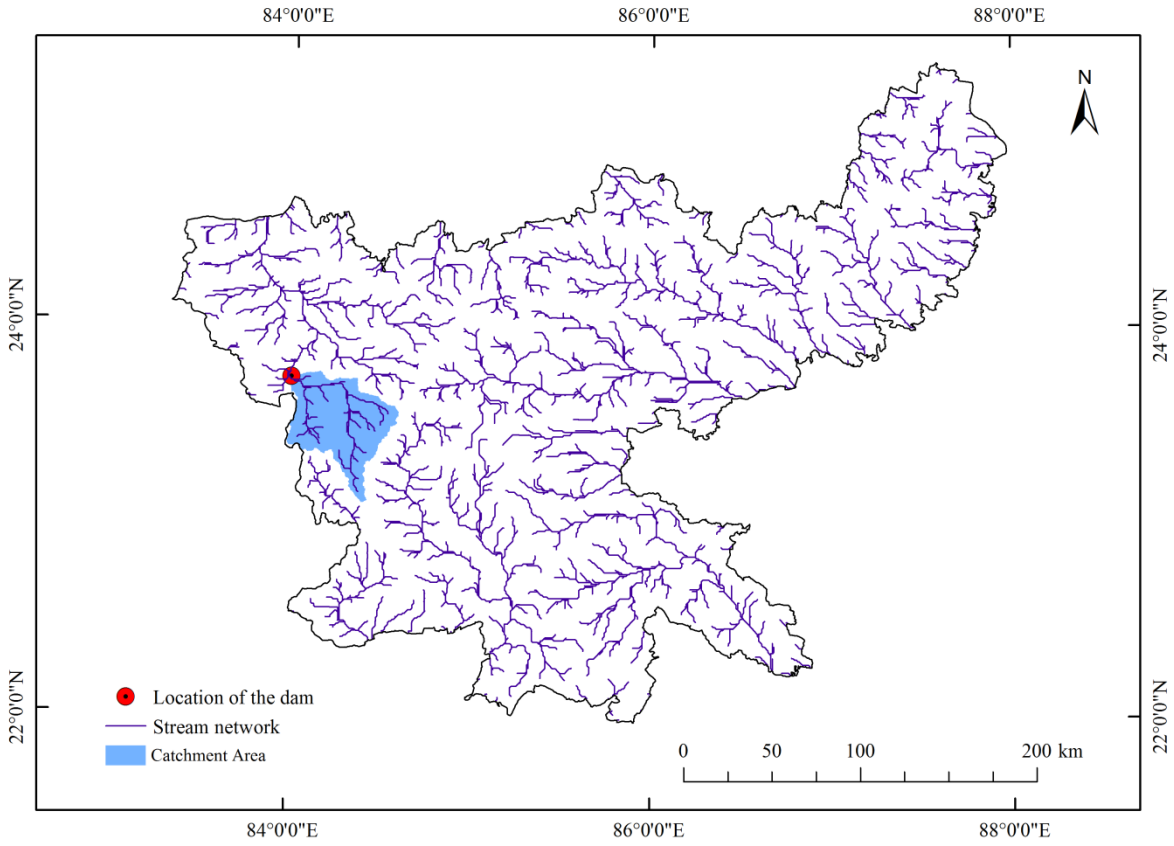
Proposed Catchment Plan for North Koel Reservoir (Mandal Dam) Project



Submitted by

WATER RESOURCES DEPARTMENT
GOVERNMENT OF JHARKHAND

LIST OF FIGURES

CATCHMENT AREA TREATMENT PLAN

1.1 INTRODUCTION

Jharkhand is one of the most prolific States in the country, consisting Chotanagpur plateau and Santhal Pargana. The State covers 79714 sq. K.M., which represents 2.41 % of total area of country. Topography of the State is mostly undulating, hilly and sloping with mountains, forests, river basins and valleys. It has sizeable Tribal population (26.3%).

State is very rich in forest & its diversity. The recorded forest area of the state is 23605 km^2 which is 29.61 % of its geographical area. Reserved forests constitute 18.58 %, protected forest 81.28% and unclassed forest 0.14%.

It has a rich endowment of mineral resources. It has some of the richest deposits of coal and iron Ore in the world. It is the largest producer of coal, copper, kynite and mica in the country. It blessed with rich fauna and flora.

Land use pattern of Jharkhand

Land Use	Area in '000 ha	Percentage
Total geographical area	7,972	
Reporting area for land utilisation	7,970	100.00
Forests	2,239	28.09
Not available for cultivation	1,332	16.71
Permanent pasture and other grazing lands	110	1.38
Land under misc. tree crops and groves	93	1.17
Culturable wasteland	336	4.22
Fallow lands other than current fallows	962	12.07
Current fallows	1,394	17.49
Net area sown	1,504	18.87

Source: Land Use Statistics, Ministry of Agriculture, GOI, 2008-09.

1.2 Project Description: - North Koel Reservoir Project

North Koel project envisages construction of a dam on river North Koel near village Mandal under Barwadih Block of Latehar district in Jharkhand. River North Koel is one of the major right bank tributary of river Sone. The North Koel rises on the Ranchi plateau and enters Palamau division, below Netarhat near Rud. After flowing nearly due west for about 32 KM^2 (20 mi), it turns north at an almost complete right angle through a gorge at Kutku, and flows through the centre of the district until it falls into the Son a few miles north-west of Haidarnagar. From its source to its junction with the Son its length is about 260 KM^2 (160 mi), and since it drains a catchment area of at least 9,100 KM^2 (3,500 sq mi), it naturally contributes a large supply of water to the Son during the rains; at other times the stream is not deep enough to enable cargo boats of even small dimensions to make their way up to Daltonganj. In many places the reaches of this river present scene of great beauty and sometimes even of grandeur, such as the rocky bed and rapids north of Hutar and the gorge at Kutku. Mention may be made of the metamorphic rocks which form the watershed between the North Koel and the Damodar to the west of the Chandwa-Balumath road. The North Koel, along with its tributaries, meanders through the northern part of Palamu Tiger Reserve.

Out of total catchment area of 9,100 KM^2, the effective catchment area of the project is **2885** KM^2 (2726.64* KM^2 in Jharkhand+ 158.45* KM^2 in Chhattisgarh) .

1.2.1 **Components of Project**

1. Dam near village Kutku/Mandal in latehar district
2. Barrage near village Mohmmadganj in Palamu district.
3. Right main canal (RMC) from Mohamadganj Barrage.
4. Left main canal (LMC) from Mohamadganj Barrage.

* Geo area

1.2.3 **Important Parameters**

1. Height of Dam - 67.80 m
2. Length of Dam - 408.5 m

1.2.3 **Total Irrigation Potential**

1. Total Irrigation Potential - 1,24,270 ha
2. Irrigation Potential in Bihar - 1,11,800 ha
3. Irrigation Potential in Jharkhand - 12,470 ha
4. Irrigation Potential Achieved in Bihar - 50,000 ha
5. Irrigation Potential Achieved in Jharkhand - 6045 ha
   (*Kharif Irrigation is being provided)*

1.2.4 **Financial Progress**

1. Year of Sanction - 1970
2. Original Project Cost - 30.00 Crore
3. Fourth revision - 814.73 Croe
4. Expenditure till march 2016 - 792.38 Core

1.2.5 **Basin Development**

Agriculture and industry are the two main essential on which the economy of any developing country or state depends. Irrigation facilities to the areas increase food production, which is one of the most pressing needs for a vast industrial and agricultural country like India at present.

Jharkhand has tremendous potential of developing tourism industry due to beautiful landscape, religious places, trekking trails, national parks, and mountain peaks historical and archeological sites. It is hoped that by development and exploitation of its natural resources, Jharkhand can overcome its economic backwardness. It is therefore very necessary that the potential of the State resources in respect of irrigation and power exploited fully and quickly for its rapid economic development.

River North Koel and its tributaries can play vital role in respect of agricultural, scientific and technological development. There is good rainfall in its catchments so that the rivers have large run off in monsoon period. The entire run off goes to waste at present, It can be utilized for the development of irrigation and power by constructing suitable schemes.

