नालको NALCO
NATIONAL ALUMINIUM COMPANY LIMITED
(A Government of India Enterprise)
COAL MINES DIVISION
S&P COMPLEX, Angul
EMAIL::tapan.pattnaik@nalcoindia.co.in, gm_uecb@nalcoindia.co.in,

Ref No:- NALCO/ Coal Mines Division /167/2022 Date: 27.08.2022

To

The Divisional Forest Officer,
Angul Forest Division,
Angul Odisha.

Sub: - Proposal seeking prior approval of Central Government under section 2 of the forest conservation Act,1980 for diversion of 169.1779 ha forest land of Utkal-E Coal Mines in Angul District by NALCO. Reg Compliance to MoEF & CC Observation.

Ref: - (i) MoEF & CC, File no 8-07/2020-FC dtd 12.03.2021
(ii) MoEF & CC, observation vide letter dtd 29.12.2022 & 18.04.2022
(iii) NALCO/ Coal Mines Div/146/2022 dtd 03.08.2022
(iv) Your Memo No 5849 /110/DRO/2022 dtd 10.08.2022

Dear Sir,

Inviting reference to the subject cited above & observation made by MoEF &CC, GoI New Delhi vide letter dtd 29.12.2021 and 18.4.2022, it is mention here that as per the condition no A-6 of the Stage-I order, RCCF Angul Circle has approved Soil Moisture Conservation plan in adjoining area of Utkal-E coal Mine with a total fanatical outlay of Rs 10,88,02,300/-.

Further NALCO has deposited Rs 10,88,02,300/- vide **UTRN No SBIN222238248669 dtd 26.08.2022** towards duly approved Soil Moisture Conservation (SMC) Plan into the account of CAMPA Fund (Payment receipt enclosed in Six Sets). Further for compliance to the condition stipulated in DFO Angul office Memo no 5849 dtd 10.08.2022, an undertaking is also enclosed herewith in 06 (Six Sets) .

In view of the above, your good office is requested to transmit the same to Head Office, MoEF & CC, GoI along with approved SMC Plan, for grant of Stage-II Forest Clearance.

Thanking You,

Yours Faithfully,
For and on behalf of NALCO

27.8.2022

Tapan Pattnaik
GGM (Coal Mines & Project)

Encl: As above in 06 Sets

AGENCY COPY

यूनियन बैंक Union Bank of India

आन्ध्रा Andhra

NEFT / RTGS CHALLAN for CAMPA Funds

Date : 25-08-2022

Agency Name.	NALCO
Application No.	5841142818
MoEF/SG File No.	8-07/2020-FC
Location.	ORRISA
Address.	NALCO Bhawan, P-1, NayapalliAnugul
Amount(in Rs)	108802300/-

Amount in Words :Ten Crore Eighty-Eight Lakh Two Thousand Three Hundred Rupees Only

NEFT/RTGS to be made as per following details;

Beneficiary Name:	ORRISA CAMPA
IFSC Code:	UBIN0996335
Pay to Account No.	150825841142818 Valid only for this challan amount.
Bank Name & Address:	Union Bank Of India Lodhi Complex Branch, Block 11,CGO Complex, Phase I, Lodhi Road, New Delhi -110003

- This Challan is strictly to be used for making payment to CAMPA by NEFT/RTGS only

BANK COPY

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After making successful payment, User Agencies may send a line of confirmation through Email: helpdeskcampa@corpbank.co.in

Note:After making the required payment through challan, if the payment status has not been updated even after 7 working days, then kindly mail a copy of your challan with transaction date to Email: cb0371@unionbankofindia.com

513093 Bhagaban Biswal SBI,KANDSAR(NALCO NAGAR) Code 8279 26 AUG 2022 Initial Journal No. ID No.

7598742 Jyoti Ranjan Behera S.B.I,Kandsar(Nalco Nagar)Branch Code 8279 26 AUG 2022 Initial Journal No. Checker ID No.

SBIN 22223824866 9

26/08/2022	108,802,300.00	TRANSFER TO 99506044303 / ORISSA CAMPA TO TRANSFER-NEFT UTR NO: SBIN222238248669--ORISSA CAMPA

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The information given in this report is not to be communicated either directly or indirectly to the press or to any person not holding an official position in the CIL/NALCO.

FINAL REPORT
ON
SOIL MOISTURE CONSERVATION (SMC) MEASURES IN THE ADJOINING AREA
OF
UTKAL-E COAL MINE (NALCO)

For

Diversion of 169.1779 Ha of Forest land
(Including safety zone)

Within 523.7325 Ha Mining Leasehold Area
of
M/s National Aluminium Company Ltd. (NALCO)

Chhendipada Tahasil,
Sub-Divn. -Angul, Dist-Angul
Odisha.

(July 2022)

(JOB No.- 091021166)

Central Mine Planning & Design Institute Ltd.
(A Subsidiary of Coal India Ltd.)
Regional Institute-VII, Bhubaneswar
&
Environment Division,Kanke Road
Ranchi - 834008 (Jharkhand), India

CONTENTS

LIST OF PLATES

ACKNOWLEDGEMENTS

Name and Designation	Broad Area/level of association
CMPDI HQ, Ranchi	
Sri Manoj Kumar, Chairman Cum Managing Director	For formulation corporate level objective, sanctioning of resources and overall monitoring and guidance.
Sri S. K. Gomasta, Director(T/CRD)	For continuous guidance and for providing the required facilities during the course of the study.
Sri Abhijit Sinha, GM(Environment)	For deployment of resources, cordial support and overall supervision.
Sri V. K. Srivastava, GM(Exploration)	For extending necessary support for timely completion of hydrogeological study.
Sri R. K. Amar, GM(BD)	For extending all support during budgeting, presales and for continuous coordination with client.
Sri R. Kumar, GM (Geomatics)	For facilitating smooth deployment of drone survey.
Sri Mohit Rastogi, GM (Geomatics)	For facilitating smooth deployment of drone survey.
Sri D. P. Singh, Ch. Manager (Environment)	For providing guidance during the analysis of soil & water samples, providing civil structure & estimate and for technical assessment of report.
Sri D. Bandopadhyay, Sr. Manager (Geology)	For extending necessary help and overall guidance for hydrogeological works.
Dr. Amarjeet Singh, Manager (Environment)	Overall project management, timely deployment of various field activities and technical report preparation.
Sri Bhuvnesh Kumar, Deputy Manager (Geo)	Drone Pilot
Sri Tanmay P Deputy Manager (Geo)	Drone Pilot
Dr. Santhan P. FAE(EB)	Ecological Studies
CMPDI RI-VII, Bhubaneswar	
Sri S. K. Bhar, Regional Director	For extending necessary support, quality assurance, and appropriate work environment.
Sri. R. C. Sahoo, GM(Mining)/ HoD(Environment)	For overall guidance and mobilization of resources
Sri T. K. Das, GM(Civil)	For scrutinizing necessary technical matters related to Civil Engineering in connection to the report and overall guidance.

Sri U. K. Mohanty, Ch. Manager (Environment)	For extending necessary help and overall guidance.
Sri. Manish Yadav, Manager (Environment)	Project Execution, Coordination, Field investigation, data sourcing, data analysis and report preparation.
Sri A. Mondal, Manager (Geology)	
Sri R. Kumar, Dy. Manager (Civil)	
Sri Amul Patwal, Dy. Manager (Environment)	
PCCF, Bhubaneswar and Forest Department, Angul	
PCCF, Bhubaneswar and Forest Department, Angul	For providing all possible arrangements for safe access to study area.
NALCO, Angul	
NALCO, Angul	For providing all necessary logistical help and support during the course of the study.

CHAPTER-1

INTRODUCTION

CHAPTER-1
INTRODUCTION

1. BACKGROUND

1.1 INTRODUCTION

Ministry of Coal, Govt. of India had allotted Utkal-E Coal Block in Talcher Coalfield to M/s NALCO. The block is located in the South-Central part of Talcher Coalfield between Utkal-F Coal Block in the West & Utkal-D Coal Block in the East. UtkaL-E Coal Mine spans over an area of 4.60 sq. km between Lattitude $20^0$56'57" and $20^0$58'58" N and Longitude $84^0$55'49" and $84^0$56'37" E. Administratively it is under the jurisdiction of Chhendipada Tahasil, Anugul district. Utkal-E Coal Mine is covered under Survey of India Toposheet No. 73D/13 on RF 1:50,000(2cm to 1km) and special toposheet No. L2 on RF 1:10,000 (10cm to 1km) and falls within the Angul District of Odisha. Utkal-E Coal Mine comprises an area of 523.7325 Ha. out of which 169.1779Ha. areas are of Revenue Forest land which is required to be diverted under Forest Conservation Act 1980. The remaining area 132.0581Ha is Govt. Non-forest land and 222.4965Ha is Private Land.

The area approved for a grant of mining lease is 523.7325ha. The total forest land is 169.1779Ha. out of which 165.2319Ha. is to be diverted for Non-Forest mining use and 3.946Ha. shall be used as a Safety Zone area. The Forest Land is required as a part of the proposed coal mining project for mining purposes only.

The Stage-I Forest clearance u/s of FC Act 1980 was granted by MoEF & CC vide their letter No.8-07/2020-FC Dt.12.03.2021 for 156.1779Ha wherein it has been stipulated to contribute towards Soil & Moisture Conservation Activities. As the lease area, Utkal-E is bounded by Utkal-D on the Eastern side, Radhikapur East (Utkal-F) coal block on the Western side, and Singra Jhore Nala on the

northern side. The only adjacent area available for Soil Conservation Measures (SMC) is Durgapur Reserved Forest (RF).

1.2 PURPOSE

National Aluminum Company Limited (NALCO), incorporated in 1981, is a premier Navaratna Public sector Enterprise under the administrative control of the Ministry of Mines, Government of India in the field of Alumina/Aluminium having integrated multi-locational facility of bauxite mining, Alumina refining, Aluminium smelting, Power generation, and the port. Besides these, the company has set up Wind Power Plants (WPP) in India.

BRIEF DESCRIPTION OF THE UTKAL-E COAL MINE

NAME OF THE PROJECT	UTKAL – E COAL MINE PROJECT
LOCATION OF THE PROJECT	LOCATION • Utkal- E Coal block is situated in the south-central part of the Talcher Coalfield, Odisha. • State Highway-63 is about 3.0 km from the project. • National Highway 55 (Bhubaneswar-Sambalpur) is passing at a distance of about 10.0 km from the project site. The nearest railhead is Jarapada is at a distance of about 20 km on the Sambalpur-Talcher-Bhubaneswar rail line of the East Coast Railway. VILLAGES : Nandichhod, Kosala, Gopinathpur jungle, Kundajhari jungle, Koroda Tha./ Dis./ State : Chhendipada , Angul , Odisha Latitude : 20^0 56’ 57” N to 20^0 58’ 58” North Longitude: 84^0 55’49” to 84^0 56’37” East Toposheet No. : 73 D/13 (RF 1:50000)
Total land Details	Forest land : 169.1779 Ha

	Non-forest Govt. land : 132.0581 Ha Pvt land : 222.4965 Ha Total : 523.7325 Ha
Quarry Surface Area	211.18 HA
PRODUCTION CAPACITY/LIFE	2.0 Mty / Life of Mine :- 36 years
Extractable Reserve / Seam/ Grade	67.49 MT; 15 seams; D to G (Mostly G)
Total overburden	205.96 Million Cubic Meter
Avg. stripping ratio	3.05 Cum/T
Mine depth	227.50 m (Maximum)
Rainfall	1270 mm/year

PRESENT STATUS OF UTKAL-E COAL MINE

- Mining Plan Approved: MoC Letter no 47011/7(60)/93-CPA/CPAM/CA dtd 31.07.2006
- Environmental Clearance: MoEF &CC letter no J-11015/31/2007-IA.II(M) dtd 10.12.2009
- R & R Plan: Approved by Collector Angul on 17.05.2018.
- Forest Clearance: Stage-I FC for 156.1779 Ha Forest land transferred in favour of NALCO on 12.03. 2021.Stage-II Clearance is Under Progress.
- Mining lease Grant: Steel & Mines Dept. Govt. of Odisha issued grant order for 523.73 Ha land of Utkal-E Coal Mines on 12.04.2021.
- SPCB, Odisha issued CTE order vide their letter 13.08.2021.

Direction	Surroundings
South	Durgapur Reserve forest in adjacent south
North	Singada Jhor Nalla in adjacent north
East	Utkal-D Coal Block in adjacent East
West	Utkal-F/ Radhikapur East Coal Block in adjacent west

Assistant Inspector General of Forests, MoEF&CC submitted a letter to Forest Conservation Division File No.8-07/2020-FC Dated: 12th March 2020 to the Addl. Secretary (Forests), Government of Odisha, Bhubaneswar regarding Proposal for seeking prior approval of the Central Government under Section-2 of the Forest (Conservation) Act, 1980 for non-forestry use of 169.1779 ha of forest land in favor of M/s NALCO for Utkal E Opencast Coal Mining Project in Angul District (Odisha).

As per the directive of the Government of Odisha's letter No. 10F(Cons) 105/2020-9681/F&E dated 25.06.2020 the for seeking prior approval of the Central Government under Section 2 of the Forest (Conservation) Act, 1980 and letter no. 18235/9F(MG)-308/2020 dated 16.10.2020 forwarding additional information as sought by the Ministry vide its letter of even number dated 12.07.2020 and the proposal examined by the Forest Advisory Committee constituted by the Central Government under Section-3 of the aforesaid Act. After examination of the proposal of the State Government and on the basis of the recommendations of the Forest Advisory Committee(FAC), and approval of the same by the competent authority of the MoEF&CC, New Delhi, the Central Government accorded 'in-principle' approval under Section - 2 of the Forest (Conservation) Act, 1980 for non-forestry use of 156.1779 ha of forest land out of originally proposed 169.1779 ha of forest land in favor of M/s NALCO for Utkal E Opencast Coal Mining Project in Angul District (Odisha) subject to fulfillment of the several conditions. The condition related to *soil-moisture conservation (SMC) is as under:*

"*Noting that the proposed area is contiguous to Reserve Forests, and heavy mechanised coal mining and transport will have significant impact both on the wildlife of the area and the overall soil-moisture condition that in turn will affect the health of flora in both short and long-term, proper wildlife and soil-moisture conservation (SMC) measures in the adjoining areas along with their long-term*

monitoring, are necessary. The user agency shall contribute towards cost of the SMC Plan duly approved by State Forest Dept".

