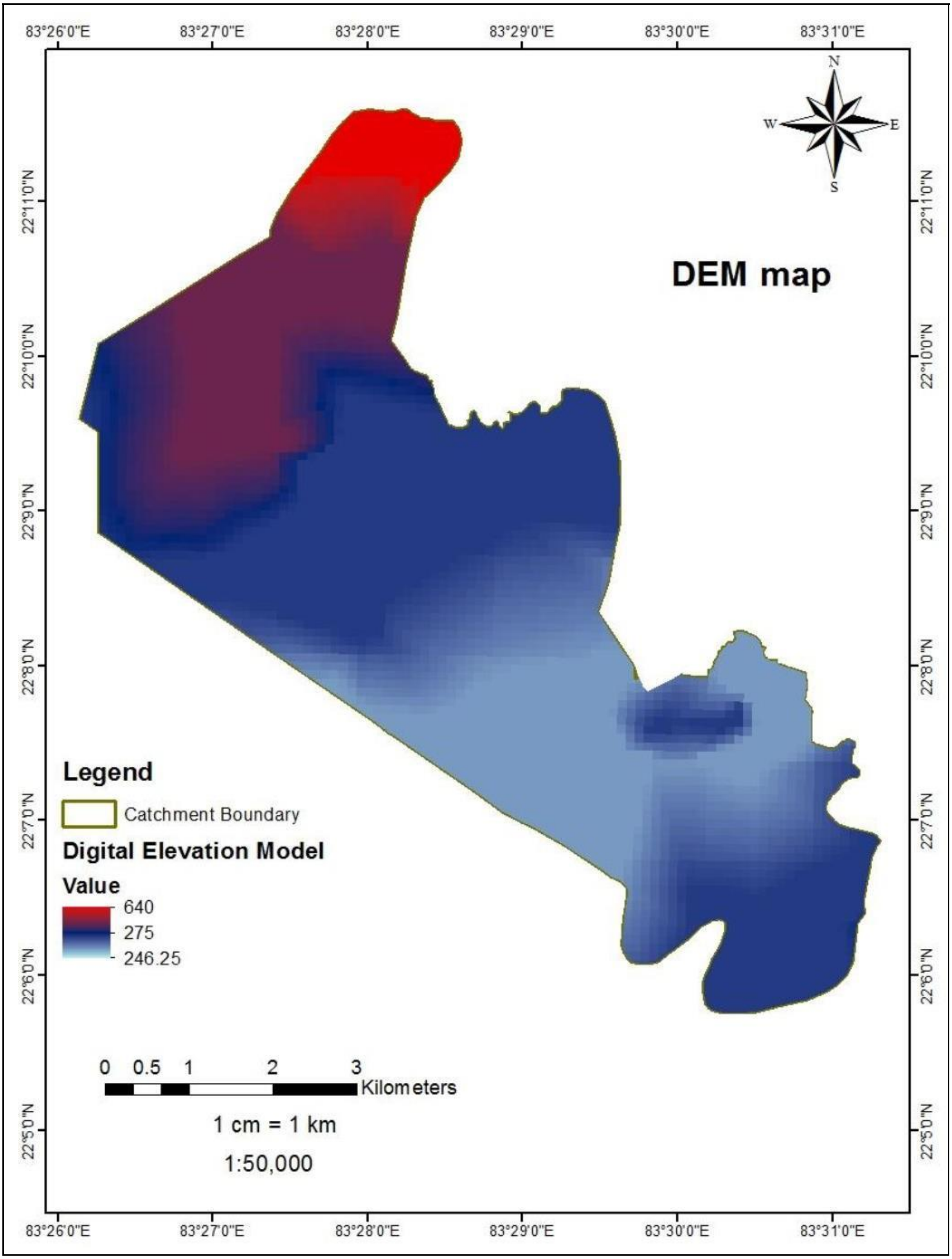


Figure 3.3 Digital Elevation Model

4.0 CLIMATIC WATER BALANCE

4.1 Rainfall:

The annual normal rainfall of study area as considered for Raigarh district is 1394.7 mm. The month wise normal rainfall is tabulated in **Table 4.1.** The monsoon rainfall 1238.1 mm i.e. 89% and non-monsoon rainfall 156.6 mm i.e. 11% are tabulated in **Table 4.2.** The relevant climatological feature of nearest IMD station at Raigarh has been attributed for the present study. As per IMD Raigarh station the heaviest rainfall in 24 hours recorded on 25.08.1970 was 315.2 mm. The heaviest rainfall in 100 year return period is estimated by IMD is 320 mm. The Normal rainfall of Raigarh is given in **Figure 4.1**

Table 4.1
Normal Rainfall of Raigarh District

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Normal Rainfall	11.6	10.8	11.6	11.7	21.3	205.0	390.8	363.7	227.5	50.8	8.7	7.7	1321.2

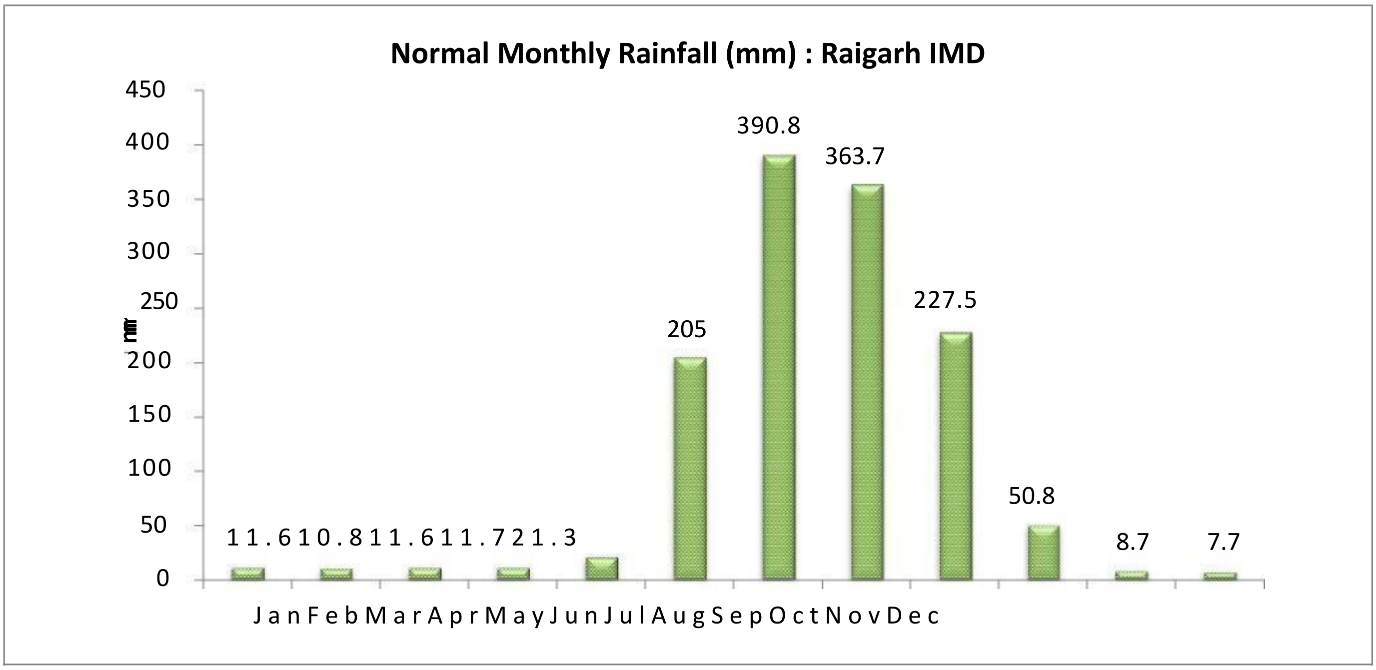


Figure 4.1: Normal Rainfall of Raigarh

Table 4.2
Distribution of Normal Rainfall

Season	Rainfall	Percentage	Heaviest Rainfall in 24 hrs. (10.07.1958)	Isopluvial Map for 100 year return period (mm)
	mm	%	mm	mm
Monsoon	1187.0	90%	360.9	320
Non-Monsoon	134.2	10%		
Total	**1321.2**	**100%**		

4.2 Potential Evapotranspiration (PE):

The PE value of Raigarh of EMP station has been considered for study. The PE value is given in **Table 4.3** and **Figure 4.2**

Table 4.3
Potential Evapotranspiration

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
PE	85	105.3	149.7	178	207	166	108.6	101.5	103.4	117.1	93	77.3	1492.4

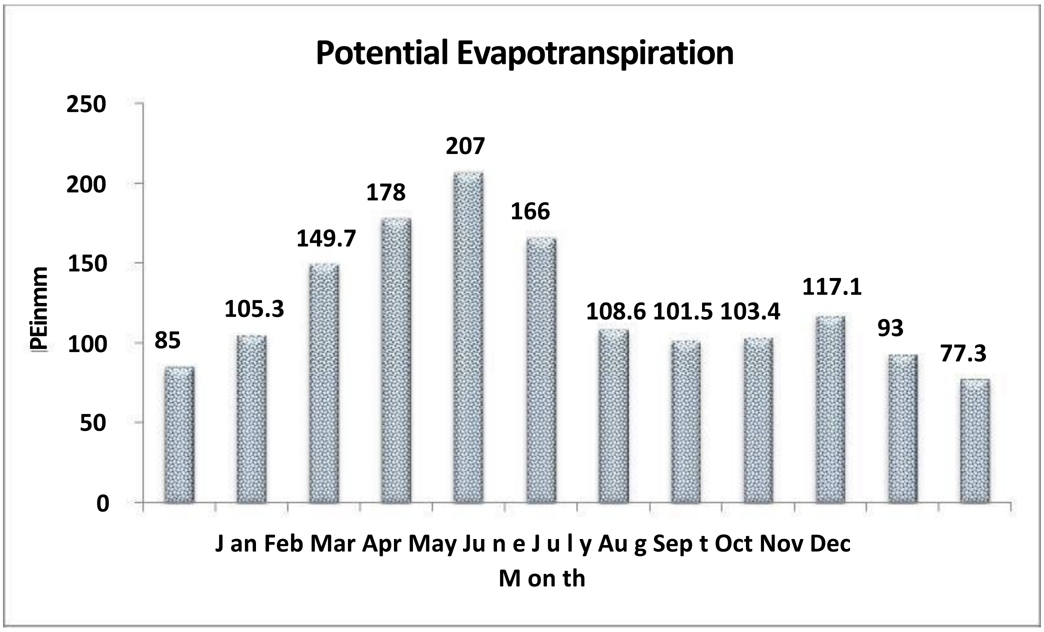


Figure 4.2 Potential Evapotranspiration

4.3 Climatic Water Balance:

The idea of climatic water balance was first put forth by Thornth waite in 1944. Subsequently he developed water balance technique. Elements of climatic water balance for watershed located in and near the project area is computed.

4.3.1 Water Balance Techniques: The term "Water Balance" refers to the balance between the incoming water from precipitation and the outgoing water by evapotranspiration resulting in change of soil moisture and runoff. It is a climatic balance obtained by comparing the match of precipitation with evapotranspiration, yielding a number of moisture parameters like water surplus, water deficiency, soil moisture change and runoff. The basic relation governing the water balance concept is;

P = E + 1S + R0

Where,

P = is precipitation in mm

AE = is Actual Evaporation in mm

1S = is change of soil moisture in mm

Ro = is runoff in mm

An important feature of the water balance concept is the recognition of the part played by soil in the exchange of moisture between the earth's surface and the atmosphere. Soil-acts as a medium for storing water (up to a limit) in times of excessive rainfall and releasing the same (in a restricted manner) at other times for purposes of evaporation and transpiration.

4.3.2 Water Balance Table : Using the method described in the above paragraph, the climatic water balance has been computed with the following information for the normal rainfall an placed in **Table 4.4**.

1. Potential evapotranspiration (PE)
2. Rainfall (P)
3. P-PE
4. Accumulated potential water loss (accumulated negative value of P-PE) = ACC (P-PE)
5. Storage (S)
6. Storage change (1S)
7. Actual evapotranspiration (AE)
8. Water deficit (WD)
9. Water surplus (WS)
10. Runoff (R_0)

Table 4.4
Climatic Water Balance of Kelo watershed

(Unit mm)

Parameter	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
PE	85	105.3	149.7	178	207	166	108.6	101.5	103.4	117.1	93	77.3	1492.4
P	11.6	10.8	11.6	11.7	21.3	205	390.8	363.7	227.5	50.8	8.7	7.7	1321.2
P-PE	-73.4	-94.5	-138.1	-166.3	-185.7	39	282.2	262.2	124.1	-66.3	-84.3	-69.6	-171.2
ACCP-PE	-293.6	-388.1	-526.2	-692.5	-878.2	0	0	0	0	-66.3	-150.6	-220.2	-3215.7
S	46.077	28.726	14.401	6.270	2.477	200	200	200	200	143.569	94.190	66.507	1202.217
ΔS	-20.430	-17.351	-14.325	-8.125	-3.793	197.523	0	0	0	-56.431	-49.379	-27.683	±197.53
AE	32.03	28.151	25.925	19.835	25.093	166	108	101.5	103.4	107.231	58.079	35.363	810.607
WD	52.97	77.149	123.775	158.175	181.907	0	0	0	0	9.869	34.921	41.917	680.683
WS	0	0	0	0	0	39	282.2	262.2	124.1	0	0	0	707.5
Ro	10.332	5.166	2.583	1.295	0.645	19.500	150.85	206.52	165.31	82.65	41.328	20.664	706.843

Climatic Water Balance :-

P = AE + RO ± ΔS.

1321 = 811 + 707 - 197

4.4 Intensity of Rainfall:

The rainfall intensity corresponding to a duration and desired probability of exceedence i.e. return period. This is rainfall-frequency duration relationship for the given catchment area. I.M.D. has prepared Isopluvial maps for the different return period for given catchment area. C.W.C. has also adopted the same for their publication of February 1997 in respect of flood estimation report for Mahanadi sub zone-3.