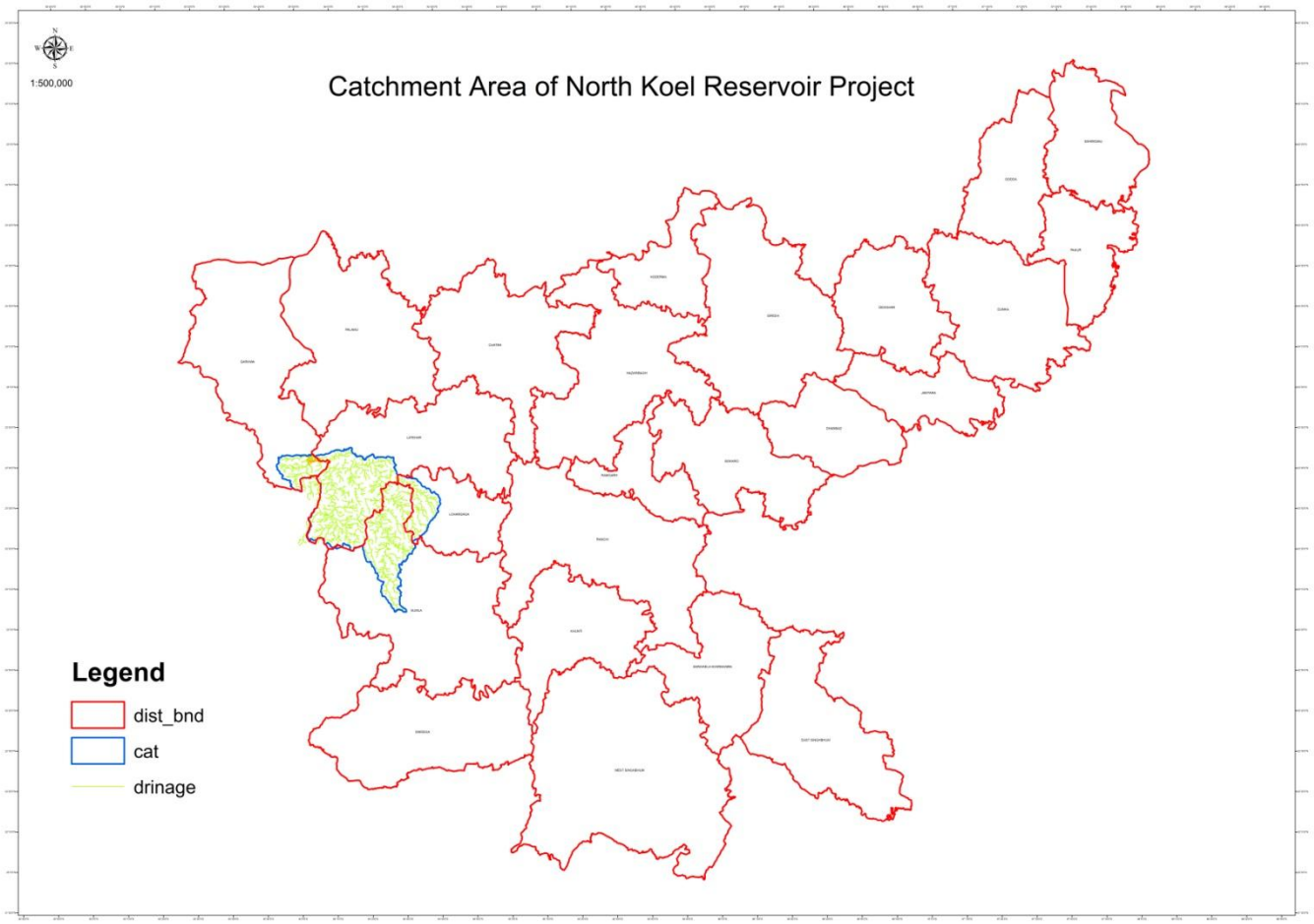


Figure 1.1 Catchment area of North Koel Reservoir Project with drainage

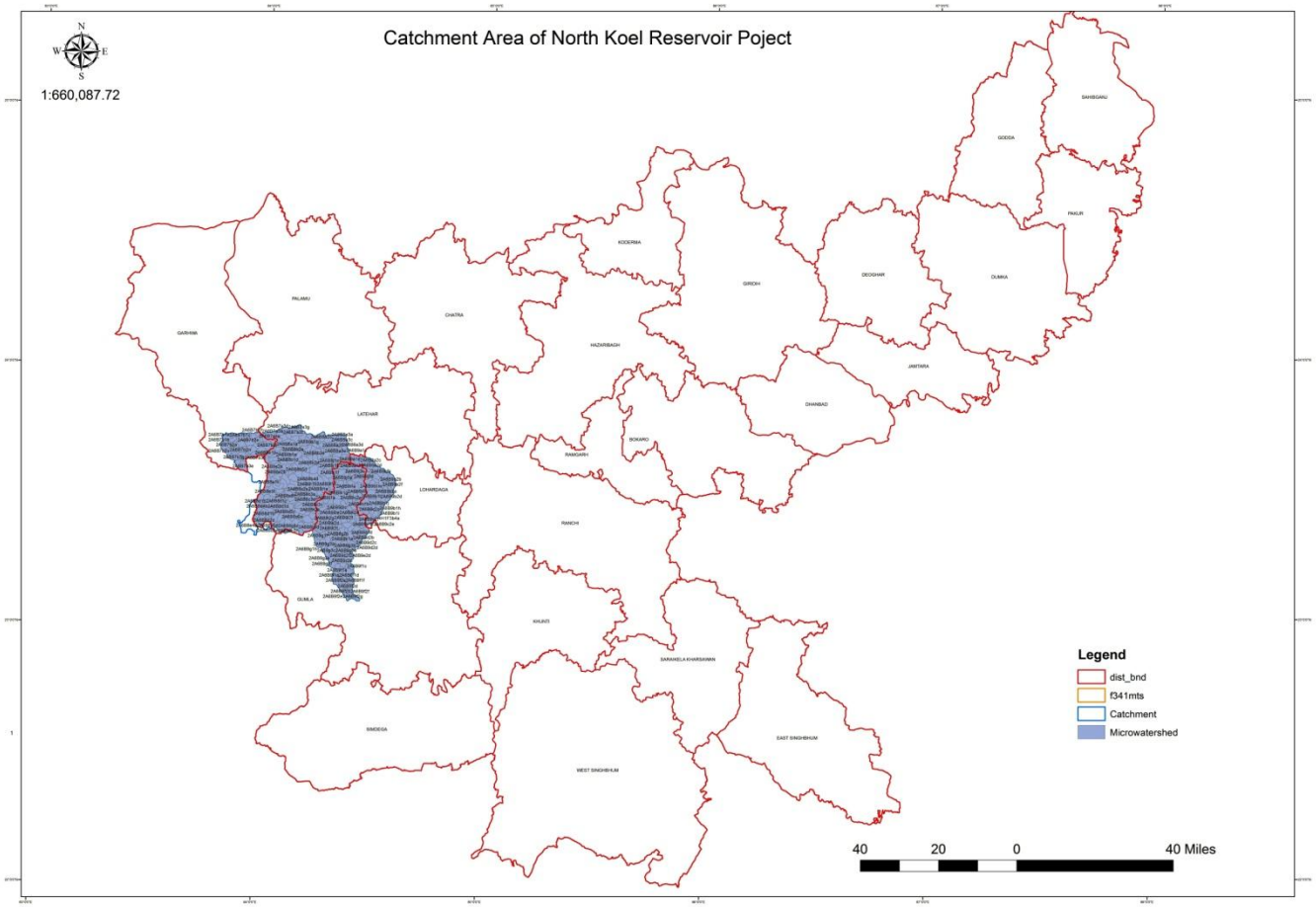


Figure 1.2 Catchment area of North Koel Reservoir Project with District boundary

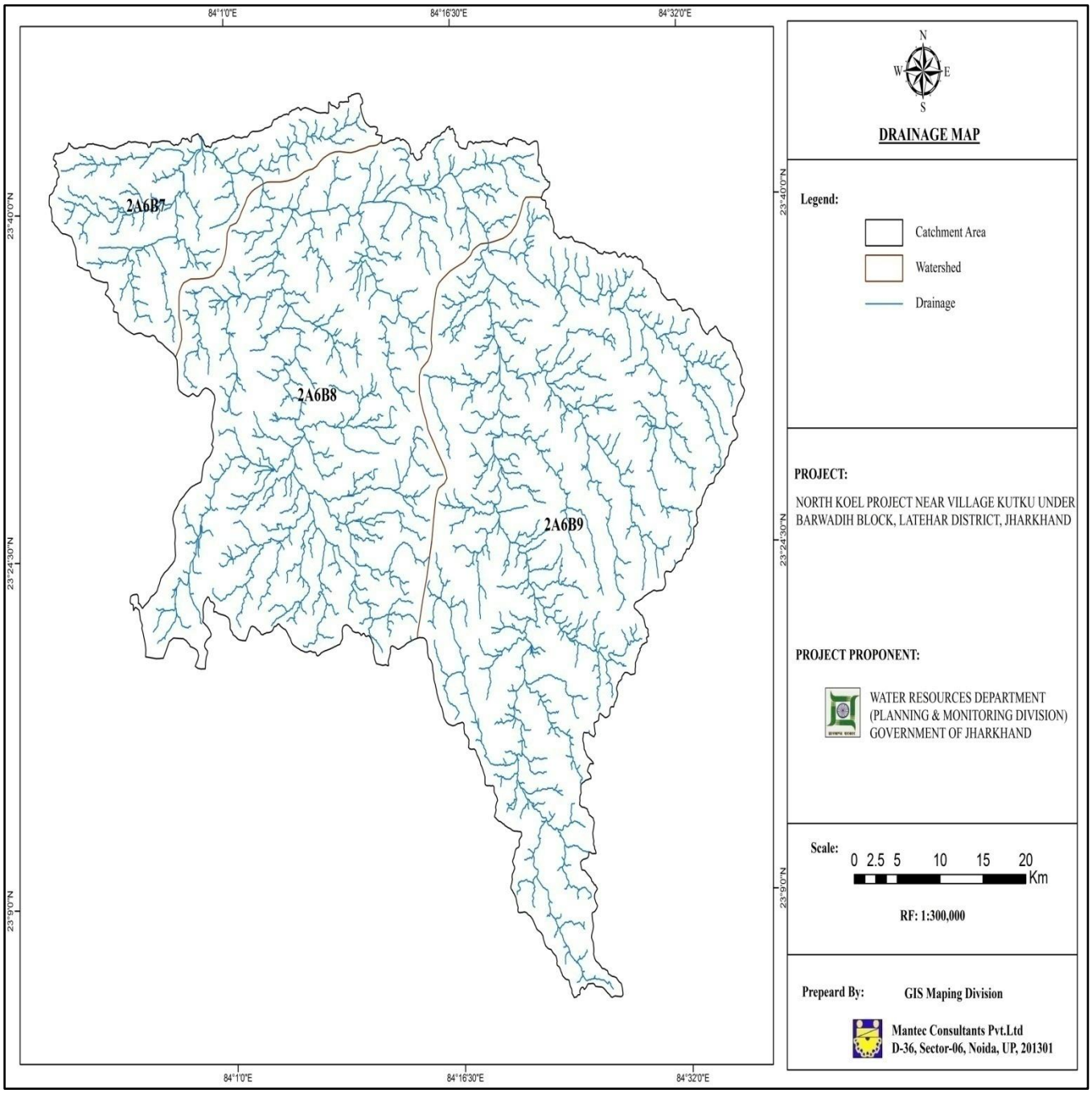


Figure 1.3: Catchment Area with watershed code & drainage, the North Koel Project

