ಕರ್ನಾಟಕ ನೀರಾವರಿ ನಿಗಮ ನಿಯಮಿತ
(ಕರ್ನಾಟಕ ಸರ್ಕಾರದ ಉದ್ಯಮ)
KARNATAKA NIRAVARI NIGAM LIMITED
(A Karnataka Government Enterprise)
Office of the Executive Engineer, KNNL GRBCC Div No 3 Gokak. Dst : Belagavi, St : Karnataka
Fax & Phone No 08332-225213 email: knnlgrbccd3.gokak@gmail.com

No : KNNL/GRBCC D-3/PB/GB/Forest/2022-23/ 2716 Dt: 3/1/2023

To,
The Deputy Conservator of Forests,
Ghataprabha Forest Division,
Gokak.

Sub: Diversion of 575.0749 Ha of Forest land for the construction of dam across Markandeya River and ancillary infrastructure in forest lands of Gokak, Godachinamalki, Konnur and Mavanura villages in Gokak and Hukkeri Taluks, Belagavi District for storing 6 TMC of water under Ghatti-Basavanna Drinking Water Supply Project by KNNL, Govt. of Karnataka (Online Proposal no. FP/KA/WATER/65437/2020) – Submission of EDS reply-reg

Ref: 1.EDS Query Raised by PCCF Bangalore on E- 322819 Dt : 26-12-2022.
2. DCF Ghataprabha Division Gokak Letter No : B2/Land/ G.Basavanna/ FC/2022-23 Dt : 03-01-2023

****

Sir,

With reference to above cited subject, please find the compliance to the observations raised under cited referred letters.

Sl.No	Observation	Compliance
1.	The 8.44 Ha of Dam view point is isolated at a distance from the Dam. The reason for having an isolated patch of land and proper justification for requiring such a large area of 8.44 Ha for the purpose of view point may be furnished.	The height of the dam being very high, it is necessary to provide watch tower at higher land where submergence and spillway portion can be watched continuously. On study of topo-sheet, the highest land available is on the right flank where the above activity can be controlled. Hence Dam View Point is located at highest point. Alternative locations are tried for this watch tower and dam View Point which are not feasible. Hence, the same is proposed. The nomenclature followed is dam view point but technically this is the highest point which will be used for assembling the people during disaster (Safe assembly point) and also place for safe evacuation. During any major disaster, people cannot be shifted towards the downstream since it will be under heavy floods and the evacuation has to be done to a higher elevation, and hence this location has been selected.

Sl.No	Observation	Compliance
2.	The 0.27 Ha of Nirvaneppa Temple located in Sy No. 410 of Gokak village and Taluk will be submerged after the project is completed. The measures taken for shifting the temple to another location may be furnished.	Nirvaneppa Temple is located in Sy No. 410 of Gokak village in Gokak Taluk and it will be submerged after the project is completed & is the part of R & R Scheme. For implementation of R & R Scheme, KNNL has submitted the proposal to Additional Chief Secretary to Govt. WRD, Vikas Soudha Bangalore for appointing the Administrator for R & R and for formation of R & R Committee as per the Right to Fair Compensation and Transparency in Land Acquisition and R & R Act 2013 through Govt Notification. Hence measures to be taken for shifting the temple to another location will be decided by the Administrator for R & R after conducting the Gram Sabha & Public hearing in the project affected area. However as per preliminary information collected by user agency from the people of the project affected area, it is planned to protect the said temple with water retaining structure without shifting the temple to another location.

Further, it is also enclosed the Catchment Area Treatment Plan for onward consideration please.

In this regard, it is requesting to consider the above justifications for onward sending the proposal to the State Government for necessary action.

Yours faithfully,

Executive Engineer,
KNNL, GRBCC-Div No-3,Gokak.

CATCHMENT AREA TREATMENT PLAN

Prepared for

GHATTI BASAVANNA DRINKING WATER PROJECT

"Construction of Ghatti Basavanna Dam across Markandeya River in Gokak Taluk, Belagavi District, Karnataka".

Project By

KARNATAKA NEERAVARI NIGAM LTD.

KARNATAKA NEERAVARI NIGAM LIMITED

(A Government of Karnataka Undertaking)

JANUARY 2023

TABLE OF CONTENT

1. INTRODUCTION ---- **1**

2. IMPORTANCE OF CATCHMENT AREA TREATMENT ---- **1**

2.1 OBJECTIVES OF THE CAT ---- 2

3. ABOUT THE PROJECT ---- **3**

3.1 GHATTI BASAVANNA DRINKING WATER PROJECT ---- 3

3.1.1 Objective of the project ---- *3*

3.1.2 Need for the project ---- *4*

3.2 PROJECT COMPONENTS ---- 4

4. STUDY AREA ---- **6**

4.1 THE RIVER MARKANDEYA ---- 7

4.2 CATCHMENT AREA ---- 7

5. CHARACTERISTICS OF CATCHMENT ---- **7**

5.1 SOIL ---- 7

5.2 DRAINAGE ---- 9

5.3 ELEVATION ---- 10

5.4 WATERSHED ---- 11

5.5 LAND USE AND LAND COVER ---- 12

6. MATERIALS AND METHODS ---- **13**

6.1 ESTIMATION OF SOIL LOSS ---- 14

6.2 EROSION INDEX (EI30) VALUES ON STORM BASIS ---- 15

6.3 SOIL ERODIBILITY FACTOR (K) ---- 16

6.4 NOMOGRAPH METHOD ---- 16

6.5 DETERMINATION OF LS ---- 17

6.6 EVALUATION OF CROPPING MANAGEMENT FACTOR (C) ---- 17

7 RESULTS AND DISCUSSIONS ---- **18**

7.1 SLOPE MAP ---- 18

7.2 SOIL EROSION ---- 20

7.3 WATERSHED DETAILS ---- 21

8. CATCHMENT AREA TREATMENT PLAN ---- **23**

8.1 SOIL AND WATER CONSERVATION ---- 23

8.1.1 Engineering methods ---- *23*

8.1.2 Biological Methods ---- *25*

8.2 INFRASTRUCTURE DEVELOPMENT ---- 27

8.3 CAT PLAN MONITORING ---- 28

9. COST ESTIMATES FOR THE IMPLEMENTATION OF CAT PLAN -------- ERROR! BOOKMARK NOT DEFINED.

LIST OF TABLE

TABLE 5.1 WATERSHED AREA DETAILS 12
TABLE 5.2 LAND USE AND LAND COVER CLASSIFICATION 13
TABLE 7.1 SUB CATCHMENT/WATERSHED OF THE CATCHMENT AREA 21
TABLE 7.2 WATERSHED CLASSIFICATION OF STUDY AREA 21
TABLE 7.3 ESTIMATION OF SOIL LOSS IN WATERSHEDS IN THE PROPOSED STUDY AREA 21
TABLE 7.4 ERRODIBILITY INDEX 22
TABLE 8.2 LIST OF SPECIES RECOMMENDED FOR FODDER DEVELOPMENT ..27

LIST OF FIGURES

FIG 4.1 INDEX MAP OF THE PROJECT 6
FIG 5.1 SOIL CLASSIFICATION MAP OF THE CATCHMENT AREA 8
FIG 5.2 DRAINAGE MAP OF THE CATCHMENT AREA OF THE DAM 9
FIG 5.3 ELEVATION MAP OF THE CATCHMENT AREA 10
FIG 5.4 WATERSHED MAP OF THE CATCHMENT AREA 11
FIG 5.4 LAND USE & LAND COVER MAP OF THE CATCHMENT AREA 13
FIG 7.1 SLOPE MAP OF THE CATCHMENT AREA 19
FIG 7.2 SOIL EROSION MAP OF THE CATCHMENT AREA 20

CATCHMENT AREA TREATMENT PLAN

1. Introduction

It is well established fact that reservoirs formed by diversion structures on rivers are subjected to sedimentation. The process of sedimentation embodies the sequential processes of erosion, entrainment, transportation, deposition and compaction of sediment. The study of erosion and sediment yield from catchments is of utmost importance as the deposition of sediment in reservoir reduces its capacity, and thus affects the water availability for the designated use. The eroded sediment from catchment when deposited on streambeds and banks causes braiding of river reach. The removal of top fertile soil from catchment adversely affects the agricultural production. Thus, a well- designed Catchment Area Treatment Plan is essential to ameliorate the above mentioned adverse process of soil erosion.

Soil erosion may be defined as the detachment and transportation of soil. Water is the major agent responsible for this erosion and it as to be studied as a part of catchment area treatment (CAT) Plan. The soil erosion leads to:

- Loss of production potential
- Reduction in infiltration rates
- Reduction in water holding capacity
- Reduction in water supply

The catchment area treatment plan highlights the management techniques to control erosion in the catchment area of a water resource project. The life span of a reservoir is greatly reduced due to erosion in the catchment area. Adequate preventative measures are thus needed for the treatment of catchment for its stabilization against future erosion[1].