The Isopluvial maps for 25 year return period, 50 year return period and 100 year return period are taken from CWC publication. The map is enclosed as **Figure 4.3, 4.4 & 4.5.** The location of mine is marked on above maps and 24 hrs maximum rainfalls for different return period have been estimated and given in **Table 4.5.**

Table 4.5

Intensity of Rainfall – 24 Hrs

Sr. No.	Annual Return Period	24 hrs Highest Rainfall in mm
1	25	230
2	50	290
3	100	320

(Source: CWC)

The conversion ratio for different duration of rainfall for Mahanadi sub zone – 3 have been worked out by C.W.C. (1997) and given in **Table 4.6**

Table 4.6

Conversion ratio

Sr. No.	Rainfall duration in hour	Conversion ratio
1	1	0.390
2	3	0.610
3	6	0.760
4	9	0.820
5	12	0.860
6	15	0.880
7	18	0.920
8	24	1.00

(Source: CWC)

The rainfall intensity for different return period for one hour is estimated by multiplying conversion ratio with 24 hrs maximum rainfall of mine. The intensity of rainfall for 1 hour have been estimated and given in **Table 4.7**

Table 4.7
Intensity of Rainfall for 1 hrs

Sr. No.	Return Period	24 hrs maximum rainfall	Conversion factor for 1 hr	Intensity of rainfall in 1 hr	Remark
	Year	**Mm/24hrs**	**Coefficient**	**Mm/hr**	**-**
1	25	230	0.390	89.7	-
2	50	290	0.390	113.1	-
3	100	320	0.390	124.8	Use for Mine

The intensity of rainfall for catchment treatment plan has been estimated based on 100 year return period which is 124.8 mm/hr (12.5 cm/hr)

Intensity of Rainfall – 12.5 cm/hr

4.5 Runoff Coefficient:

The runoff coefficient is a dimensionless coefficient relating to amount of runoff to the amount of precipitation received. It is larger value for area with low infiltration and high runoff and lower for permeable well vegetated area (forest, flat land). The runoff coefficient has been considered is 25% as per Central Ground Water Board Report on Mahanadi Basin.

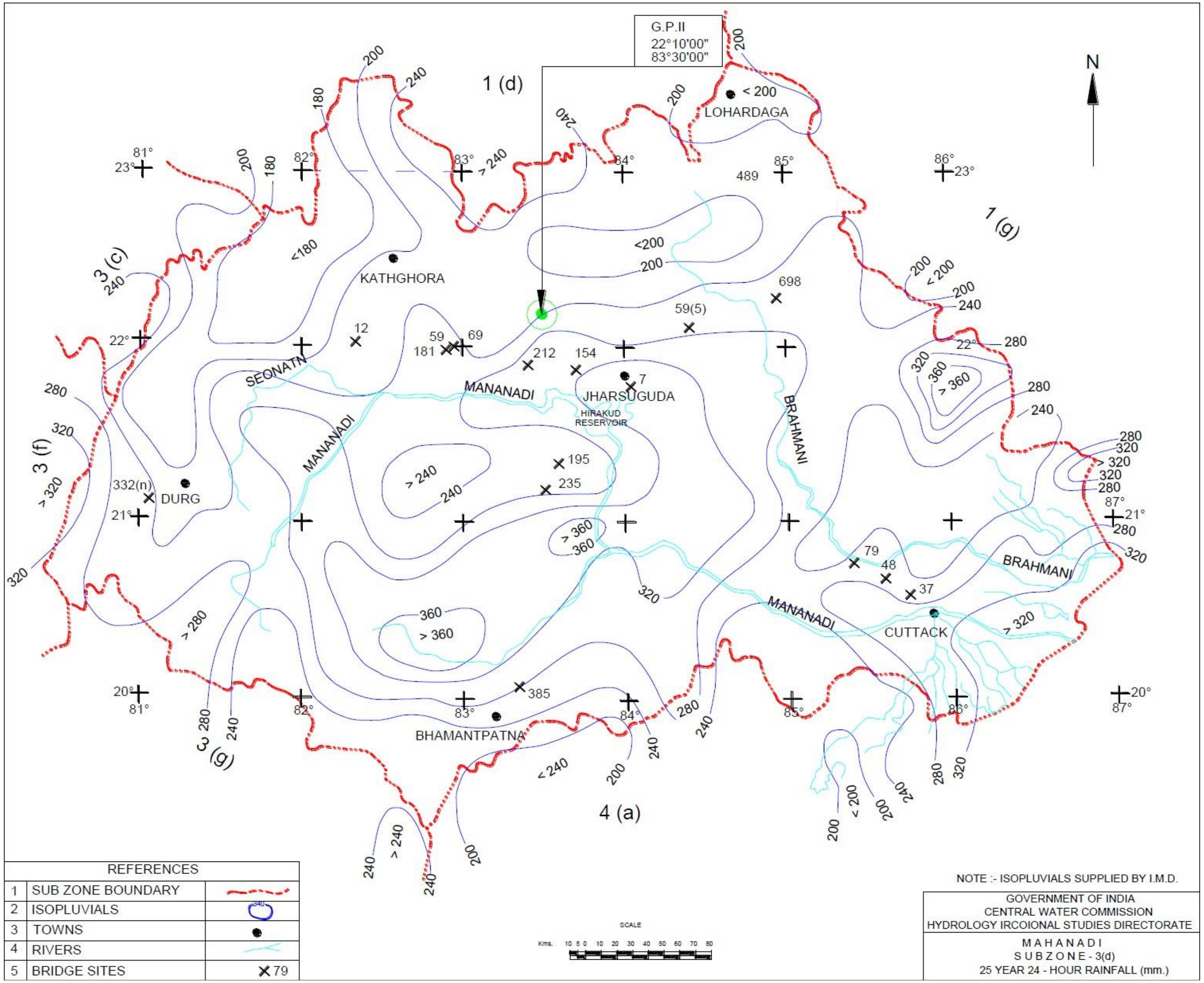


Figure 4.3: Isopluvial Map for 25 Year Return

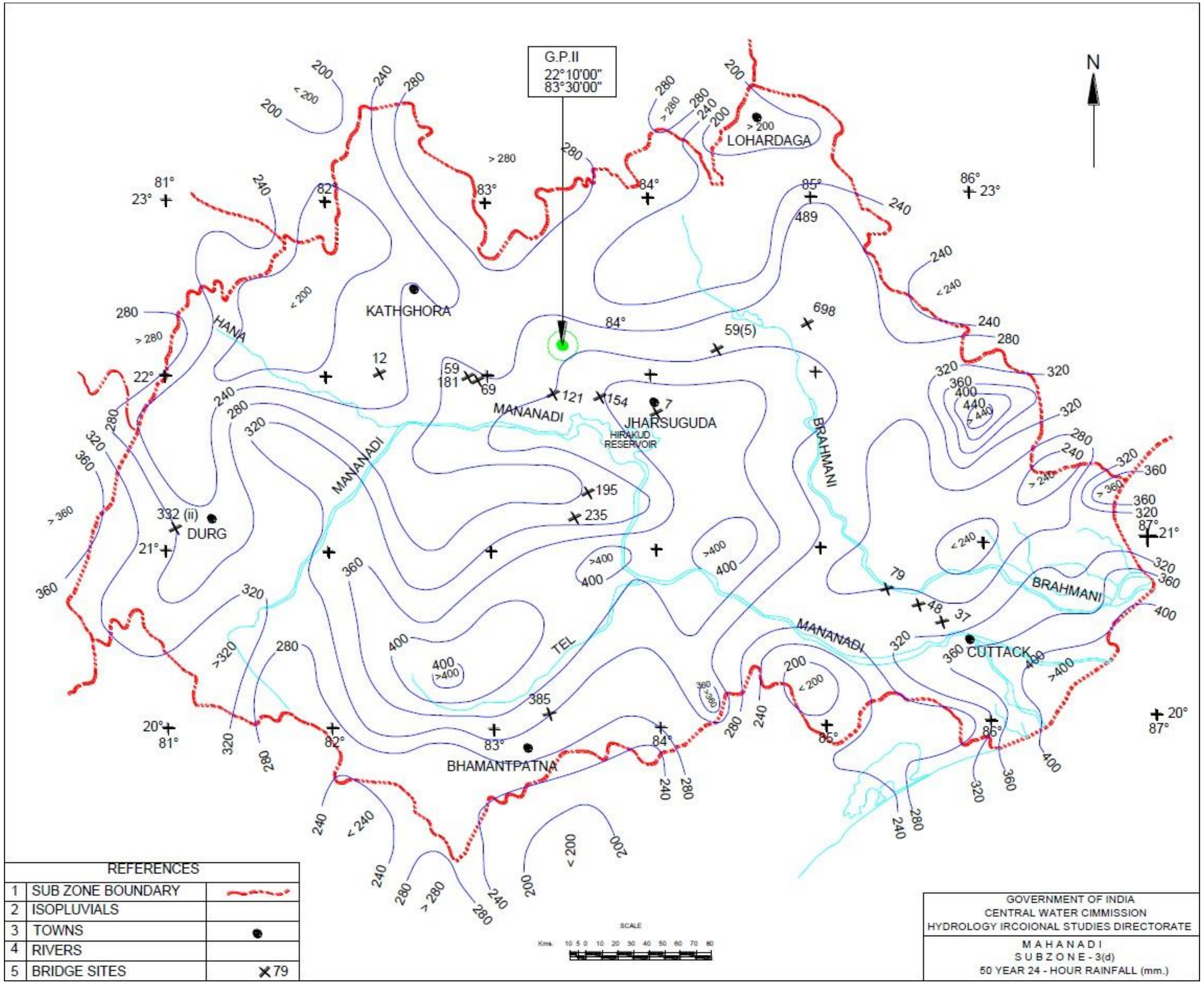


Figure 4.4: Isopluvial Map for 50 Year Return

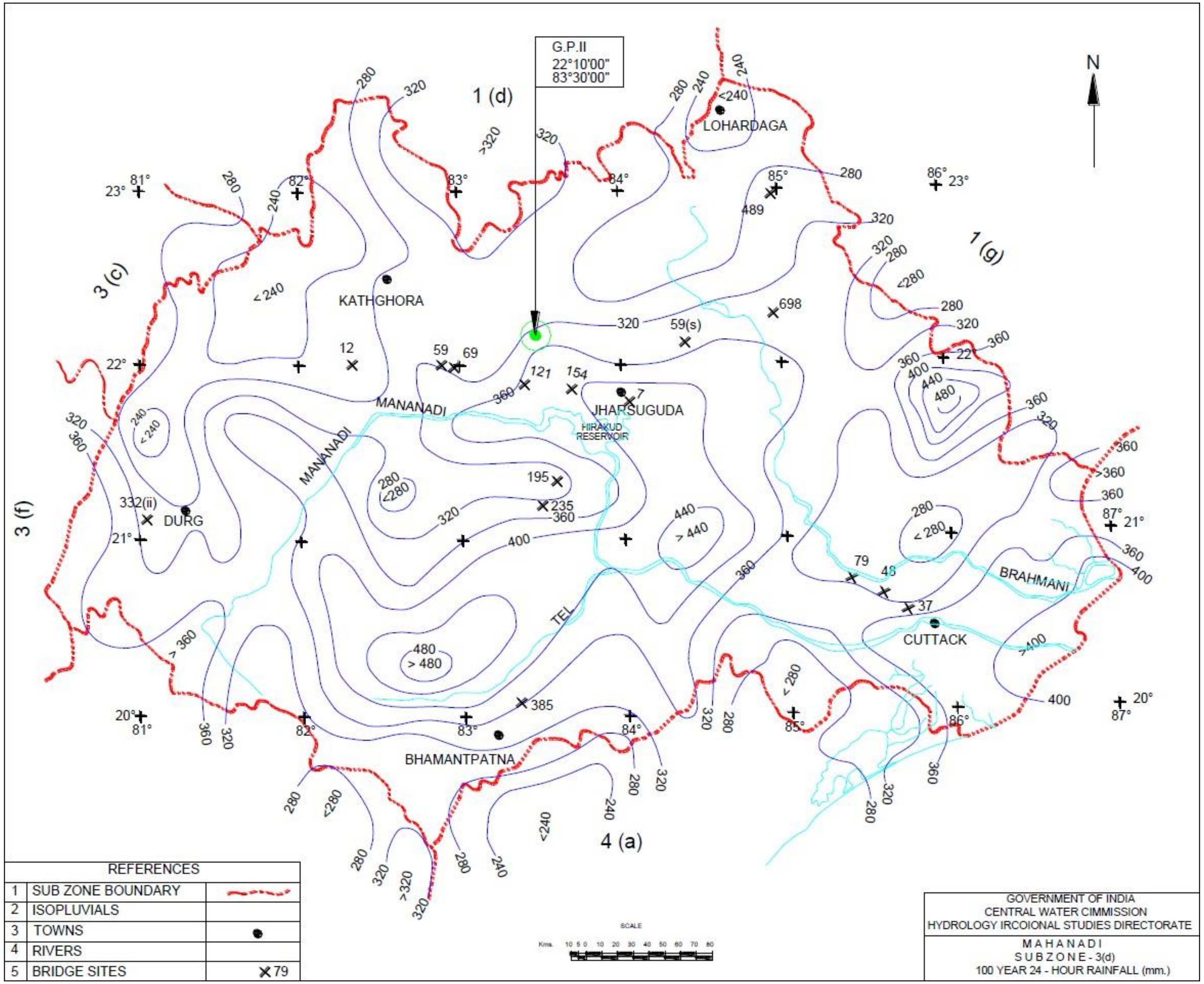


Figure 4.5: Isopluvial Map for 100 Year Return

5.0 INFILTRATION TEST:

Infiltration is the flow of water into the ground through the soil surface. Since infiltrated water may contribute to the ground water discharge in addition to soil moisture, the process can be schematically modeled. The infiltration characteristics of a soil at a given location has been estimated by using flooding infiltrometer. The flooding type infiltrometer are experimental devices known as double ring infiltrometer and used to obtain data relating to variation of infiltration capacity with time. The experiment for infiltration test was carried out in three different locations. The locations of infiltration tests are given in **Table-5.1and Figure 5.1.** The test data have been plotted on arithmetic graph and placed in **Figure 5.1 A, B, C, D.** The results of infiltration experiment was analyzed and inferred that the location in the nala is low infiltration zone this may be due to compact formation.