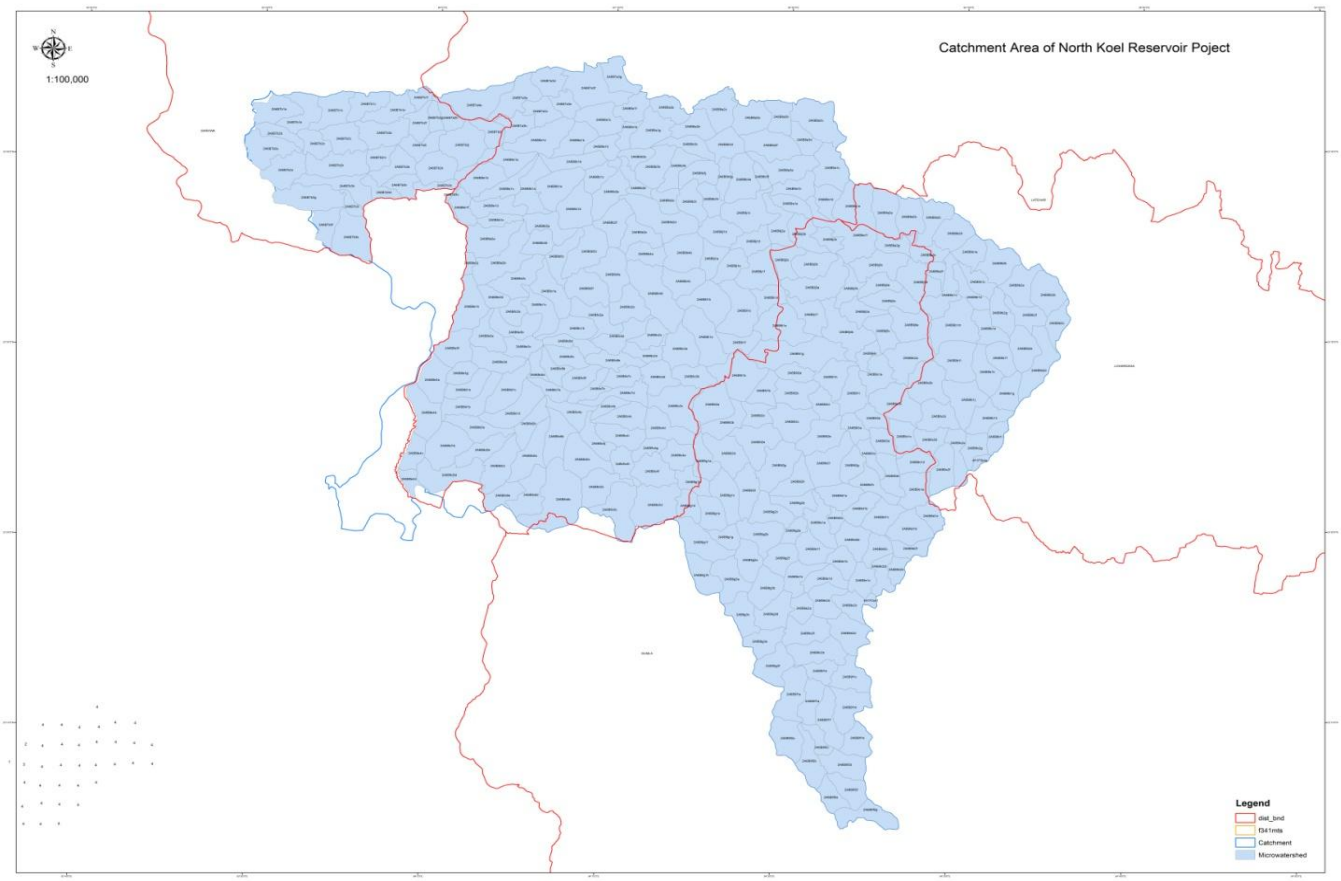


Figure 1.4: Catchment Area of the North Koel Project with Micro Watershed

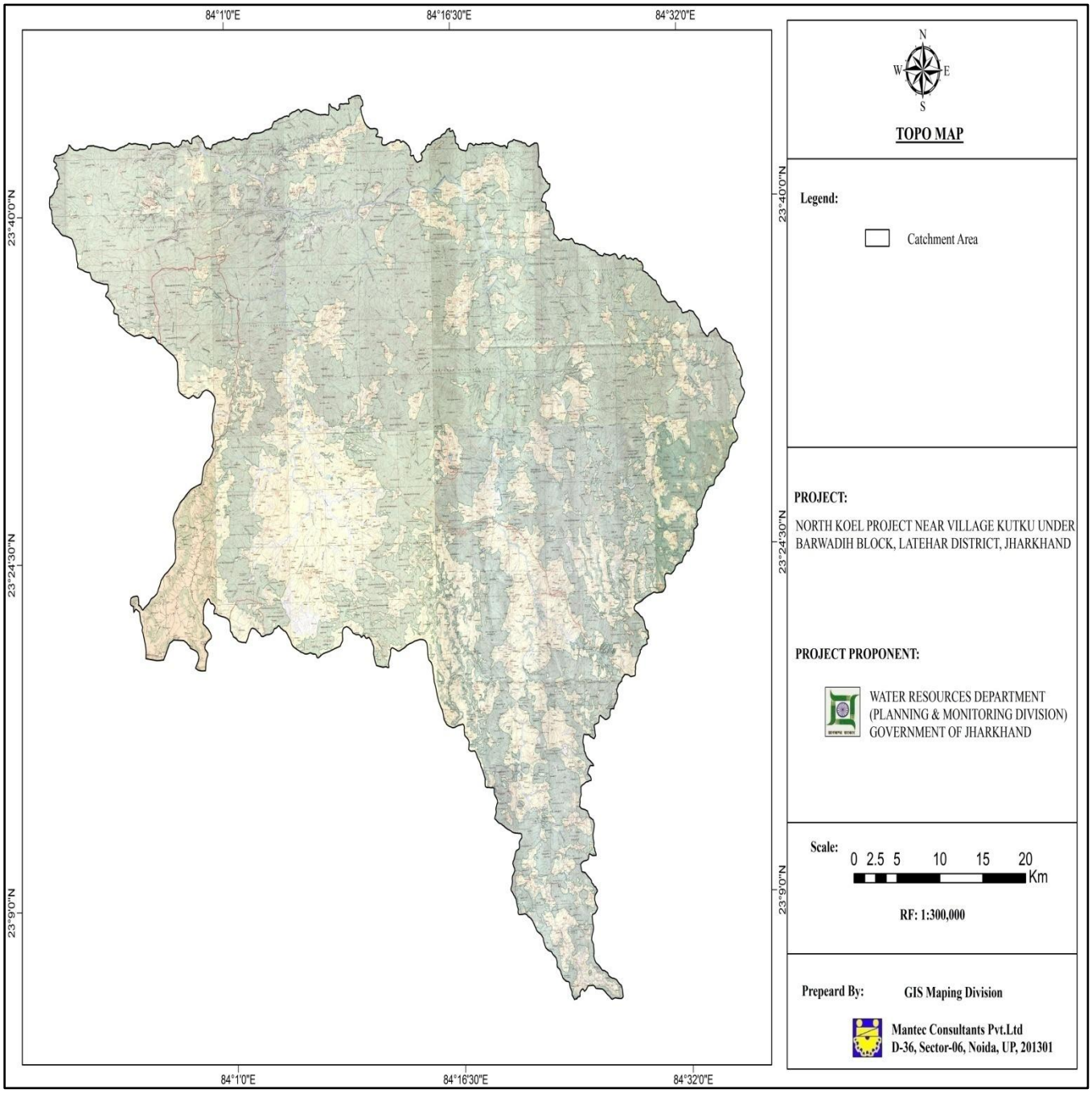


Figure 1.5: Toposheet Map of North Koel Project Catchment Area

1.3 OBJECTIVES

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

1. To facilitate hydrological functioning of the catchment and to augment the quality of water of the river North Koel and its tributaries.
2. Conservation of soil covers by arresting soil erosion, reducing run-off causing floods and siltation of the river and its tributaries and consequent reduction of siltation in the reservoir of the project.
3. Soil conservation measures proposed on Ridge to valley concept after demarcation of watersheds/Micro watershed in catchment area.
4. Rehabilitation of degraded forest areas through afforestation and other means.
5. Mitigation of landslide, landslip and rock falls.
6. To meet fuel, wood and fodder requirements of local people through measures proposed in revenue land.
7. Employment generation and community participation.
8. Ecosystem conservation through increased vegetal cover and enhanced water retaining properties of soil.
9. Increased rural employment leading to economic upliftment in the rural areas.
10. Promotion of non-conventional energy device to reduce pressure on forest for fuel wood.
11. Promotion of community based eco-tourism by maintaining designated path eco-treks and overnight camping facilities.

1.4 Free Draining Catchment

The Sone River is an important right bank tributary of the Ganga River. It originates from Amarkantak high lands in hills of Maikala range in Bilaspur district of Chhattisgarh at an elevation of 640 m and latitude 20°44’ N and longitude 82°4’E. The river outfalls into the Ganga at about 16 km. upstream of Patna at latitude 25°14’ N and longitude 84°42’ E. The total length of the river is 881 km. The total catchment area of river system is 70,055 km2. which is about 8.72% of Ganga river basin. The river meets the Ganga Riverabout 16 km upstream of Dinapur in the Patna district of Bihar. The important tributaries of the river Sone are Rihand, Kanhar, Ghaghar,

and Koel. The river has a steep gradient with quick run off and ephemeral regimes, becoming a roaring river with the rain waters in the catchment area but turning quickly into a formidable stream. The river being wide and shallow leaves disconnected pools of water during summers (lean period). The river Sone was very notorious for changing course but this tendency has been checkedby the formation of anicut at Dehri in the year 1873-74 and construction of Indrapuri Barrage in 1968. The Rihand Dam was also constructed in the upstream catchment of the river Rihand, a tributary of river Sone in 1962. Further the Bansagar Dam in Madhya Pradesh was constructed and commissioned in the river in 2008.

As per nomenclature given in the Watershed Atlas of India (1990), the free draining catchment under study area lies in Water Resources Region-2, Basin-2A, Catchment 2A6 and sub-Catchment 2A6B. A Catchment Area Treatment Plan has been formulated for the free draining catchment by using satellite data subset of 1Rs LISS-III Gen: 12.11.07, Path 94, Row-48 which has been presented in **Fig. 1.6**

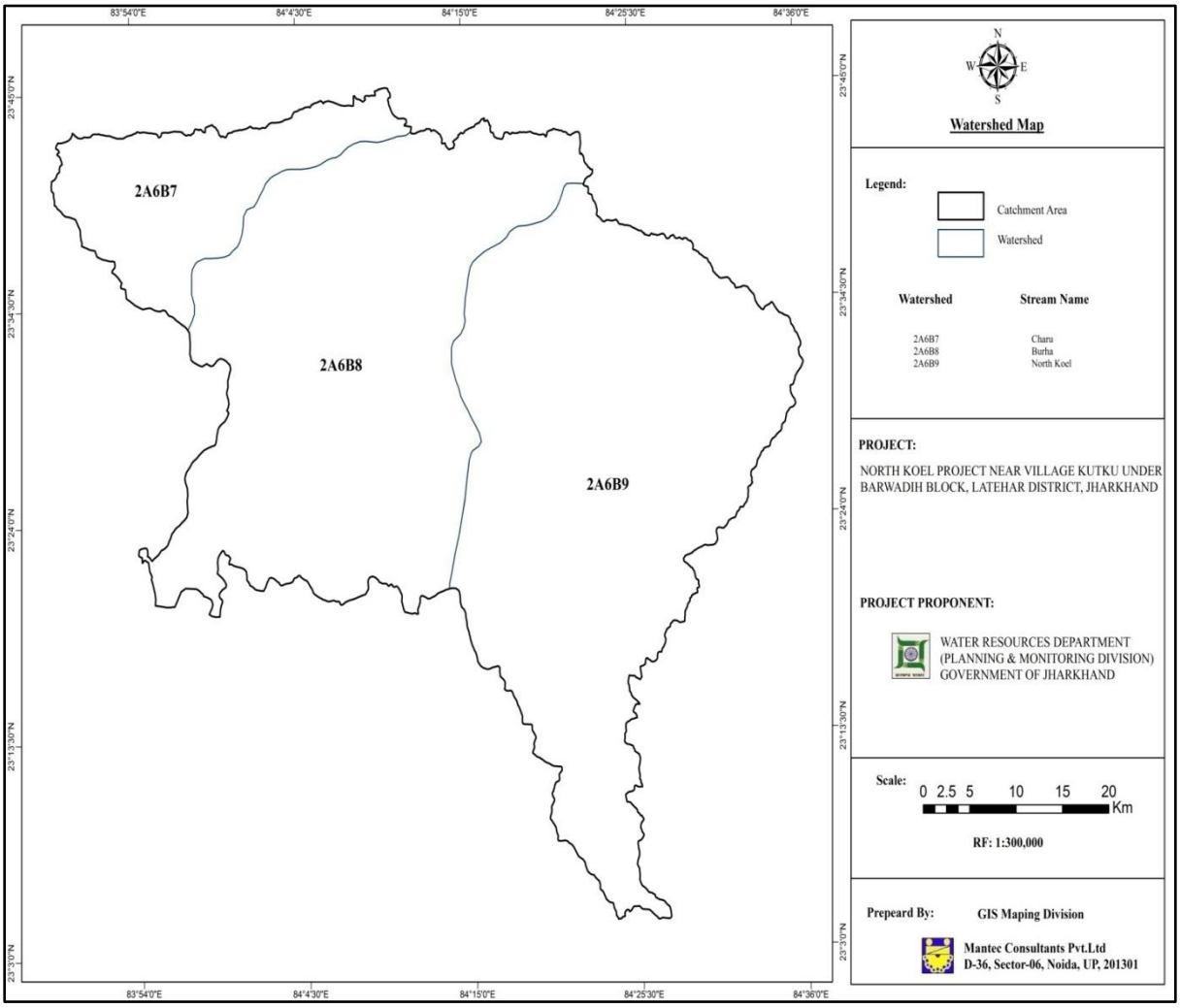


Fig. 1.6 The free draining watershed details are given in **Table 1.1**and depicted in

Table 0-1: Hydrological Units of Free Draining Catchment Area

Watershed Details	SWS	Area (KM^2.)
North Koel Watershed	2A6B7	413
	2A6B8	1120
	2A6B9	1352
Total Area		**2855**

1.5 TOPOGRAPHY

The study area lies in the part of Chhota Nagpur Plateau which is the region formed by the vast tract of land between the feet of the small hills. The hilltops are laden with sub-tropical forest, which covers the plateu slopes. There are small streams formed out of draining of rainwater. These finally drain into the North Koel and Sone. The free draining catchment area varies from EL 284 masl to El 1190 masl.