2. Importance of Catchment area treatment

A healthy water catchment provides high-quality drinking water and supports livelihoods such as agriculture, recreational angling, and water

[1] Draft EMP Report Par HEP of Catchment area treatment plan by KVK Par Power Pvt. Ltd.

sports. It also supports local ecosystems so plants, animals, fish, and insects that depend on having healthy water can thrive and flourish.

As per Chapter-9 (Page No. 80-81) of Handbook of guidelines for effective and transparent implementation of the provisions of Forest (Conservation) Act, 1980 issued by Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India, 2019, states that, "*the CAT plan is an important and essential plan for enhancing and* maintaining *the ecological health of the catchment area of the proposed irrigation/ hydroelectric project through site-specific biological and engineering measures for conservation of soil & moisture and management of water regime. Among other provisions, the measures should focus on arresting soil erosion, improving effective drainage in the area and rejuvenation of the degraded eco system in the catchment*"[2].

2.1 Objectives of the CAT

- Understanding the catchment and estimation of soil loss.
- Soil & water conservation by construction of check dams, gully plugging, gabion dams, contour trenches and vegetative structures.
- Plantation of local indigenous tree and shrub species, including rare/medicinal plants.
- Fodder development on the civil/ soyam forest or on revenue/private lands in order to meet the requirement of fodder/small timber/fire wood for the local population with a view to reduce pressure on the natural ecosystem.
- Socio-economic component like supply of CNG connections to the adjoining villagers to reduce burning of fuel wood.
- The infrastructure component like construction of Office buildings for forest staff and Vehicles to Forest Department for monitoring.

[2] Handbook of guidelines for effective and transparent implementation of the provisions of Forest (Conservation) Act, 1980 issued by Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India, 2019

3. About the project

3.1 Ghatti Basavanna Drinking Water Project

The Ghatti Basavanna Drinking Water Project is a project undertaken by the Government of Karnataka to improve drinking water supply needs of Gokak town and surrounding villages including Hukkeri Taluk, Bhailahongla Taluk and Savadatti Taluk. The project also envisages filling up of MI tanks and providing water to industrial needs. The Ghatti Basavanna Drinking Water Project involves diversion of west flowing Markandeya River in Gokak by construction of diversion dam across the river. It is proposed to store 6 TMC of water during monsoon season. The project is exclusively proposed for providing drinking water facilities to Gokak town and surrounding villages including Hukkeri Taluk, Bhailahongla Taluk and Savadatti Taluk.

The project requires a total land of 638.08 Ha. Out of which, forest area is 575.07 Ha (including submergence) and Private area is 63.01 Ha. The private land will be acquired as per the Right to Fair Compensation and Transparency in Land Acquisition Act, 2013. Whereas, the forest land will be diverted as per the provisions of Forest (Conservation) Act, 1980. The total cost of the project is Rs. 990 Crores.

3.1.1 Objective of the project

Ghatti Basavanna Reservoir project will have a storage capacity of about 6.00 TMC. The proposed project is envisaged to address the following Objectives:

- To facilitate in creating storage to meet the Drinking water requirements of Gokak town and surrounding villages, taluks in the Ghataprabha Basin within Karnataka.
- To meet the industrial water requirement in and around Gokak Taluk.
- To feed selected tanks in and around Gokak town to facilitate sustaining livestock and recharging of ground water.
- To protect the Gokak town from inundation during peak floods in Markandeya River.

3.1.2 Need for the project

Gokak is a Taluk headquarters in the Belagavi District of Karnataka state, India. It is located around 70 Km from Belgaum at the confluence of two rivers, the Ghataprabha and the Markandeya. The population of the town according to 2011 census is approximately 135,773.

- Gokak town and its surrounding villages are facing acute drinking water shortage and mostly depended on bore wells to meet their requirements.
- Estimated population of the Gokak town and adjoining 3 towns as per census 2011-12 is 1, 35,715.
- Besides there are nearly 131 number of villages with an estimated population of 4, 76,448.
- Bhailahongla, Saudatti and Hukkeri taluks are also having acute drinking water problems.
- Considering the growth for next 40 years, the estimated drinking water needs will be 2.76 TMC, which includes livestock requirements.[3]

The only nearest source of surface water is Markandeya river. Unfortunately, the river is seasonal and the rainfall is erratic and hence cannot be considered for harnessing the same without storage. Hence construction of a Dam is inevitable to meet the long term objective of proving drinking water from an assured source.

3.2 Project Components

The project construction activities include seating of Dam, retaining wall, construction of dam office, guest office, view point, WTP, Colony, approach roads, steps, rehabilitation centre, etc. across Markandeya river.

Table 3.1 The Details of the Dam[3]

Sl. No.	Particulars	Details
1	Water levels (EL m.)	
	Maximum Water level (MWL)	618.00 m

[3] DPR Vol I Ghatti Basavanna Drinking Water Project Prepared By EI Technologies Pvt Ltd., June 2020.

Sl. No.	Particulars	Details
	Full Reservoir level (FRL)	618.00 m
	Minimum Draw Down Level (MDDL)	566.00m
2	Others	566.00 m (River) sluice)
3	Dead Storage Level	566.00m (0.30 TMC)
4	Free Board (m)	3.00 m
5	Wave height (m)	0.94 m
6	Live Storage (M.cum)	5.74 TMC (162.50 MCM)
7	Capacity (M.cum)	
	Maximum Water Level	618.00 m
	Full Reservoir Level	618.00 m
	Minimum Draw Down Level	565.50 m
	Dead Storage Level	564.00 m

4. Study Area

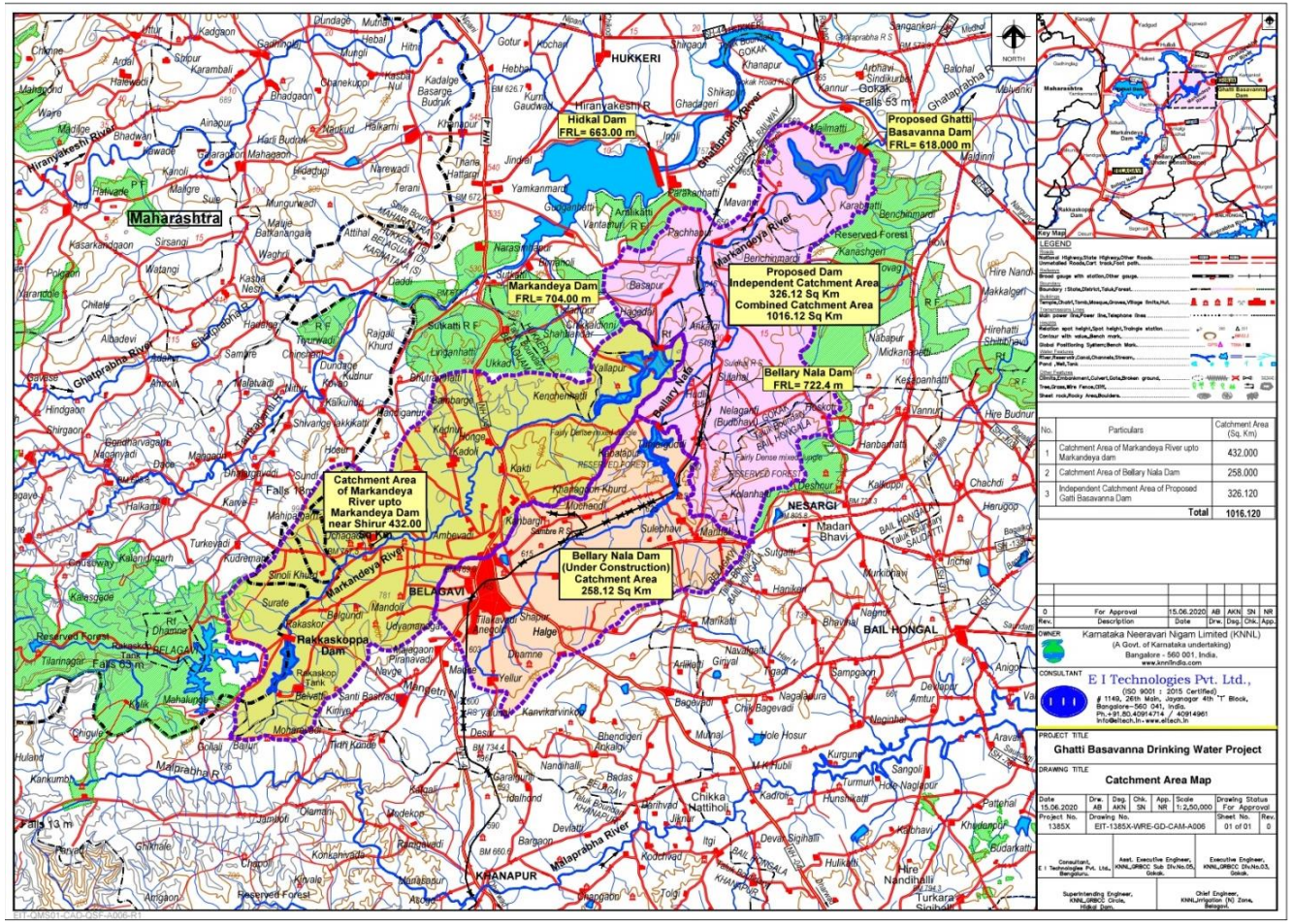


Fig 4.1 Index Map of the Project[4]

[4] DPR Vol III Ghatti Basavanna Drinking Water Project Prepared By EI Technologies Pvt Ltd., June 2020.