Table-5.1 Location of Infiltration Test Site

Site. No.	Village	Location	Coordinate	
I-1	Saraitola	Nala	22°08' 59.011" N	83°28' 56.198" E
I-2	Dholnara	Access Trench	22°10' 22.322" N	83°27' 39.342" E
I-3	Mudagaon	Forest	22°09' 28.781" N	83°28' 15.258" E
I-4	Podopali	Pond	22°09' 47.685" N	83°26' 42.758" E

The infiltration test data of different locations were processed and summarized in **Table-5.2**

Table-5.2 Infiltration Test Data

Time since start		Infiltration rate (cm/hr)			
Minutes	**Hour**	**Site I-1 Saraitola Nala**	**Site I-2 Dholnara Incline**	**Site I-3 Mudagaon Forest**	**Site I-4 podopali pond**
10	0.16	18.28	14.02	12.65	10.10
20	0.33	7.24	5.98	3.80	4.15
30	0.50	4.82	3.05	3.10	3.74
45	0.75	3.98	2.10	2.05	2.82
60	1.00	2.30	1.50	1.02	1.40
90	1.50	2.00	0.98	0.72	0.64
120	2.00	1.70	0.81	0.54	0.52
150	2.50	0.85	0.54	0.42	0.30
180	3.00	0.85	0.54	0.42	0.30
210	3.50	0.85	0.54	0.42	0.30
Constant Infiltration rate cm/hr		0.85	0.54	0.42	0.30
Infiltration zone		High	Moderate	Moderate Low	Low
Recharge/Discharge		Recharge	Transit	Discharge	Discharge

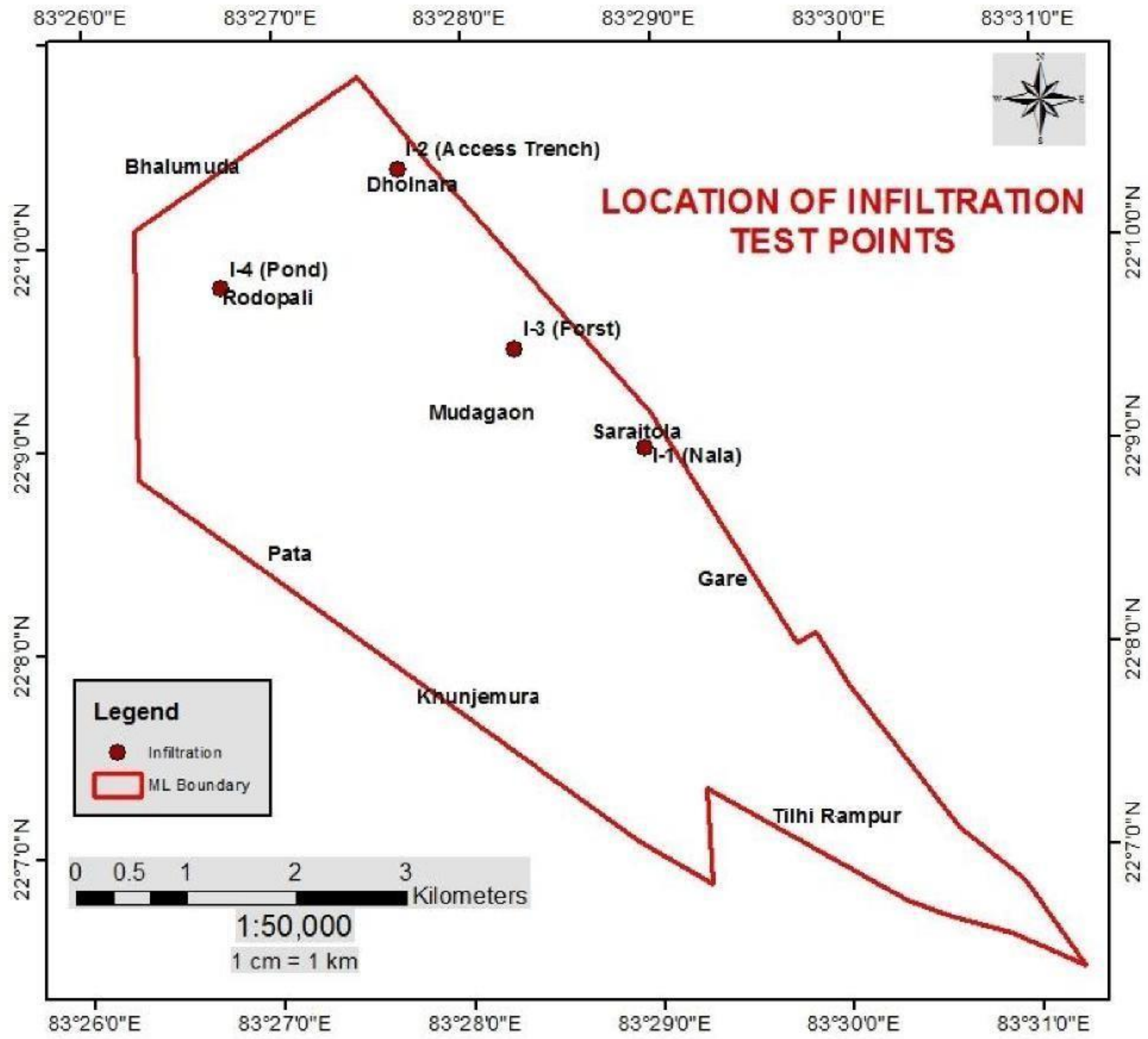


Figure 5.1 location of Infiltration Test Point

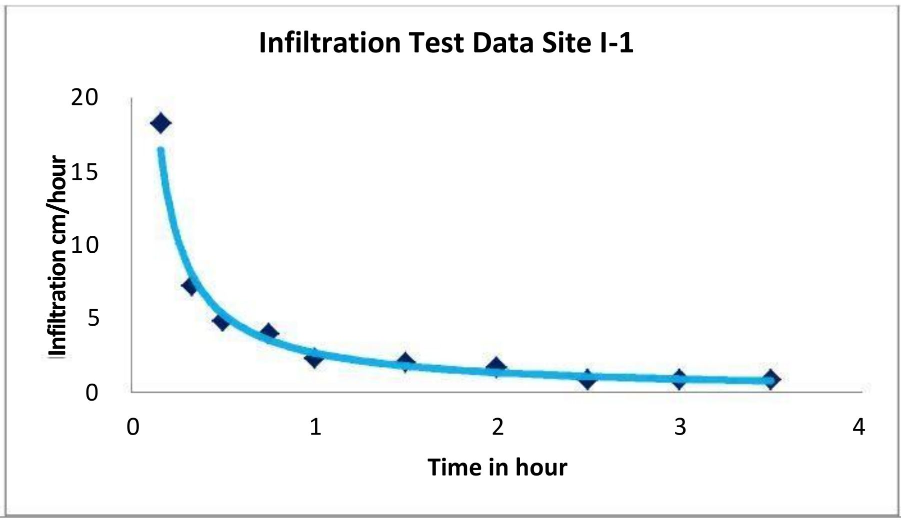


Figure 5.1 A Infiltration Test Site I-1: Saraitola Nala

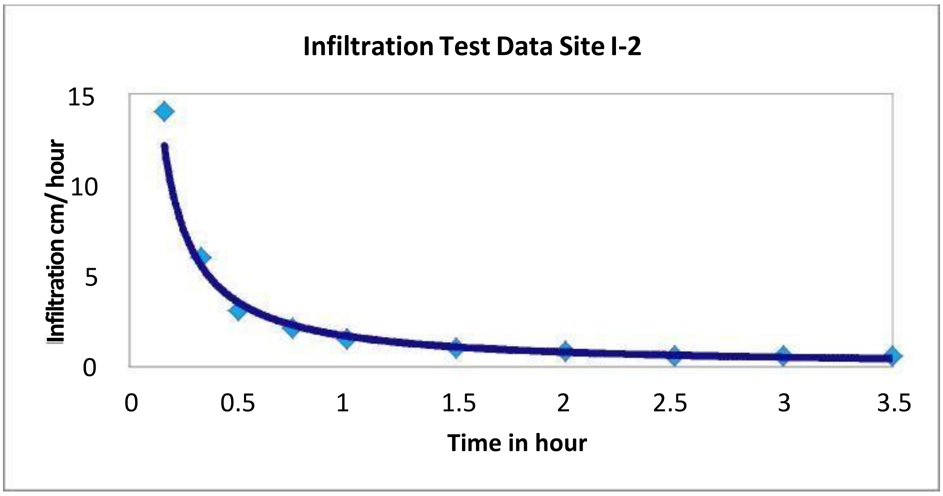


Figure 5.1 B Infiltration Test Site I-2: Dholnara Incline

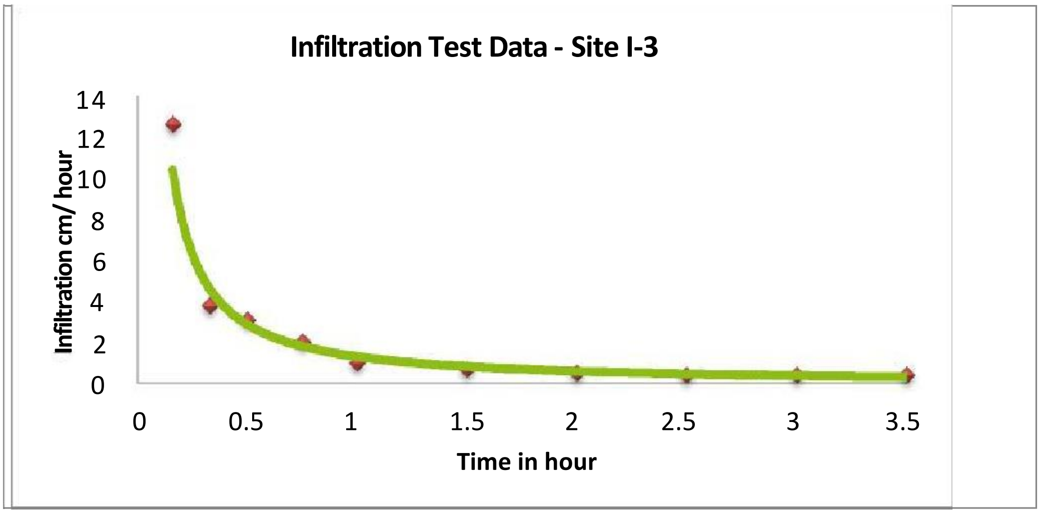


Figure 5.1C Infiltration Test Site I-3: Mudagaon Forest

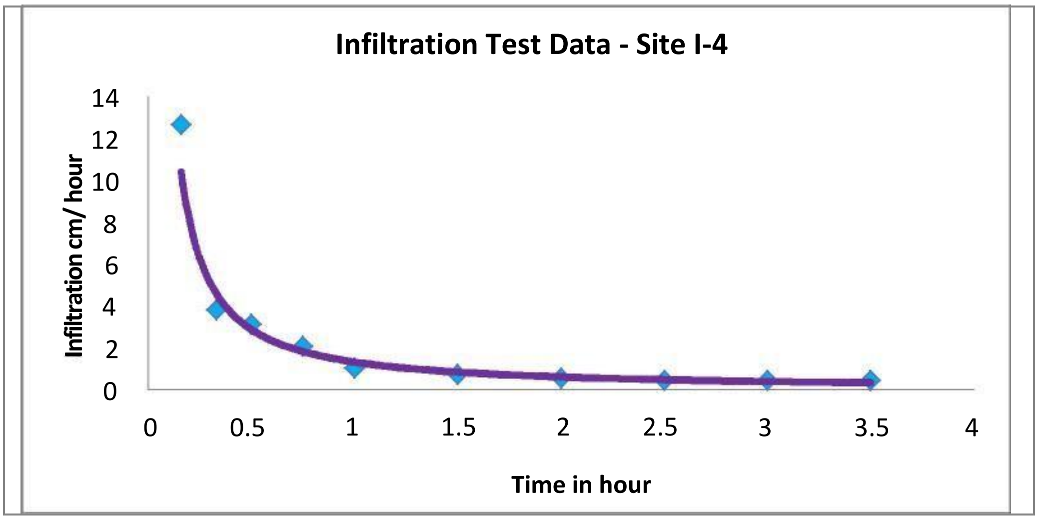


Figure 5.1 D Infiltration Test Site I-4: Podopali pond

6.0 HYDROGEOLOGY:

6.1 Local geology of CAT Study Area

Gare Palma Sector- II Coal Block is located in the south-eastern part of Mand Raigarh Coalfield. The Geology of the block is in conformity with the regional set up, Major part of Gare Palma Sector-II Coal Block is covered by Barakar Formation and the stratigraphy is given in **Table 6.1.**

Table 6.1

Geological Succession in Gare Palma Sector – II Coal Block

Age	Formation	Thickness (m)	Lithology
Recent	Recent	0.50 to 15.00	Laterite soil
Lower Permian	Barakar	203.00 to 477.20	Fine, medium and oase grained felspathic, grey sandstone, micaceous and laminated at places. Grey shale, fire clay, intercalation of shale and sandstone and carbonaceous shales with Coal Seams
Upper carboniferous to Permian	Talchir	0.30 to 45.90	Boulder bed, rhythmite, fine grained greenish sandstone, greenis to purple shale, Khaker colured silstones
Archaeans	Pre-cambrian	0.10 TO 12.50	Mica-schists, gneisses and quartzite

6.2 Groundwater:

The groundwater regime of the area under study have been dealt in brief.