1.3 CONSULTATION WITH FOREST OFFICIALS

A formal meeting between an official of NALCO, Team of CMPDI, and DFO, Angul was held on 26.04.2022 in the office of DFO, Angul to discuss the fulfillment of the compliance lay down by Assistant Inspector General of Forests, MoEF&CC submitted a letter to Forest Conservation Division **File No.8-07/2020-FC Dated: 12th March 2020.**

The study area has been selected after a discussion with DFO Angul dated 26.04.2022 and the total area covering 561 Ha lies in Durgapur RF, near Monnet Power Plant. The bounding coordinate of the area falls between longitude 84° 57' 46.971" E to 84° 59' 13.927" and latitude 20° 54' 45.663" N to 20° 56' 32.904" N.

On the basis of the above meeting, In the Utkal E coal block, CMPDI undertook UAV based survey for the generation of a high-resolution orthomosaic image, DTM, DSM, and contour map of the proposed area for SMC study.

1.4 SCOPE AND OBJECTIVE OF THE WORK

A. LiDAR Survey work in the adjoining area of Utkal-E Coal Mine ie. Durgapur Reserve Forest.

B. To co-ordinate with the forest department to carry out the Survey work at the Site.

C. Preparation of *DPR for Soil- Moisture Conservation (SMC) Measures in the adjoining area of Utkal-E Coal Mine.* The DPR should contain the following:

- Site selection for implementation of Soil -Moisture (SMC) plan in the Durgapur Reserve Forest. DGPS coordinate, KML file & Topo Sheet of the SMC implementation site.
- Existing land use pattern & Satellite Imagery Analysis. Soil Characterization of the adjoining area.
- *Impact on Soil & Moisture conditions of the adjoining area due to Coal Mining & transportation.*
- Micro Water concept and proposed technique for Soil - Moisture Conservation depending upon nature of Soil/Sediment/Gradient of the area.
- Detailed Cost Estimate (Based on latest Cost Norm of Forest Department) of the Soil – Moisture conservation along with their long-term monitoring.
- KML files showing the location of each measure proposed in the DPR.

D. Submission of draft DPR to NALCO for comments. Inclusion of observations of NALCO if any in the draft DPR and submission of final DPR to DFO Angul in 06 (Six) Sets.

E. Compliance to the quarries raised by the Forest Department on the DPR & Final approval of the DPR from the Forest Department.

F. Any point specially not mentioned but essential for the preparation & approval of the DPR for Soil Moisture Conservation measures shall be included in the scope of work as mentioned above & for this, no extra payment will be made to the agency.

1.5 COMPLIANCE OF OBSERVATIONS

Draft Report was submitted to DFO, Angul on 04th June 2022. The observations were given by DFO, Angul vide letter no. 4030 dated 07.06.2022. Further, a meeting was called in the office of DFO, Angul on 10.06.2022. In the meeting officials from NALCO and CMPDI participated. The suggestion as made by DFO has been complied in the final report. Pointwise compliance of the observations made by DFO, Angul is presented as under:

Table 1.1 Compliance of observations made by DFO , Angul

Sl. No.	Observations	Compliance
1	Though soil moister index map of study area on V-14 page shows around 80% of study area under moisture stress and conservation activity have been recommended for this area on V-l3 Page, treatment is only suggested for open area.	The area of Grassing and mulching have been revised. Mulching has been suggested for the open and degraded areas (185 Ha). 30 Ha of grassing has been proposed.
2	Suggested counter trenches are not along the contour but along east west direction crossing drains and elevations.	The contour trenches have been proposed as per the contour map. Refer to Table No. 6.1 and Fig. No. 6.2 The total proposed length of the contour is 8755 m.
3	It is evident from the soil sample data that soil is deficient in a number of nutrients, particularly phosphorus. Grassing of 60% of open area without any soil treatment and without recommendation for future maintenance is most likely to fail.	Providing and laying doob grass turf with earth 50-60mm thickness and maintenance for 30 days or more till the grass is established properly. Additionally, organic manure like cow dung has been proposed for treatment before grassing. Total cost for

Sl. No.	Observations	Compliance
		Manure along with spreading of Manure have been provided as Rs. 41.41 Lakhs.
4	Five number of water bodies have been suggested without analysing their catchment and siltation load. On that basis, size and de-siltation schedule can be recommended in the plan.	The size of the pond has been calculated considering the catchment area and annual rainfall. (Refer Table. No. 6.3 to 6.5 and Fig No. – 6.5)
5	While recommending check dams, top-down approach should be followed. Five number of check-dams may not be sufficient. A series of check dams along the drains may be explored.	Total 10 nos. of check dams have been proposed in place of earlier proposed 05 nos .of check dams.
6	Monitoring, supervision charges, contractor profits have not been included in the plan and estimates.	The rate has been taken from CPWD DSOR which includes the contractor profit. In addition to the above, 3% contingency fund and 5 % Monitoring, Evaluation, Learning, Documentation, and other contingency have been proposed.
7	Calendar of operation detailed were estimates including labour less, excavation cost, contingency etc. are to be included in detailed project report.	The time period for the completion of the proposed SMC activities is 2 years. A calendar for maintenance of SMC structures has been proposed for 4 years after the completion of the activities as proposed.

Sl. No.	Observations	Compliance
		A calendar of operation of detailed proposed SMC activity has been provided in Table No – 6.10 to 6.13.
8	Further, you are requested to provide spatial data (GPS location) of various activates such as catchment pits, counter trench water bodies etc. while mentioning their alignment, length, spacing etc for effective implementation of your recommendation on field.	Latitude, Longitude, length, width, and depth of proposed structures have been given in Fig 6.2 to 6.7 and Table No. - 6.1 to 6.5.

As per letter no. 4708 dated 04.07.2022 of DFO, Angul, a power point presentation of the final report submitted was made by CMPDI team on 07.07.2022. In this meeting DFO Angul, RCCF, Angul Circle, officials from M/s NALCO, M/s Utkal E were present.

Comments/Observations on the final report was given by DFO Angul vide letter no. – 4806 dated 08.07. 2022. The pointwise compliance of the comments/observation is given below in the **Table No.1.2.**

Table 1.2 Compliance of observations made by DFO , Angul on the Power Point Presentation made on 07.07.2022

Sl. No.	Observations	Compliance
i	1 % of the labour cess is to be explicitly included in the cost estimates as required under the building and other construction workers' welfare cess Act, 1966.	1 % as labour cess has been provided in the cost estimate. **(Refer Table 6.8).**
ii	Drainage Line Treatment should follow the top-down approach along the stream taking into consideration their longitudinal profiles and it should be planned in-saturation mode.	The top-down approach along the stream has been considered for taking calculation of spacing and no. of check dams. Thus revised no. of check dams are 20 instead of earlier proposed 10 nos. The height of the 2 nos check dam has been taken as 1 m and remaining 18 nos. have 0.6m height. **(Refer Page No.- VI-16 to VI-19).**
iii	As APO 2022-23 has already been approved and is under operation, the commencement year for the SMC plan should be 2023-24. Escalation cost should accordingly be included accordingly for the first year and all subsequent years.	The same has considered. The Starting year has been taken as 2023-24. **(Refer Table 6.7 and 6.8).**
iv	Maps should be provided in at least 1:5000 scale showing GPS locations, general topography as it will be useful for the implementation of the plan.	The required maps have been prepared as per suggestion. KML file of all the maps are enclosed.
v	GPS locations of the interventions should be included in the table format in the plan.	GPS locations of the interventions have been included in the table

		format in the required plans .KML file of all the maps are enclosed.
vi	A chapter on long term monitoring and assessment should be included in the plan mentioning at least the followings – Expected outcome of the plan. Monitoring Mechanism for progress of the above outcomes. Plan Review and revision Procedure: Parameters based on which plan is to be reviewed and revised periodically.	A separate chapter on long term monitoring and assessment has been included in the report as **Chapter-VII.** Monitoring Mechanism for progress of the outcomes of the proposed activities have been provided. The Cost for the same has been kept as Rs. 50,000,00/-. It has been proposed that assessment of the outcome of the proposed activities will be measured in 3rd and 5th year. **Refer Table 7.7.**

CHAPTER-2

Soil Moisture Conservation: An Overview

CHAPTER-2
SOIL MOISTURE CONSERVATION: AN OVERVIEW

2.1 SOIL MOISTURE

Soil moisture is “the total amount of water, including the water vapor, in an unsaturated soil.” Soil moisture—sometimes also called soil water—represents the water on inland surfaces that are not in rivers, lakes, or groundwater, but instead resides in the pores of the soil. In turn, soil moisture levels affect a range of soil and plant dynamics. Surface soil moisture is the water that is in the upper 10 cm of soil, whereas root zone soil moisture is the water that is available to plants—generally considered to be in the upper 200 cm of soil.

Water that enters a field is removed from a field by runoff, drainage, evaporation, or transpiration. Runoff is the water that flows on the surface to the edge of the field; drainage is the water that flows through the soil downward or toward the edge of the field underground; evaporative water loss from a field is that part of the water that evaporates into the atmosphere directly from the field's surface; transpiration is the loss of water from the field by its evaporation from the plant itself.

Water affects soil formation, structure, stability, and erosion but is of primary concern with respect to plant growth. Water is essential to plants for four reasons:

1. It constitutes 80%-95% of the plant's protoplasm.
2. It is essential for photosynthesis.
3. It is the solvent in which nutrients are carried to, into and throughout the plant.

4. It provides the turgidity by which the plant keeps itself in the proper position.

In addition, water alters the soil profile by dissolving and re-depositing mineral and organic solutes and colloids, often at lower levels, a process called leaching. In a loam soil, solids constitute half the volume, gas one-quarter of the volume, and water one-quarter of the volume of which only half will be available to most plants, with a strong variation according to matric potential.

Water moves in soil under the influence of gravity, osmosis and capillarity. When water enters the soil, it displaces air from interconnected macropores by buoyancy and breaks aggregates into which air is entrapped, a process called slaking. The rate at which a soil can absorb water depends on the soil and its other conditions. As a plant grows, its roots remove water from the largest pores (macropores) first. Soon the larger pores hold only air, and the remaining water is found only in the intermediate- and smallest-sized pores (micropores). The water in the smallest pores is so strongly held to particle surfaces that plant roots cannot pull it away. Consequently, not all soil water is available to plants, with a strong dependence on texture. When saturated, the soil may lose nutrients as the water drains. Water moves in a draining field under the influence of pressure where the soil is locally saturated and by capillarity pull to drier parts of the soil. Most plant water needs are supplied from the suction caused by evaporation from plant leaves (transpiration) and a lower fraction is supplied by suction created by osmotic pressure differences between the plant interior and the soil solution. Plant roots must seek out water and grow preferentially in moister soil microsites, but some parts of the root system are also able to remoisten dry parts of the soil. Insufficient water will damage the yield of a crop. Most of the available water is used in transpiration to pull nutrients into the plant.

2.2 SOIL EROSION

Soil erosion has affected land all over the world from small residential landscaped properties to large forests and deserts. Due to the action of rain and wind, some portion of soil gets eroded and transported naturally and at the same time disintegration of rocks goes on naturally at some places to form the soil. These are continuous processes that naturally balance the erosion and formation of soil.

Soil erosion is described as soil particles being shifted around due to the devastating impact of

- Rainfall
- Wind and
- Ice melts

It is a natural process but, in most cases, human activity speeds up the process. Description of different types of soil erosion has been enumerated below in which above agencies have the major role: -

2.3 RAINFALL EROSION

The investigation has shown that most of the soil erosion done by water is due to the impact of the falling raindrops. The erosion capacity of surface runoff is small and it acts only as a partner.

The water erosion process starts as soon as the rain starts. The two principal erosive agents that become active during the rain storm are:

(a) Falling rain drops.

(b) Flowing run-off

2.3.1 FALLING RAINDROPS

When a raindrop strikes the soil surface, it breaks down the clods and the aggregates of the soil and thus, the soil particles are torn loose from their

moorings in the soil mass. The energy of the falling water is applied from the above and is utilized in detaching the soil particles, while the energy of the surface runoff is applied parallel to the surface and is made used in transporting the dislodged soil particles.

The erosion caused by rain storms is also known as ***Splash-Erosion-Process***. Another important fact that we must mention here is that the amount of erosion from hilly catchments is always more than that from flat catchments (provided all other conditions remain the same).

This is, because, when rain falls over the flat area, the incoming

Fig-2.1 Splash-Erosion

splash balances the outgoing splash; while when the raindrops strike the sloping land surfaces, a major proportion of the splash moves down. Hence, relatively

larger quantities of soil are transported when catchments are sloping than the catchments is flatter.

2.3.2 FLOWING RUN-OFF

The fraction of the rainfall which does not infiltrate (soak into) the soil will flow downslope under the action of gravity; it is then known as runoff or overland flow.

If the rain continues, the increasing depth of water will eventually increase. Overland flow that is released in this way is likely to flow downslope more quickly and in greater quantities (i.e. possess more flow power as a result of its kinetic energy), and so may be able to begin transporting and even detaching soil particles. Where it does so, the soil's surface will be lowered slightly. Lowered areas form preferential flow paths for subsequent flow, and these flow paths are in turn eroded further.

2.4 WIND EROSION

Soil erosion by wind may occur wherever dry, sandy, or dusty surfaces, inadequately protected by vegetation, are exposed to strong winds. Erosion involves the picking up and blowing away of loose fine-grained material within the soil. Damage from wind erosion is of numerous types. The most serious and significant by far, however, is the change in soil texture caused by wind erosion. Finer soil fractions (silt, clay, and organic matter) are removed and carried away by the wind, leaving the coarser fractions behind. This sorting action not only removes the most important material from the point of productivity and water retention, but leaves a more sandy, and thus a more erodable soil than the original. Wind erosion mainly depends upon the type of storm, speed, and duration.

2.5 ICE EROSION

Snow and glacier melt occur only in areas cold enough for these to form permanently. Typically snowmelt will peak in the spring and glacier melt in the summer, leading to pronounced maximum flow in rivers affected by them. The determining factor in the rate of melting of snow or glaciers is both air temperature and the duration of sunlight. In high mountain regions, streams frequently rise on sunny days and fall on cloudy ones for this reason. Soil erosion due to ice melting is not applicable in this region because it is a tropical region and temperatures do not go down to the freezing point.