4.1 The River Markandeya

Markandeya River (Tributary of Ghataprabha) originates in Bailur village of Khanapur Taluk at an elevation of 927.000 M above mean sea level, in the state of Karnataka (Western Ghats). The river enters Belagavi Taluk on northern side and further flows towards eastern side of the Belagavi city and it is a tributary of Ghataprabha River, Krishna Basin. Markandeya River has a Length 106 Km from origin till it joins Ghataprabha River. It runs for 72 Km in Belagavi Taluk, 21 Km length in Hukkeri Taluk and 13 Km length in Gokak Taluk.

Bellary Nala originates near Yellur village in Belgaum Taluk and is a tributary to Markandeya River. The length of the Nala up to its confluence with Markandeya river is 57 Km.

4.2 Catchment area

The catchment area of the river Markandeya from the origin to the present dam site is 1016.120 Sq. km.

In the present studies the Independent catchment area (i.e., 210 Sq. Km) is considered.

5. Characteristics of catchment

5.1 Soil

The description of Soil type in the catchment area is based upon the Soil map Fig 5.1. There are 4 types of soil observed in the study area i.e.,

1. Very deep, well drained cracking clay soils on slide slopes of plateau, valleys and undulating plains, with moderate erosion: associated with: moderately deep, well drained, clayey soils.

2. Very shallow, well drained, gravelly clay soils with very low AWC on gently sloping plains with moderate erosion: associated with: very deep, well drained, clayey soils.

3. Very shallow, well drained, loamy soil with very low AWC in valleys, with moderate erosion: associated with very deep, well drained, clayey soils.

4. Extremely shallow, excessively drained, loamy soils with stoniness on ridges, with severe erosion: associated with: moderately shallow, well drained, clayey soils with very low AWC.

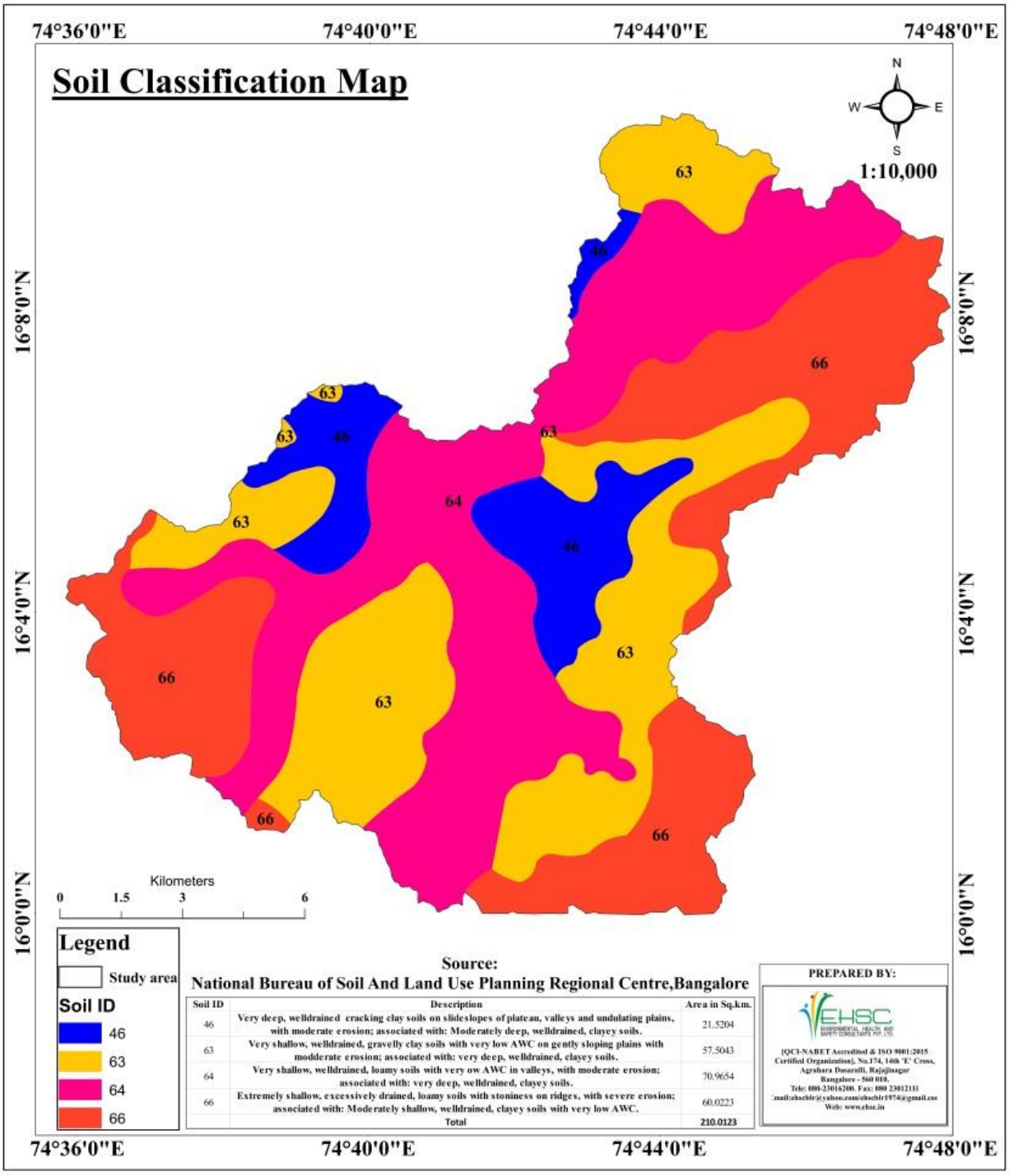


Fig 5.1 Soil Classification Map of the Catchment area

5.2 Drainage

The drainage Pattern of the catchment area of the river Markandeya shows a total of 5 stream orders as shown in the fig 5.2.

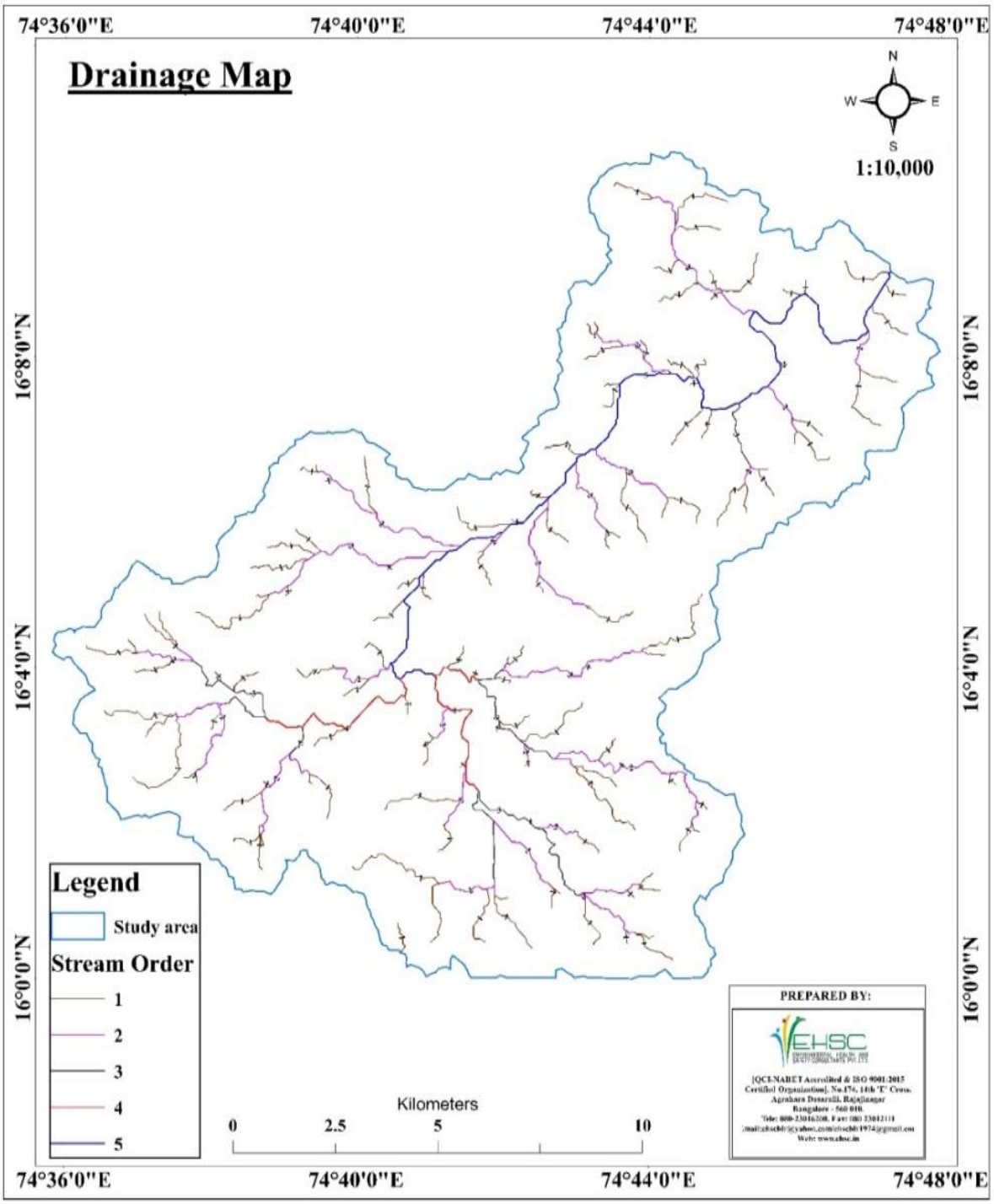


Fig 5.2 Drainage Map of the Catchment area of the Dam

5.3 Elevation

Elevation in the Catchment area ranges from El. 796 m to 1025 m above MSL. However, the Elevation in the Catchment area ranges from 473 to 717m as shown in the Fig 5.3