6.2.1 Water Level : The Hydrogeological Survey of the area have been done to ascertain the Groundwater regime of the study area. The inventory of 16 observation wells has been done. The locations of the observation wells are located on map and same is given at **Figure. 6.1.** The relevant data is given at **Table 6.2.** The average water level in pre & post monsoon are approximately 4.6 mbgl and 2.0 m bgl respectively. Annual fluctuation is 2.7 m.bgl

6.2.2 Water table : Based on data of observation wells a water table map has been prepared for the pre-monsoon and post-monsoon period. The pre-monsoon and post-monsoon water table maps are depicted at **Figure 6.2 and 6.3** respectively. The study of map reveals that the water table is following topography of the area. The movement of groundwater flow is towards Kelo River both from West & East sides. The groundwater is contributing into Kelo River. Thus, the Kelo River is gaining river and the post-monsoon water available in Kelo River is strictly groundwater runoff.

Table 6.2 Water Level Data

Sr. No.	Code. No.	Village Name	Dia (m)	Ht. Of Parapet	Depth (m)	SWL		Fluctua-tion (m)	Co-ordinate	
						Post-Monsoon (m)	Pre-Monsoon (m)		Latitude	Longitude
1	DW-1	Sarasmal	3.20	0.90	8.40	2.6	6.3	3.7	22° 07 '54.3"	83°30'27.0"
2	DW-2	Libra	1.10	0.60	9.10	0.0	1.9	1.9	22°06 '36.0"	83°30' 40.0"
3	DW-3	Libra	2.90	1.00	6.70	2.5	5.2	2.7	22°06 '26.8"	83°30' 47.8"
4	DW-4	Jhinkabahal	1.00	1.20	10.50	8.1	9.3	1.2	22° 06' 44.3"	83°30'02.6"
5	DW-5	Tihli Rampur	2.00	GL	8.70	2.3	6.1	3.8	22° 07' 12.3"	83° 29' 39.5"
6	DW-6	Kunjemura	2.50	0.80	6.50	2.6	3.3	0.7	22°07' 40.6"	83° 28' 06.5"
7	DW-7	Kunjemura	1.90	0.80	6.70	1.2	4.0	2.8	22° 07'42.9"	83°28'06.1"
8	DW-8	Murogaon	3.30	GL	7.10	2.1	3.1	1.0	22° 09' 027"	83°28'07.3"
9	DW-9	Saraitola	3.30	GL	9.50	1.5	4.6	3.1	22°09'10.8"	83°28'50.8"
10	DW-10	Gare	5.10	0.40	7.90	2.0	4.3	2.3	22°08'24.1"	83°29'30.1"
11	DW-11	Bhalumura	1.50	0.60	7.50	1.0	7.0	6.0	22°10'27.0"	83°26.43.2"
12	DW-12	Dholesara	3.90	0.60	5.50	0.5	3.1	2.6	22°08'41.4"	83°25'59.4"
13	DW-13	Dholnara	1.20	0.60	7.30	1.2	4.4	3.2	22°10'20.4"	83°27'49.9"
14	DW-14	Rodopali	1.20	0.40	6.20	0.9	3.5	2.6	22°09'53.4"	83°26'47.0"
15	DW-15	Chitwahi	2.20	0.80	6.40	1.3	3.4	2.1	22°09'26.3"	083°25'56.2"
16	DW-16	Pata	3.30	0.60	8.30	1.9	4.7	2.8	22°08'34.3"	83 °27'06.2
					Average	**2.0**	**4.6**	**2.7**		

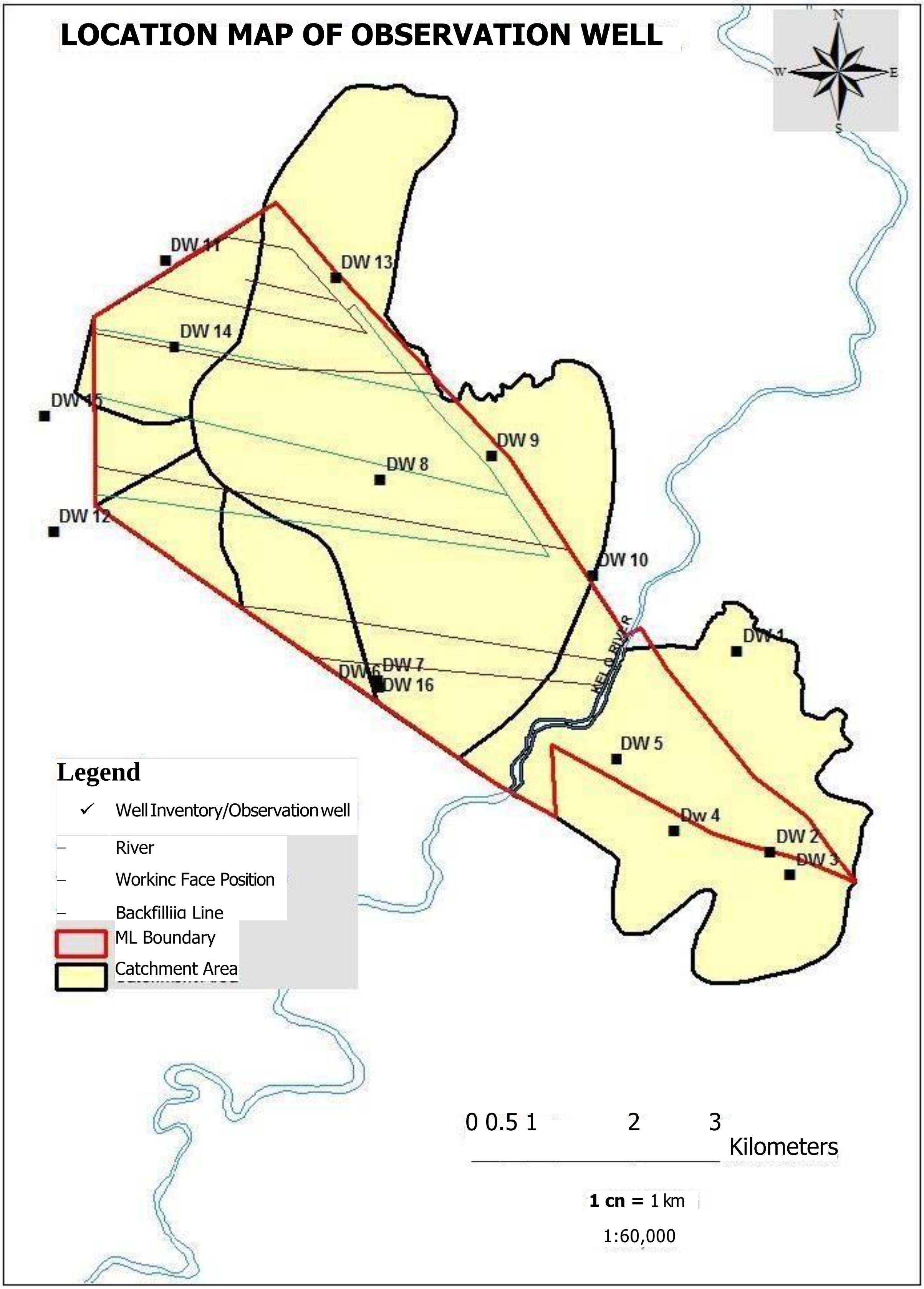


Figure 6.1 Location Mapof Observation wells

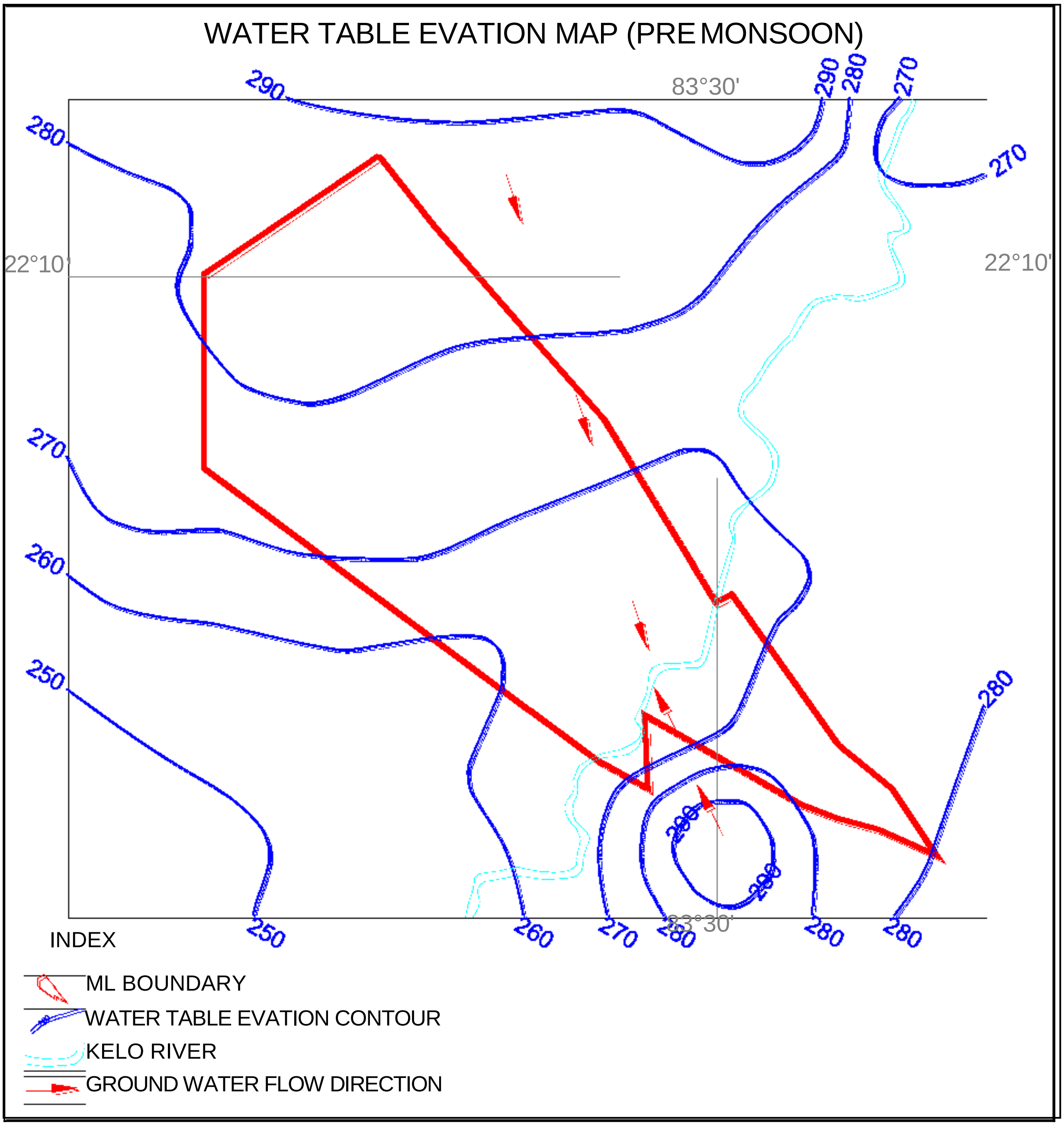


Figure 6.2: Pre-monsoon water table map

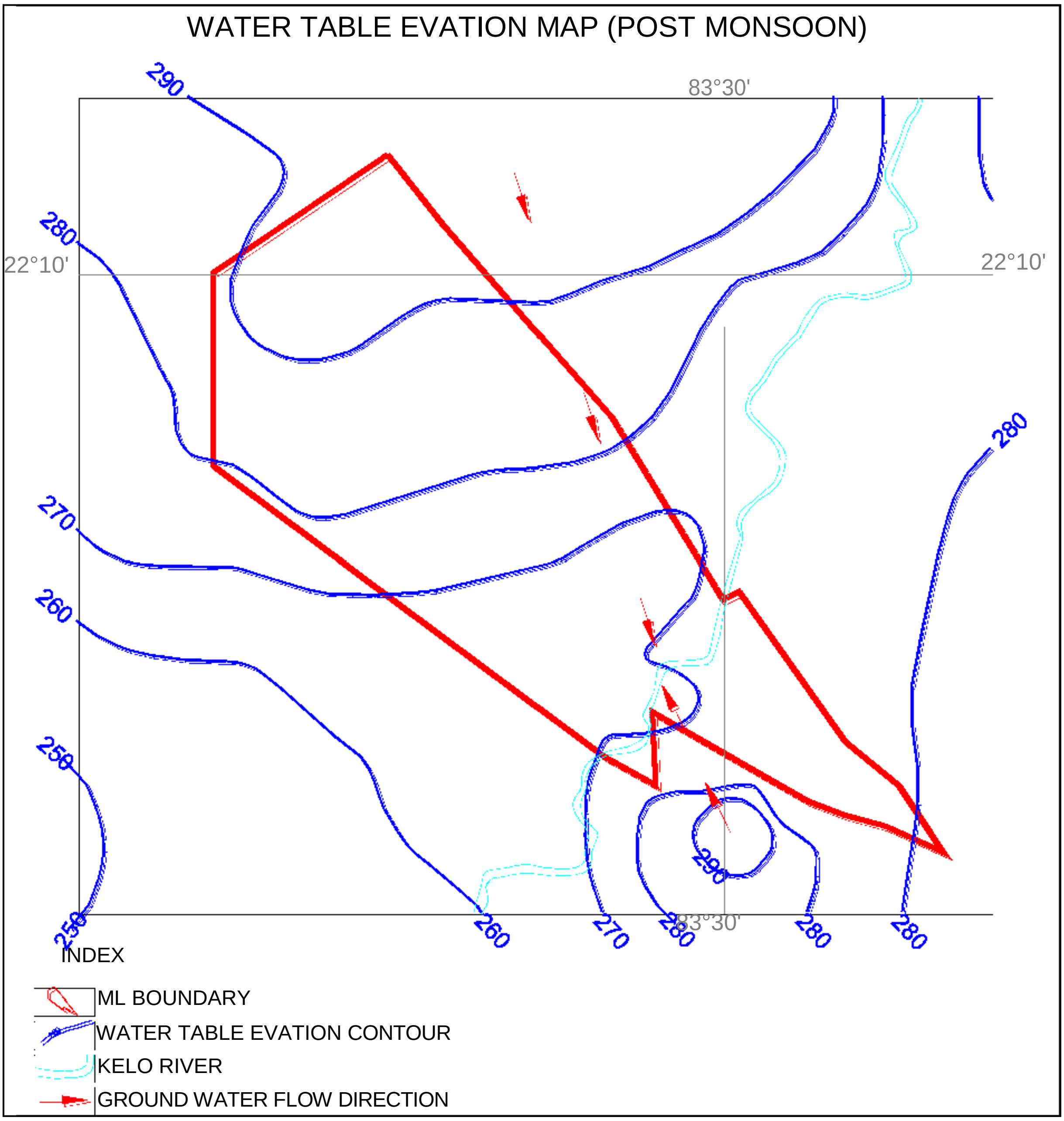


Figure 6.3: Post-monsoon water table map

6.2.3 Aquifer parameter : The pumping test have been conducted by a earlier consultant of MAHAGENCO at Gare Palma-II Coal Block. The Aquifer parameter as estimated is given below in **Table 6.3.**