2.6 CONSEQUENCES OF SOIL EROSION

Damage from the soil erosion is of numerous types however the most serious and significant consequences are mentioned below-

1) Water Pollution
2) Improper water availability
3) Chocking of Streams
4) Change in soil texture

2.6.1 WATER POLLUTION

Water is the most essential requirement after air for the survival of any kind of life which needs more or less some quantity of water. It holds a pivotal position in the total environment so that if its availability is in optimum quantity, it can protect all aspects of the environment and if availability is less or more than the requirement then the quality of all aspects of the environment gets endangered. Water is made available by the nature in good quantity and quality in the form of rainwater, underground water, and through the river, Nala, ponds etc. This water gets affected due to disturbance in nature using man's activities associated with construction, mining activities, etc.

Mainly two types of actions cause water pollution.

a) Mixing foreign substances with natural water causes physical and chemical changes.

b) Interception or diversion of full or part of any waterway.

The operation of mining and allied activities of this project would have an impact on water quality through the generation of wastewater in the surrounding area in many ways. The source of such a polluted liquid effluent has an impact on water quality and these are discussed elaborately in the EMP report.

2.6.2 IMPROPER WATER AVAILABILITY

A lesser amount of the soil is covered with vegetation, mulches, crop residues, etc., more the soil is exposed to the impact of raindrops. When a raindrop hits bare soil, the energy of the velocity detaches individual soil particles from soil clods. These particles can clog surface pores and form many thin, rather impermeable layers of sediment at the surface, referred to as surface crusts. They can range from a few millimeters to one cm or more, and they are usually made up of sandy or silty particles. These surface crusts obstruct the passage of rainwater into the ground reservoir and reduce the water holding capacity of the earth a consequence surface runoff increases and cause more soil erosion. This eroded soil is transported and settled at depressed land, pond, stream/Nala, etc, and reduces the water holding capacity. Moreover, due to the low infiltration rate groundwater reservoir does not get a full recharge. So overall water holding capacity of the area gets reduced to a large extent and resulting in a shortage of water in the region during the dry time.

In another scenario, the increased speed and volume of the surface runoff generate at these places create a flood-like situation anywhere on the downstream side. These create improper water availability in the region.

2.6.3 CHOKING OF STREAMS

Rainfall water that does not infiltrate into the soil starts to flow downhill under the action of gravity. Initially, run-off moves down the slope as a thin diffused film of water that has lost virtually all the kinetic energy which it possessed as falling rain. Thus, it moves only slowly, has a low flow power, and is generally incapable of detaching or transporting soil particles.

If the rain continues, the increasing depth of water will eventually increase. Overland flow that is released in this way is likely to flow downhill more quickly and in greater quantities (i.e. possess more flow power as a result of its kinetic energy), and so it may be able to begin transporting and even detaching and picking up the soil particles. When the speed of runoff is decreased, the carrying capacity of the runoff gets reduced, subsequently, sedimentation takes place, causing the choking of the stream. Following are the main area where maximum soil erosion takes place.

2.6.4 CHANGE IN SOIL TEXTURE

The most serious and significant effect of soil erosion, by far, is the change in soil texture caused by wind/water erosion. Finer soil fractions (silt, clay, and organic matter) are removed and carried away by the wind, leaving the coarser fractions behind. This sorting action not only removes the most important material from the standpoint of productivity and water retention but leaves a more sandy soil and thus a more erodible soil than the original. Successive removals eventually create such a soil condition wherein plant growth is minimized and erodibility is greatly increased. Damage results both from water erosion and the consequent dust storms. Control becomes more and more difficult. In the extreme, the sand begins to drift and form unstable dunes which encroach on

better surrounding lands. Throughout recorded history, huge agricultural areas have been ruined for further agricultural use in this manner

2.7 ESTIMATION OF SOIL EROSION

Erosion is a natural geomorphic process occurring continually over the earth's surface and it largely depends on topography, vegetation, soil, and climatic variation and, therefore, exhibits pronounced spatial variability due to catchments heterogeneity and climatic variation.

Soil erosion is a three-stage process:

(1) Detachment,

(2) Transport, and

(3) Deposition of soil.

Different energy source agents determine different types of erosion. There are five principal sources of energy that affect erosion such as wind, water, gravity, chemical reactions, and anthropogenic, such as tillage. Soil erosion begins with detachment, which is caused by the breaking down of aggregates by raindrop impact, sheering, or drag force of water and wind. Detached soil particles are transported by flowing water (overland flow and inter-flow) and wind, and deposited when the velocity of water or wind decreases by the effect of slope or ground cover. Three processes viz. dispersion, compaction, and crusting accelerate the natural rate of soil erosion. These processes decrease structural stability, reduce soil strength, exacerbate erodibility and accentuate susceptibility to transported by overland flow, interflow, wind, or gravity. These processes are accentuated by soil disturbance (by tillage, vehicular traffic), lack of ground cover (bare fallow, residue removal or burning), and harsh climate (high rainfall intensity and wind velocity).

The above problems can be circumvented by describing the catchments into approximately homogeneous sub-areas using the Geographic Information

System (GIS). In this study, the remote sensing and GIS techniques (through Satellites Imagine and interrelated software) were used for the derivation of spatial information, catchments description, data processing, etc.

2.8 SOIL AND MOISTURE CONSERVATION IN THE FOREST AREAS

Forest is the origin of the streams and rivers, therefore it is very important to conserve soil and moisture in its catchment area. Soil and moisture Conservation works have become an integral part of the Forest Development. Soil Moisture Conservation works in the forest area marked for the plantation activity are carried out on a micro- watershed basis. This approach is aimed at enhancing land productivity and increasing soil moisture availability for a longer period.

2.9 NATURE OF SMC WORKS

Emphasis is to be given to the drainage line treatment. SMC works on the site are carried out as per the site-specific approved treatment plan. Emphasis is to be given to contour line treatment with small and medium SMC works. The SMC and area development works are concerned, the entire area is to be treated as a unit. In an area prone to Soil Erossion and degraded forest, following measures are suggested to increase moisture level :

- Earthen Pits
- Contour Trenches
- Check Dams
- Earthen Ponds
- Grassing
- Mulching

Various plantation models such as mangrove plantation, coastal border plantation, plantation as per the provision in different areas, soil and moisture conservation works of forest and plantation areas, maintenance & up-keep of plantation areas with different models are formulated for different areas.

CHAPTER-3

Soil Characterization & Ecological Survey

CHAPTER-3

SOIL CHARACTERIZATION & ECOLOGICAL SURVEY

3. INTRODUCTION

3.1 SOIL QUALITY

Soil is one of the most significant ecological factors on which plants depend for their nutrients; water and mineral supply. Indiscriminate deforestation, digging for minerals, and destruction of grazing lands for human habitation have done irreparable damage to the environment and even led to harsh climatic change. Some of the dangers posed by soil pollution are due to the fact that while the number of the earth's inhabitants are increasing, the earth's natural resources are by and large fixed as well as limited. Thus, the soil gets heavily polluted day by day by rapid anthropogenic activities and population explosion in developing countries.

Further, major mining activities affect the soil regime of the surrounding areas directly or indirectly. Hence, it becomes important to study soil quality as knowledge of soil parameters is essential for the planning and implementation of afforestation. Keeping the above aspects in view, four locations were selected to represent the entire area study area, and samples were collected from two depths viz. 0-30 and 30-60 cm during the study period.

3.2 METHODOLOGY

Soil samples were collected by digging a pit at the appropriate location from depths 0-30 and 30-60 cm with the help of a spade/ AGAR and a ' Khurpi'. The samples were brought to the CMPDI's laboratory at Ranchi and air-dried for a few days. The air-dried samples were then ground in an agate mortar with the help of a

wooden hammer and passed through a 2 mm (10mesh) sieve. The coarser materials were rejected and the sieved material was sampled by the standard Coning & quartering method (Ref. Jackson, M.L., 'Soil chemical analysis', Prentice Hall, India 1958).

The processed samples were analyzed for the different parameters according to the standard methods as described under Jackson, M.L., 'Soil Chemical Analysis, Prentice Hall, India 1958; millar, CE, turk, L.M. Foth, H.D. Fundamentals of Soil Science, John Wiley & Sons, Inc., New York, 1962, Indian Council of Agricultural Research, New Delhi, ' Hand Book of Agriculture', IS:2720 (Part IV), 1975 and IS:2720, Part (V), 1970 ; Methods of Soil Analysis, Part I & II, Black, CA et.al. American society of Agronomy, Inc. USA, 1965.

3.3 EQUIPMENT AND INSTRUMENTS USED

a. Ion Chromatograph
b. AAS
c. pH Meter
d. Conductivity Meter
e. Double-Beam Spectrophotometer
f. Standard Sieves
g. Oven
h. Muffle Furnace, etc.

3.4 RATIONALE BEHIND SAMPLING

The main aim of the soil testing is to assess the soil quality of the area for assessment of the production potential, selection of suitable species of plants for the green belt and afforestation as an anti-pollution measures. Thus, to assess the soil quality, eight nos. of samples were collected from four different locations from the depths of 0-30 and 30-60 cm for the study period. These sampling locations were

selected in as per details given in the table below:

3.5 SAMPLING LOCATIONS

Details of sampling location are given below:

Table-3.1

Sampling location for soil quality assessment

Sl. No.	Name of Sampling Locations	Total No. of Samples	Remarks
01.	U-1	Two (0-30 & 30-60 cm depth)	Degraded Land
02.	U-6	Two (0-30 & 30-60 cm depth)	Degraded Land
03.	U-7	Two (0-30 & 30-60 cm depth)	Degraded Land
04	U-11	Two (0-30 & 30-60 cm depth)	Dense Forest
		Total No. of Samples	**08**

Fig. 3.1: Soil Sampling locations

3.6 OBSERVATIONS

The observed characteristics of soil samples collected from four different locations are presented hereunder:

Table-3.2

Characteristics of soil: Sampling location: U1

	Sampling Location: U1	**Date of Sampling: 26.04.2022**	
Sl. No.	**Parameters**	**Observed Value**	
		(0-30 cm)	**(30-60 cm)**
1	Soil Texture	Sandy Clay	Sandy Clay
2	Grain Size, %		
	a) Sand	50.5	51.0
	b) Silt content	12.0	12.5
	c) Clay content	37.5	36.5
3	Porosity, %	46.56	45.81
4	Bulk Density, g/cm^3	1.46	1.47
5	pH	6.27	6.34
6	Elect. Conductivity (mS/cm at 20^OC)	1.42	1.57
7	Water holding capacity (inches of water per foot of soil)	1.74	1.69
8	Infiltration Rate (mm/hr.)	11.64	12.47
9	Cation Exchange Capacity, meq/100 g	16.8	16.2
10	Organic Carbon %	0.44	0.42
11	Phosphorous as P_2O_5 kg/ha	5.72	5.91
12	Potash as K_2O, kg/ha	116.8	118.2
13	Nitrogen as N, kg/ha	98	86

Table-3.3

Characteristics of soil sampling location: U6

	Sampling Location: U6	**Date of Sampling: 26.04.2022**	
Sl. No.	**Parameters**	**Observed Value**	
		(0-30 cm)	**(30-60 cm)**
1	Soil Texture	Clay	Clay
2	Grain Size,%		
	a) Sand	29.5	30.0
	b) Silt content	15.5	16.0
	c) Clay content	55.0	54.0
3	Porosity, %	57.41	56.74
4	Bulk Density, g/cm^3	1.19	1.21
5	pH	5.04	5.11
6	Elect. Conductivity (mS/cm at 20^OC)	1.84	1.92
7	Water holding capacity (inches of water per foot of soil)	1.78	1.67
8	Infiltration Rate (mm/hr.)	4.18	4.07
9	Cation Exchange Capacity, meq/100 g	28.9	26.7
10	Organic Carbon %	0.91	0.76
11	Phosphorous as P_2O_5 kg/ha	16.26	16.38
12	Potash as K_2O, kg/ha	158.86	162.48
13	Nitrogen as N, kg/ha	120	110

Table-3.4

Characteristics of soil sampling location: U7

	Sampling Location: U7	**Date of Sampling: 27.04.2022**	
		Observed Value	
Sl. No.	**Parameters**	**(0-30 cm)**	**(30-60 cm)**
1	Soil Texture	Sandy Clay Loam	Sandy Clay Loam
2	Grain Size, %		
	a) Sand	55	56
	b) Silt content	17	17
	c) Clay content	28	27
3	Porosity, %	48.94	48.22
4	Bulk Density, g/cm^3	1.27	1.29
5	pH	4.74	4.86
6	Elect. Conductivity (mS/cm at 20^OC)	0.96	0.97
7	Water holding capacity (inches of water per foot of soil)	1.81	1.79
8	Infiltration Rate (mm/hr.)	22.16	21.84
9	Cation Exchange Capacity, meq/100 g	8.7	8.2
10	Organic Carbon %	0.42	0.39
11	Phosphorous as P_2O_5 kg/ha	14.78	15.59
12	Potash as K_2O, kg/ha	118.09	119.61
13	Nitrogen as N, kg/ha	104	78

Table-3.5

Characteristics of soil sampling location: U11

	Sampling Location: U-11	**Date of Sampling: 27.04.2022**	
Sl. No.	**Parameters**	**Observed Value**	
		(0-30 cm)	**(30-60 cm)**
1	Soil Texture	Sandy Loam	Sandy Loam
2	Grain Size, %		
	a) Sand	69.5	70.5
	b) Silt content	21	19.5
	c) Clay content	9.5	10
3	Porosity, %	52.29	51.67
4	Bulk Density, g/cm^3	1.29	1.31
5	pH	4.68	4.72
6	Elect. Conductivity (mS/cm at 20^OC)	1.28	1.31
7	Water holding capacity (inches of water per foot of soil)	1.42	1.38
8	Infiltration Rate (mm/hr.)	27.61	27.28
9	Cation Exchange Capacity, meq/100 g	7.2	6.9
10	Organic Carbon %	0.54	0.49
11	Phosphorous as P_2O_5 kg/ha	17.26	17.85
12	Potash as K_2O, kg/ha	156.49	157.46
13	Nitrogen as N, kg/ha	166	143

Table-3.6

Soil Fertility Quality Standard w.r.t C:N:P: K

Sl. No.	PARAMETERS	QUALITY STATUS		
		Poor	**Medium**	**Fertile**
1	Organic Carbon %	<0.5	0.5 to 0.75	>0.75
2	Nitrogen as N, kg/ha	<280	280 to 560	>560
3	Phosphorus as P_2O_5, kg/ha	<23	23 to 57	>57
4	Potash as K_2O, kg/ha	<133	133 to 337	>337

3.7 HIGHLIGHTS OF ANALYTICAL RESULTS

The highlights of some of the parameters as depicted in analytical results presented in Tables – 5.2 to 5.4 are given hereunder:

(i) Texture

The texture of the soils was Sandy Clay, Clay, Loam and Sandy Clay Loam and Sandy loam.