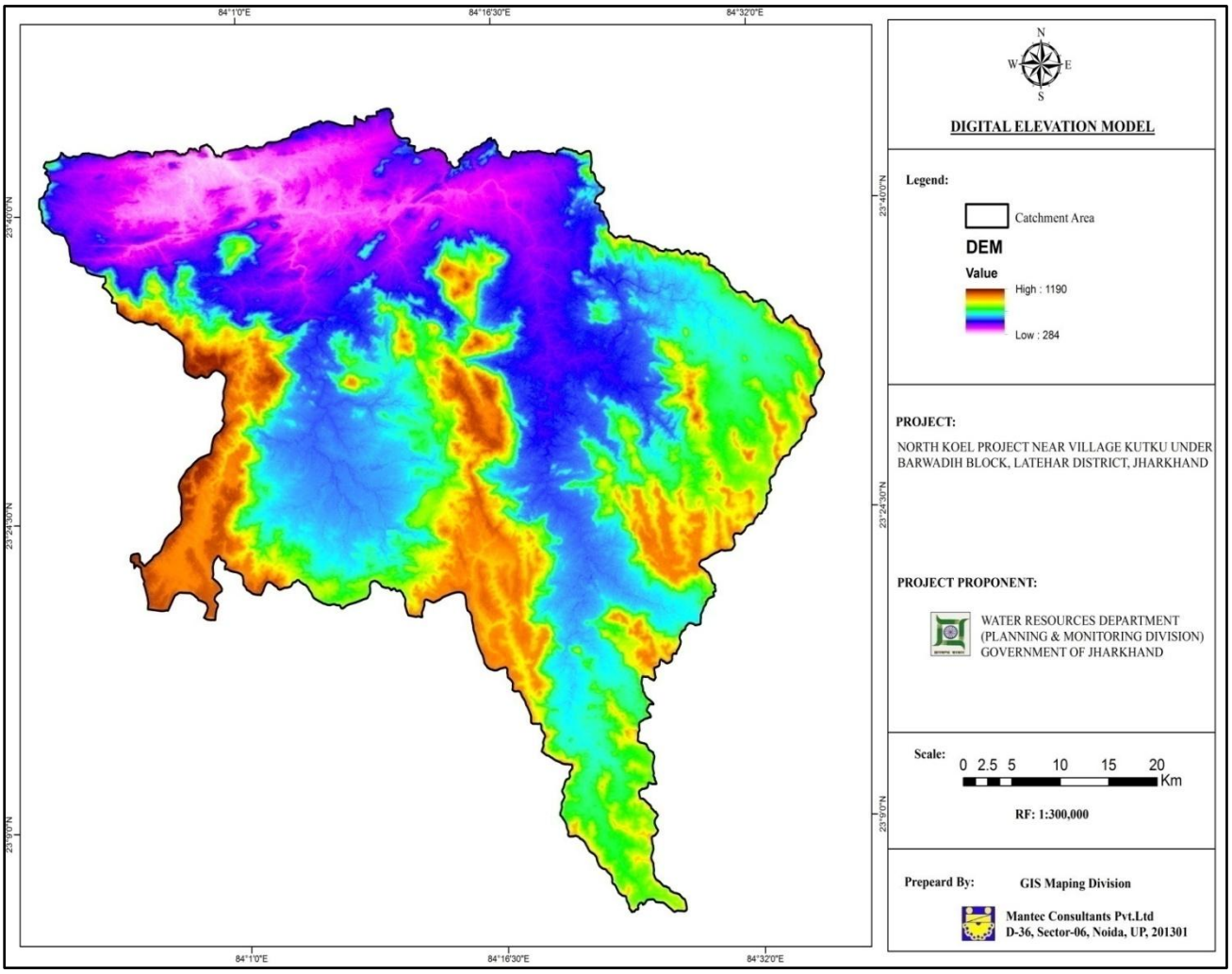


Figure 1.77: Digital Elevation Model of Free Draining Catchment

1.6 SOIL

The soil resource map of Chhota Nagpur Plateau in Jharkhand and Chhattisgarh (NBSS Publication No Bihar 50, MP 59) has been used in the present study. The soil is predominantly loamy to sandy loam. The soil map presented in **Fig. 1.8** reveals that the soil of the area belongs to Chhota Nagpur plateu (Eastern), Baghelkhand Plateau (Eastern), Central Highland, Pathar, Bundelkhand Upland (Alluvium) and Eastern Baghelkhand Plateau (Laterite) having map units 38, 84, 87, 88, 89, 90, 92, 105, 106, 108, 110, 112, 826, 827, 840, and 842 being soil of side and reposed slopes, whose characteristics are described hereunder.

Recent Alluvial Plain

1.6.1 Soil belonging to map unit 38

The soil of this area is very deep, well drained; calcareous fine loamy soils on very gently sloping plain with loamy surface texture, slight erosion, severe flooding and slight salinity/sodicity associated with; very deep imperfectly drained calcareous fine loamy soils with loamy surface texture, slight erosion, severe flooding and slight salinity/sodicity.

Chhota Nagpur Plateau, Eastern

(Granite Gneiss Landscape)

1.6.2 Soil belonging to map unit 84

The soil of this area is very deep, imperfectly drained, fine soils on gently sloping landscape with loamy surface texture and moderate erosion associated with; shallow well drained loamy soils on moderately steeply sloping land with loamy surface texture and severe erosion.

1.6.3 Soil belonging to map unit 87

The soil of this area is shallow, somewhat excessively drained, gravely loamy soils on gently sloping hill slope with loamy surface texture and severe erosion associated with; deep, moderately well drained fine loamy soils with loamy surface texture and moderate erosion.

1.6.4 Soil belonging to map unit 88

The soil of this area is shallow, somewhat excessively drained, loamy soils on moderately sloping hill slope with sandy surface texture and severe erosion associated with; moderately deep, moderately well drained fine soils with loamy surface texture and moderate erosion.

1.6.5 Soil belonging to map unit 89

The soil of this area is deep, somewhat excessively drained, coarse loamy soils on moderately sloping hill slope with loamy surface texture and moderate erosion associated with; Deep moderately well drained fine soils on gently sloping land with clayey surface texture and slight erosion.

1.6.6 Soil belonging to map unit 90

The soil of this area is deep, moderately well drained, fine soils on gently sloping hill slope with loamy surface texture and moderate erosion associated with; Deep moderately well drained fine soils on moderately sloping land with clayey surface texture and moderate erosion.

1.6.7 Soil belonging to map unit 92

The soil of this area is deep, imperfectly drained, fine soils on very gently sloping upland with loamy surface texture and moderate erosion associated with; very deep, well drained fine loamy soils on gently sloping land with loamy surface texture and moderate erosion.

1.6.8 Soil belonging to map unit 105

The soil of this area is shallow, well drained, loamy soils on gently sloping undulating plateau with loamy surface texture and severe erosion associated with; deep, moderately well drained fine soils with loamy surface texture and moderate erosion.

1.6.9 Soil belonging to map unit 106

The soil of this area is very deep, well drained, fine loamy soils on gently sloping undulating plateau with loamy surface texture and moderate erosion associated with; Deep, well drained fine loamy soils with loamy surface texture and severe erosion.

1.6.10 Soil belonging to map unit 108

The soil of this area is deep, moderately well drained, fine loamy soils on gently sloping undulating plateau with loamy surface texture and moderate erosion associated with; deep, well drained fine loamy soils on moderately sloping land with loamy surface texture and moderate erosion.

1.6.11 Soil belonging to map unit 110

The soil of this area is deep, moderately well drained, fine soils on gently sloping undulating plateau with loamy surface texture and moderate erosion associated with; deep, well drained fine loamy soils with loamy surface texture and moderate erosion.

1.6.12 Soil belonging to map unit 112

The soil of this area is very deep, poorly drained, fine soils on very gently sloping valley with loamy surface texture and moderate erosion associated with; deep, imperfectly drained fine soils on gently sloping land with clayey surface texture and moderate erosion.

Eastern Chhota Nagpur Plateau, Granitic-Laterite

1.6.13 Soil belonging to map unit 826

The soil of this area is very shallow, somewhat excessively drained, loamy soils on moderately steeped sloping hills with narrow valleys with very severe erosion and strongly stony associated with; slightly deep well drained, loamy soils on moderately sloping with very severe erosion and slightly stony.

1.6.14 Soil belonging to map unit 827

The soil of this area is slightly deep, well drained, loamy soils on moderately steep sloping hills with narrow valleys with severe erosion and moderately stony associated with; slightly deep somewhat excessively drained, loamy soils on steeply sloping with very severe erosion and moderately stony.

Eastern Dandakaranya Plateau (Sedimentary)

1.6.15 Soil belonging to map unit 840

The soil of this area is deep, well drained, loamy soils on gently sloping undulating to rolling plateau (moderately dissected) with moderate erosion associated with; deep well drained, loamy soils on gently sloping with severe erosion.

1.6.16 Soil belonging to map unit 842

The soil of this area is deep, well drained, loamy soils on gently sloping undulating to rolling plateau (highly dissected) with moderate erosion associated with; deep well drained, loamy soils on gently sloping with moderate erosion.

.