Table 6.3 Aquifer Parameter

Sr. no.	Aquifer parameter	Unit	Value
1	Hydraulic conductivity	m/day	0.14
2	Transmisivity	m^2/day	27.79
3	Storativity	-	0.78×10^{-5}

6.2.4 Groundwater resources : The Groundwater resources have been estimated by aconsultant of .

The salient features is given below

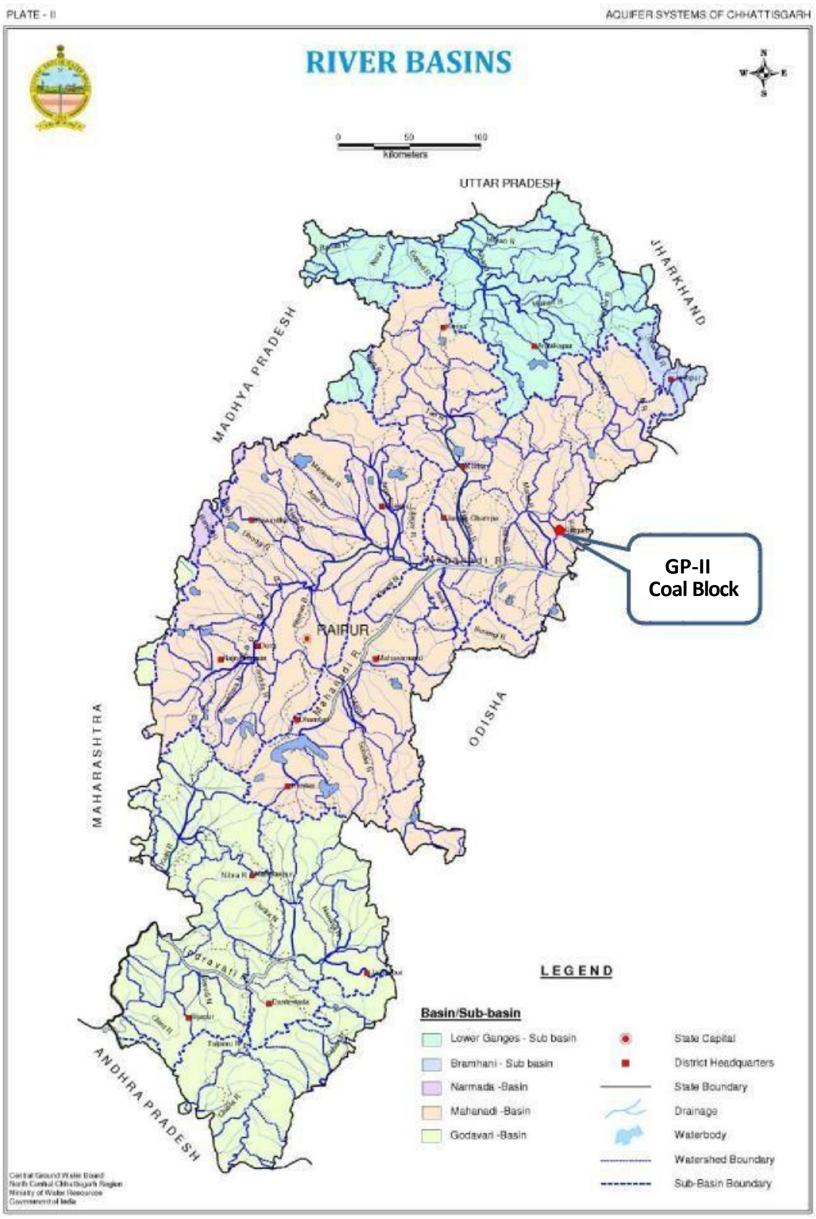
1. Study Area (Mine area) - 25.54
2. Annual Groundwater replenishable resource - 8.808 MCM
3. Annual Grounwater - 0.924 MCM
4. State of groundwater development - 10.48 %
5. Category of area - Safe

7.0 HYDROLOGY

7.1 River basin of Chhattisgarh:

Kelo River and its local tributaries is the focus for treatment under CAT plan.

Kelo River is a tributary of Mahanadi River flowing directly into the Hirakud Reservoir. The Kelo river originates in hills near Boturakaohhar pahad at an elevation of 723 m amsl. It classified by CWC under Mand Subbasin wherein Kelo River is contributing as direct tributary to Mahanadi River. Thus, Kelo River ultimately joins Mahanadi Basin. The Mahanadi Basin in midway impounded at Hirakud Dam in the Odisha. The river basin of Chhattisgarh with location of study area is given **Figure 7.1**



Source : CGWB

Figure 7.1: Location of Study area on River basin map of Chhattisgarh

7.2 Watershed of Kelo River

The drainage and watershed boundary of Kelo River including study area is given in **Figure 7.2.** There is Kelo River Dam located at 20 km downstream south from this mine.

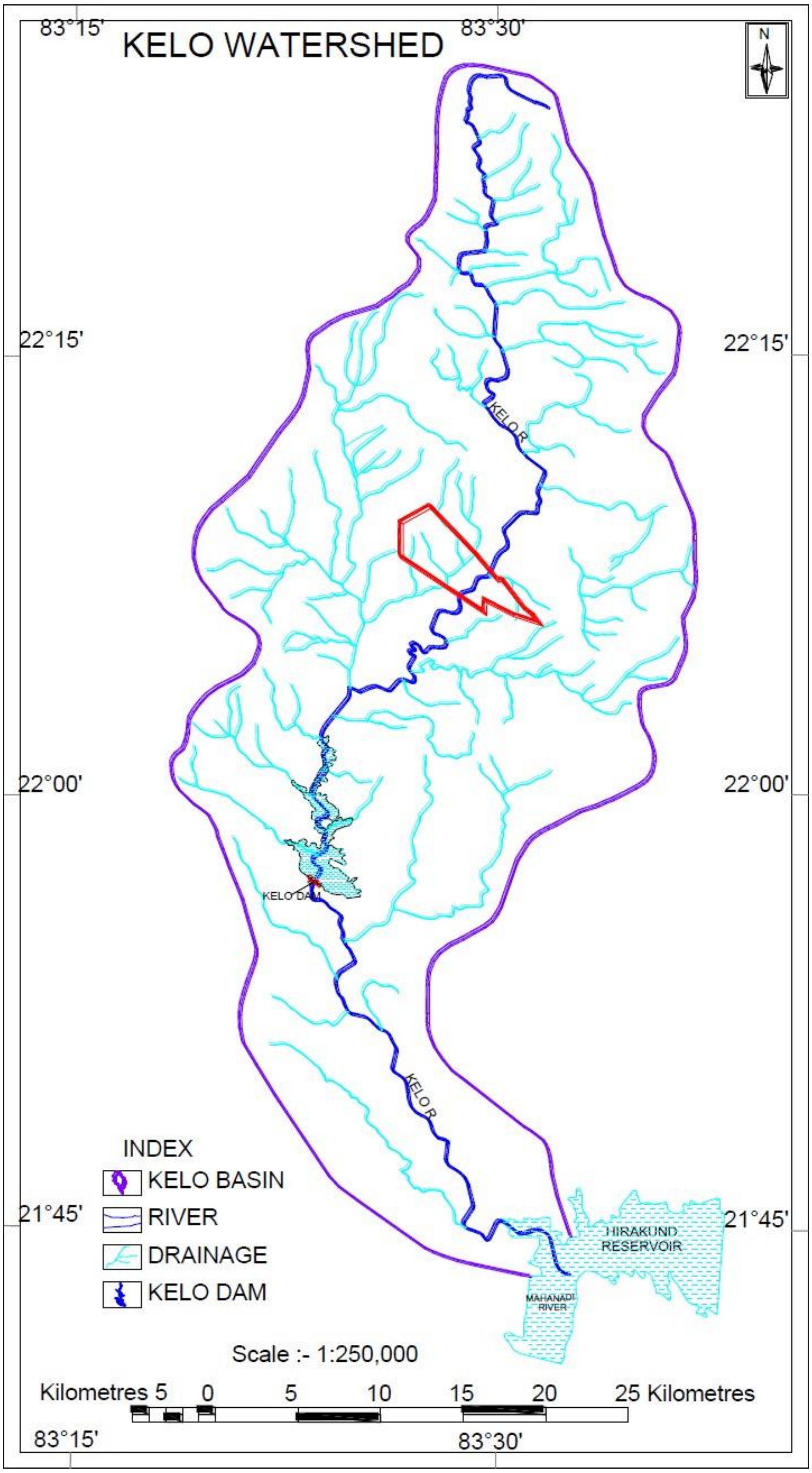


Figure 7.2: Drainage map of Kelo River with study area

7.3 Watershed of Study area

Study area has been divided into number of watershed which are the smallest sized hydrologic units in the macro level category as micro watershed and map is depicted at **Figure 7.3.**

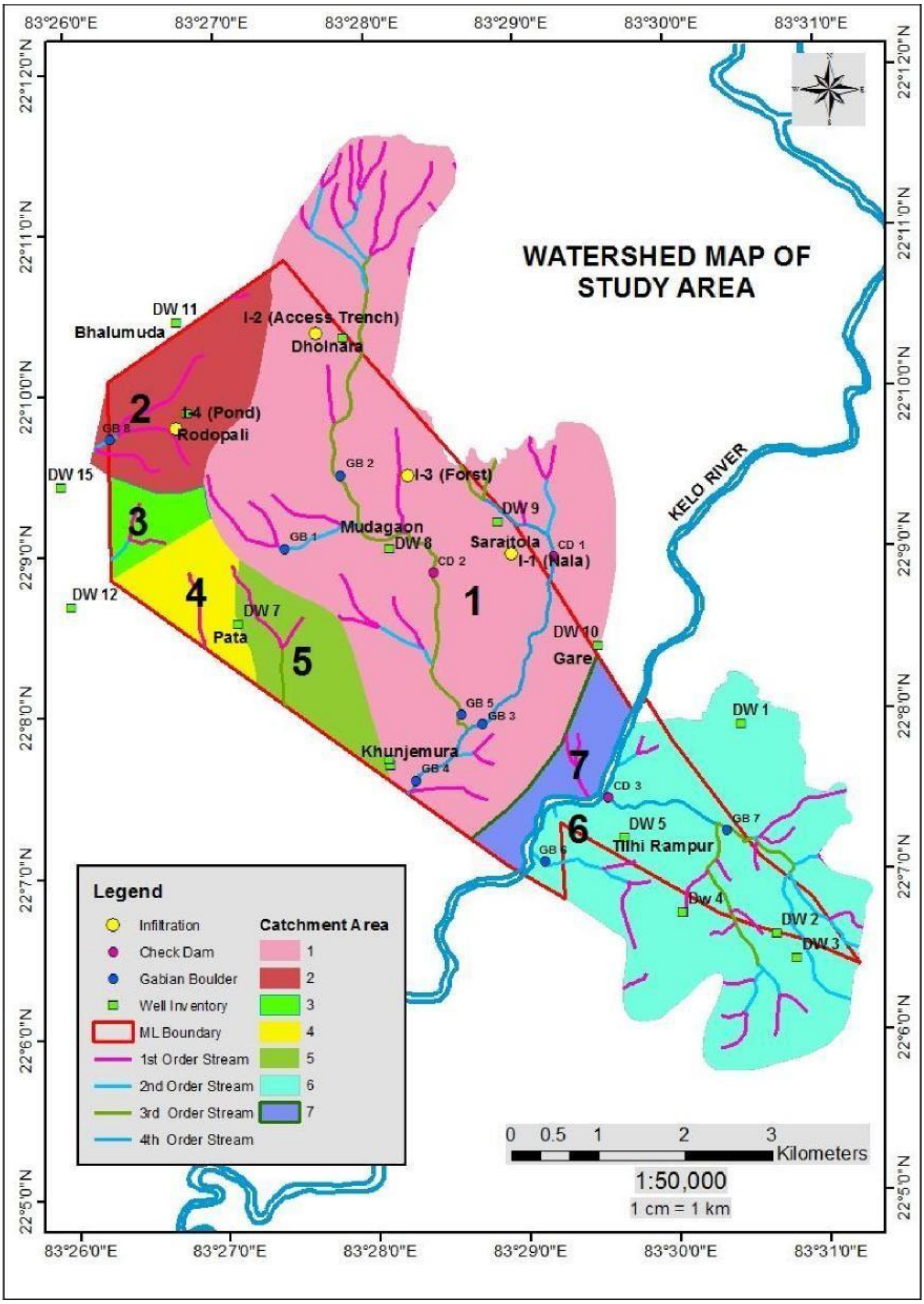


Figure 7.3 Watershed of Study Area

7.3.1 Delineation of micro watershed for CAT Plan:

CAT watershed is further divided into micro watersheds on 1:50000 scale (SOI topographical map) in which main tributaries and streams are taken up for delineation of micro-watersheds. Micro watersheds designated as 1, 2, 3, 4, 5, 6 & 7. Hence, the total numbers of micro-watersheds is restricted to 7. The GIS tool have been used for analysis of micro watershed

7.3.2 Area of Micro Watershed:

The catchment boundary and code number has been designated for 7 number of micro watershed and their respective areas have been estimated by GIS tool. The area of each micro watershed is given in **Table 7.1**.