(ii) pH

The pH of the soils ranged between 4.68 to 6.34.

(iii) Electrical Conductivity

The electrical conductivity varied from 1.42 to 1.92 dS/cm at $20^{O}C$.

(iv) Organic Carbon

The organic carbon ranged between 0.39 to 0.91 %. Organic carbon is one of the important characteristics of the soil represents for fixation of nitrogen and survival of the various macro and microorganisms. It has been found in the range of poor quality the degraded forest land.

(v) Phosphorus as P_2O_5

The concentration of Phosphorous varied between 5.72 to 17.85 Kg/ha.

(vi) Potash as K_2O

The concentration of Potash ranged between 116.8 to 162.48 Kg/ha.

(vii) Nitrogen as N

The concentration of Nitrogen varied between 86 to 166 Kg/ha.

3.8 SOIL TEXTURE DIAGRAM

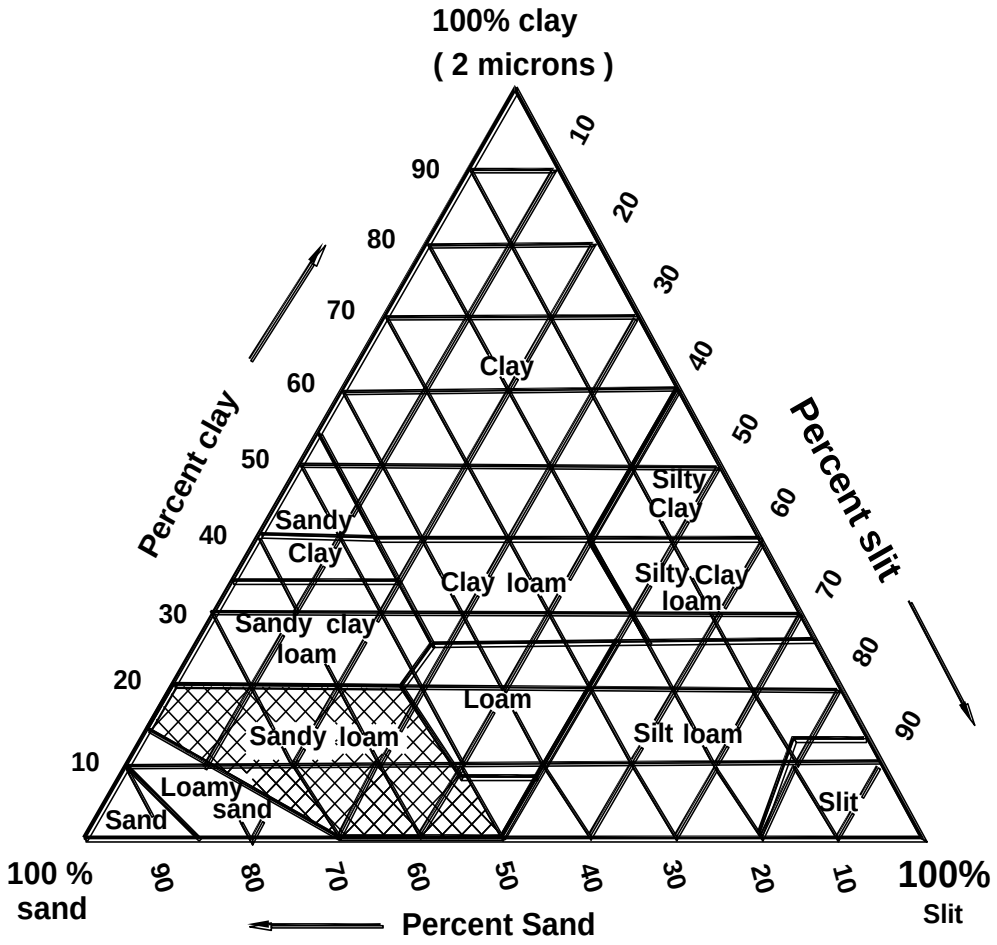


Fig 3.2 Soil Texture Diagram

3.9 FLORA DETAILS OF UTKAL E WITH REFERENCE TO TREE SPECIES.

The vegetation around the study area is dominantly Sal forest, which predominantly comprises deciduous type of trees. One can easily find 5-15 Sal trees in 100 meter square area. At the same time there are various important tree species such as aam (Mangifera indica), mahua (Madhuca longifolia), Palm (Borassus flabellifer), date (Phoenix sylvestris), Bargad (Ficus benghalensis), Diospyros melanoxylon (Tendu), Polash (Butea monosperma), Diospyros ebenum and *Alangium salvifolium*(Ankola), *Strychnos nuxvomica* (Kuchila)are frequently found in Sacred goves. Anogeissus latifolia, Anogeissus acuminata (Daura) *Lagerstoemis sparviflora* (Lendia), *Acacia leucophloea* (safed babul) are frequently found. *Terminalia arjuna* is found near nallas and rivers. Dry area Ailanthus excels also found.are dominant in several areas. Nowadays forest department planted Bamboo at several places. Mohin (*Lannaea coromandelica*), Rohin (*Soymida febrifuga*), Chhar (*Buchanania cochinchinensis*), Tendu(*Diospyros melanoxylon*),Polash (*Butea monosperma*), Kurrah (*Holarrhena pubescence*), *Cesaeria tomentosa*, jamun (*Syzygium cumini*), (*Lagerstroemia speciosa*) Lendia are common trees. Sal tree is the dominant native tree, has high important value index based on the ecological estimate. Fig trees (*Ficus benghalensis* Forest is a composite structure which will have so many types of plants intertwined each other. If one enters for thorough enumeration, more than 500 species of higher plants (Dicotyledons, monocotyledons and ferns), can be identified from this forest. When the soil is rich in humus and moisture trees will grow tall and thick, in the hill slopes, coarse soil trees will not grow tall and thick. Trees like jamun, Arjun, varun, Nirgundi, Kaim will grow well in the stream edges. Several semi-parasitic plants, climbers, epiphytic orchids, Ferns depend trees as their habitat. Tuberous herbs, climbers, annual herbs grasses grow well in the forest floor. This natural forest is the suitable habitat for thousands of insects, butterflies, rodents, birds and mammals. Mine areas, roadsides often plants like *Acacia auriculiformis, Delonix regia, Pithecellobium dulce, Peltophorum pterocarpum, Senna siamea, Eucalyptus tereticornis, Lucaena leucocephala, Dalbergia sissoo, Albizia lebbeck, Acacia catechu* etc. are planted.

There are very useful, strong, drought resistant, fast growing, timber value, fruit yielding, medicinal indigenous tree species are present in our forest. Those tree species can be used for afforestation, green belt developing programmes. Some tree species are found

relatively higher altitudes. The present project is falling around 200 m altitude, high altitude tree species will not survive here, even if survives performance will not be up to the expected level.

Drought resistant fast growing trees are *Gmelina arborea* (Gamhar), *Holoptelea integrifolia* (Dhauranjan) *Anogeissus acuminata, Anogeissus latifolia*, *Ficus religiosa, Ficus racemose, Ficus benghalensis, Azdirachta indica*, *Butea monosperma, Madhuca longifolia, Aegle marmelos, Albizia lebbeck, Alpbizia odorattissima, Albizia procera, Haldina cordifolia, Terminalia tomentosa, Terminalia bellirica. Cassini glauca, Miliusa tomentosa, Chloroxylon swietenia, Pterocarpus marsupium* is an important timber, medicinal tree, found in our forests. Wood is used in medicine, hence it is considered as endangered tree and efforts are on to conserve this tree.

Near river and nallah plants like *Terminalia arjuna, Mitragyna parviflora, Ficus hipida, Syzygium cumini, Putranjiva roxburghii, Barringtonia 12hloroxy, Salix tetrasperma, vachilla indica, Pongamia pinnata* etc. can be planted. The trees will survive in standing water and water logging.

Data analysis: For the calculation of species richness, data analysis was carried out in Microsoft excel. Collected field data was coded and tabulated into excel sheet. At first, data collected in the field targeting different site of the study area.

Dominance analysis: In order to assess the relative share of each species in plant community, Importance Value Index (IVI) for a total score of 300 has been calculated using the frequency, density, abundance, relative frequency, relative density and relative abundance. (Sharma, 2005)

Frequency (F) and Relative Frequency (RF): Frequency (%)**:** The frequency refers to the degree of dispersion of individual species in an area and usually expressed in terms of percentage occurrence (Sharma, 2005). It is calculated using the equation:

$$\text{Frequency (\%)} = \frac{\text{No. of quadrats in which the species occurred}}{\text{Total number of quadrats studied}} \times 100$$

Frequency does not give the correct idea of the distribution of any species, unless it is

correlated with other character (Sharma, 2005).

$$\text{Relative Frequency (\%)} = \frac{\text{Frequency of the species}}{\text{Total frequency of all the species}} \times 100$$

Density (D) and Relative Density (RD): Density is an expression of the numerical strength of a species where the total number of individuals of each species in all the nested quadrat divided by the total number of nested quadrat studied (Sharma, 2005). Density is calculated by the equation:

$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total no of quadrats studied}}$$

$$\text{Relative Density} = \frac{\text{Density of the species}}{\text{Total density of all the species}} \times 100$$

Relative Dominance (%): Dominance is the parameter which is determined by the value of basal area For the comparative analysis Relative dominance is determined. It is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.

$$\text{Basal area} = \frac{(\text{Circumference at breast height})^2}{12.56}$$

$$\text{Relative dominance} = \frac{\text{Basal area of the species}}{\text{Basal area of all the species}}$$

Circumference at Breast Height*:* The second most important parameter of field data is circumference at breast height/diameter at breast height of the tree, this parameter used to calculate the volume or weight of the tree, which can converted to biomass per unit area (tonnes/hectare). The diameter and height can be used for estimating the volume by simple equations.

Height of trees: Next to DBH/CBH, height is the most important indicator of the volume or weight of a tree and used in many allometric functions along with DBH. To measuring the height of tall trees, 4 – 5 tall individuals were measured using the Range Finder and then for other tree species. Eye or ocular estimation was also practiced especially those with overlapping canopies.

Basal area: the basal area of individual tree is also calculated in Microsoft-excel using the CBH with the formula:

Basal area = πr^2

Important Value Index (IVI): The concept of 'Important Value Index (IVI)' has been developed for expressing the dominance and ecological success of any species, with a single value (Mishra, 1968, Sharma, 2005). This index utilizes three characteristics, they are (i) Relative requency,(ii) Relative density and (iii) Relative abundance. The three characteristics computed using frequency, density and abundance for all the species falling in all the quadrat by using the following formula.

The relative frequency, relative density and relative abundance has been calculated to calculate the IVI value

IVI = Relative frequency + Relative abundance + Relative density [RF + RA + RD]

The IVI of all species, Genus, and Family has been calculated.

Table-3.7

Importance value index of tree species found in the Talcher area

	Common name	Botanical name	Relative frequency	Relative abundance	Relative density	Important Value index
1	Black wattle	Acacia auriculiformis	1.06	0.61	1.82	3.49
2	Safed baul	Acacia leucophloea (Roxb.) Willd.	1.74	0.98	3.42	6.14
3	Bael	Aegle marmelos (L.) Corrêa	1.74	0.98	2.72	2.72
	Maharuk	Ailanthus excelsa	-	-	-	-
4	Ankola	Alangium salviifolium (L.f.) Wangerin	4.87	5.31	0.57	10.75

	Common name	Botanical name	Relative frequency	Relative abundance	Relative density	Important Value index
5	Cashew	Anacardium occidentale L.	1.74	0.98	0.594	3.314
6	Tall Dhaura	Anogeissus acuminata	-	-	-	
7	Dhaura	Anogeissus latifolia (Roxb. Ex DC.) Wall. Ex Guill. & Perr	3.13	1.77	0.59	5.49
8	Sirish	Albizia lebbeck	5.78	4	15.09	24.87
9	Safed sirish	Albizia procera	-	-	-	-
10	Kala sirish	Albizia odorattissima	-	-	-	
11	Rain tree	Albizia saman	1.06	0.61	0	1.67
12	chatin	Alstonia scholaris	3.46	4	0	7.46
13	powder-puff tree	Barringtonia racemosa	-	-	-	-
14		Bauhinia racemosa	1.74	0.98	0.14	2.86
	Kanchnar	Bauhinia purpurea				
		Bauhinia variegata				
15	Palm	Borassus flabellifer L.	3.13	4.33	4.01	11.47
16	Khaj	Bridelia crenulata Roxb.	3.13	1.77	0.38	5.28
17	Chaar	Buchanania cochinchinensis (Lour.) M.R.Almeida	1.74	1.77	0.14	3.65
18	Polash	Butea monosperma (Lam.) Taub.	1.74	0.98	0.21	2.93
19	Cilla	Casearia graveolens Dalz.	3.13	0.98		4.11
20	Bhirra	Chloroxylon swietenia	-	-	-	-
21	Varun	Crateva religiosa	-	-	-	-
22	Phansi	Dalbergia paniculata	-	-	-	-
23	Green ebony persimmon	Diospyros chloroxylon Roxb	1.74	0.98	0.14	2.86
24	Indian ebony	Diospyros ebenum J.König	3.13	2.75	3.42	9.3

	Common name	Botanical name	Relative frequency	Relative abundance	Relative density	Important Value index
		ex Retz.,				
25	Tendu	Diospyros melanoxylon Roxb	3.13	1.77	3.42	8.32
26	Bistendu	Diospyros montana Roxb.	1.74	1.77	0.14	3.65
27	Amaltas	Cassia fistula	3.46	4	2.86	10.32
28	Chikondi	Senna siamea	10.42	10.04	7.56	28.02
29	Sisam	Dalbergia sissoo	3.46	10.7	0	14.16
30	Blue gum	Eucalyptus tereticornis	1.06	0.61	10.33	12
31	Bat fig	Ficus amplissima				
32	Bargad	Ficus benghalensis L.	3.13	1.77	49.63	54.53
33	Curtain fig	Ficus microcarpa	-	-	-	-
34	Hill fig	Ficus mollis	-	-	-	-
35	Gular	Ficus racemosa	-	-	-	-
36	Peepal	Ficus religiosa	-	-	-	-
37	Devil Fig	Ficus hispida L.	1.74	0.98	0.14	2.86
38	White fig	Ficus virens	-	-	-	-
39	Gamhar	Gmelina arborea	2.29	2	0.57	4.86
40	Haldu	Haldina cordifolia	-	-	-	-
41	Kurra	Holarrhena pubescence	1.06	0.61	0.11	1.78
42	Banaba	Lagerstroemia speciosa	2.29	3.34	0	5.63
43	mohin	Lannea coromandelica	1.06	0.61	1.82	3.49
44	Maharuk	Ailanthus excelsa	2.29	1.32	25.07	28.68
45	Mahua	Madhuca longifolia var. latifolia (Roxb.) A.Chev.	1.74	2.75	3.42	7.91
46	Aam	Mangifera indica L.	1.74	3.54	5.2	10.48
47	Kari	Miliusa tomentosa	3.13	1.77	0.14	5.04
48	Bakul	Mimusops elengi	-	-	-	-
49	Kaim	Mitragyna cordifolia	-	-	-	-
50	Aal/Auch	Morinda coreia Buch.-Ham.,	1.74	1.77	0.21	3.72
51	Bakul	Mimuspops elengii	1.06	0.61	0	1.67