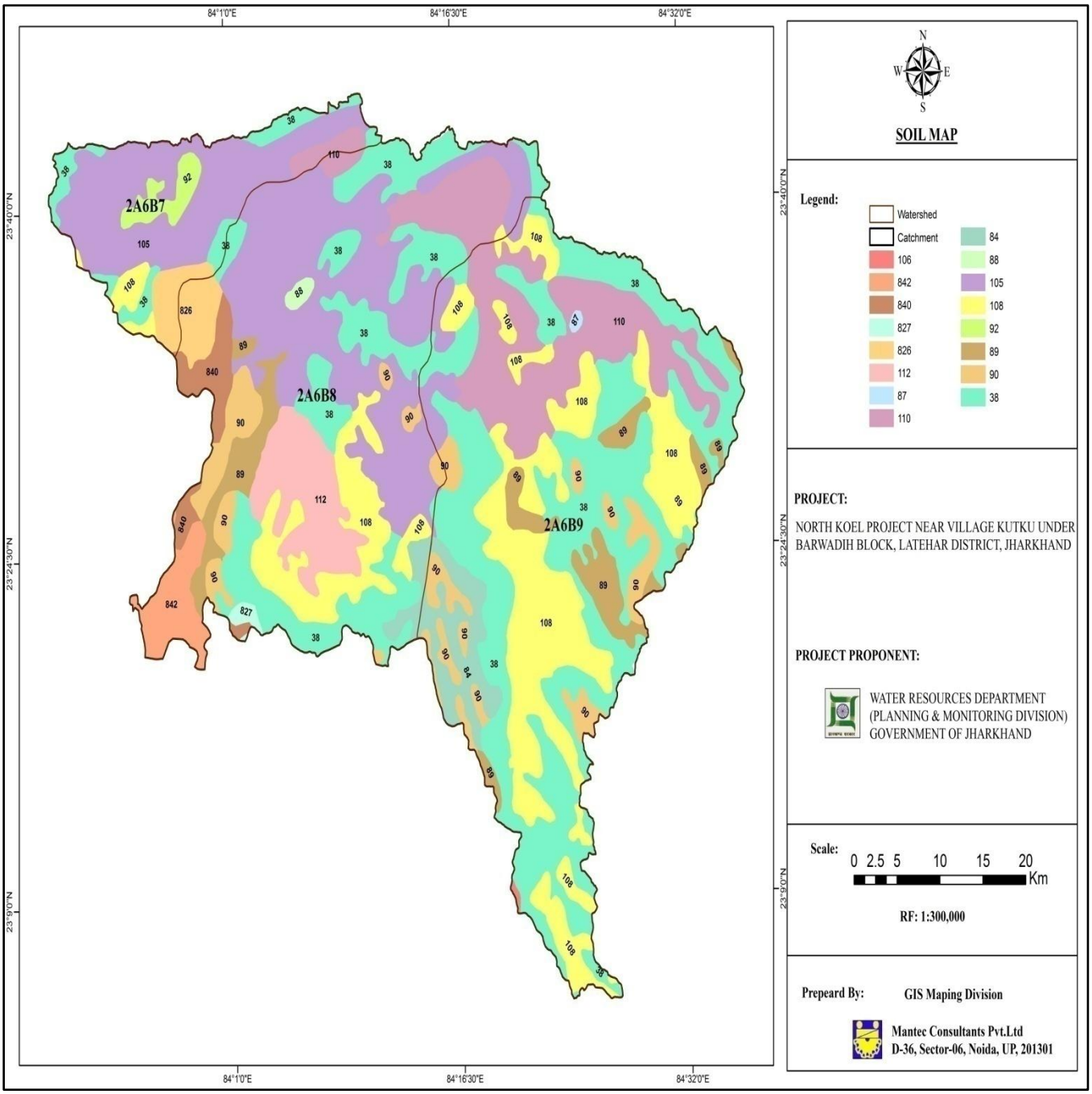


Figure 1.8: Soil map of free draining catchment

1.7 METHODOLOGY USED FOR THE STUDY

The digital satellite data (Resourcesat-1) of IRS P6 LISS-III acquired from NRSA was evaluated on ERDAS Imagine Software. The standard False Colour Composite (FCC) was generated by assigning blue, green, and red colors to visible green, visible red, and near infrared bands respectively. Expressing image pixel addresses in terms of a map coordinate base is often referred to as geo-coding. As various thematic layers were to be overlaid for this project, all the layers were geo-referenced to real world coordinates. The 1:50,000 scale toposheets No 64M5, 64M6, 64M9, 64M10, 64M11, 64M12, 64M13, 64M14, 64M15, 64M16, 73A3 and 73A4 the catchment area were used for the purpose of geo-referencing. A large number of GCPs were selected for reasonably accurate geo-referencing/geo-coding. A map projection system (real world) was also defined.

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

Detailed field survey was conducted for study of soil characteristics, and erosion prone areas and landslides in the catchment area. The vulnerable and problematic areas were identified in different physiographic zones in the entire catchment area. The data was generated on physiographic, land-use/land cover, lithology, structure, drainage pattern, slope characteristics, landslides/slips etc. These data sets were used for preparation of the thematic maps, calculation of sediment yield index and Erosion Intensity Units in the catchment area according to the following procedures:-

1.8 Land use/Land cover Classification

- Prior to ground truthing the satellite data was classified using unsupervised classification technique. Further, after collecting ground truth details maximum likelihood classification based supervised classification method used with remote sensing image data.
- After the supervised classification procedure, a land-use map was prepared which the team at field verified, and any errors or omissions identified.
- A reclassification of the land-use categories implementing the details and corrections, if any, was done. The reclassification output was used for the preparation of the final land-use classification map. This map after due verification was then composed and printed as desired.
- The Land use map of the study area and free draining catchment area presented in **Fig. 1.9** The Land-use/Land-cover details for free-draining catchment & its sub-watershed is presented in**Table 1.2**.

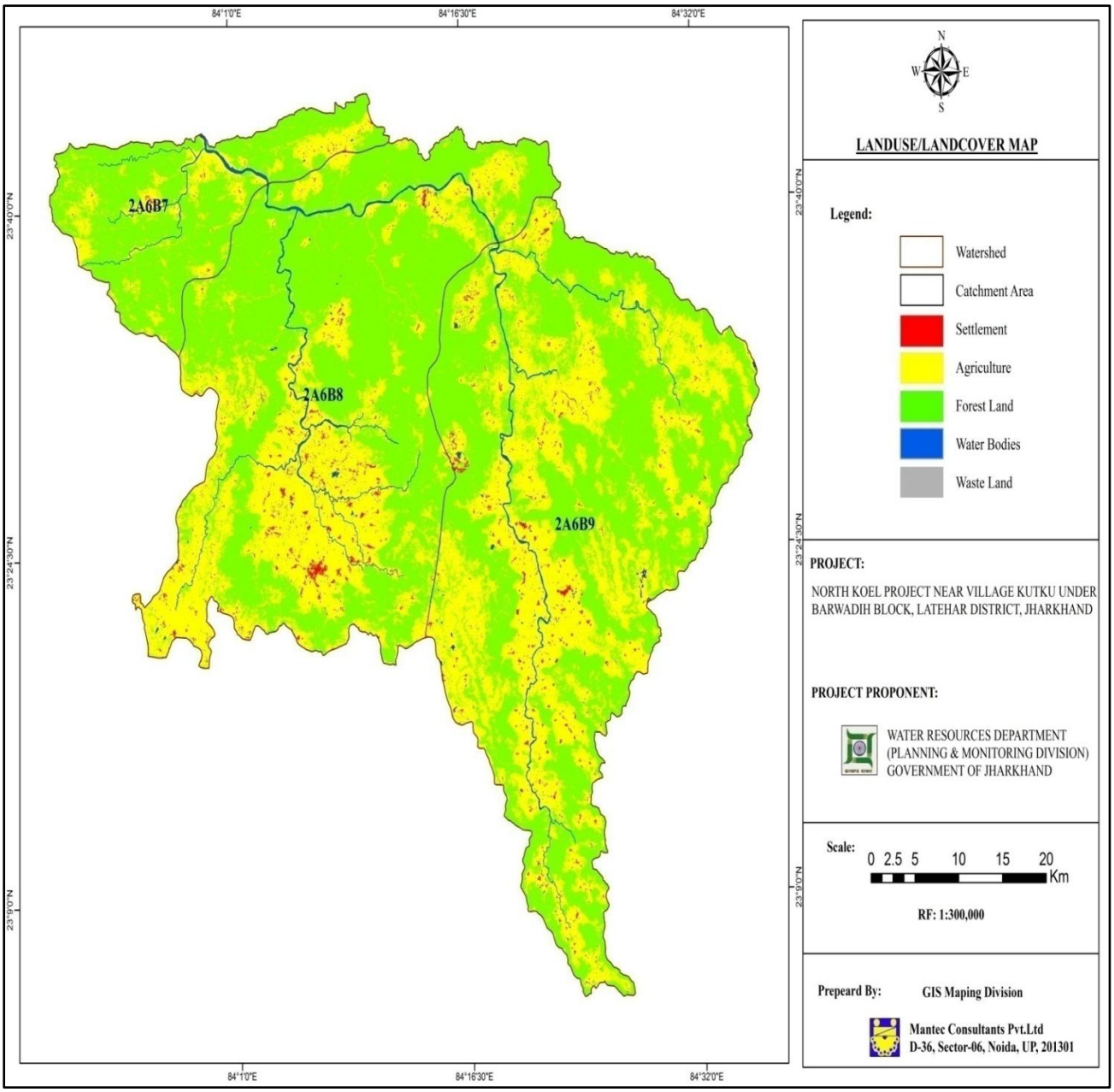


Figure 1.9:Land use Map of Free Draining Catchment Area

Table 1.2:Land Use cover of Free Draining Catchment Area

S. No.	Land use category	Area (Sq-KM)	Area (%)
1.	Agriculture	985	34.14
2.	Settlement	204	7.07
3.	Forest Land	1676	58.09
4.	Waste Land	13	0.45
5.	Water Bodies	7	0.24
	Total		

1.8.1 Slope Map Preparation

- Slope is a measure of change in the value of altitudes over distance, which can be expressed in degrees or as a percent. The first step generation of slope map is to create surface using the elevation values stored in the form of contours or points. Surface is a representation of geographic information as a set of continuous data in which the map features are not spatially discrete, i.e., between any two locations there are no clear or well defined breaks between possible values of the map feature. Models, built from regularly or irregularly spaced sample points on the surface can represent surfaces.
- Slope map of the catchment area was prepared using the elevation information for the area from contour heights. Toposheets of the scale 1:50,000 were collected for the entire directly draining catchment area. These toposheets were then manually pasted together to form a seamless mosaic of the area and the directly drained catchment boundary for the proposed Project was marked on them.
- After marking the catchment area, all the contours on the toposheet were digitized. The output of the digitization procedure was the contours as well as points contour in the form of x, y & z points. (x, y location and z their elevation). All this information was in real world coordinates (latitude, longitude and height in meters above sea level).
- A Digital Elevation Model (DEM) of the area then prepared **Fig.-1.7**, which used to derive a slope map. The slope divided in classes of slope percentages.
- The slope of a watershed plays an important role in controlling the soil and water retention thereby affecting the land-use capability. The percentage of the slope in a watershed determines the soil erosion susceptibility and forms the basis for classifying different watershed into suitable capability classes for formulating suitable soil erosion conservation measures. Broadly, the following slope classes and ranges (**Table 1.3**.) as per norms of All India Soil & Land Use Survey were adopted for the present study. The Slope map of the free draining catchment is presented in **Fig. 1.7**. The slope details are as presented under**Table 1.5**.

Table 0-3: Slope Class

Slope Rank	Slope Range (Degrees)	Description
1	< 20	Very Gentle Slope
2	20 - 35	Gentle Slope
3	35 - 50	Moderate Slope
4	50 - 80	Steep Slop
5	> 80	Very Steep Slope