Table 7.1
Area of Micro-watershed of CAT Plan

Sr. No.	Nomenclature of Micro-Watershed	Area in Hectar
1	W-01	1945.53
2	W-02	289.22
3	W-03	81.59
4	W-04	137.51
5	W-05	199.18
6	W-06	1072.11
7	W-07	125.11
8	**Total Area**	**3850.25**

7.4 Morphometric Analysis

The morphometric analysis showed that drainage density over the catchment is low indicating moderate generation of storm water. Such a phenomenon occurs when land slope is moderate and terrain is not so rugged. A perusal of the various reports available about the Kelo Dam project shows that low to moderate velocity is anticipated in the river,

Kelo River and its tributaries is the focus of treatment under this program. The morphometric analysis of the study area incorporating deferent sub micro watershed station 1 to 7 nos. The drainage system of catchment area under study is given in **Figure 7.4**

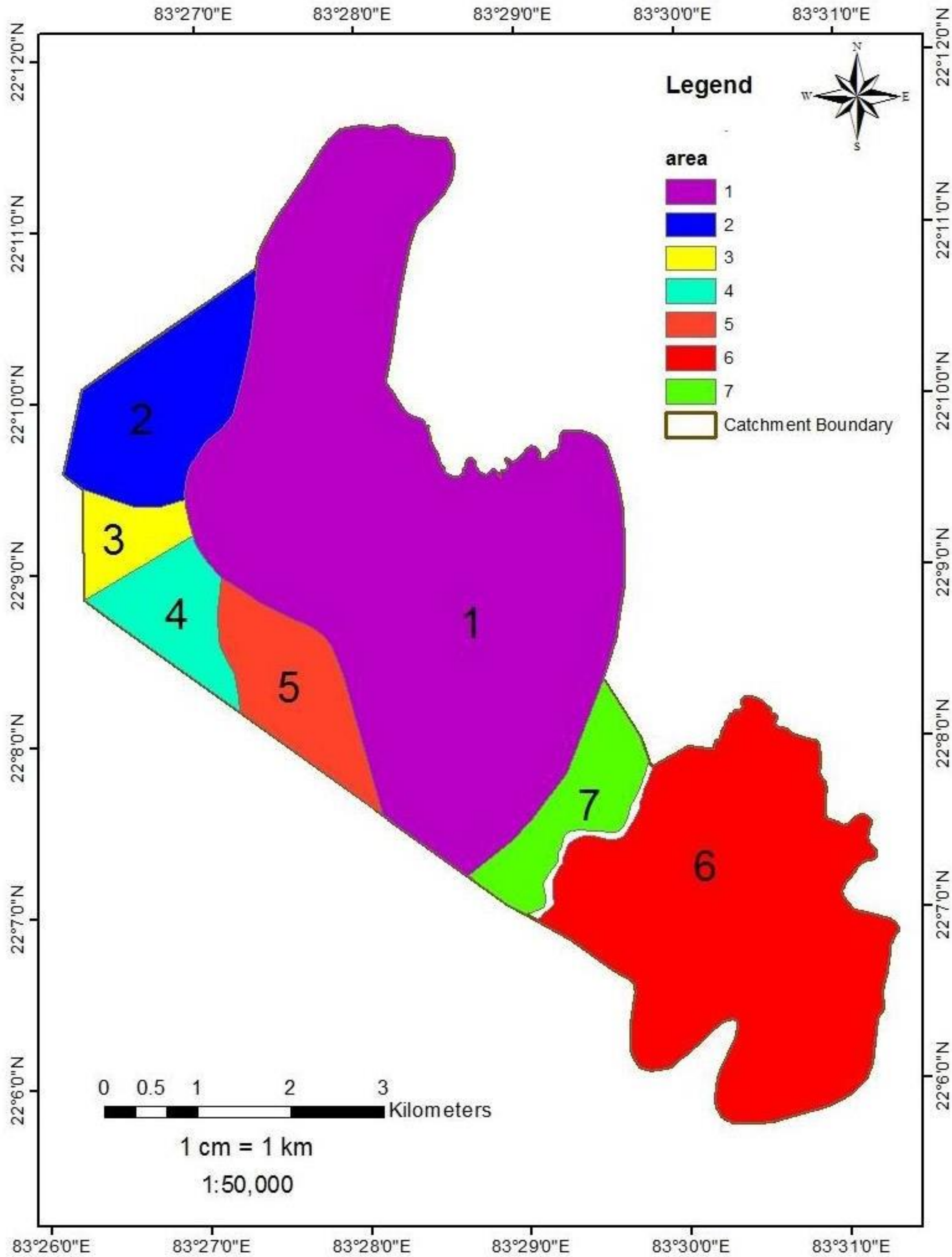


Figure 7.4: Map showing Micro-Watershed (1-7)

The different parameter as derived in MAHAGENCO report is an given in this chapter. The results of morphometric analysis of sub catchment of study area is given in **Table 7.2**

Table 7.2

Results of Morphometric Analysis of Sub Catchment

Sl. No.	Factors	1	2	3	4	5	6	7
1.	Area of basin, sq.km.	19.45	2.89	0.82	1.37	1.99	10.72	1.25
2.	Total length of various order drains in basin, km	36.896	3.717	0.893	0.86	2.35	20.497	1.772
3.	Length of basin, km	7.895	2.567	0.871	1.383	2.15	3.713	2.595
4.	Width of basin, km	4.735	1.216	0.81	0.838	1.282	3.071	0.733
5.	Perimeter of basin, km	23.148	6.862	3.544	4.496	7.285	15.2	7.237
6.	Form factor	0.31	0.39	0.89	0.44	0.45	0.75	0.24
7.	Circulatory Ratio	0.45	0.68	0.67	0.52	0.5	0.56	0.39
8.	Elongation ratio	0.63	0.7	1.06	0.75	0.76	0.98	0.56
9.	Compactness coefficient	0.31	0.46	0.65	0.65	0.53	0.34	0.59
10.	Relief							
	Highest elevation (m.ams1)	580	302	288	286	285	282	266
	Lowest elevation (m.amsl)	260	273	276	270	261	246	248
	Distance between both point, m	6807	2125	548	1287	3117	3551	844
	Slope m/km	47.01	13.65	21.90	12.43	7.70	10.14	21.33
11.	Drainage density km/sq.km	1.93	1.46	1.32	1.03	1.12	1.98	1.09
12.	Average length of over land flow, km	0.26	0.34	0.38	0.49	0.45	0.25	0.46

(Source; MAHAGENCO study)

7.5 Rainfall –Runoff – Infiltration Relation: Based on UNDP study, carried out in Indian Coalfield, for Hydrological consequences in respect of pre & post mining in CAT study area, the relationship between Rainfall –Runoff – Infiltration has been studied and result given in **Table 7.3.**

Table: 7.3

Rainfall –Runoff – Infiltration Relation

Phase/Condition	Area of CAT	Normal rainfall in monsoon	Surface Water		Ground water	
			Runoff Coefficients	Runoff	Infiltration coefficient	Groundwater Recharge
	Km^2	m	%	MCM	%	MCM
Pre mining	38.50	1.187	25	11.42	10	4.57
Post Opencast mining	38.50	1.187	15	6.87	21	9.60

The study reveal that due to mining operation and backfilling there is reduction of surface runoff to the tune off 4.55 MCM whereas, due to high rate of infiltration there is increase in groundwater recharge to the tune of 5.03 MCM

8.0 DATA BASE GENERATION :

8.1 General:

A detailed database on natural resources, terrain conditions, soil type of the catchment area, socio- economic status, etc. is a pre-requisite to prepare treatment plan keeping in view the concept of sustainable development. Various thematic maps have been developed and used in preparation of the CAT plan. Due to the spatial variability of site parameters such as soils, topography, land use and rainfall, not all areas contribute equally to the erosion problem. Several Techniques like manual overlay of spatially index-mapped data have been used to estimate soil erosion in complex landscapes.

Geographic Information System (GIS) is a computerized resource data base system, which is referenced to some geographic coordinate system. In the present study, real coordinate system has been used. In order to ensure that latest and accurate data is used for the analysis, satellite data has been used for deriving land use data and ground truth studies too have been conducted.

The various steps covered in the study are as follows:

> Data acquisition,

> Data preparation,

> Ground verification &

> Output presentation

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

8.2 Data Acquisition:

The data on Drainage pattern, Soil Type, Slope of terrain, Watershed boundary super imposed on Topo map, Land use classification, are prepared / Collected and ground truthing made through field visit.

8.3 Data Preparation.

The data available from various sources have been collected. The ground maps, contour information, etc. were scanned, digitized and registered as per the requirement. Data has been prepared depending on the level of accuracy required and any corrections required were made. All the layers were geo-referenced and brought to a common scale (real coordinates), so that overlay could be performed. A computer program has been used to estimate the soil loss. The formats of outputs from each layer were firmed up to match the formats of inputs in the program. The grid size to be used was also decided to match the level of accuracy required, the data availability and the software and time limitations.

8.4 Soil Erosion:

Soil erosion may be defined as the defacement and transportation of soil. Water is the major agent responsible for this erosion.

The Catchment Area Treatment Plan highlights the management technique to control erosion in the catchment area. The catchment Area Treatment involves the following parameters.

1. Understanding the erosion characteristics
2. Suggesting remedial measures to reduce the erosion rate
3. Detain the Silt/Charged particles in the runoff in nala on the way and prevent/reduce the transportation of soil to streams/reservoirs.

The result of the modeling was interpreted in pictorial form to identify the areas with high soil erosion rates. The primary and secondary data collected as a part of the field studies have used as an input for the model.

8.4.1 Grain size analysis of soil : The grain size analysis of the soil in respect of area in and aound of study area is given in **Table 8.1.** The data obtain from EIA of GP-III is adopted for the study area as it has similar soil condition.

Table 8.1
Grain size Analysis in %

Type of Grain	Notation	Bajaramunda S1	Mallupara S2	Khamariya S3	Karuwahi S4	Bhalumuda S5	Average %
Sand	(SAN)	54.49	57.32	30.79	15.42	15.42	34.688
Silt	(SIL)	23	27.88	46.73	59.73	59.73	43.414
Clay	(CLN)	8.08	7.88	16.41	23.22	23.22	15.762
Organic	(C)	14.43	6.92	6.07	1.63	1.63	6.136
	%	**100**	**100**	**100**	**100**	**100**	**100**

(Source : EIA of GP-III)

8.4.2 Estimation of Soil Loss Using Silt Yield Index (SYI) Method.

The Silt Yield Index Model (SYI), considering sedimentation as product of erosivity, erodibility and aerial extent was conceptualized in the All India Soil and Land Use Survey (AISLUS) as early as 1969 and has been in operational use since then to meet the requirements of prioritization of smaller hydrologic units. The erosivity determinants are the climatic factors, soil and land attributes that have direct or reciprocal bearing on the unit of the detached soil material.

The relationship can be expressed as:

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

8.4.3 Silt Yield Index:

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.

8.4.4 Prioritization of Watersheds/Sub-watersheds:

The prioritization of smaller hydrologic units within the vast catchments is based on the Silt Yield Indices (SYI) of the smaller units. The boundary values or range of SYI values for different priority categories are arrived at by studying the frequency distribution of SYI values and locating the suitable breaking points. The watersheds/ sub-watersheds are subsequently rated into various categories corresponding to their respective SYI values. The application of SYI model for prioritization of sub watersheds in the catchment areas involves the evaluation of:

a) Climatic factors comprising total precipitation, its frequency and intensity,

b) Geomorphic factors comprising land forms, physiography, slope and drainage characteristics,

c) Surface cover factors governing the flow hydraulics and

d) Management factors

The data on climatic factors are obtained for different locations in the catchment area from the meteorological stations whereas the field investigations information are collected from Secondary source for estimating the other attributes.

The various steps involved in the application of model are:

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

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

8.4.5 Equation for calculation of Silt Yield Index (SYI).

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

Where,

Ai = Area of the unit (EIMU)

Wi = Weightage value of i^{th} mapping unit

n = No. of mapping units

Aw = Total area of sub-watershed.

The Weightage value of i^{th} mapping unit has been estimated based on rainfall (mm) slope (deg.), soil texture (numeric), forest land (%) and bare-barren land (%). Thus the value estimated as under from the reference of Hasan Raja Naqvi (2015) size digest ELSEVIER. The Assigned weightage value is given in **Table 8.2.**

Table 8.2. Assigned Weightage value

S. No.	Parameter/ factor Unit		Category/ class	Assigned weightage value
1	Rainfall	mm	1000-1500	8
2	slope	(deg.),	0-20	2
3	soil texture	(numeric),	Sandy loam	6
4	forest land	(%)	0-25	8
5	bare-barren land	(%)	50-75	6
Total				**30**

The Silt Yield Index (SYI) in respect of micro watershed has been estimated and given in **Table 8.3**

Table 8.3
Silt Yield Index (SYI)

Sr. No.	Nomenclature of Watershed	W1	Area in Hectar A1	Silt Yield Index
1	W-01	30	1946	1516
2	W-02	30	289	225
3	W-03	30	82	64
4	W-04	30	138	108
5	W-05	30	199	155
6	W-06	30	1072	835
7	W-07	30	125	97
8	Total		3851	3000

8.4.6 Erosion Intensity and Delivery Ratio:

Determination of erosion intensity unit is primarily based upon the integrated information on soil characters, physiographic condition, slope, land-use/land-cover, lithology and structure. This is achieved through super-imposition of different thematic map overlays. Based upon the field data collected during the field survey and published data, weightage value and delivery ratio were assigned to each erosion intensity unit.