	Common name	Botanical name	Relative frequency	Relative abundance	Relative density	Important Value index
52	Neem	Azadirchta indica	15.05	17.41	3.97	36.43
53	Kadam	Neolamarkia cadamba	1.06	0.61	4.83	6.5
54	Avla	Phyllanthus emblica	2.29	2.61	0	4.9
55	Jungi jilebe	Pithecellobium dulce	5.78	6.02	4.43	16.23
56	Karanj	Pongamia pinnata	5.78	8.65	0	14.43
57	Mesquite	Prosopis juliflora	3.46	2	0.93	6.39
58	Khejri	Prosopis spicigera	-	-	-	-
59	Bijay	Pterocarpus marsupium	1.06	1.32	0	2.38
60	Putrajevi	Putranjiva roxburghiana	-	-	-	-
61	Swarna moola	Salacia chinensis	-	-	-	-
62	Indian willow	Salix tetrasperma	-	-	-	-
63	Kusum	*Schleichera oleosa* (Lour.) O				
64	Bilawa	Semecarpus anacardium L	1.74	0.98	0.21	2.93
65	Sal	Shorea robusta	2.29	1.32	2.86	6.47
66	Laxmitaru	Simaruba glauca	1.06	0.61	0	1.67
67	Rohin	Soymida febrifuga	1.74	3.54	0.25	5.53
68	Nux vomica	Strychnos nux-vomica L.	3.13	1.77	3.42	8.32
69	Padri	Stereospermum personatum	-	-	-	-
70	Sihora	Streblus asper	-	-	-	-
71	Mahogany	Swietenia mahogani	1.06	0.61	0	1.67
72	Sagwan	Tectona grandis	2.29	2.61	0	4.9
73	Arjun	Terminalia arjuna	1.06	1.32	0	2.38
74	Saj.	Terminalia tomentosa Wight &	3.13	2.75	0.38	6.26
75		Trewia nudiflora	-	-	-	-
76	Babul	Vachilla nilotica	2.29	1.32	1.82	5.43
77		Wrightia arborea	-	-	-	-
78	Pala Indigo	Wrightia tinctoria	-	-	-	-

	Common name	**Botanical name**	**Relative frequency**	**Relative abundance**	**Relative density**	**Important Value index**
79	Date	Phoenix sylvestre	1.06	0.61	11.46	13.13
80	Jamun	Syzigium cumini	1.06	0.61	0.46	2.13
81	Polash	Butea monosperma	1.06	0.61	1.02	2.69
82	Ber	Zizyphus mauritiana	-	-	-	-
Pterocarpus marsupium is a vulnerable category tree. Trees are common indigenous or introduced trees. IVI = Relative frequency(Rel Fr) + Relative abundance(ReD) + Relative density [RF + RA + RD]						

Table-3.8

Native wild fruit Trees

1	Bael	Aegle marmelos (L.) Corrêa
2	Ankola	Alangium salviifolium (L.f.) Wangerin
3	Neem	Azadirchta indica
4	Chaar	Buchanania cochinchinensis (Lour.) M.R.Almeida
5	Palm	Borassus flabellifer L.
6	Varun	Crateva religiosa
7	Kumbhi	Careya arborea
8	Green ebony persimmon	Diospyros chloroxylon Roxb
9	Indian ebony	Diospyros ebenum J.König ex Retz.,
10	Tendu	Diospyros melanoxylon Roxb
11	Bistendu	Diospyros montana Roxb.
12	Indian Bat fig	Ficus amplissima
13	Bargad	Ficus benghalensis L.
14	curtain fig	Ficus microcarpa
15	Hill fig	Ficus mollis
16	Gular	Ficus racemosa
17	Peepal	Ficus religiosa
18	Devil Fig	Ficus hispida L.
19	White fig	Ficus virens
20	Ramontchi	Flacourtia ramontchi
21	Gamhar	Gmelina arborea
22	mohin	Lannea coromandelica
23	Mahua	Madhuca longifolia var. latifolia (Roxb.) A.Chev.
24	Aam	Mangifera indica L.
25	Kari	Miliusa tomentosa
26	Bakul	Mimusops elengi
27	Avla	Phyllanthus emblica
28	Jungi jilebe	Pithecellobium dulce

29	Putrajevi	Putranjiva roxburghiana
30	Swarna moola	Salacia chinensis
31	Nux vomica	Strychnos nux-vomica L.
32	Date	Phoenix sylvestre
33	Jamun	Syzigium cumini
34	Ber	Zizyphus mauritiana

Bargad *Ficus benghalensis* - 54.53 ,Neem *Azadirchta indica* 36.43, Maharuk *Ailanthus excelsa* 28.68, Sirish *Albizia lebbeck* 24.87, Shorea robusta 6.47 are Talcher area trees with high importance value index.

Fig. 3.3 Rohituk (Soymida)

Fig. 3.4 Diospyros montana, Sal, Bahera, Daura

Fig. 3.5 Sal, Chhar , Jamun, Morinda

Fig. 3.6 Bahera, Tendu, Mohin,sal trees

Fig. 3.7 Sal, Kendhu, Bahera trees

Fig. 3.8 Mango and Neem trees

Fig.3.9 CMPDI Survey Team

Fig. 3.10 CMPDI Team on the Site

Fig. 3.11 Drone flying above the site

CHAPTER-4

Hydrogeological Studies

CHAPTER- 4
HYDROGEOLOGICAL STUDY

4.1 GROUNDWATER OCCURRENCE

The study area south of Utkal E Block is located in the southwestern part of Talcher coalfield. Geological exploration in this area has revealed that the surface soil is generally sandy containing quartz pebbles and boulders. The area is further represented by rough, rigid, and hilly terrain and is under forest cover and certain patches are being utilized for agricultural purposes. Patches of forest and open shrubs also occur along seasonal streams & the Singhada jhor/ stream. The stratified sedimentary deposit contains coal seams, shale and sandstone in multi layers. Coal seams and shale act as a confining bed.

In the area, groundwater occurs under the phreatic or unconfined condition in a weathered portion of rocks and semi-confined to confined conditions in fractures/cavernous parts of rocks i.e. sandstone and shale at depths. The shallow aquifers of the study area occur within an average depth of 25-30 m. The shallow aquifers of the area are mostly developed by way of dug wells in the area whose depth varies from 7 to 14 m. In general, the yield of dug wells ranges from 25 to 40 m^3 /day. Deep aquifer system in the area is mainly formed by the Gondwana supergroup of rocks mainly Barakar, Kamthi and karharbari formations which comprise sandstone and shale. The deep aquifers of the area are mostly developed by way of bore wells in the area whose depth varies from 50 to more than 100m in some places. In general, the yield of bore wells ranges from 5 to 20 lps.

4.2 TOPOGRAPHY AND DRAINAGE

The area exhibits undulating topography with moderately dissecting hills and valleys. The general elevation of the project site is RL 140 m to RL 220 m.

Drainage of the study area is mainly controlled by easterly flowing

Singhada jhor/ stream which forms the northern boundary of the block and maintains the base flow even during the dry summer. Gundijeri nala and Katau nala traversing the area drain into Singhada jhor/ stream which ultimately meets the Brahmani River towards further north-east of the area. There are a few ponds in the block area and mainly used for domestic & irrigation purposes.

4.3 CLIMATE AND RAINFALL

The area experiences a sub-tropical climate with hot summer followed by well-distributed rainfall through the South-West monsoon season. The winter commences in December and lasts till the mid of February. The area is governed by a hot weather climate typically between the end of March to the Mid June. The monsoon season starts in the middle of June and lasts till the end of September. The average rainfall in the area is 1250mm (20-year period).

4.4 DRAINAGE ANALYSIS

The Singhada jhor/ stream is having a drainage network with the Gundejeri stream and another unnamed seasonal stream which are draining the study area. The total catchment of the Singhada jhor/ stream is estimated as 360 km^2. The drainage density and stream frequency for this basin are respectively computed as 1.75 km/km^2 and 2.09/km^2. The overland flow distance is 1.14 km and 0.095 is the overall slope for this basin. It is observed from the catchment characteristic of the Singhada jhor basin that the drainage network of the area is more favorable for long extended discharge than to generate sudden peak discharge. The stream flow data available from the previous studies from Singhada jhor/ stream indicate that the maximum daily discharge is 17.809 m^3/sec and the minimum daily discharge is 0.0046 m^3/sec.

The stream Gundejeri is one of the tributaries of Singhada jhor/ stream traversing the proposed mining area from southwest to northeast. This stream has to be diverted away from the mining area and to be directed to the natural

drainage slope. Gundejeri stream originates at an elevation of 280 m AMSL near Durgapur reserve forest and attains 3rd order magnitude before joining to Singhada jhor at an elevation 140 m AMSL. The total catchment of the drainage is 14.62 km^2. The total length of the stream from its origin to the place of joining at Singhada jhor is 7.107 km. Another unnamed northeast flowing seasonal drain which is traversing the mine site is originating at an elevation of 200 m AMSL near Korada village and also attains 3rd order magnitude before joining Singhada jhor at an elevation of 145 m AMSL. The total catchment of the drainage is 9.43 km^2, out of which 1.07 km^2 falls in the mine site. The total length of the drainage is 5.46 km.

4.5 GEOLOGY AND STRUCTURE

The generalized geological/stratigraphic succession of the study area as available from exploratory boreholes in the area is compiled below in table 4.5.A.

Table 4.5.A Stratigraphic succession of Study area

Age	Group	Formation	Thickness (m)	Lithology
Recent		Recent deposits	2 – 30	Soil, Sub-soil, etc.
Lower Permian		Barakar Formation	315	Medium to coarse-grained greyish felspathic sandstone, grey to dark grey shale, and coal seams.
	Gondwana Super Group	Karharbari Formation	160	Pale brownish yellow colored massive medium to coarse-grained sandstone containing clasts of Talchir shale and coal seams.
Upper Carboniferous to Lower Permian		Talchir Formation	102	Diamictite, sandstone, needle shale, turbidite, rhythmites and varves.
---------- Unconformity ----------				
Archaean to Lower Proterozoic		Pre-Cambrian Metamor-phics		Granites, gneisses and associated supracrustals.

The general strike of the beds is mainly E-W to ESE-WNW with slight variations in the central part of the block. The direction of the dip of the strata is towards N to NNE and the amount varies from 3º to 8º.

Geological Map of the study area is given in Figure 4.1

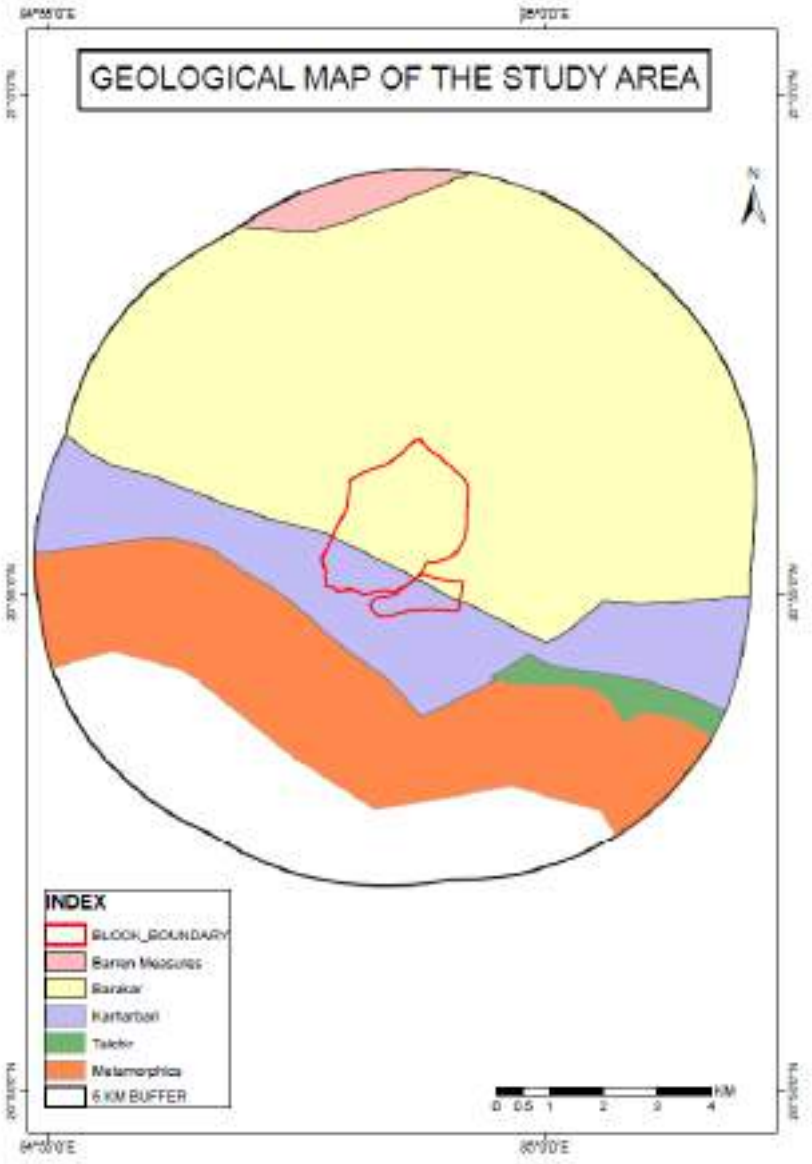


Figure 4.1: Geological Map of the study area

4.6 AQUIFER DESCRIPTION

On the basis of geological exploration data, in the order of superposition, two formations namely Karharbari and Basal Barakar formations are encountered in this area. Two aquifer formations are distinguished namely Karharbari aquifer and Basal Barakar aquifer.