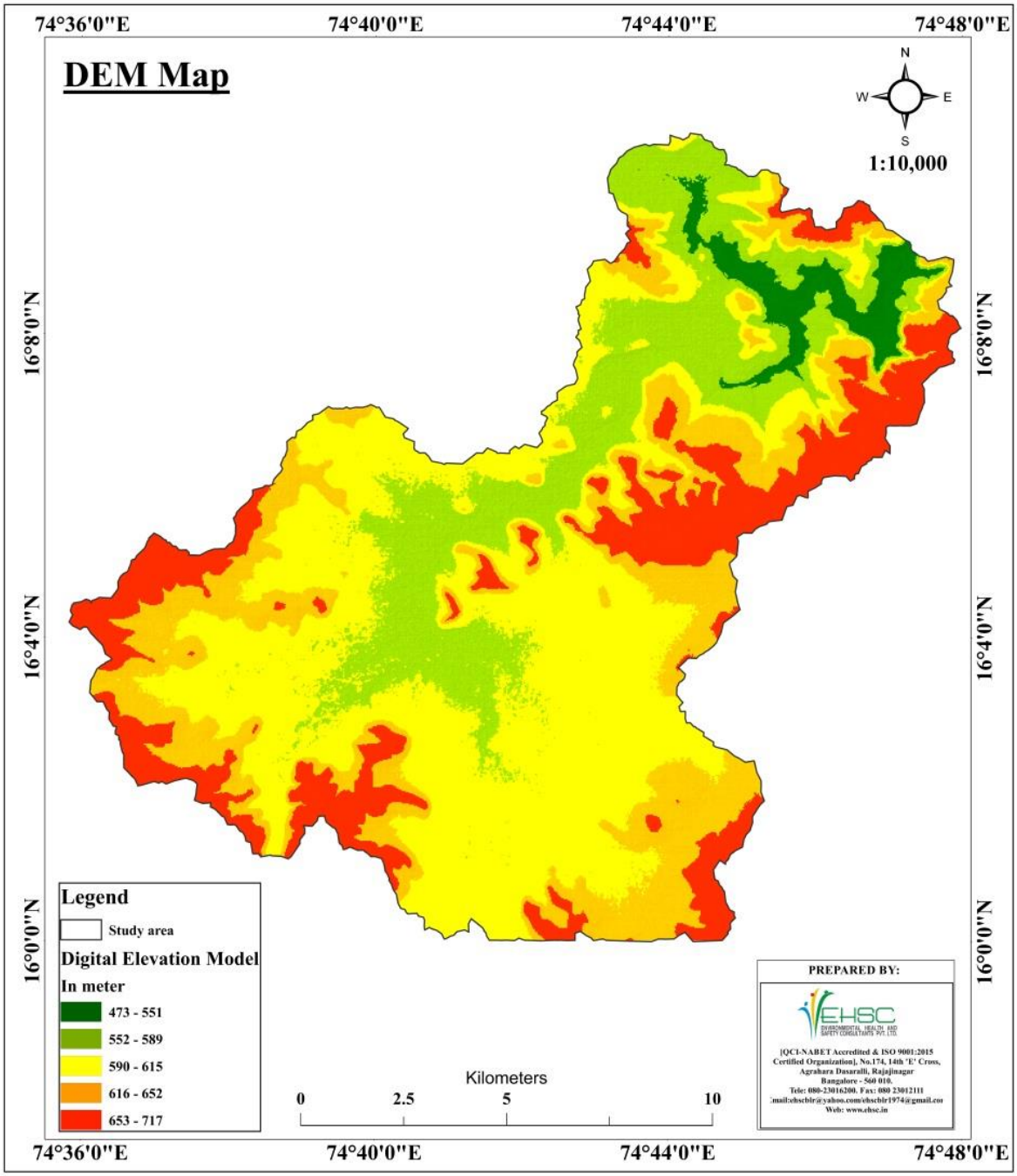


Fig 5.3 Elevation Map of the Catchment area

5.4 Watershed

Based on the Watershed map, total 12 Micro- watersheds are observed in the Catchment area.

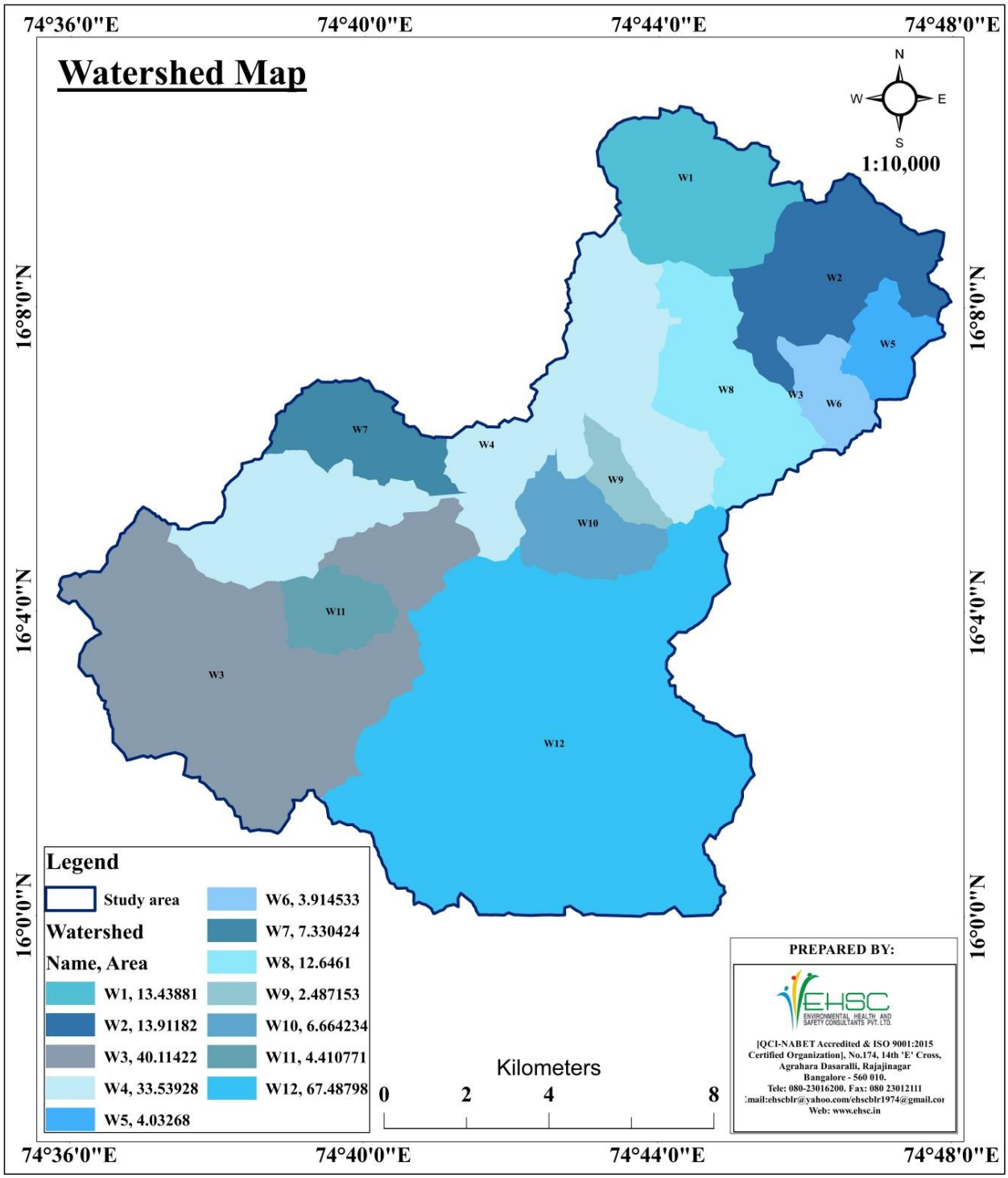


Fig 5.4 Watershed Map of the Catchment area

Table 5.1 Watershed area Details

Sl. No	Watershed Code	Watershed area (Sq. Km)
1	W1	13.43881
2	W2	13.91182
3	W3	40.11422
4	W4	33.53928
5	W5	4.03268
6	W6	3.914533
7	W7	7.330424
8	W8	12.6461
9	W9	2.487153
10	W10	6.664234
11	W11	4.410771
12	W12	67.48798
	Total	**209.978005**

5.5 Land Use and Land cover

The land use and land cover of the entire catchment area consisting of following classes agriculture land (43.58%), Reserve Forest(43.05 %), Sparse vegetation(5.14%), built up(3.29%), Fallow land (3.10 %) and waterbody (0.52%).