In the present study the delivery ratio to the erosion intensity units were assigned upon their distance from the nearest stream (being the most important factor responsible for delivery of the sediments) according to the following scheme. The delivery ratio criteria adopted for the study is presented below.

- **Delivery Ratio (DR) Criteria Adopted.**

The Criteria for Delivery Ratio is given in **Table 8.4.**

Table 8.4
Criteria for Delivery Ratio

Sr. No.	Nearest Stream distance	Delivery ratio
1	0-0.9 km	1.00
2	1.0-2.0 km	0.95
3	2.1-5.00 km	0.90
4	5.1-15.00 km	0.80
5	15.1- 30 km	0.7

The SYI values for classification of various categories of erosion intensity rates are given below in **Table 8.5.**

Table 8.5
Priority Category

Sr. No.	Priority Category	SYI Values
1	Very High	>1300
2	High	≥ 1200 to 1299
3	Medium	≥ 1100 to 1199
4	Low	≥ 1000 to 1099
5	Very Low	<1000

In order to arrive at priority category, the following parameters are derived / calculated and ground trothing made by experts.

8.4.7 Soil of the Tract.

The soil of this tract is mostly laterite origin. In pockets sandy alluvial, red soil with lateritic origin are seen. On analysis of Soil characteristics the soil types and extent of area is furnished below. The detail soil type is at **Table 8.6.**

Table 8.6

Details of Soil Type

Sr. No.	Soil Type	Area in ha	Percentage.
1	Laterite origin Red sandy soil	3850	100%

8.4.8 Slope of the Tract.

From Satellite imagery the slope of the tract has been studied in detail. The slope wise area distribution is furnished below in **Table 8.7** and depicted in **Figure 8.1**.

Table 8.7

Slope of the Tract

Sr. No.	Slope class (Gradient in %)	Area in Ha	Percentage	Remark
1	0-0.5%	5066	51.74%	Low soil loss
2	0.5 – 10%	2294	45.19%	Medium
3	>10-%	6.00	3.07%	High
	Total	**3850**	**100**	

The slop of the tract analysis shows that about 97% come under medium to low soil loss

The above study has been considered and average value in respect of average slope length (L) and of slop in degree has been worked out and given in **Table 8.8**

Table 8.8

Average Slope length (L) and Average Steepness

Sr. No.	Parameter	Value
1	Slope length	100 m
2	Steepness	5°

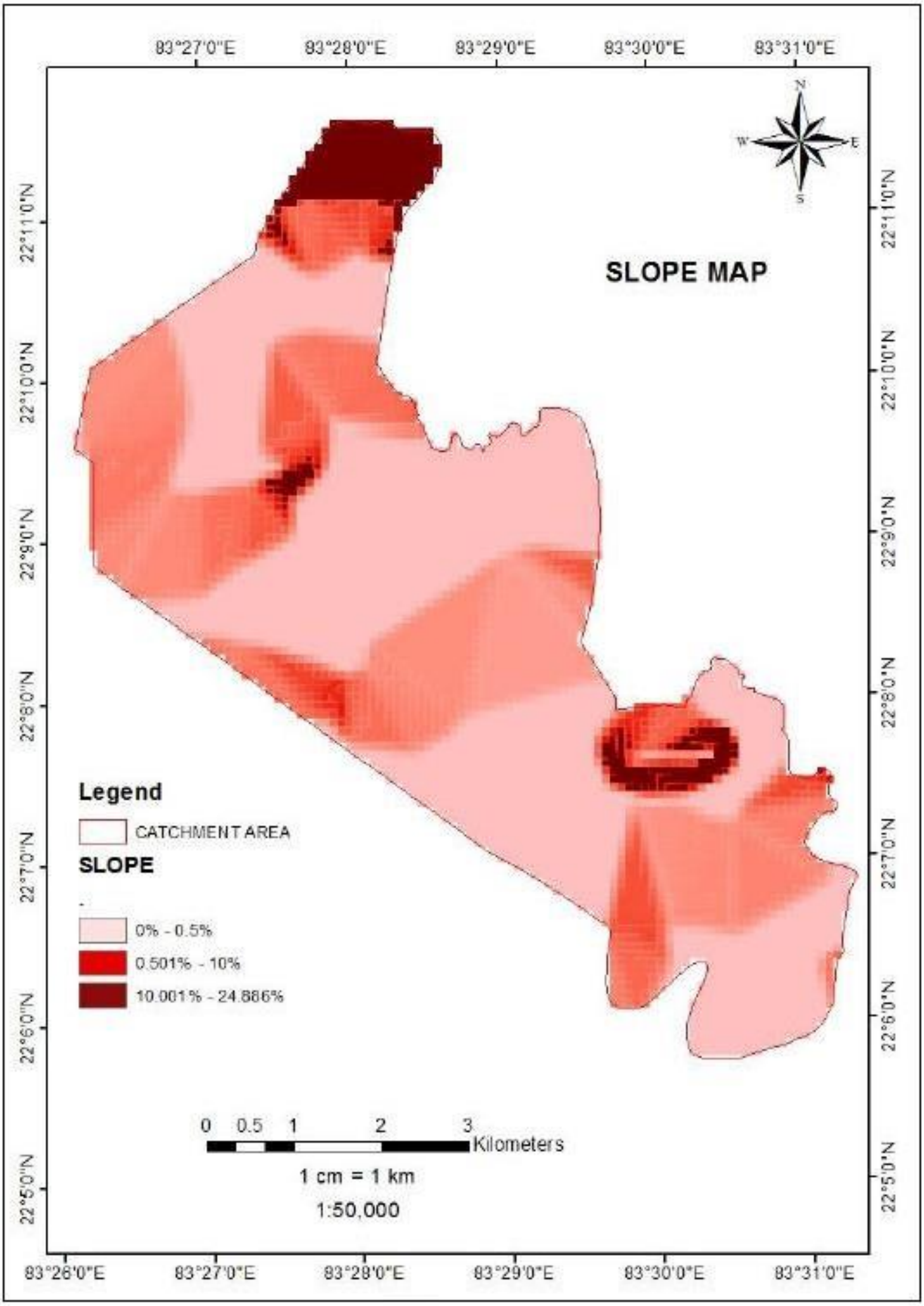


Figure 8.1: Slope of the Tract

organic carbon content and soil particle size distribution (sand, silt and clay). The equation is as follows.

$$K = \left(0.2 + 0.3e^{\{-0.0256\mathrm{SAN}\left(1\frac{SIL}{100}\right)\}}\right) \times \left(\frac{SIL}{CLA + SIL}\right)^{0.3} \times \left(1 - \frac{(0.25C)}{C + e^{(3.72-2.95C)}}\right)$$

$$\times \left(1 - \frac{0.7SN1}{SN1 + e^{(22.9SN1-5.51)}}\right)$$

Where K is soil erodibility factor, (ton-ha-h ha^{-1} MJ^{-1} mm^{-1}), SAN is the sand content , % ; SIL is the silt content, %; CLA is the clay content, %; C is the soil organic carbon content, %; and S

NI = 1-SAN/100.

Input : data from Table 8.1

SAN = 34.688, SIL = 43.414, C = 6.136

Output : The Input data is used and relevant values are put in above equation. The results is as under

K = 0.11

Soil Erodibility Factor (K) = 0.11

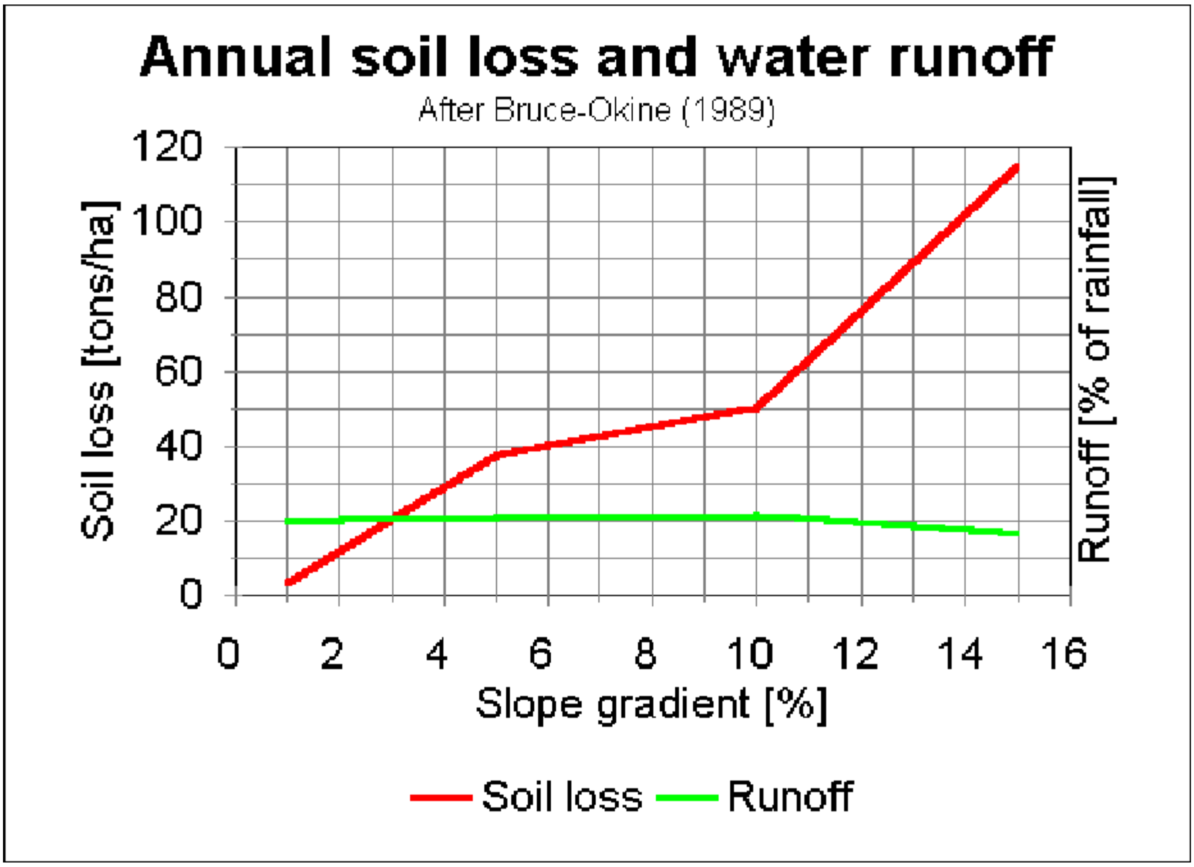


Figure 8.2: Theoretical Annual Loss and Water Runoff

8.5.4 The LS factor was calculated by the following equation (USDA, 1978).

LS = $\left(\frac{L}{22.1}\right)^{0.7} \times [(6.432\,\sin(S)^{0.79}\ \times \cos(S)]$

Where *L* is the slope length (m), *S* is the steepness of slope (Degree).

Input :- The input data in respect of L & S has been taken from table 8.8

L = 100m, S = 5°

Output : - The Input data is used and relevant values are put in above equation. The results is as under

LS = 1.77094

LS factor = 1.77

8.5.5 Crop Management Factor (C)

The crop management factor have been taken as 20% from the standared table 10 from

Publication of wischmeler and smith 1978

Crop Management Factor (C) = 0.20

8.5.6 Conservation practice factor (p)

The conservation practice facter has been adopted considering from the stanared Table 13 from

(Publication wischmeler and smith 1978.

Conservation practice factor (p) = 0.50

8.5.2 Rainfall Erosivity Factor (R)

The R factor was calculated by equations developed were as given below.

R = 50 + 0.389 x P (r = 0.88)

Where, R = Rainfall erositivity factor in MJ mm ha^{-1} h^{-1}, P = Average monsoon rainfall in mm.

Input :- From table 4.4

P = 1394.7 mm

Output :- The Input data is used and relevant values are put in above equation. The results is as under

R = 50 + 0.389 x 1394.7

R = 592.53

Rainfall Erosivity Factor (R) = 592

8.5.3 Soil Erodibility Factor (K)

The estimates the K fator using soil properties that tare most closely corrected with soil erodibility. Few soil properties are needed to calculate the soil erodibility K-value, that is soil organic carbon content and soil particle size distribution (sand, silt and clay). The equation is as follows.

$$\mathrm{K} = \left(0.2 + 0.3e^{\{-0.0256\mathrm{SAN}\left(1\frac{SIL}{100}\right)\}}\right) \times \left(\frac{SIL}{CLA + SIL}\right)^{0.3} \times \left(1 - \frac{(0.25C)}{C + e^{(3.72-2.95C)}}\right)$$

$$\times\left(1 - \frac{0.7SN1}{SN1 + e^{(22.9SN1-5.51}}\right)$$

Where K is soil erodibility factor, (ton-ha-h ha^{-1} MJ^{-1} mm^{-1}), SAN is the sand content , % ; SIL is the silt content, %; CLA is the clay content, %; C is the soil organic carbon content, %; and S

NI = 1-SAN/100.

Input : data from Table 8.1

SAN = 34.688, SIL = 43.414, C = 6.136

Output : The Input data is used and relevant values are put in above equation. The results is as under

K = 0.11

Soil Erodibility Factor (K) = 0.11

8.5.7 Calculation of Soil Erosion Using USLE:

A = R x K x LS x C x P

Table 8.9

Factor for Soil Loss Equation

Sr. No.	Factor	Symbol	Value
1	Rainfall and Runoff	(R)	592
2	Soil Erodibility	(K)	0.11
3	Crop/Vegetation and Management	(C)	0.20
4	Support Practice	(P)	0.50
5	Slope Length-Gradient	(LS)	1.77
6	Tolerable Soil Loss (A = R x K x LS x C x P)	A	7.6748

RATE OF SOIL LOSS = 7.67 ton/ha/year

8.6 Discussion – Database Generation :

The data base generated in the preceding subchapter has been concluded as under and given in **Table 8.10**

Table 8.10 Results of Database Generation

Sr. no.	Parameter	Value	Area Ha Covered	Result
1	Silt yield Index W-1	1516	1946	Very High priority for CAT Plan
	Silt yield Index W-6	835	1072	Low priority for CAT Plan
2	Slop of tract	0-0.05%	5060	Low soil loss. Area possesses 52% of total area
	Slop of tract	0.5-10%	2294	Medium soil loss. Area possesses 45% of total area
3	Universal Rate of Soil loss		3016	Rate of soil loss is 7.67 Tonn/Ha/Year
4	Net treatable Area		3016	Based on data analysis the area recommended for Catchment Treatment Plan

The area under investigation have mine soil loss and proper CAT Plan will ensure low silt content in Kelo River dam from this mine.