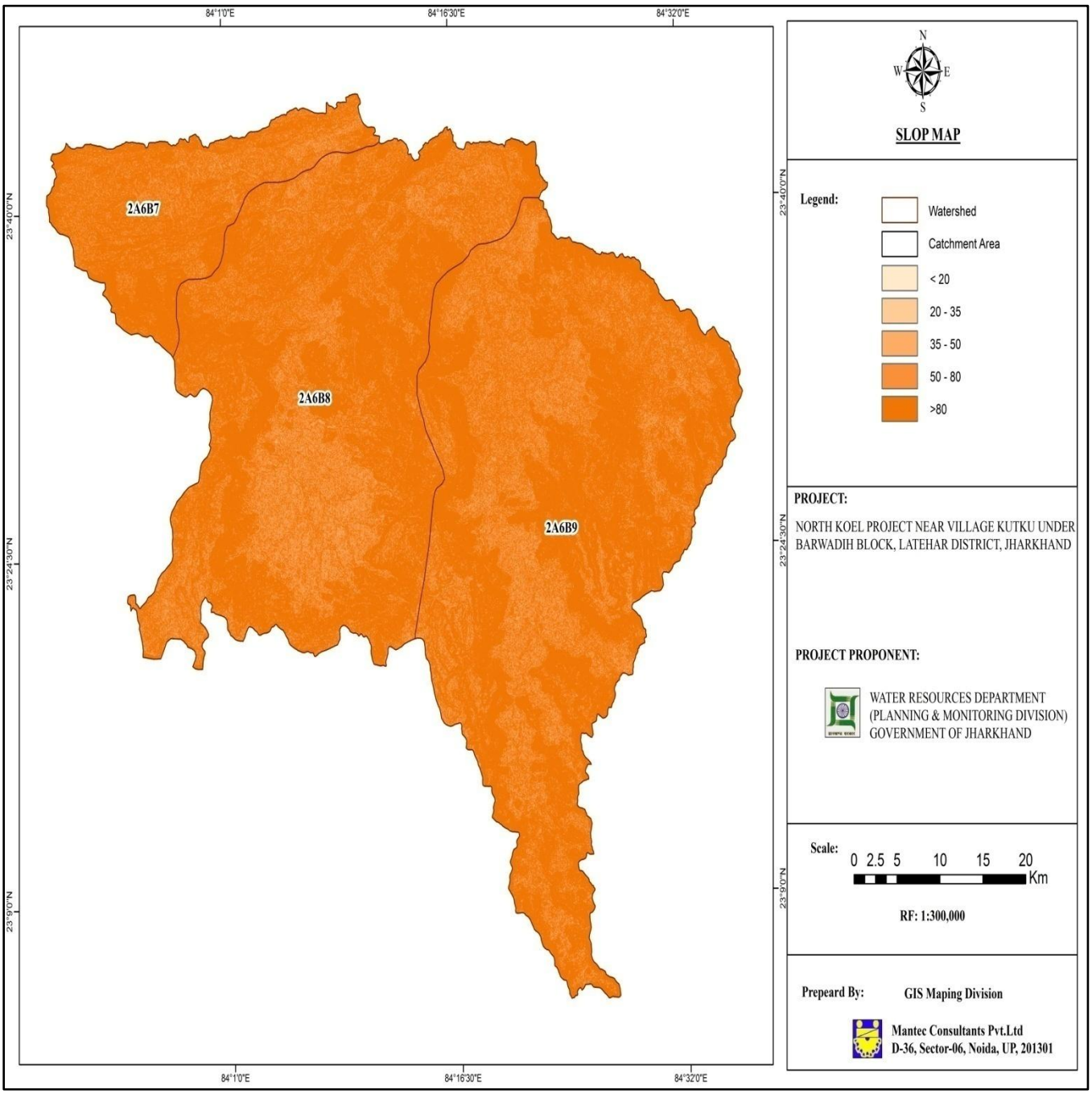


Figure 1.10: Slope Map of Free Draining Catchment Area

Table 0-4: Land use Details of Sub-watersheds in the Free Draining Catchment

Row Labels	AGRICULTURE	SETTLEMENT	FOREST	Waste Land	Water Bodies	Grand Total	% OF TOTAL
2A6B7	161	21	147	2	1	332.00	11.51
2A6B8	354	70	761	5	2	1192	41.32
2A6B9	470	113	768	6	4	1361	47.18
Grand Total	**985**	**204**	**1676**	**13**	**7**	**2885.00**	**100.00**
% of Total	**34.14**	**7.07**	**58.09**	**0.45**	**0.24**	**100.00**	

Table 0-5: Slope Categories in Sub-Watersheds

MWS	0-20	20-35	35-50	50-80	>80	Grand Total	% OF TOTAL
2A6B7	39	58	65	73	97	332	11.51
2A6B8	178	215	229	275	295	1192	41.32
2A6B9	198	252	283	299	329	1361	47.18
Grand Total	**415**	**525**	**577**	**647**	**721**	**2885**	**100.00**
% of Total	**14.38**	**18.20**	**20.00**	**22.43**	**24.99**	**100.00**	

1.9 Soil Loss Using Silt Yield Index (SYI) Method

- The Silt Yield Index Model (SYI), considering sedimentation as product of erosivity, and erodibility was conceptualized in the All India Soil and Land Use Survey (AISLUS) as early as 1963 and has been in operational use since then to meet the requirements of prioritization of smaller hydrologic units within river valley project catchment areas.
- Methodology for the calculation of sediment yield index developed by All India Soil & Land Use Survey (Development of Agriculture, Govt. of India) was followed in this study.

(i) Erosion Intensity and Delivery Ratio

- Determination of erosion intensity unit is primarily based upon the integrated information on soil characters, physiography, slope, land-use/land-cover, lithology and structure. This is achieved through superimposition of different thematic map overlays. Based upon the field data collected during the field survey and published data, weightage value and delivery ration were assigned to each erosion intensity unit. The composite map for delineating different erosion intensity units was prepared through superimposition of the maps showing soil types, slope, and land-use/land-cover. This thematic mapping of erosion intensity for entire catchment was done using the overlay and union techniques. Based on ground truth verification conducted during fieldwork and published data, weightage and delivery ratio was assigned to each erosion intensity units. The composite erosion intensity map was then superimposed on the drainage map with sub-watershed boundaries to evolve CEIU for individual sub-watershed.
- Each element of erosion intensity unit is assigned a weightage value. The cumulative weightage values of the erosion intensity units represent approximately the relative comparative erosion intensity within the watersheds. A basic factor of K=10 was used in determining the cumulative weightage values. The value of 10 indicated an equilibrium condition between erosion and deposition. Any value of K (10+X) is suggestive of erosion intensity in an ascending order whereas the value of K (10-X) is suggestive of deposition intensity in descending order.
- The delivery ratio was calculated for each composite erosion intensity unit. The delivery ration suggests the percentage of eroded material that finally finds entry into the reservoir or river/stream. Total area of different erosion intensity classes (composite erosion intensity unit) in each watershed was then calculated.
- The delivery ratio is generally governed by the type of material, soil erosion, relief length ratio, soil cover conditions, distance from the nearest stream, etc. However, 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 as presented in **Table 1.6**.

Table 0-6: Delivery Ratio (DR) Criteria Adopted for the Project

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

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

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

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

- The Silt Yield Index (SYI) is defined as the Yield per unit area and SYI value for hydrologic unit is obtained by taking weightage arithmetic mean over the entire area of the hydrologic unit by using suitable empirical equation.
- Prioritization of Watersheds/Sub-watershed within the vast catchment is based on the SYI of smaller units. Studying frequency distribution of SYI values and locating suitable breaking points arrive at the boundary valuesor range of SYI values for different priority categories. The watersheds/sub-watersheds is 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 evaluation of:
    - Climatic factors comprising total precipitation, its frequency and intensity
    - Geomorphic factors comprising land forms, physiography, slope and drainage characteristics
    - Surface cover factors governing flow hydraulics
    - Management factors

- The data on climatic factors can be obtained for different locations in the catchment area from the meteorological stations whereas field investigations are required for estimating other attributes. The various steps involved in the application of model are :

    - Preparation of a framework of sub-watershed through systematic delineation
    - Rapid reconnaissance surveys on 1:50,000 scale leading to 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 equation:

Silt Yield Index

SYI = (Ai x Wi x Di) x 100/Aw;

Where i = 1 to n

Ai = Area of i^{th} (EIMU)

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

Di = Delivery ratio

n = No. of mapping units

Aw = Total area of sub-watershed

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

Table 1.7: Classification of SYI for erosion intensity rate

S. No.	Priority Category	SYI Values
1.	Very High	>1300
2.	High	1200-1299
3.	Medium	1100-1199
4.	Low	1000-1099
5.	Very low	<1000
(Refer pp 27-28 of AISLUS Bulletin-99)		

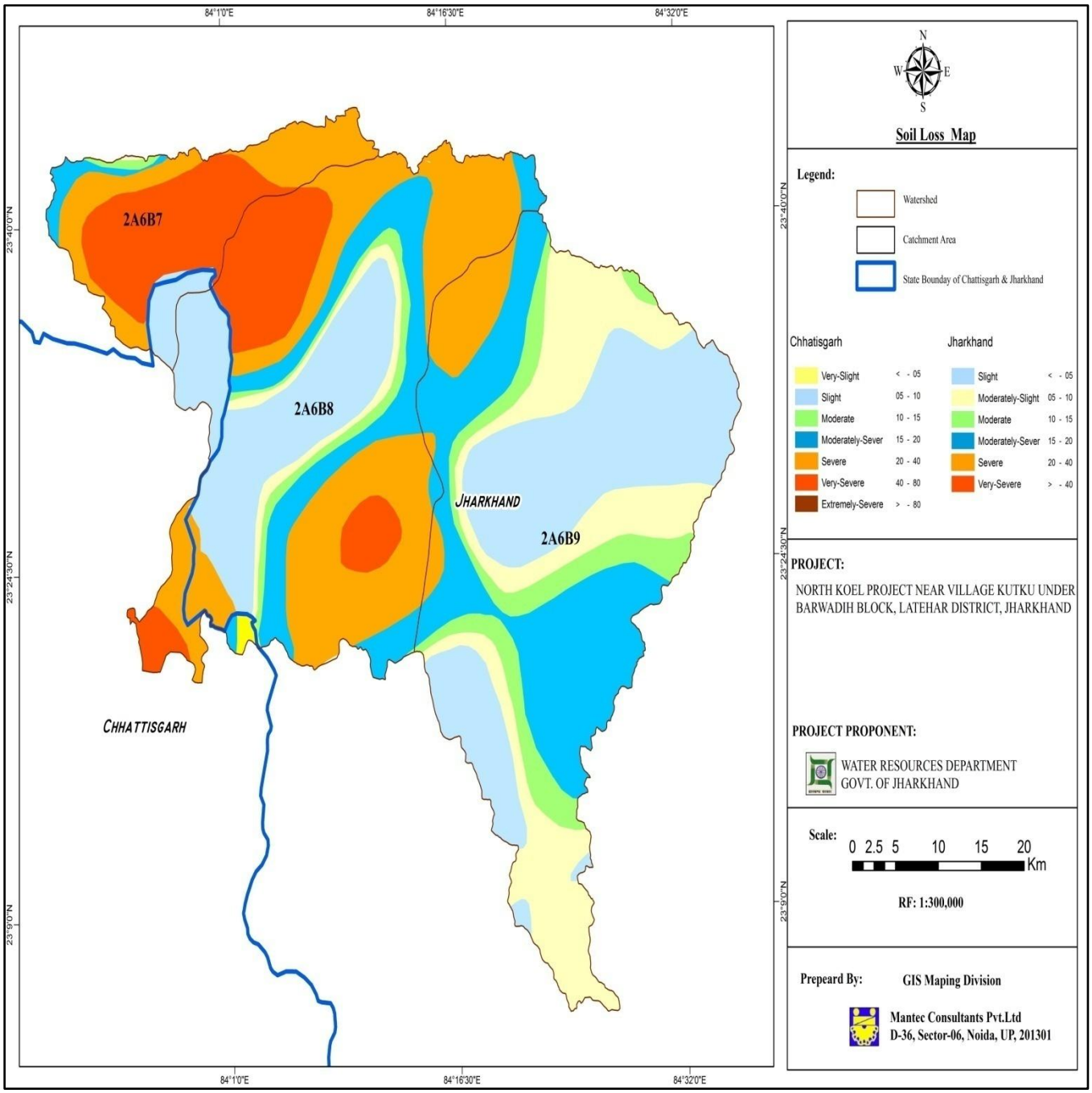


Figure 1.11: Soil Erosion Map of the Catchment Area

Table 1.8 : Silt Yield Index in the Sub Watershed Area

SWS	Erosion Intensity Class	Area (A), S.qm	Weightage (W)	A X W	DR	Gross Silt (EXF)	SYI	Priority
2A6B7	Very Slight		10					
	Slight	99.34	11	330	1	99.39759		
	Moderately Slight	0.72	12	12	0.7	2.53012		
	Moderate	4.73	13	65	0.8	15.66265		
	Moderately Severe	16.38	14	238	0.7	50.18072		
	Severe	117.02	15	1725	0.8	415.6627		
	Very Severe	174.81	16	2624	0.8	632.2892		
	Extremely Severe		17					
Total		**413.00**					**1215.7**	**High**
2A6B8	Very Slight	5.91	10	60	0.9	7.573633		
	Slight	223.01	11	3168	1	444.3198		
	Moderately Slight	44.00	12	540	0.8	60.58906		
	Moderate	40.82	13	533	0.8	59.80365		
	Moderately Severe	195.55	14	42	0.7	4.123422		
	Severe	446.14	15	3090	0.5	216.69		
	Very Severe	164.57	16	1984	0.6	166.9565		
	Extremely Severe		17					
Total		**1120.00**					**960.06**	**Very Low**
2A6B9	Very Slight		10	0	0			
	Slight	447.09	11	4917	1	361.2785		
	Moderately Slight	354.00	12	4248	0.8	249.6988		
	Moderate	148.11	13	1937	0.9	128.0896		
	Moderately Severe	332.23	14	4704	0.9	311.0654		
	Severe	70.57	15	1125	0.8	66.12785		
	Very Severe		16					
	Extremely Severe		17					
Total		**1352.00**					**1116.3**	**Medium**

The objective of the SYI method is to prioritize sub-watershed in a catchment area for treatment. There is 2A6B7 under high erosion category area. certain engineering and biological measures are proposed to avoid accumulation of silt in the reservoir. Area under sever to extensive severe are identified for the treatment.