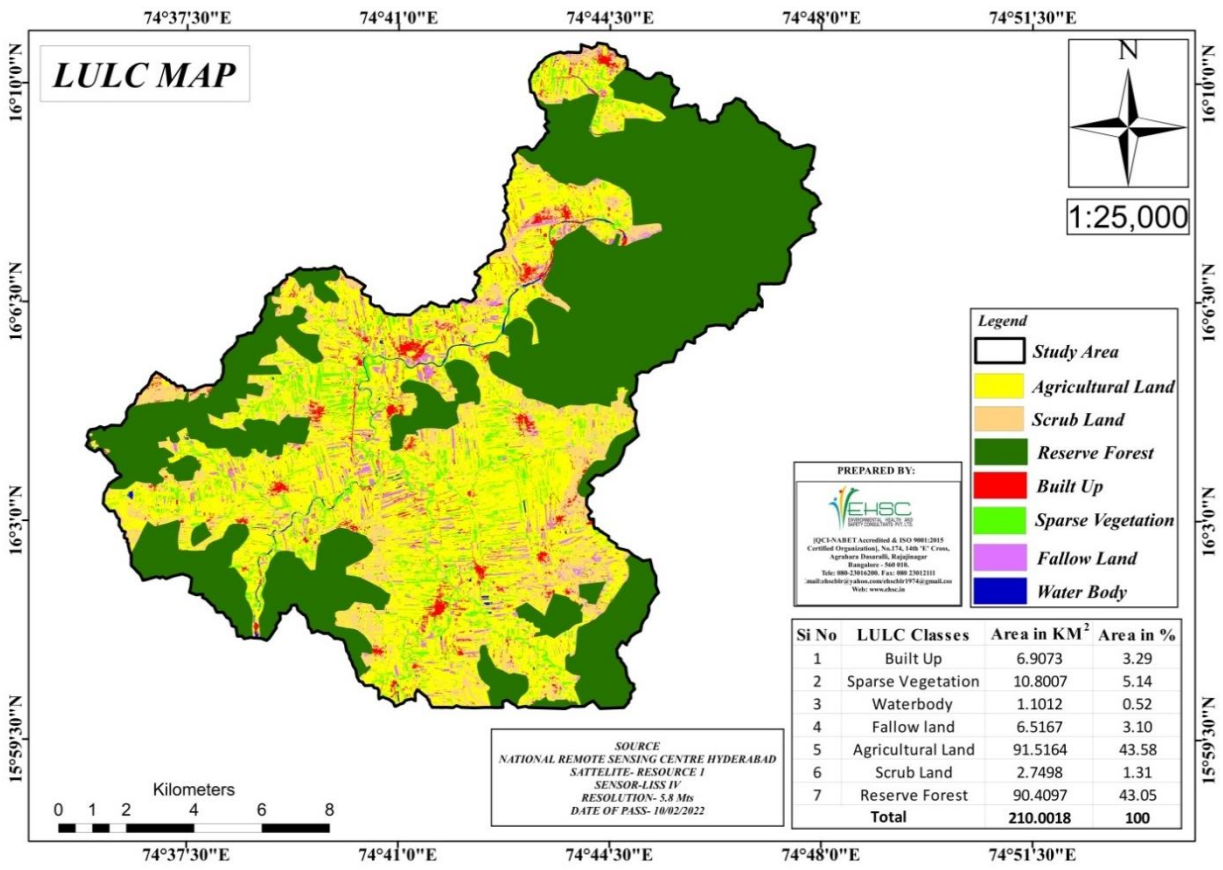


Fig 5.4 Land Use & Land Cover Map of the Catchment area

Table 5.2 Land use and Land cover classification

Sl. No.	LULC Class	Area in Sq. Km	Area in %
1	Built Up	6.9073	3.29
2	Sparse Vegetation	10.8007	5.14
3	Water body	1.1012	0.52
4	Fallow Land	6.5167	3.10
5	Agriculture Land	91.5164	43.58
6	Scrub Land	2.7498	1.31
7	Reserve Forest	90.4097	43.05
Total		**210.0018**	**100**

6. Materials and methods

A catchment characteristic has been collected through secondary data and forest working plan. Estimation of soil loss in the catchment area has been calculated using Universal Soil Loss equation. Further, using the publications of All India Soil Survey and Land Use Board Watershed

boundaries has been demarcated and based on the site conditions and requirements of MOEF&CC, engineering and biological remedial measures were suggested. Detailed analysis of estimation of soil loss in the study area is given below;

6.1 Estimation of Soil Loss

A number of methods for assessing soil loss have been developed. They range from simple, qualitative models to elaborate watershed simulations. Qualitative models rely on subjective evaluation of a series of criteria. Watershed simulation models are often very theoretical. Several empirical models also are available and most models are best suited for estimating erosion from very large areas (more than 1 sq mile) and lack precision for use on small sites such as construction sites. The universal soil loss equation (USLE) is given by,

A = RKLSCP --------- Eqn (1)

Where,

- A = is computed Soil loss per unit area expressed in the units selected for K and for the period selected for R. In practice, these are usually so selected that they compute A in m tons /ha/year, but other units can be selected.
- R = the Rainfall erosivity, is the number of rainfall erosion index units for a particular location.
- K = the Soil erodability is the soil loss rate per erosion index unit for a specified soil as measured on a unit plot, which is defined as 21.13 mtr (72.6 ft.) length of uniform 9 percent of slope continuously in cleaned tilled fallow.
- L = The Slope Length factor, is the ratio of soil loss from the field slope length to that from 21.13 mtr (72,6 ft.) under identical conditions.
- S = the slope steepness factor, is the ratio of soil loss from field slope gradient to that from a 9 percent of slope under otherwise identical conditions.

- C = the Cover and management factor is the ratio of soil loss from an area with specified cover and management to that from an identical area in tilled continuous fallow.
- P = the support practice factor, is the ratio of soil loss with a support practice like contouring, strip cropping or terracing to that with straight row farming up and down the slope.

6.2 Erosion Index (EI30) Values on Storm Basis

The rainfall erosion index R is a measure of the erosive force and intensity of rain in a normal year. The two components of the factor are the total energy E and the maximum 30-minutes intensity (I_{30}) for all the storms in an area during an average year. Values of R have been computed for the various regions in India and abroad from rainfall records and probability statistics, and hence R should not be considered as a precise factor for any given year or location.

The energy of the rainstorm is a function of the amount of rain and all the storms component intensities. Median raindrop size increases with the rain intensity and terminal velocities of free falling water drops increases with increased drop size. Since the energy of the given mass in motion is proportional to velocity-squared, the rainfall energy is directly related to rain intensity. The relationship in metric units is expressed by the equation, where KE is the kinetic energy in metre tones / ha-cm and is the rainfall intensity in cm /hr.

The index values (EI_{30}), for each storm was determined. The product term EI was expressed as:

$EI_{30} = (KE \times I_{30}) / 100$ ---------- Equation (2)

Where,

- EI30 = Erosion Index
- KE is Kinetic Energy of the storm
- I30 = maximum 30 minutes Rainfall intensity of the storm

For computing Kinetic Energy of Rain storm the equation proposed by Wishmeier (1959) is

KE=916+331 log I ----------Equation (3)

Where,

- KE = Kinetic Energy of the storm in foot tons per acre inch and
- I = Rainfall intensity in inch per hour

The Equation (2) has been modified into metric units by Wishmeier & Mannering (1965) and Ranganath, et al., (1970) the equation in metric units is:

KE = 210.3 + 89 log I ---------- Eqn (4)

Where,

- EI30 is the erosion index
- KE is the total storm kinetic energy in tonnes – m/ha
- I30 is the maximum 30 minutes intensity of rainstorm.
- The monthly, seasonal and yearly EI values will be determined by adding the storm EI values for that length of period.

6.3 Soil Erodibility Factor (K)

The soil Erodibility factor K is a measure of the susceptibility of soil particle detachment and transport by rainfall and runoff. Texture is the principal factor affecting K, but structure, organic matter and permeability also contribute K values ranging from 0.45 to 0.59.