9.0 METHOD OF TREATMENT & PLANNING:

9.1 General:

The characteristics of the area discussed in earlier chapter it is proposed to have a holistic treatment approach with grass root level consideration. It is proposed to

i. Identify area for treatment with priority.
ii. Listing of Streams / Rivulets for treatment.
iii. Select the forests for treatment depending upon contribution to head water flow.
iv. Engineering & Biological treatment.
v. Treatment for Agricultural land.
vi. Peoples involvement (Watershed Committee)
vii. Cost estimate.
viii. Phasing of Program.

9.2 Identification of area for Treatment

There are 7 watersheds as enlisted. As per study of thematic maps and GIS Modeling, 7 watersheds need treatment against soil erosion. The main area identify for catchment treatment are located on CAT plan map and depicted at **Figure 9.1**

9.3 Net Treatable area:

On Examination of Land use pattern and field study it is revealed that the land use actual treatable area available within the CAT Area is 3016 ha out of 3850 ha (around 78 %) as per land capability classification as detailed below:

Table 9.1
Land use and Land cover in the study area

Sr. No.	Net Treatable Area	CAT Area in Ha	Treatable area	Percentage to the total area
1	Geographical area	3850	3016	78%

Hence it is proposed to treat 3016 ha.

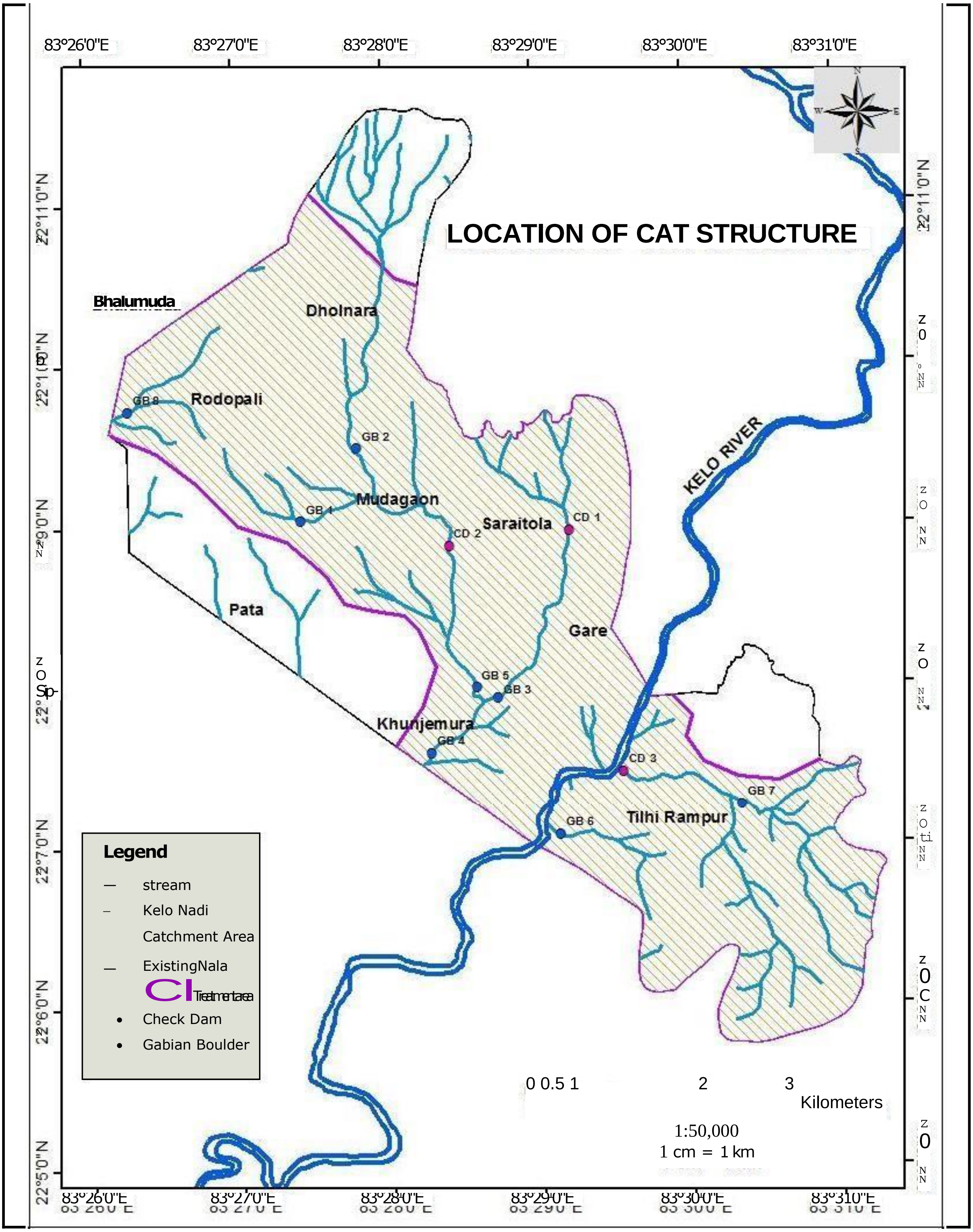


Figure 9.1 Location of Map Structure

9.4 Listing the Rivulets / Nalla, Nadi for Treatment

The following Rivulets / Nalla/ Nadi are proposed for treatment. The list is given **Table 9.2** located on Figure 9.1.

Table 9.2

Rivulets/Nalla /Nadi are proposed for Treatment under this Treatment Plan

S.No.	Type of Structure	Sample	Location	
			Latitude	Longitude
1	Check Dam	CD 1	22° 8'58.10"N	83°29'11.90"E
		CD 2	22° 8'52.60"N	83°28'25.70"E
		CD 3	22° 7'28.00"N	83°29'31.60"E
2	Gabian Boulder	GB 1	22° 9'6.40"N	83°27'25.30"E
		GB 2	22° 9'28.40"N	83°27'57.50"E
		GB 3	22° 7'56.70"N	83°28'41.70"E
		GB 4	22° 7'36.50"N	83°28'14.50"E
		GB 5	22° 7'59.00"N	83°28'35.50"E
		GB 6	22° 7'7.40"N	83°29'10.91"E
		GB 7	22° 7'16.90"N	83°30'22.40"E
		GB 8	22° 9'41.90"N	83°26'16.60"E

9.5 Agricultural land:

All agricultural land is under private ownership. Any activities can be implemented through people's participation and high level of motivation. It is proposed to assist farmers

> Activate / implement activities constituted under Joint Forest Management Committee or Watershed Committee in the village.

9.6 Method of Treatment :

The method of Catchment Area Treatment Plan will include both Biological & Engineering.

1) Biological method includes following activity on forest and agriculture land

- Strip cropping
- Agroforestry
- Conducting training camps of non erosive tillage practice
- Land with or without scrub
- Gross land development

2) Engineering method on Nala

- Loose boulder Gabion structure (GB)
- Check Dam

10.0 COST ESTIMATES FOR CAT PLAN:

10.1 Strip cropping:

Strip cropping is similar to alley cropping in that trees alternate with crops. The difference is that, with alley cropping, the trees are in single row. With strip cropping, the trees or shrubs are planted in wide strip. The purpose can be, as with alley cropping, to provide nutrients, in leaf form, to the crop. With strip cropping, the trees can have a purely productive role, providing fruits, nuts, etc. while, at the same time, protecting nearby crops from soil erosion and harmful winds.

It is proposed to cover 100 ha of agricultural land @of 20 plants per ha i.e. planting of 2000 trees. The cost will be @ Rs 250 per plant. Thus the total cost will be 5 Lakhs

10.2 Agroforestry.

Agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. This intentional combination of agriculture and forestry has varied benefits, including increased biodiversity and reduced erosion. Agro-forestry practices have been successful in many parts of the state during Social Forestry Project. Agro-forestry systems can be advantageous over conventional agricultural, and forest production methods. They can offer increased productivity, economic benefits, and more diversity in the ecological goods and services provided. It is proposed to have agroforestry in the 100 ha of land the inconsultation with forest department. The cost of agroforestry for each ha will be @ Rs 4000/-. Thus, the total cost envisage to the tune of Rs 4,00,000/-. Species which will remain useful to local public for obtaining only user facts . Some important tree species proposed for plantation are:

1		Acacia nilotica
2		Azadirachta indica (Vepa, Neem)
	1	Cochlospermum religiosum
	2	Dendrocalamus strictus (Veduru)
	3	Denis indica (Kanuga)
	4	Dolichandrone crispa (neeruddi)
	5	Emblica officinalis (Usiri)
	6	Feronia limonea (Velaga)
	7	Ficus benghalensis (Marri)
	8	Ficus microcarpa
	9	Ficus religiosa
	10	Hardwickia binata (Narepi)
	11	Pterocarpus santalinus (Erra chandanam)
	12	Sapindus emarginatus (Kumkudu)
	13	Sterculia urens
	14	Tenninalia arjuna (tella maddi)
	15	Terminalia catappa
	16	Vitex negundo
	17	Wrightia tinctorea
	18	Eucalyptus

10.3 Conduct training camps of non erosive tilage practice:

It is proposed to conduct training camps for Farmers to adopt non erosive tilage practice, Cropping pattern and Agro- Forestry Practices. 2 camp per year i.e 10 camps will be conducted in 5 years. Training camps, Planting of trees under under Agro- Forestry and planting of Bena Grass slips should be implemented simultaneously to derive effect of motivation in training camps. A sum of Rs 30000/- per camp is proposed. Hence A sum of Rs 3.00 lakh is required.

10.4 Land With & Without Scrub:

The land with Scrub is generally Govt. Lands without tree cover and being more and more being utilized for developmental purpose. It is observed that most of the soil is either compact or affected by Rills / Gullies. It is proposed to provide staggered trenches and Grass land development on fellow lands near to Nalla bank, Forest fringes and blank government lands. Total area to be treated is 200 ha. There will be provision for Lumsum cost to the tune of Rs. 5 Lakhs.

10.5 Grass land development.

Grass lands in villages are though available but mostly devoid of palatable grass. It is proposed to develop grass lands either in Revenue Forest lands / Gochar land or in open forests in pockets. The grass land development involves a- Ploughing of area, sowing of grass seeds and application of manure periodically to have a sustainable growth. Instead of grazing, villagers may be motivated to cut and take the grass as required after 45 days of seed sowing. Planting of grass slips may also be preferred to seed sowing for ease establishment.

Cost break up involves Ploughing of land @ Rs 1500/- per ha, Seed cost: 2000/- per ha, Manuering etc : 1000/- per ha Maintenance Rs 1000/- per ha per year. Contigency- Rs500/- After 5 years it may be replanted to juvinate the grass production. Hence for Five year the grass land development is Rs 1500+2000+1000+5000+ 500/-= Rs10,000/- It is proposed to develop 20 ha of Grass land during 5 years. Hence a sum of Rs 2.00lakh anf is proposed. It may be implemented for 5 years.

10.6 Loose Boulder Gabion Structure (G.B.)

AS discussed in earlier paragraphs, the following forest blocks are the origin of many nalla, rivulets those ultimately flows to Kelo River. It is proposed to have intensive Soil & Moisture conservation measures in an integrated manner. The nallas will be treated with loose boulder Gabion Structure (G.B.). There will be 8 nos of GB Structure as per locations on figure 9.1. The cost of each G.B. is estimated @ Rs 50,000/- . Thus, the total cost will be Rs 4,00,000/-

10.7 Check Dam in Nala

Besides the treatment provided to rivulets / nalla originating from Forest blocks, it is also necessary to adopt soil and moisture conservation measures. to check runoff and allow percolation of water to improve quality of vegetation and prevent loss of top soil (Sheet errosion). It is proposed to provide 3 nos check dam. The cost of each check dam likely to be Rs 5,00,000/- thus the total cost for 3 Nos check dam will be Rs 15,00,000/-.

10.8 Preparation of Detail Project Report (DPR)

There will be need for preparation of Detail Project Report (DPR) for implementation of both Biological and Engineering method. The DPR will be prepared in consultation with concerned Government Authority. The cost estimate and location may change subject to mining activity and concerned Government Authority.

10.9 Abstract of Financial Interventions:

The total financial intervention to execute CAT Plan is given in **Table 10.1.**

Table 10.1

Abstract of Financial Interventions

Sl No	Description	Unit	Rate in Rs	Target	Amount in lakh Rs
1	Strip cropping	No	250	2000	5.00
2	Agroforestry.	ha	4000	100	4.00
3	Taining camps for Farmers.	No	30000	10	3.00
4	Land With & Without Scrub Treatment	ha	2500	200	5.00
5	Grass land development.	Ha	10000	20	2.00
6	Treatment of Nalla / Rivulets. Loose boulder Gabion Structure (G. B.)	No	50000	8	4.00
7	Treatment of Nalla / River banks.	No	5,00,000	3	15.00
8	Sub- Total				**38.00**
9	Escalation LS				**7.00**
10	**Total**				**45.00**

(Total Rs. Forty Five Lakhs only) plus GST as applicable .

10.10 Total Project Cost & Time :

The Total Project Cost for the CAT Plan will be Rs. 45 Lakhs plus GST as applicable . The work will be undertaken one monsoon year before commencement of mining operation. The total duration of the project will be five year.

CAT project Cost – Rs 45 lakhs plus GST	**Time of CAT Plan – 5 year**

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