- **Karharbari Aquifer**

This is the lower most aquifer considered in the present study area. This aquifer outcrops south of active coal mining belt. This aquifer is expected to spread over the entire areas with the general strike of east west and a gentle dip of 3 to 4^{o} towards north. This aquifer consists of Karharbari sandstones and Talcher greenish sandstone. These sandstones are associated with shales and coal seam-I, which act as confining bed. Ground water in this aquifer occurs in the confining hydraulic condition. At outcrop areas, these sandstones are highly weathered and support dug wells for domestic water supply needs.

- **Basal Aquifer**

This aquifer represents the lowermost granular horizons of the area. This aquifer is bounded by Karharbari coal seam-I at the bottom and weathered sandstone and shale at the top. This aquifer outcrops in the southern parts of the area. In the outcrop region, the aquifer material is weathered and essentially unconfined. The basal aquifer consists of Karharbari sandstones and Basal Barakar conglomerates. The sandstones and conglomerates are weathered. The primary porosity seldom exists. However, the secondary porosity induced during the post-depositional weathering accounts for most of their yields.

As per earlier hydrogeological investigation in the area by CMPDI, the average hydraulic conductivity of an unconfined aquifer is 2.13 m/day. The average hydraulic conductivity of the semi-confined aquifer is 0.87 m/day. The transmissivity ranges between 80-180 m^2/day.

The hydrogeology Map of the area is given in Figure 4.2.

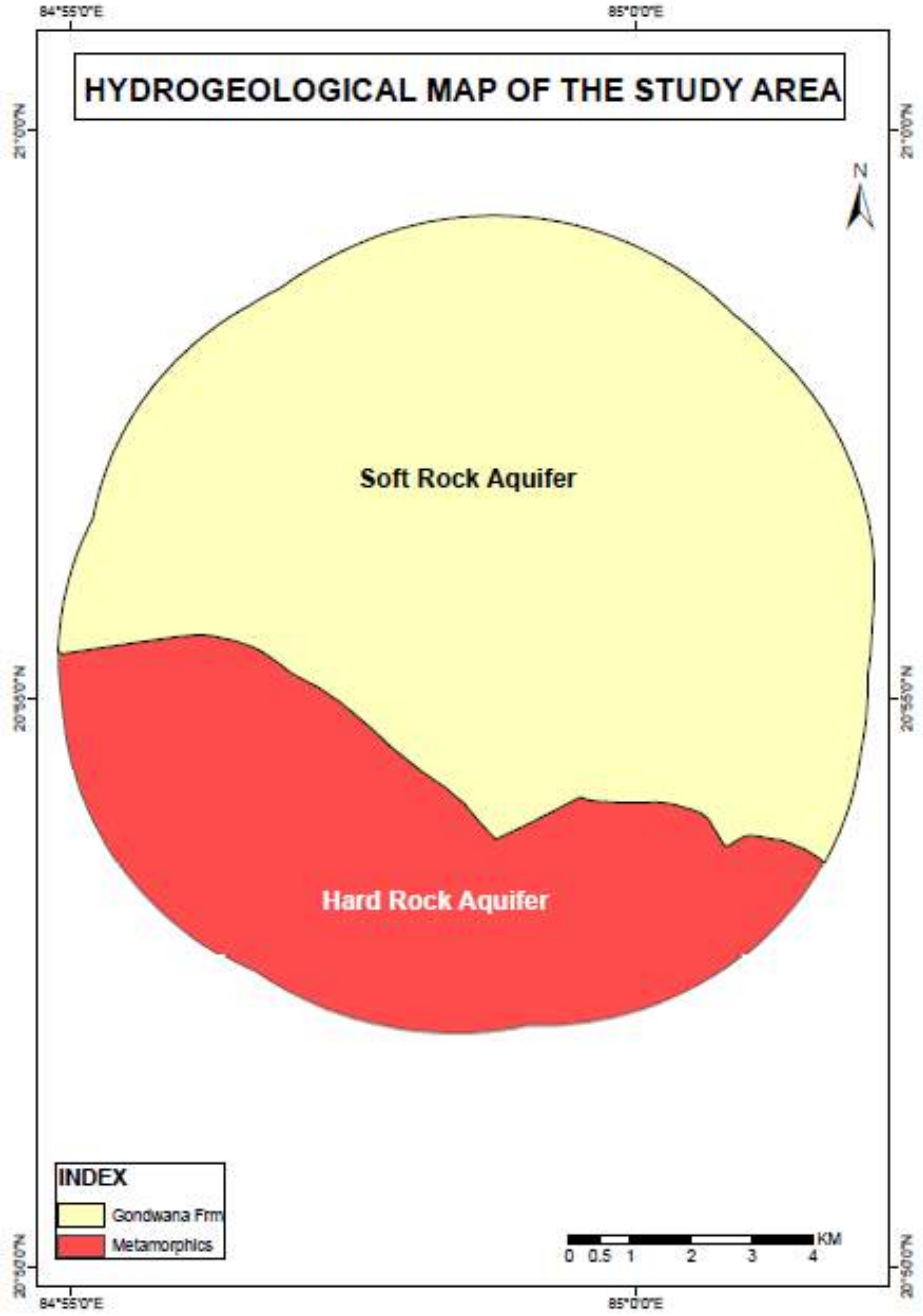


Figure 4.2: Hydrogeology Map of the study area

4.7 GROUNDWATER FLOW AND AQUIFER INTERACTION

Groundwater is a dynamic system. It always remains under the influence of periodic recharging and discharging factors. Due to this continuous influence,

water levels of the aquifer system fluctuate and the range depends on the period of influence. The recharge to the ground water system is controlled by many factors such as rainfall, seepage from reservoirs, lakes, ponds, rivers and irrigation, etc. The output from the ground water system includes ground water withdrawal, natural seepage to rivers, evaporation from shallow water table and transpiration through vegetation.

Present ground water scenarios of the area are assessed from the open dug wells used for domestic water consumption in an around 5km buffer area. The details of selected hydrograph stations in and around Study area are given in Table 4.7A. The water level in these wells represents hydraulic head of water table aquifers. The hydraulic heads of all observed wells are calibrated to reduced level. The hydraulic head of all hydrograph stations are connected to construct water table contour map. Groundwater flow maps & Depth to water level maps for study area for premonsoon and postmonsoon seasons are given in **figure 4.3, 4.3A & 4.4, 4.4A**. The average water table slope works out as 0.005. The altitude of water table in the 5 km buffer zone the project area ranges between 245 m above MSL to less 105 m above MSL. The generic groundwater flow direction is west to east.

Table 4.7A: Details of hydrograph stations in and around Study area

WELL ID	VILLAGE	LONGITUDE	LATITUDE	PRE-MON WATER LEVEL (mbgl)	POST-MON WATER LEVEL (mbgl)
NAL-01	RAIJHARAN	84.97045937	20.95672892	6.55	5.05
NAL-02	JHINTIPAL	84.8980041	20.96545566	8.02	5.89
NAL-03	KORARA	84.90536135	20.95642974	8	4.4
NAL-04	MALLIBRAHMIN	84.99385088	20.92508426	5.01	4
NAL-05	DURGAPUR	84.88231025	20.91824205	6.85	2.5
NAL-06	DURGAPUR TANGRISAHI	84.90862325	20.91939488	6.55	4.28
NAL-07	UDKAPA	84.9152267	20.88351648	7.66	3.04
NAL-08	JARPARHA	84.8839567	20.88342855	6.5	3.08
NAL-09	TUKURA	84.89923661	20.87044313	6.23	2.55

WELL ID	VILLAGE	LONGITUDE	LATITUDE	PRE-MON WATER LEVEL (mbgl)	POST-MON WATER LEVEL (mbgl)
NAL-10	JANGAL	84.93267565	20.87251123	7.75	6
NAL-11	MUNDASAHI	84.92015719	20.85400732	4.05	2.44
NAL-12	MARATIRA	84.9755654	20.82994204	6.5	3.45
NAL-13	RANTALEI	85.03674344	20.82430703	7.66	5.86
NAL-14	BENAGARHIA	85.04301402	20.85489108	4.12	3.99
NAL-15	BERHASAR	85.05617458	20.87165551	4.5	3.5
NAL-16	BHUBANPUR	85.01323706	20.89290854	7.9	4.11
NAL-17	DERJANGA	85.01699251	20.82926889	5.25	2.55
NAL-18	DABOMOLIA	84.94939446	20.96000371	10	5.5
NAL-19	PURIOBAHAL	85.01345544	20.91285425	7.6	6.1