6.4 Nomograph Method

The United States Department of Agriculture (1978) has suggested a Nomograph and the following equation for the determination of soil erodability for soils containing less than 70% silt and very fine sand:

100K = 2.1M1.14 x 10-4 (12-a) +3.25 (b-2) +2.5(c-3) -------- Eqn (5)

Where,

- K is the soil erodability factor,
- M is the particle size parameter which is equal to: (percent silt + very fine sand) / (100% clay),
- ‘a’ is the percentage of organic matter content,

- 'b' is the soil structure and
- 'c' is the profile permeability class.

The preferred method for determining K values is the Nomograph method. Use of the Nomograph requires a particle size. The soil samples collected from the field were characterizes carefully for estimating, the K values.

6.5 Determination of LS

Since the LS factor has a considerable effect on predicted erosion, care in figuring values for the factor is warranted. In particular, results of the soil loss calculation will be more accurate if the USLE is individually applied to portions of a site with similar slopes (similar gradient and length) and summing the individual soil loss estimates. Slope gradient is the field or segment slopes, usually expressed as percentage. The topographic component, LS, was evaluated by using the contour length method for large watersheds.

LS was calculated base on the following equation

LS = (L)m / 22.1(0.065 + 0.0454S + 0.0065 S2) --------- Eqn (6)

Where,

- LS = Average length slope component
- L = Slope length in meters
- S = Average watershed slope in percent and
- m = Exponent (m= 0.2 if slope < 1%)

6.6 Evaluation of Cropping Management Factor (C)

The cover factor C is defined as the ratio of soil loss from land under specified crop or mulch conditions to the corresponding loss from tilled, bare soil. In the USLE, the C factor reduces the soil loss estimate according to the effectiveness of vegetation and mulch at preventing detachment and transport of soil particles. On activity sites, recommended control practices include the seeding of grasses and the use of mulches. These measures are often considered "temporary" -they are designed to control erosion primarily during the activity period. Permanent landscaping may be added later, or

temporary erosion control plants may be left as a permanent cover. Any product that reduces the amount of soil exposed to raindrop impact will reduce erosion.

The cropping management factor, C is computed as follows:

$C= \Sigma n\ Ci\ Ai\ /\ A$ ------- Eqn (7)

Where,

- C is the cropping management factor for the watershed
- Ci is the cropping management factor for crop i,
- Ai is the drainage basin area growing crop i with a particular management level,
- n is the number of land use areas in the watershed, and
- A is total watershed area.
- Evaluation of Support Practice Factor (P)

The erosion control practice factor P is defined as the ratio of soil loss with a given surface condition to soil loss with up and down hill ploughing. Practices that reduce the velocity of runoff and the tendency of runoff to flow directly down slope reduce the P factor. In agricultural uses of the USLE, P is used to describe ploughing and tillage practices.

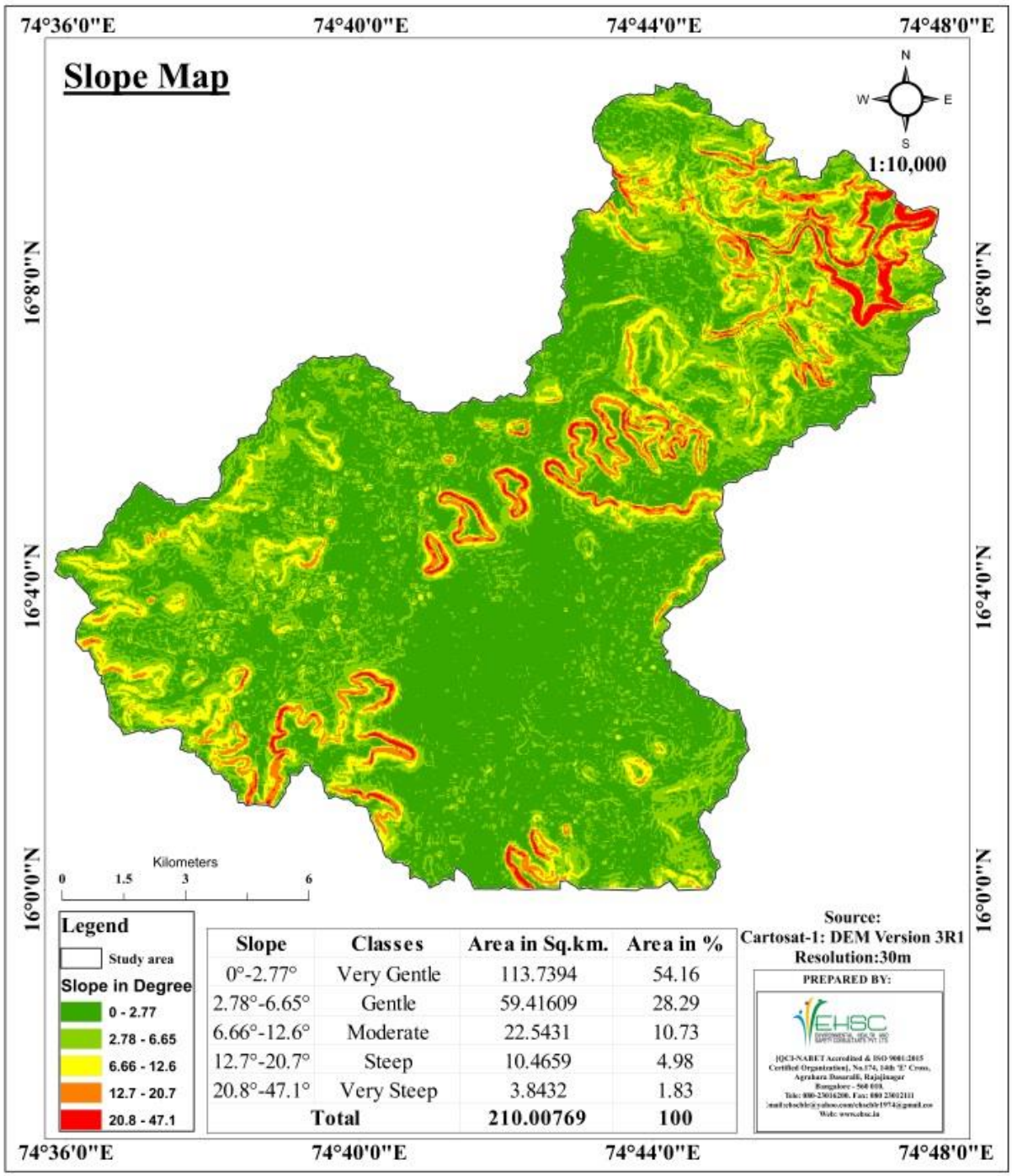
In activity site applications, P reflects the roughening of the soil surface by tractor treads or by rough grading. In computing the P factor, land cover conditions are considered depending upon the cultivated and uncultivated area of the watershed. In addition, slope is also considered as a key factor in assigning the value. For the study area, a P factor considered is 0.6 for terraced agricultural land having slope less than 2% and for the rest of the land having a slope more than 2%, a value of 0.5 is assigned.

7 Results and Discussions

7.1 Slope Map

The slope map of the study area is given in Fig 7.1. As seen from the map and table nearly 54.16 % of the study area is Very Gentle sloping, 28.29 %

of gentle sloping and 10.73 % of moderate sloping of the total area catchment area.



Slope	Classes	Area in Sq.km.	Area in %
0°-2.77°	Very Gentle	113.7394	54.16
2.78°-6.65°	Gentle	59.41609	28.29
6.66°-12.6°	Moderate	22.5431	10.73
12.7°-20.7°	Steep	10.4659	4.98
20.8°-47.1°	Very Steep	3.8432	1.83
Total		**210.00769**	**100**

Fig 7.1 Slope Map of the Catchment area

7.2 Soil erosion

Based on the soil erosion map, the study area is prone to 'Sheet Erosion' type.