Area under Severe Erosion:	633.74 Ha	
Area under Very Severe Erosion:	339.39 Ha	
Total Treatment Required:	973.12 Ha	(34% of Total catchment area)

1.10 Treatment Measures

Watershed management is the optimal use of soil and water resources within a given geographical area sustainability of natural resources. Catchment plan proposed integrated watershed management in catchment area according to ridge to valley concept.

The overall objectives of watershed management programme are to:
- increase infiltration into soil;
- control excessive runoff;
- Manage & utilize runoff for useful purpose.

The required Engineering and Biological measures will implement in the catchment area.

1.10.1 Proposed Treatment

The entire catchment area of North Koel Reservoir Project will managed accordingly to integrated watershed management, taken up Micro watershed as a unit. Whole catchment area divided into three watershed and 399 micro watershed.

The 124 Micro watershed area 814.88 sq km falls under Palamu Tiger Reserve taken up into the priority and 30 % of its area should be cover under soil conservation work. 30 % area of 275 Micro watersheds, area 1911.76 outside of PTR but inside the catchment is also cover under soil conservation work. 158.45 sq,km catchment area falls outside of state (Chhattisgarh), Hence this catchment plan didn't proposed any measures for that area.

1.10.2 Component of Treatment

Treatments will conduct under guidelines of Jharkhand Watershed Mission with following components.

Table 1.9 : Treat component

Head	**Components**
Preparatory phase	DPR
Entry Point Activity Institutional and Capacity Building	Entry point activity, PIA H.Q. Share, SHG Promotion, Training on NRM
Natural Resource Management	Soil and Moisture Conservation
	Run off management
	Water harvesting structure
Livelihoods activity Production System & Micro enterprise	Promotion of livelihood in area
Consolidation	Consolidation phase

1.6.2 Detail of Micro Watershed in Catchment Area

Table 1.10 : Detail of Micro Watershed

S.No	**Status of Area**	**Micro watershed**	**Area sqkm**
1	Under Palamu Tiger Reserve	2A6B7b1a	0.00058
2		2A6B7b2b	0.63787
3		2A6B7b1b	5.34354
4		2A6B7b1c	8.54443
5		2A6B7b2a	0.32209
6		2A6B7b2o	3.35492
7		2A6B7b2c	6.32922
8		2A6B7b1c	6.87679
9		2A6B7b2c	9.47815
10		2A6B7b2n	12.87505
11		2A6B7b3g	5.89967
12		2A6B7b3f	4.49688
13		2A6B7b3e	11.86460
14		2A6B7b3i	2.95327
15		2A6B7b3h	8.62532
16		2A6B7b3d	4.20972
17		2A6B7b3b	5.24942
18		2A6B7b3c	2.08895
19		2A6B7b3c	0.88340

20		2A6B7b2k	9.91790
21		2A6B7b2m	4.90466
22		2A6B7b3a	8.15891
23		2A6B7b2e	11.06585
24		2A6B7b1e	8.15527
25		2A6B7b1f	3.14305
26		2A6B7b2f	3.50352
27		2A6B7b2g	2.02061
28		2A6B7b2i	6.91143
29		2A6B7b2h	4.17044
30		2A6B7a4e	5.58372
31		2A6B7b2i	5.74463
32		2A6B7b2j	13.93810
33		2A6B8e1f	5.85068
34		2A6B8e1d	7.92150
35		2A6B8e1b	10.93221
36		2A6B8e1a	8.81223
37		2A6B7a3b	6.88737
38		2A6B7a3a	7.35873
39		2A6B7a3d	7.39113
40		2A6B7a3e	4.92260
41		2A6B7a3c	6.75189
42		2A6B7a3f	15.73917
43		2A6B7a3g	7.72103
44		2A6B8a1f	6.60618
45		2A6B8a2a	6.55097
46		2A6B8a1e	3.64106
47		2A6B8a1c	9.96069
48		2A6B8a1b	8.56662
49		2A6B8a1a	13.64529
50		2A6B8a1d	5.48976
51		2A6B8e1c	7.05976
52		2A6B8b1b	7.99047
53		2A6B8b1a	9.79638
54		2A6B8b1e	12.07894
55		2A6B8b1c	5.76800
56		2A6B8b3a	4.26186
57		2A6B8a1g	10.37840
58		2A6B8a2b	7.58784
59		2A6B8a2c	9.74771
60		2A6B8a3a	3.55427
61		2A6B8a3b	3.49511
62		2A6B8a3c	11.17482
63		2A6B8b2b	4.87588
64		2A6B8b2a	10.50243

65		2A6B8b2c	4.91138
66		2A6B8b5a	7.45925
67		2A6B8b1d	11.49483
68		2A6B8e1e	4.14386
69		2A6B8a3d	1.11168
70		2A6B9a1c	1.55800
71		2A6B8a3e	0.01396
72		2A6B8b3f	1.31743
73		2A6B8b3b	10.11063
74		2A6B8b3k	6.98868
75		2A6B8b3c	4.43227
76		2A6B8b3d	0.16158
77		2A6B8b3j	7.54176
78		2A6B8b3e	7.83429
79		2A6B8b3g	3.30331
80		2A6B8b3i	7.59153
81		2A6B8b3h	5.54350
82		2A6B8b2d	16.44864
83		2A6B9j1b	5.86795
84		2A6B9j1c	7.93857
85		2A6B8b2f	9.62219
86		2A6B8b2e	7.88264
87		2A6B8b5b	5.98537
88		2A6B8b5c	2.52525
89		2A6B8b5d	5.77449
90		2A6B8b5e	11.05807
91		2A6B8b4a	6.59261
92		2A6B8b5f	9.19967
93		2A6B8c1a	2.25338
94		2A6B8c2b	4.50827
95		2A6B8b4b	12.00333
96		2A6B9j1a	5.56215
97		2A6B9j1e	5.30018
98		2A6B8b4c	8.66479
99		2A6B9i1b	12.58777
100		2A6B8c2a	0.34898
101		2A6B8c2e	0.21418
102		2A6B8c2c	1.86926
103		2A6B8c2d	0.57218
104		2A6B8b4d	19.28551
105		2A6B9i1a	13.72300
106		2A6B9i1c	14.71988
107		2A6B8c3a	11.10880
108		2A6B8c3d	5.46037
109		2A6B8e2c	1.27170

110		2A6B8e2a	12.70265
111		2A6B8e2b	13.29665
112		2A6B8e3j	0.26077
113		2A6B8c7d	0.30579
114		2A6B8c3b	7.22601
115		2A6B8c4d	0.04694
116		2A6B8c3c	10.20165
117		2A6B9i2a	0.16350
118		2A6B9i1a	3.60675
119		2A6B9j1d	0.93420
120		2A6B9j1f	10.89587
121		2A6B9i1d	5.04803
122		2A6B9i1f	6.31476
123		2A6B9i1e	5.96934
124		2A6B9i1g	3.76925
	Sub Total		**814.88222**
125	Area Out Side Of Palamu Tiger Reserve	2A6B9b2d	12.14127
126		2A6B7b1a	9.05695
127		2A6B7b2b	4.41289
128		2A6B7b1b	4.03877
129		2A6B7b1c	1.04265
130		2A6B7b2a	11.18127
131		2A6B7b2o	7.25810
132		2A6B7b2c	0.02775
133		2A6B7b1c	0.83751
134		2A6B7b3g	8.10643
135		2A6B7b3f	2.28391
136		2A6B7b3e	1.87045
137		2A6B7b3h	1.52508
138		2A6B7b3d	0.02152
139		2A6B7b3b	0.04407
140		2A6B7b3c	1.21952
141		2A6B7b3c	0.00966
142		2A6B7b2k	0.01126
143		2A6B7b1e	0.25785
144		2A6B7b1f	0.23772
145		2A6B7b2f	2.49799
146		2A6B7b2g	1.25679
147		2A6B7b2h	0.34641
148		2A6B7a4e	8.83803
149		2A6B7b2i	0.06998
150		2A6B7b2j	0.00170
151		2A6B8e1f	0.00089
152		2A6B8e1b	0.08561
153		2A6B7a3b	0.15166

154		2A6B7a3a	3.32452
155		2A6B7a3g	0.04125
156		2A6B8a2b	0.31309
157		2A6B8a2c	0.30302
158		2A6B8a3a	6.39386
159		2A6B8a3b	3.40606
160		2A6B8a3c	3.49977
161		2A6B8b5a	0.70211
162		2A6B8a3d	4.53083
163		2A6B9a1e	14.24889
164		2A6B9a1c	9.75693
165		2A6B9a1d	5.97369
166		2A6B8a3f	12.04122
167		2A6B8a3e	11.50401
168		2A6B9a1b	6.93136
169		2A6B8b3f	1.41767
170		2A6B8b3k	0.12628
171		2A6B8b3c	2.15846
172		2A6B8b3d	7.87972
173		2A6B8b3e	3.49058
174		2A6B8b3g	0.85561
175		2A6B9j1b	3.02715
176		2A6B9j1c	5.28963
177		2A6B9a1a	5.49618
178		2A6B8b5b	0.07413
179		2A6B8b5c	5.22976
180		2A6B8b5d	6.89998
181		2A6B8b5e	0.56634
182		2A6B8b5f	1.89825
183		2A6B8c1a	7.68892
184		2A6B8c2b	5.30496
185		2A6B9j1a	0.66966
186		2A6B9j1e	1.77437
187		2A6B9j2a	7.75591
188		2A6B9j2b	8.65016
189		2A6B9j2e	4.52635
190		2A6B9j2d	8.62305
191		2A6B8c2a	8.60133
192		2A6B8c1b	7.70185
193		2A6B8c2e	8.77506
194		2A6B8c2c	4.14262
195		2A6B8c2d	4.68767
196		2A6B8c3a	0.00135
197		2A6B8c3d	2.83557
198		2A6B8c1c	8.83974

199		2A6B8e2c	9.83407
200		2A6B8c3a	5.03451
201		2A6B8e3b	8.67892
202		2A6B8e3c	5.88752
203		2A6B8c8d	5.82648
204		2A6B8e3d	8.88397
205		2A6B8e3g	5.06605
206		2A6B8d1a	6.99106
207		2A6B8e2a	0.22192
208		2A6B8e2b	1.30652
209		2A6B8e3j	1.52028
210		2A6B8e2d	4.35484
211		2A6B8e1k	11.81979
212		2A6B8e3e	7.61163
213		2A6B8e3f	9.66211
214		2A6B8e4a	9.48714
215		2A6B8d1c	10.83796
216		2A6B8c8a	3.51161
217		2A6B8c8c	6.33190
218		2A6B8c8b	5.16287
219		2A6B8c8e	6.76304
220		2A6B8c7c	6.13219
221		2A6B8c8f	6.45945
222		2A6B8c7a	4.72871
223		2A6B8c7b	5.81287
224		2A6B8c7d	7.23045
225		2A6B8c4b	3.84785
226		2A6B8e4b	10.76218
227		2A6B8d1b	10.20940
228		2A6B8e4c	5.82533
229		2A6B8d2a	8.68977
230		2A6B8d1b	13.80142
231		2A6B8d1d	12.13310
232		2A6B8e4d	3.52233
233		2A6B8d2d	13.37054
234		2A6B8d2e	7.80308
235		2A6B8d2c	11.54670
236		2A6B8c6e	6.57798
237		2A6B8d2b	7.27334
238		2A6B8c4a	6.79984
239		2A6B8c6b	9.84846
240		2A6B8c6a	11.15410
241		2A6B8c6d	10.88078
242		2A6B8c6c	24.15746
243		2A6B8c5c	13.97344