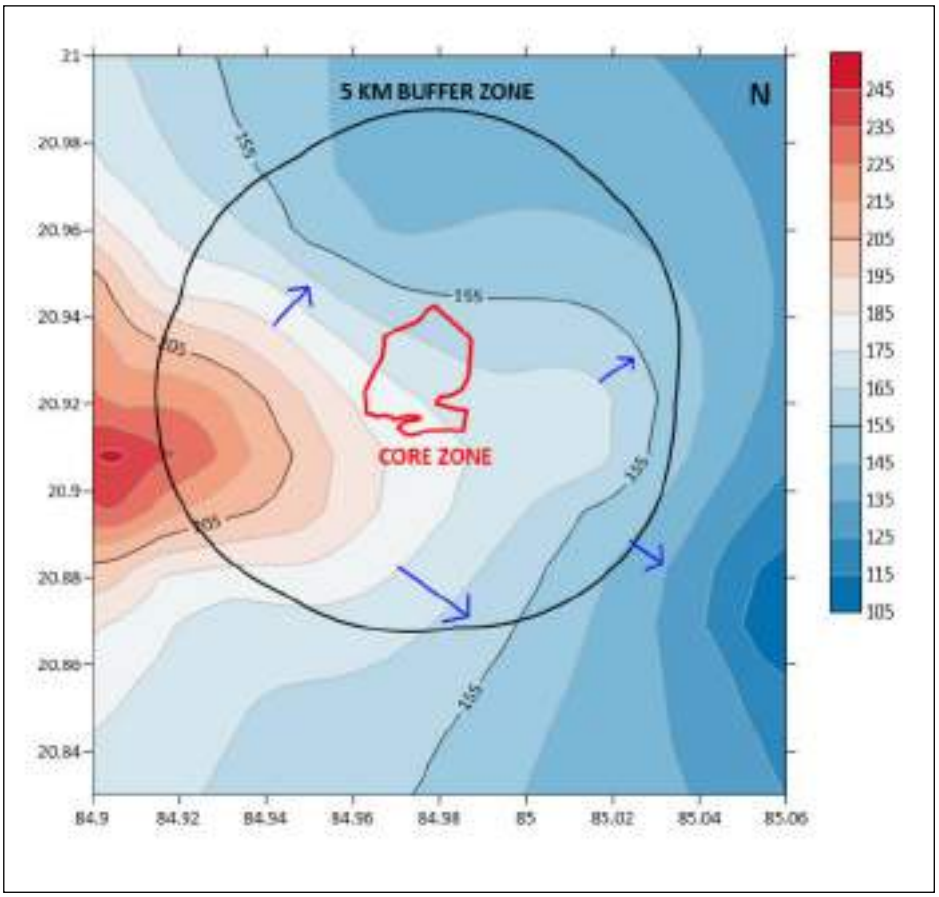


Figure 4.3: Groundwater flow map of Pre-monsoon season around Study area

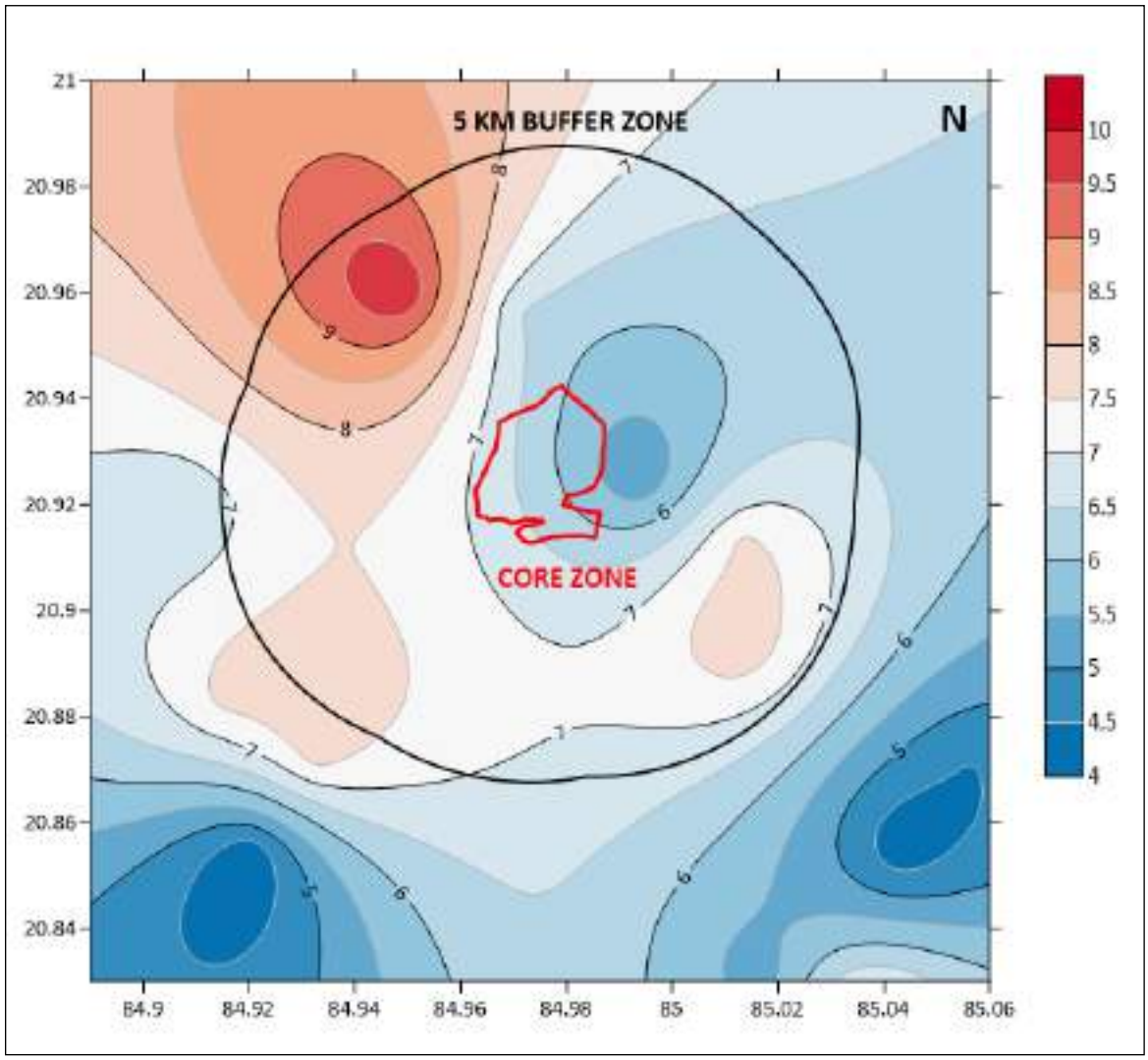


Figure 4.3 A: Depth to Water map of Pre-monsoon season around Study area

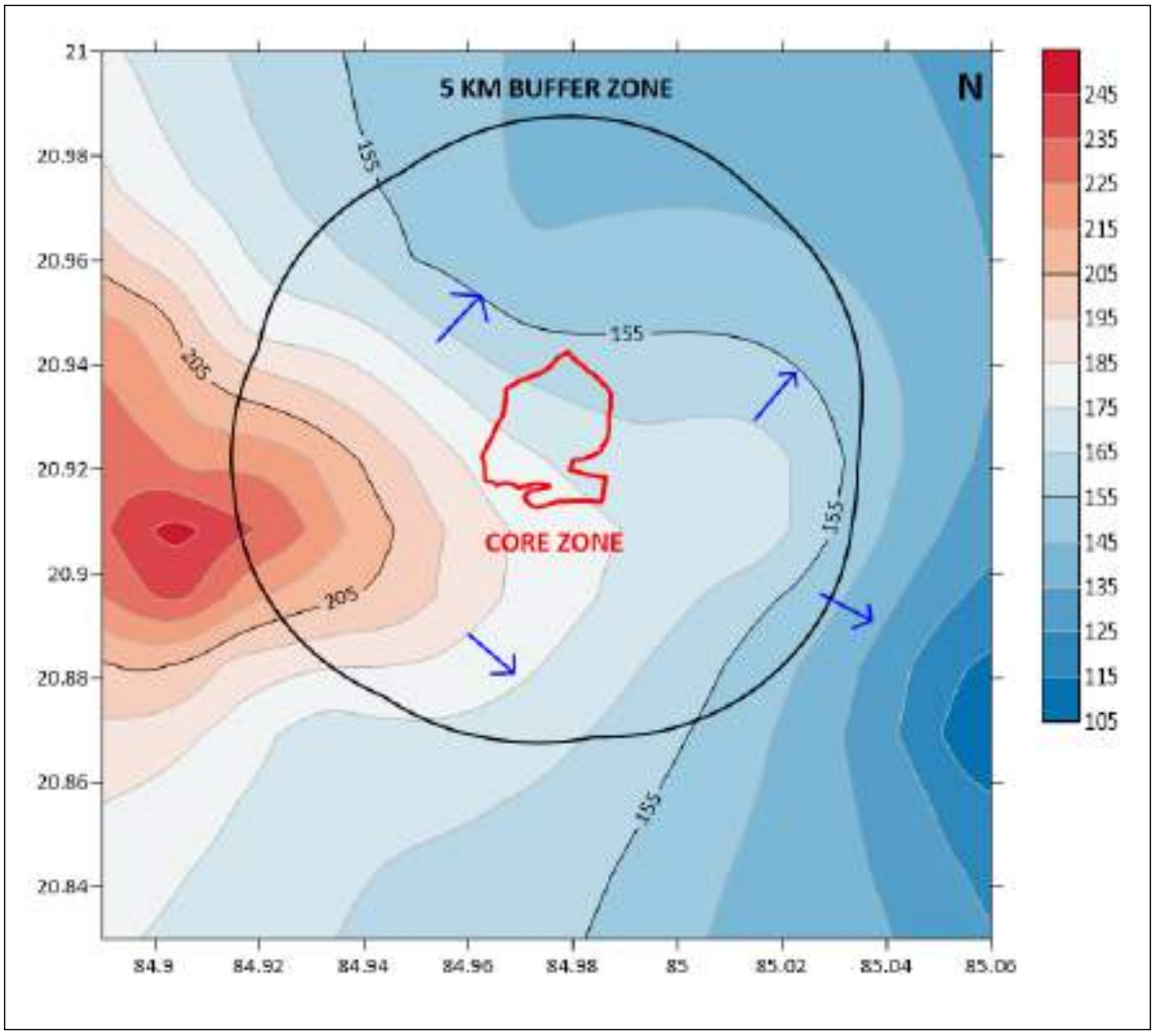


Figure 4.4: Groundwater flow map of Post-monsoon season around Study area

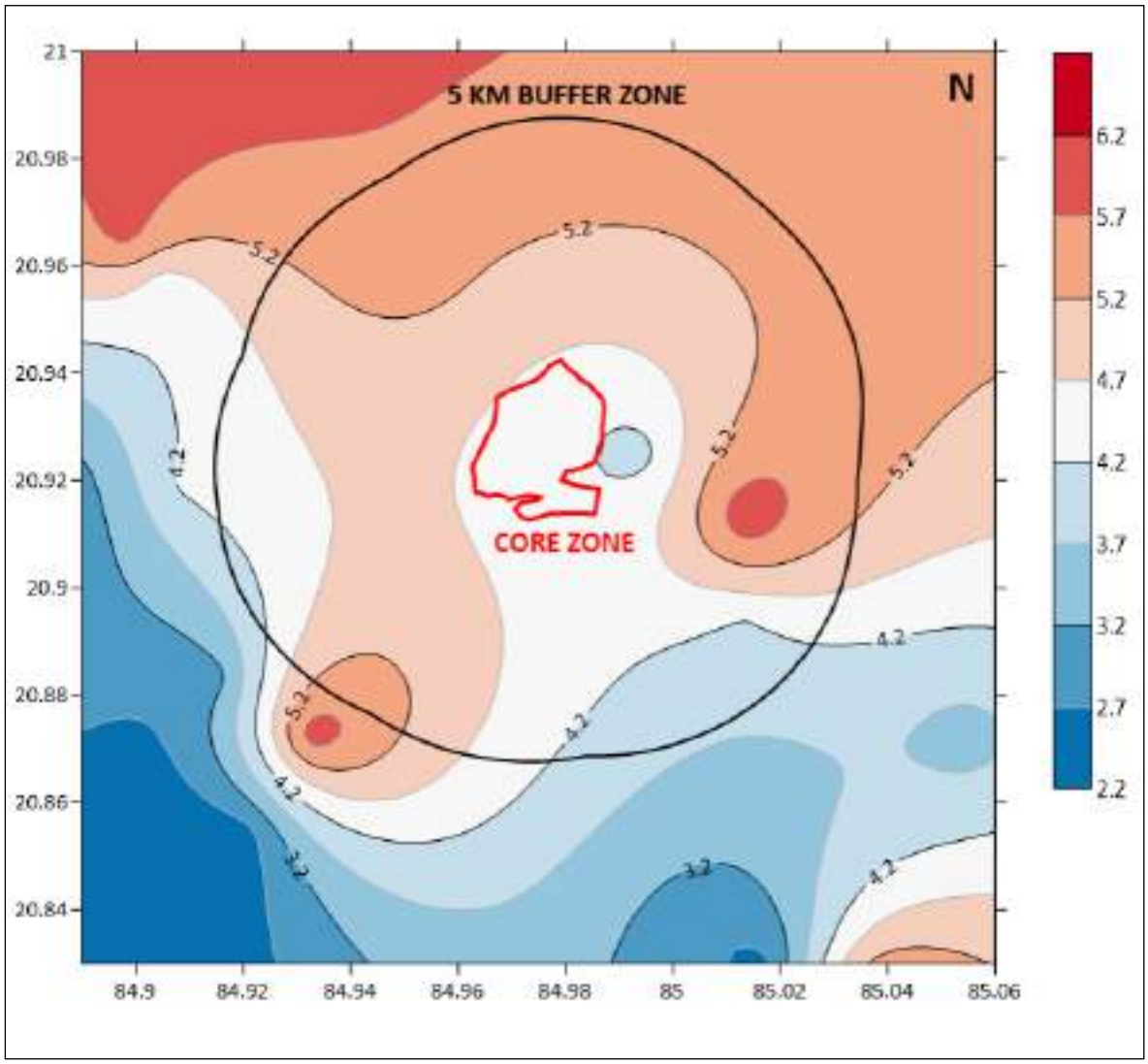


Figure 4.4A: Depth to Water map of Post-monsoon season around Study area

4.7 GROUNDWATER LEVEL TRENDS

The long-term water level change (between 2014 and 2020) of two hydrograph stations from the village of Durgapur and Jharparha is presented in this section.

Village Durgapur hydrograph shows the decline in water levels over the period of observation indicating that the area nearby is affected by the overall

groundwater utilization. However, Village Jharparha shows an increasing trend which signifies that the groundwater is not affected by the overall groundwater utilization.

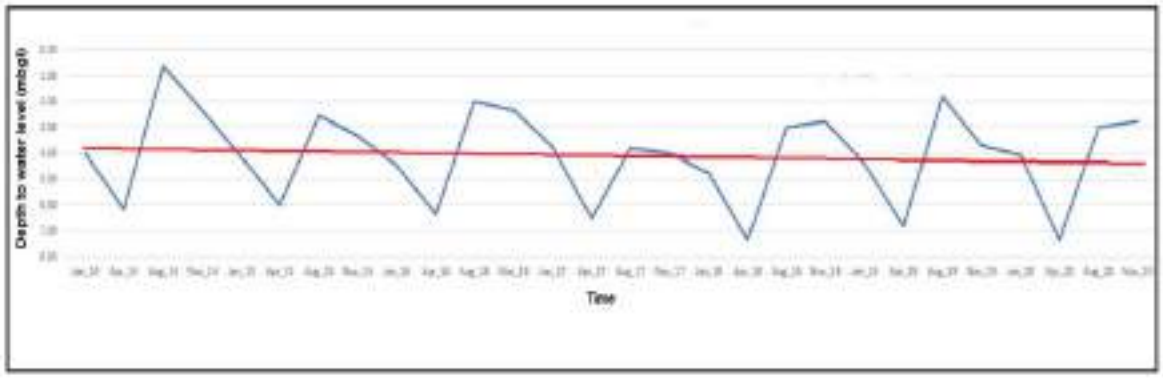


Figure 4.5: Hydrograph of Durgapur dug well, Dist Angul.

Source: CGWB

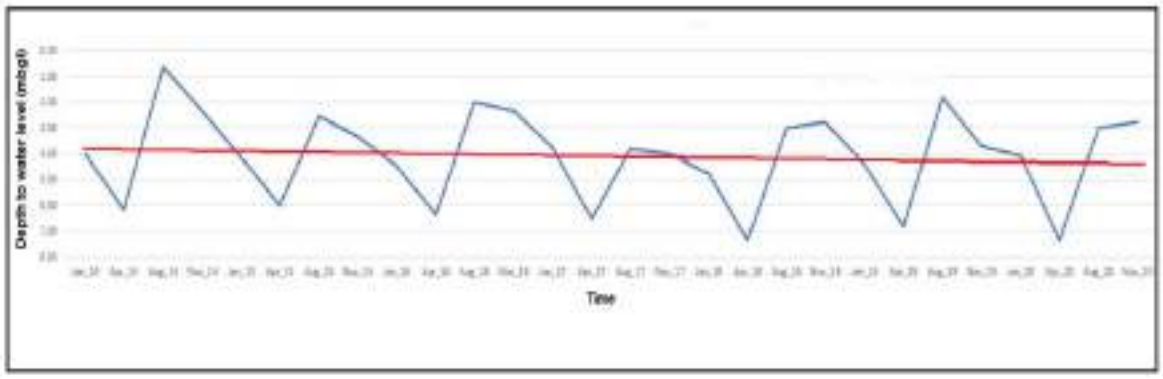


Figure 4.6: Hydrograph of Jharparha dug well, Dist Angul.

Source: CGWB

4.8 WATER ENVIRONMENT

The water quality characterization has been conducted by collecting water samples from the surface water of the forest area. The various purposes of surface water monitoring are to assess the water quality characteristics for critical parameters; to facilitate predication of the impact on water quality by the area.

4.8.1 METHODOLOGY

The grab sampling method was adopted for the collection of the surface water samples from different sources of water bodies.

Three nos. of surface water were collected as representative samples to assess the water quality of the area during the study period. The sampling locations were selected from the available water body in the area. These samples were analyzed as per the "Standard Method for the Examination of Water & Waste Water" published by the American Public Health Association (APHA: 22nd Edition, 2012).

Samples for chemical analysis were collected in polyethylene containers. Samples collected for metal content were acidified with 1 ml. Conc. HNO_3 per liter. Samples for bacteriological analysis were collected in sterilized glass bottles. Some of the parameters such as temperature, pH, DO, alkalinity, total hardness and chloride, etc., which were liable to change with time were analyzed at the site with the help of an analytical kit, and one set of "Preserved" samples were brought to CMPDI's laboratory at Ranchi for detailed analysis of the remaining parameters stated in the tables.

4.8.2 MAJOR INSTRUMENTS USED

- Double-Beam Spectrophotometer
- Nephelometer
- Atomic Absorption Spectro - Photometer
- Conductivity Meter
- pH Meter
- Analytical Balance (Mettler)
- BOD Incubator
- High Speed Centrifuge
- Oven

- Muffle Furnace
- Ion Chromatography etc.

4.8.3 RATIONALE BEHIND SAMPLING

Any adverse impact or pollution consequence of water will have a serious effect on the environment. Thus, to assess the surface water quality, samples from different water bodies were collected from 3 different locations and analyzed for physicochemical and heavy metal parameters.