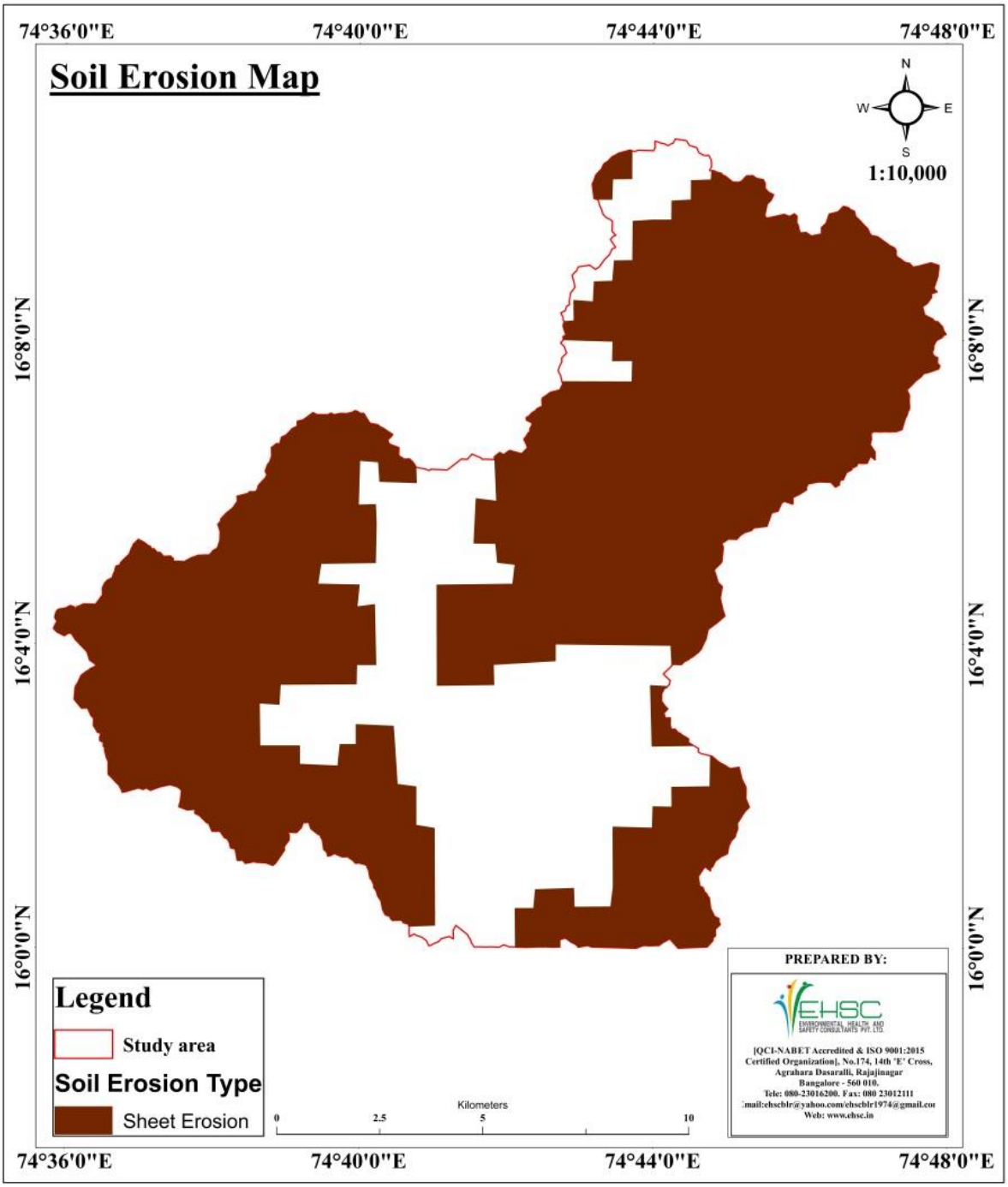


Fig 7.2 Soil Erosion map of the Catchment area

7.3 Watershed details

Table 7.1 Sub catchment/Watershed of the Catchment area

Sl. No	Watershed Name	Watershed Code
1	Markandeya	4D5D6

Table 7.2 Watershed classification of study area

Region	Basin	Catchment	Sub catchment	Watershed	Sub Watershed	Micro watershed
Bay of Bengal (4)	Krishna (4D)	Meet Krishna above confluences with Bhima(4D5)	Ghataprabha (4D5D)	Markandeya (4D5D6)	4D5D6t	4D5D6t1
						4D5D6t2
					4D5D6b	4D5D6b3
						4D5D6b4
					4D5D6a	4D5D6a2
						4D5D6a3
						4D5D6a4
					4D5D6c	4D5D6c3
					4D5D6n	4D5D6n1
						4D5D6n2
						4D5D6n3
						4D5D6n4

Upon considering the above classification data, soil loss has been estimated as give below:

Table 7.3 Estimation of soil loss in Watersheds in the proposed study area

Sl. No	Watershed	R	K	LS	C	P	A(Tons/ha)
1	4D5D6t1	1.62	0.47	0.461	0.192	0.7	0.047
2	4D5D6t2	1.42	0.49	0.491	0.232	0.6	0.048
3	4D5D6b3	1.52	0.43	0.458	0.212	0.56	0.036
4	4D5D6b4	1.43	0.42	0.4	0.186	0.8	0.036
5	4D5D6a2	1.62	0.62	1.523	0.381	0.6	0.350
6	4D5D6a3	1.96	0.32	0.523	0.173	0.75	0.043
7	4D5D6a4	2.18	0.53	0.133	0.173	0.8	0.021
8	4D5D6c3	1.84	0.46	0.447	0.23	0.75	0.065
9	4D5D6n1	1.86	0.41	0.272	0.22	0.6	0.027

Sl. No	Watershed	R	K	LS	C	P	A(Tons/ha)
10	4D5D6n2	1.48	0.42	0.182	0.26	0.55	0.016
11	4D5D6n3	1.72	0.48	0.481	0.252	0.63	0.063
12	4D5D6n4	1.49	0.46	0.63	0.21	0.75	0.068

Table 7.4 Errodibility Index

Sl. No	Watershed	R	K	LS	Erodibility Index (R x K x LS) / T
1	4D5D6t1	1.62	0.47	0.461	7.47
2	4D5D6t2	1.42	0.49	0.491	7.27
3	4D5D6b3	1.52	0.43	0.458	6.37
4	4D5D6b4	1.43	0.42	0.4	5.11
5	4D5D6a2	1.62	0.62	1.523	4.35
6	4D5D6a3	1.96	0.32	0.523	6.98
7	4D5D6a4	2.18	0.53	0.133	3.27
8	4D5D6c3	1.84	0.46	0.447	8.05
9	4D5D6n1	1.86	0.41	0.272	4.41
10	4D5D6n2	1.48	0.42	0.182	2.41
11	4D5D6n3	1.72	0.48	0.481	8.45
12	4D5D6n4	1.49	0.46	0.63	9.19
				Average loss	**6.11**

Estimated potential soil erodability in the study area is 6.11 which is less than 8 and therefore it is inferred that this is a moderately erodible land.

8. Catchment area Treatment Plan

8.1 Soil and Water Conservation

Soil and Water are the two most important Natural resources which have a direct bearing on agricultural production. These resources have to be used judiciously to obtain optimum yield of crops. Therefore, utmost care has to be exercised in management of these resources, not only to prevent soil degradation but also to improve the productivity of the soil for sustained agricultural development. Measures to conserve soil *in-situ,* allow more infiltrations opportunity time for rain water and safe disposal of runoff water from arable lands are of prime concern in rain fed areas, since they directly affect soil erosion rates and consequent crop productivity. Some of the methods suggested for soil conservation for catchment area are engineering methods and Biological methods.

8.1.1 Engineering methods

Mechanical measures or engineering structures are designed to modify the land slope, to convey runoff water safely to the waterways, to reduce sedimentation and runoff velocity, and to improve water quality. These measures are either used alone or integrated with biological measures to improve the performance and sustainability of the control measures. In highly eroded and sloppy landscape biological measures should be supplemented by mechanical structures.

Some of the engineering/mechanical methods recommended for the treatment plan include,

- Brushwood Check Dams
- Dry Stone Masonry Check Dams
- Gabion Check Dams

8.1.1 (A) Brushwood Check Dams

Brushwood check dams are constructed with the help of locally available wooden poles and brushwood. Wooden poles are driven into the ground in a single or double row across the Nala and brushwood is packed on the

upstream face of the check dam. Brushwood check dams are very feasible where vegetative material for construction is abundant. Brushwood check dams can only be constructed in small gullies not deeper than 1m depth. As material required for construction of these types of dam is available locally these can be constructed faster and in very short span of time thereby effectively reducing the erosion in early phase of Project.

The numbers of check dams are estimated using number of first order streams in an area under severe and very severe erosion intensity, and constructed at an interval of 100 m. In the study area, 3225 number of first order streams are identified and hence, brushwood check dams are proposed in the 3225 locations within the catchment area.

8.1.1 (B) Dry Stone Masonry Check Dams

These types of check dams are used for checking runoff velocity in steep and broad gullies where good size of stones is available in abundance. Dry stone check dams have longer life and usually require less maintenance as compared to brushwood check dam.

Dry stone masonry dams can be constructed to the tune of 2 no's per 100 Ha. Total of 10,500 no's of Dry stone masonry dams are recommended for the study area.

8.1.1 (C) Gabion Check Dams

If dry stone masonry check dams are considered not to be stable in a particular reach of the stream, Gabion structure can be installed. This is not very much encouraged therefore with proper judgment about the site conditions these structures may be installed[5].

Gabion Check Dam are proposed too be constucted all along the seconday nalas. About 210 no's (considering 1 no's per 100 Ha) of Gabion Check Dams will be constructed.

[5] Catchment area treatment plan for Gond major irrigation Project in Madhya Pradesh and Chhattisgarh by RS Envirolink Technologies Pvt. Ltd.

8.1.2 Biological Methods

It is always better to undertake preventive measures than to mitigate the factors that ultimately leads to soil erosion. Such preventive measures will indirectly help to conserve soil in the long run, keeping in view the importance of integrating eco-restoration strategy with socio-economic needs of the local community wherein both ecology and economics are developed[6].