244		2A6B8c5d	15.89546
245		2A6B8c5b	10.26735
246		2A6B8c3b	0.02664
247		2A6B8c6a	11.84350
248		2A6B8c4j	6.53286
249		2a6b8c4h	5.98026
250		2A6B8c4f	10.28115
251		2A6B8c4g	4.38218
252		2A6B8c4i	8.63874
253		2A6B8c4c	8.72439
254		2A6B9g1d	5.68701
255		2A6B9g1e	7.67851
256		2A6B9g1f	12.13169
257		2A6B9g1g	5.01216
258		2A6B8c4e	7.32535
259		2A6B9g1b	5.98665
260		2A6B9g1c	9.64715
261		2A6B9g2b	10.25110
262		2A6B9g2c	8.63935
263		2A6B9i2t	8.79644
264		2A6B9g2e	4.06875
265		2A6B9g2d	6.26825
266		2A6B9e1f	7.87317
267		2A6B9g1a	7.22513
268		2A6B8c4d	9.97271
269		2A6B8c3c	4.51858
270		2A6B9e1a	9.07495
271		2A6B9d2a	2.81126
272		2A6B9d2b	8.29575
273		2A6B9d1a	8.19120
274		2A6B9d1b	6.58621
275		2A6B9d1c	8.53320
276		2A6B9d2c	5.85846
277		2A6B9i2a	11.30885
278		2A6B9i1a	12.21945
279		2A6B9i1b	6.16983
280		2A6B9i2b	9.50822
281		2A6B9i2c	11.84030
282		2A6B9i2c	5.85355
283		2A6B9i2b	7.43093
284		2A6B9i2d	10.94350
285		2A6B9i2e	12.43289
286		2A6B9i2g	13.08051
287		2A6B9i2h	8.50921
288		2A6B9i2h	6.87602

289		2A6B9i2g	5.89791
290		2A6B9i3a	5.09447
291		2A6B9i2e	11.11978
292		2A6B9i2f	13.26047
293		2A6B9i3c	4.39006
294		2A6B9i3e	7.04255
295		2A6B9i2d	6.27500
296		2A6B9i2a	5.11619
297		2A6B9i3b	5.08994
298		2A6B9i1i	9.06392
299		2A6B9i1h	9.05017
300		2A6B9c1a	8.45933
301		2A6B9i3d	5.41445
302		2A6B9d1d	10.23411
303		2A6B9d1e	5.01792
304		2A6B9g3d	9.26654
305		2A6B9d2f	5.17636
306		2A6B9c1e	9.14728
307		2A6B9c1d	7.15591
308		2A6B9c1c	6.72112
309		2A6B9c1b	13.69945
310		2A6B9c2d	6.07986
311		2A6B9c2f	8.92212
312		2A6B9c2e	7.13600
313		2A6B9c2c	9.22899
314		4H1F3b4a	1.52409
315		2A6B9c2g	5.96079
316		2A6B9b1i	4.53557
317		2A6B9b1h	8.18880
318		2A6B9b1g	7.43698
319		2A6B9c2b	12.57895
320		2A6B9b1j	12.11438
321		2A6B9a1f	15.39375
322		2A6B9a2g	5.06598
323		2A6B9j3c	10.85047
324		2A6B9j5b	5.84278
325		2A6B9j5a	6.53570
326		2A6B9j5c	7.38348
327		2A6B9j5c	8.82609
328		2A6B9j2c	7.15118
329		2A6B9j3a	14.65563
330		2A6B9j3b	5.14999
331		2A6B9j1d	5.68798
332		2A6B9j1f	0.69059
333		2A6B9i1d	1.19505

334		2A6B9i1f	0.06341
335		2A6B9i1e	8.84355
336		2A6B9j1f	8.82423
337		2A6B9i1g	17.67034
338		2A6B9j4c	3.87854
339		2A6B9j4b	14.79882
340		2A6B9a2a	10.20776
341		2A6B9a2b	8.62662
342		2A6B9bfb	10.91588
343		2A6B9b1a	7.01006
344		2A6B9a2d	9.57267
345		2A6B9a2c	9.11253
346		2A6B9b2b	10.32650
347		2A6B9b2a	9.57966
348		2A6B9a2e	6.37946
349		2A6B9a2f	3.02294
350		2A6B9j3d	11.15353
351		2A6B9b1n	10.01316
352		2A6B9b1c	5.83339
353		2A6B9b1d	6.05119
354		2A6B9j5e	10.52042
355		2A6B9c2a	12.77664
356		2A6B9b1l	12.66517
357		2A6B9b2g	7.20784
358		2A6B9b2f	6.97443
359		2A6B9b1m	15.28255
360		2A6B9b1k	9.00291
361		2A6B9b1e	7.17044
362		2A6B9b1f	6.88258
363		2A6B9b2e	9.39123
364		2A6B9b2c	5.85080
365		2A6B9f2a	10.10180
366		2A6B9f2b	9.01865
367		2A6B9f2e	5.79247
368		2A6B9f2g	9.29062
369		2A6B9f2f	7.67915
370		2A6B9f1e	7.09421
371		2A6B9f1d	10.78043
372		2A6B9f2d	9.22601
373		2A6B9f2c	4.25830
374		2A6B9f1f	9.21689
375		2A6B9f1a	7.25904
376		2A6B9f1a	11.67935
377		2A6B9g1h	8.41377
378		2A6B9g3a	10.04968

379		2A6B9g2a	8.10563
380		2A6B9g2f	7.39091
381		2A6B9e1b	5.77071
382		2A6B9d2e	3.90778
383		2A6B9d2d	5.73694
384		2A6B9e1c	6.46593
385		4H1F2o4f	1.19788
386		2AB9g3c	8.42795
387		2A6B9g3e	7.52050
388		2A6B9g3f	9.86123
389		2A6B9f1c	9.02839
390		2A6B9c2f	10.17124
391		2A6B9f1b	5.31896
392		2A6B9c2e	11.09154
393		2A6B9e2d	10.29197
394		2A6B9e2c	6.09997
395		2A6B9g3b	9.44710
396		2A6B9e1e	7.21693
397		2A6B9e1d	6.67744
398		2A6B9e2b	8.41077
399		2A6B9e2a	5.02316
	Sub Total		**1911.76709**
	Area outside of State (Chhattishgarh)		158.45
Total			2885.09931

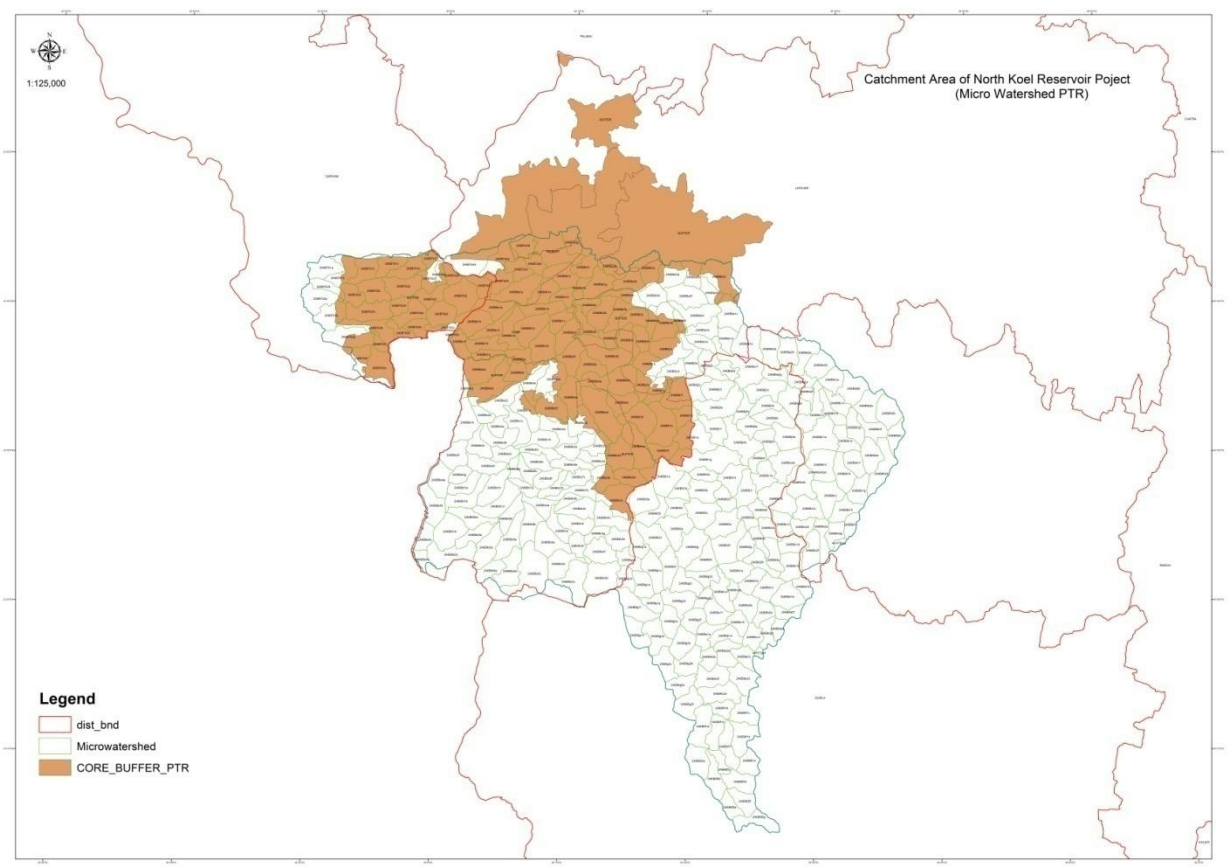


Fig no. 1.12 Micro watershed overlaps with PTR

CAT Plan for Proposed North Koel Project, Jharkhand

1.11 Cost Estimation

The cost required for Catchment Area Treatment is calculated by taking rate of INR 15000/*- per ha for Integrated Watershed Management.

(*15000/ is a standard rate used by Jharkhand State Watershed Mission for Integrated Watershed Management)

1.11.1 Requirement estimated of **Fund** for Soil & conservation Measures as per integrated watershed management.

Table 1.11 Details of required fund

S.No	Item	Total area of Micro Watershed (ha)	30 % of Area Proposed (ha)	Rate per ha	Total Amount in Lakh (INR)
1	Inside Palamu Tiger Reserve (124 Micro Watershed)	81488.22	24446.47	15000	3666.97
2	Out Side Palamu Tiger Reserve (124 Micro Watershed)	191176.71	57353.01	15000	8602.95
	Total	272664.93	81799.48	30000.00	12269.92

Ex-Engineer
Planning & Monetring Division
Medininagar

Approved.
30/1/17
मुख्य अभियंता
जल संसाधन विभाग
मेदिनीनगर

Mantec Consultants Pvt Ltd, Noida Page 44

WATER RESOURCES DEPARTMENT
GOVERNMENT OF JHARKHAND