Some of the Biological methods recommended for the treatment plan are

- Afforestation
- Pasture Development
- Nursery development

8.1.2 (A) Afforestation

The trees and vegetation cover play an important role in the conservation of soil and ecology. Afforestation programme would be taken up in such forest areas that contain large patches of barren grassy slopes and are generally devoid of trees. In critically degraded areas, plantation of locally useful, diverse and indigenous plant species would be undertaken. 1,100 plants per hectare will be planted under this method. Planting will be done in pits. Earth work will be done well in advance. Plants should be healthy with strong stems. Planting will be done in monsoon. RCC fence posts with 4 strand barbed wire fencing, interlaced with thorny bushes will be done in the plantation areas. Provision is also made for five years maintenance of afforestation undertaken as part of the catchment area treatment. Plantation is proposed in 1354 Ha in the study area (cosidering 279 ha of open scrub land and 1080 ha of sparse vegetation).

Table 8.1 List of Tree species recommended for Plantation[7]

Sl. No	Scientific name	Common Name	Family	Uses
1	*Senegalia catechu*	Kaggali	Fabaceae	Edible & Medicinal

[6]http://forestsclearance.nic.in/writereaddata/FormA/CTLetter/4111612581213IWDMLMagoCATPlan.pdf

[7] Working Plan of Ghataprabha Forest Division, Gokak for the period of 2012 -13 to 2021-22 by Anil Kumar Ratan, IFS, Conservator of Forest, Working plans and Forest Survey Belagavi, Karnataka

Sl. No	Scientific name	Common Name	Family	Uses
2	*Senegalia ferruginea*	Banni	Fabaceae	Timber
3	*Acacia leucophloea*	Beala	Fabaceae	Medicinal
4	*Aegle marmelos*	Bilwapatre	Rutaceae	Medicinal & traditional
5	*Albizia amara*	Chigure	Fabaceae	Fodder, fuel wood
6	*Albizia lebbeck*	Bagge	Fabaceae	Timber
7	*Artocarpus heterophyllus*	Halasu	Moraceae	Edible & Medicinal
8	*Azadirachta indica*	Bevu	Meliaceae	Medicinal, edible
9	*Bombax ceiba*	Kempu Buruga	Malvaceae	Edible and Medicinal
10	*Cassia fistula*	Kakke mara	Fabaceae	Ornamental
11	*Dalbergia sissoo*	Agara	Fabaceae	Timber
12	*Emblica officinalis*	Nelli	Euphorbiaceae	Medicinal
13	*Ficus racemosa*	Attimara	Moraceae	Medicinal
14	*Mangifera indica*	Mavina mara	Anacardiaceae	Edible and Fuel wood
15	*Syzygium cumini*	Jambunerale	Myrtaceae	Edible and Medicinal
16	*Tamarindus indica*	Hunase mara	Fabaceae	Edible and medicinal
17	*Terminalia arjuna*	Arjuna mara	Combretaceae	Edible and medicinal
19	*Terminalia bellirica*	Thare Mara	Combretaceae	Medicinal
20	*Terminalia chebula*	Alalekaayi	Combretaceae	Medicinal

8.1.2 (B) Nursery Development

Proper development of nursery and allied services, like drip irrigation or micro irrigation, will be crucial for successful execution of CAT plan. It will be important to prepare a stock of plant material for the supply of saplings for afforestation programme and various other activities. Main nursery may be developed near dam site, proposed colony areas, preferably along the road side for easy accessibility. The nurseries may be developed around colony area because of its proximity to both the upstream and downstream part of the CAT plan area as it lies in the middle of catchment. Besides, this area possesses necessary infrastructure and various raw materials for nursery development can be easily made available. In addition, provision will also be made for two green-houses/chick houses for maintaining plant saplings.

8.1.2 (C) Fodder development

Provision of fodder development will be made to reduce the pressure on the forest. Fodder development is also known as Energy plantation scheme which is essential for a continuous supply of fuel and fodder. It can be easily carried out and it is economical to carry out. Agricultural land will not be used for energy plantation, instead, fallow land and scrub land falling under severe and very severe erosion intensity category will be used for energy plantation. Fodder development is proposed in 651 Ha in the study area (which is a fallow land).

Table 8.2 List of species recommended for Fodder development[8]

Sl No	Scientific name	Common Name	Family
1	*Azadirachta indica*	Neem	Meliaceae
2	*Delonix regia*	Gul mohur	Fabaceae
2	*Ficus benghalensis*	Banyan	Moraceae
3	*Ficus religiosa*	Peepal tree	Moraceae
4	*Leucaena leucocephala*	Subabul	Fabaceae
5	*Melia dubia*	Hebbevu	Meliaceae
6	*Sesbania grandiflora*	Agati	Fabaceae
7	*Tamarindus indica*	Tamarind	Fabaceae

8.2 Infrastructure Development

The works of the catchment area treatment plan will be executed by the Forest Department, Government of Karnataka. These works will be an added responsibility for the Forest Department that may not have adequate facilities and infrastructure to execute the work as suggested in the plan. Therefore, provision has been made under CAT plan to develop infrastructure of Forest Department in the region.

KNNL has committed to provide following infrastructure facilities:

- Provision of construction of watch towers to the forest guards will be made.
- Vehicular provision for easy patrolling of Forest officials.
- Construction of office building to the Forest Department staff.

[8]http://ekrishiuasb.karnataka.gov.in/ItemDetails.aspx?depID=9&subDepID=%206&cropID=0

8.3 CAT Plan monitoring

Monitoring and evaluation will be undertaken as a part of project management. A process of self-evaluation at specified intervals of time will ensure the field level verification of suggested treatment measures and efficacy of the CAT plan. The year-wise areas requiring treatment measures have been suggested but have not been marked. The spatial location of specific treatment to be carried out in the catchment area would require extensive detailing during the implementation of CAT and a provision for micro-planning has been made in the total CAT financial allocation. Thereafter, annual work plan would be prepared well in advance after undertaking initial ground surveys during micro-planning, specifying physical and financial targets, sites, locations and beneficiaries of each component of the project activity. Month-wise work schedule of various items of each component for the financial year would also be prepared in advance and its timely implementation would be ensured. Monthly progress report on all activities would be submitted by the Range Officers to Divisional Forest Officer. The monitoring committee shall be constituted at the project level for this purpose which too would monitor on a regular basis the quality and quantity of works being carried out under the CAT plan area.

Regular monitoring is essential for effective implementation of CAT Plan. The Chief project officer of the user agency must be associated in implementation as well as monitoring of the progress of Cat Plan. For this, a committee with fallowing composition may be constituted at state level for quarterly review of progress of implementation of various CAT plans and take immediate steps to ensure the same[9]:

1	PCCF & HoFF	Chairman
2	Secretary (Agriculture) or his representative	Member

[9] Handbook of guidelines for effective and transparent implementation of the provisions of Forest (Conservation) Act, 1980 issued by Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India, 2019

3	Secretary (Animal Husbandry) or his representative	Member
4	Project Officer- User agency	Member
5	Concerned conservator of Forests	Member
6	Nodal officer (FC) o/o PCCF	Member Secretary

9. Cost estimates for the implementation of CAT Plan

The total estimated cost for the implementation of Catchment area treatment plan is 41.43 Crores.

Sl. No.	Item	Rate[10] (Rs)	Unit	Target	
				Physical	Financial
I Engineering Measures					
1	Brushwood Check Dams	10,000/-	No	3225	3,22,50,000/-
2	Dry Stone Masonry Check Dam	25,000/-	No	10,500	26,25,00,000/-
3	Gabion Check Dams	30,000/-	No	210	63,00,000/-
				Sub-Total (A)	**30,10,50,000/-**
II Biological Measures					
1	Afforestation				
	a. Creation	50,000/-	Ha	1,354	6,77,00,000/-
	b. Maintenance for 5 years	10,000/-	Ha	1,354	1,35,40,000/-
2	Fodder Development				
	a. Creation	40,000/-	Ha	651	2,30,40,000/-
	b. Maintenance for 5 years	5,000/-	Ha	651	32,55,000/-
3	Nursery Development				
	a.Creation	1,00,000/-	No	5	5,00,000/-
	b. Maintenance	50,000/-	No	5	2,50,000/-
				Sub-Total (B)	**10,82,85,000/-**
III Infrastructure Development					
1	Building for Forest staff	10,00,000/-	No	2	20,00,000/-
2	Vehicles	15,00,000/-	No	2	30,00,000/-
				Sub-Total (C)	**50,00,000/-**
				Total cost for implementation of CAT (A+B+C)	**41,43,35,000/-**
In Words- Forty one Crores forty three lakhs thirty five thousand only					

Assistant Executive Engineer,
KNNL GRBCC Sub Div No 5 Gokak

Executive Engineer,
KNNL GRBCC Div No 3 Gokak

[10]Government of Karnataka Forest/Horticulture/Watershed Department Common Sanctioned Schedule of Rates for the year 2022-23.

30