4.8.4 Sampling Locations

Details of sampling location are given:

Sl. No	Name of Sampling Locations	Latitude (X)	Longitude (Y)
01.	SW-1 (Nala- Down Steam)	84.98127	20.93783
02.	SW-2 (Pond Water)	84.98177	20.93425
03.	SW-3 (Nala- Up Steam)	84.98429	20.93275

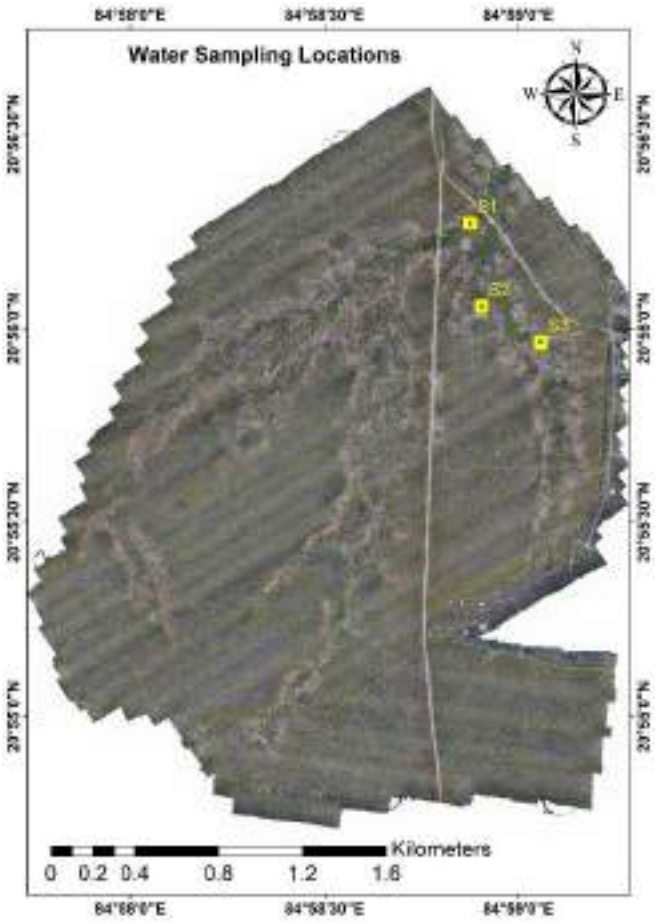


Fig 4.7: Water Sampling locations

4.8.5 CHARACTERISTICS OF SURFACE WATER SAMPLES

The Physicochemical characteristics of three nos. of surface water samples collected locations have been presented here under:

- **Physico-Chemical Characteristics Of Surface Water Quality**

(Wherever not specified, characteristics are expressed in mg/l)

Date of Sampling: 27.04.2022

Sl. No	Parameter	Sampling Stations			Detection Limit	BIS Standard & Method
		SW-1	SW-2	SW-3		
1	Arsenic (as As), mg/l, Max	<0.002	<0.002	<0.002	0.002	IS 3025/37:1988 R : 2003, AAS-VGA, Method
2	BOD (3 days 27°C), mg/l, Max	2.4	2.2	2.6	2.00	IS 3025 /44: 1993, R: 2003 3 day incubation at 27°C
3	Cadmium(as Cd), mg/l, Max	<0.0004	<0.0004	<0.0004	0.0004	APHA, 23rd Edition AAS-GTA Method, 2017
4	Chlorides (as Cl), mg/l, Max	26	24	16	2.00	IS-3025/32:1988, R-2007, Argentometric Method
5	Copper (as Cu), mg/l, Max	<0.02	<0.02	<0.02	0.02	IS 3025/42: 1992, R : 2009, AAS (Air-Ac-Flame)

Sl. No	Parameter	Sampling Stations			Detection Limit	BIS Standard & Method
		SW-1	SW-2	SW-3		
6	Dissolved Oxygen, min.	6.6	6.8	6.2	0.10	IS 3025/38: 1989, R:2003, Winkler Azide Method
7	Fluoride (as F) mg/l, Max	0.36	0.35	0.40	0.02	APHA, 23rd Edition, SPADNS Method, 2017
8	Hexavalent Chromium, mg/l, Max	<0.01	<0.01	<0.01	0.01	APHA, 23rd Edition, Diphenylcarbohydrazide, 2017
9	Iron (as Fe), mg/l, Max	<0.04	<0.04	0.05	0.04	IS 3025 /53: 2003, R : 2009, AAS (Air-Ac-Flame)
10	Lead (as Pb), mg/l, Max	<0.001	<0.001	<0.001	0.001	APHA, 23rd Edition AAS-GTA Method, 2017
11	Nitrate (as NO_3), mg/l, Max	1.7	1.4	1.1	0.50	APHA, 23rd Edition, UV - Spectrophotometric, 2017
12	pH value	7.11	7.41	7.35	1.0	IS-3025/11:1983, R-1996, Electrometric Method
13	Phenolic compounds (as C_6H_5OH), mg/l, Max	<0.001	<0.001	<0.001	0.001	APHA, 23rd Edition, 4-Amino Antipyrine Method, 2017
14	Selenium (as Se), mg/l, Max	<0.0005	<0.0005	<0.0005	0.0005	IS 3025/56:2003 AAS-VGA Method
15	Sulphate (as SO_4) mg/l, Max	47.6	45.9	27.6	2.00	APHA, 23rd Edition Turbidity Method, 2017
16	Total Dissolved Solids, mg/l, Max	236	218	144	25.00	IS 3025 /16:1984 R : 2006, Gravimetric Method
17	Total Suspended Solids, mg/l, Max	18.2	20.5	17.3	10.00	IS 3025 /17:1984, R :1996, Gravimetric Method
18	Zinc (as Zn), mg/l, Max	0.006	<0.005	0.008	0.005	IS 3025 /49: 1994, R : 2009, AAS (Air-Ac-Flame)

4.8.6 RESULTS & DISCUSSION

The physicochemical characteristics of the surface water samples collected from the 3 locations have shown great resemblance with respect to the characteristics like temperature, turbidity, pH, color, odor, chloride, sulphate, total alkalinity, total hardness, TDS and heavy metals, etc.

From the results presented above in, it may safely be concluded that the Physico-chemical characteristics of the surface water samples had a good resemblance with respect to almost all the parameters.

4.8.7 Groundwater Quality

The suitability of groundwater for drinking/irrigation/industrial purposes is determined keeping in view the effects of various chemical constituents present in water. The ranges of different chemical constituents present in groundwater are given in Table 4.8.7.A.

Table – 4.8.7.A

Groundwater Quality Data

	Chhendipada Block		**Indian Drinking Standards (IS-10500):2012**	
	Village Durgapur Dug well	**Village Jharpada Dug well**	**Acceptable**	**Permissible**
Date of Sampling	**Apr-2019**	**Apr-2019**		
p H	8.12	7.98	**6.5-8.5**	**No Relaxation**
EC (µS/cm at 25 ^{0}C)	750	1050	**-**	**-**
TDS (mg/L)	370.55	487.31	**500**	**2000**
TH (mg/L as Ca CO3)	246	393	**200**	**600**
TA (mg/L as Ca CO3)	225.41	343.44	**200**	**600**
Ca (mg/L)	92	45	**75**	**200**
Mg (mg/L)	4	68.25	**30**	**100**
Na (mg/L)	51	65	**-**	**-**
K (mg/L)	17.8	1	**-**	**-**
CO3 (mg/L)	0	0	**-**	**-**
HCO3 (mg/L)	275	419	**-**	**-**
Cl^- (mg/L)	72	104	**250**	**1000**
$SO4^{2-}$(mg/L)	45	46	**200**	**400**
F^- (mg/L)	0.261	0.478	**1**	**1.5**

Source: CGWB

It is observed from the table below, shows that groundwater in both the stations are fit to be used for drinking purposes.

The suitability of groundwater for Irrigation purposes is an important aspect in this study. Good water quality promotes better plant growth. But when concentration of ions, are found in excess in the water, it affects the plant growth

and reduces the plant yield. Sodium Adsorption Ratio (SAR) SAR is an expression pertaining to cation makes up of water and soil solution and is used for characterizing the sodium hazard of irrigation water. The main problem with high sodium concentration is its effect on soil permeability & water irrigation. Sodium also contributes directly to the total salinity of the water and may be toxic to sensitive crops such as fruit trees. SAR is calculated from the following equation-

$$\mathbf{SAR = Na^{+}/((1/2(Ca^{2+} + Mg^{2+}))^{1/2})},$$

where Na^{+}, Ca^{2+} and Mg^{2+} are all measured in meq/L (milliequivalents per liter).

The SAR value for both Durgapur and Jharparha is below 10, also the EC (uS/cm)at 25°C in both the stations are in the range 750-2250. Therefore, the groundwater in the region is considered good for irrigation.

CHAPTER-5

Soil Moisture Index and Soil loss estimation

CHAPTER-5

SOIL MOISTURE INDEX AND SOIL LOSS ESTIMATION

5.0 DRONE SURVEY

In the Utkal E coal block, CMPDI undertook UAV based survey for the generation of high-resolution orthomosaic image, DTM, DSM, and contour map of the proposed area for SMC study. The study area has been selected after a discussion with DFO Angul dated 26.04.2022 and the total area covering 561 Ha lies in Durgapur RF, near Monnet Power Plant. The bounding coordinate of the area falls between longitude 84° 57' 46.971" E to 84° 59' 13.927" and latitude 20° 54' 45.663" N to 20° 56' 32.904" N. Location of the study area along with the total 11 Ground Control Points (GCPs) taken for UAV survey and image geo-referencing has been illustrated in the map (Fig 5.1). These GCPs have been precisely measured on the ground using Leica DGPS, and the post-processing of the data has been done using Survey office software.

Fig 5.1: Location map and GCP plan of the study area

5.1 METHODOLOGY FOR DRONE SURVEY

A small category dual 50-volt battery-operated hexacopter UAV with almost 60 min endurance along with Sony oblique camera as payload has been used by CMPDI for this project (Fig 5.2). The total weight of the drone was about 21 kg and it can cover approximately 1.5 sq km area in a single flight. However, considering the extreme heat at Angul in the summer season, only 45 min flying time has been performed for the safety of the equipment. Considering the topography and forest cover in the area, a drone-based optical sensor was used for accurate results.

Fig 5.2: Image of Hexa-copter Drone

Flight planning has to be executed prior to the drone survey. For this, the KML of the study area has been prepared using Google Earth and GCPs planned in such a way that it should be well distributed within the study area. Proper marking of GCPs has been done on the ground so that later they could be identified in the drone image also. The take-off location or the home location has

been chosen on a flat open surface near the study area. The radio antenna and ground control station have been set up near the home location. After planning and placing all the GCPs on the ground, flight planning has been done using Dhaksha Space software. For this project, the flying height has been kept at 220 m with 4.4 cm GSD. A sample drone image showing the trees and village road has been shown below (Fig 5.3).

Fig 5.3: Sample drone image of the area

The final flight plan has been uploaded to the drone autopilot before every single flight. After completion of a single flight, the POS data, which stores the positional information and image timing in excel format has been downloaded from the drone autopilot. The images from the memory card have also been copied and stored sequentially in a folder. All the images acquired through a UAV survey consisting of 4 days have been processed using Pix 4D software. DGPS location of the GCPs has been used during data processing for geo-referencing of the images and generation of orthomosaic as well as DTM (Fig 5.4). DEM extraction has been done by Global Mapper software.

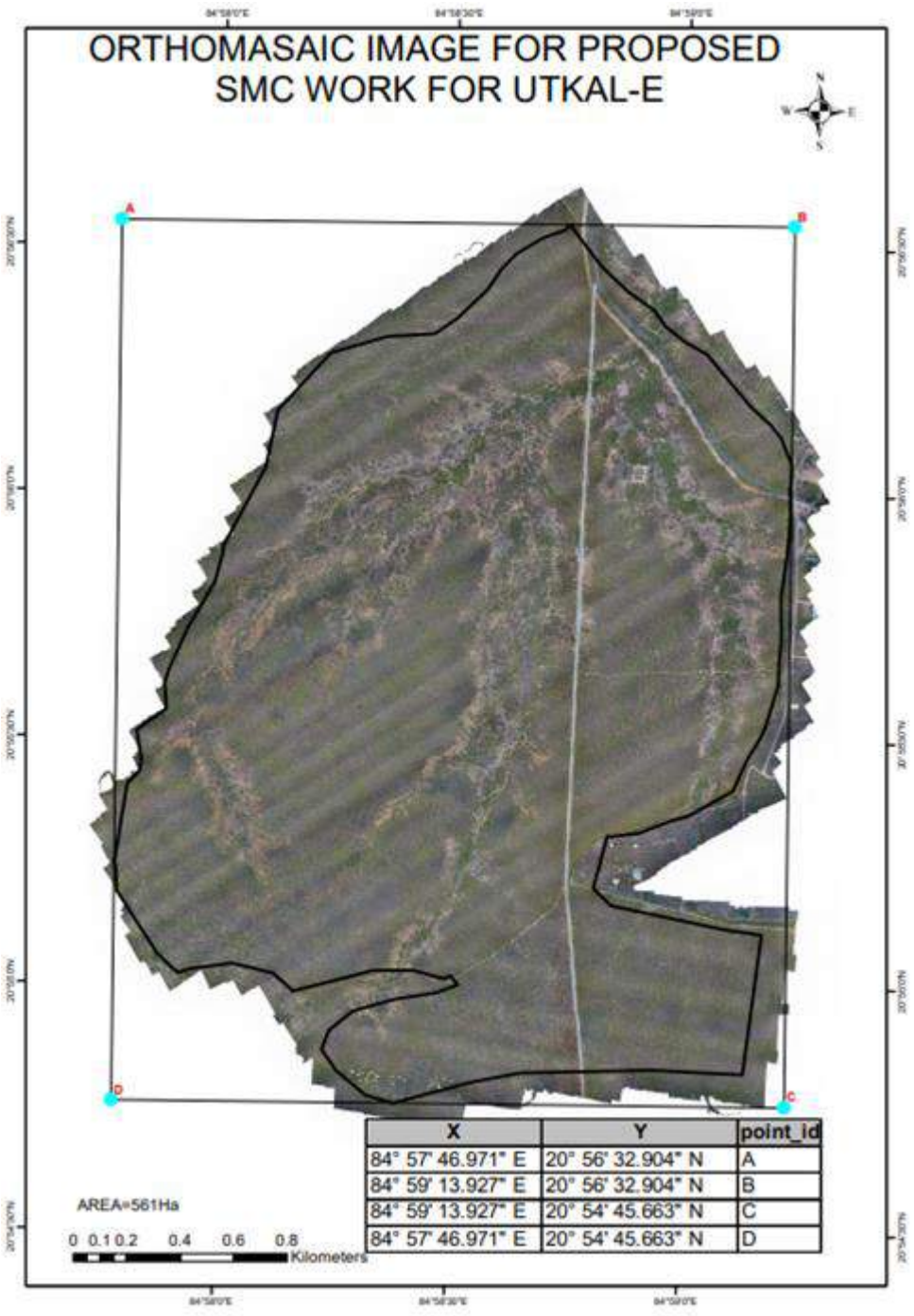


Fig 5.4: Orthomosaic of the study area

A contour map of 2 m interval has also been generated as the final output (Fig 5.5).

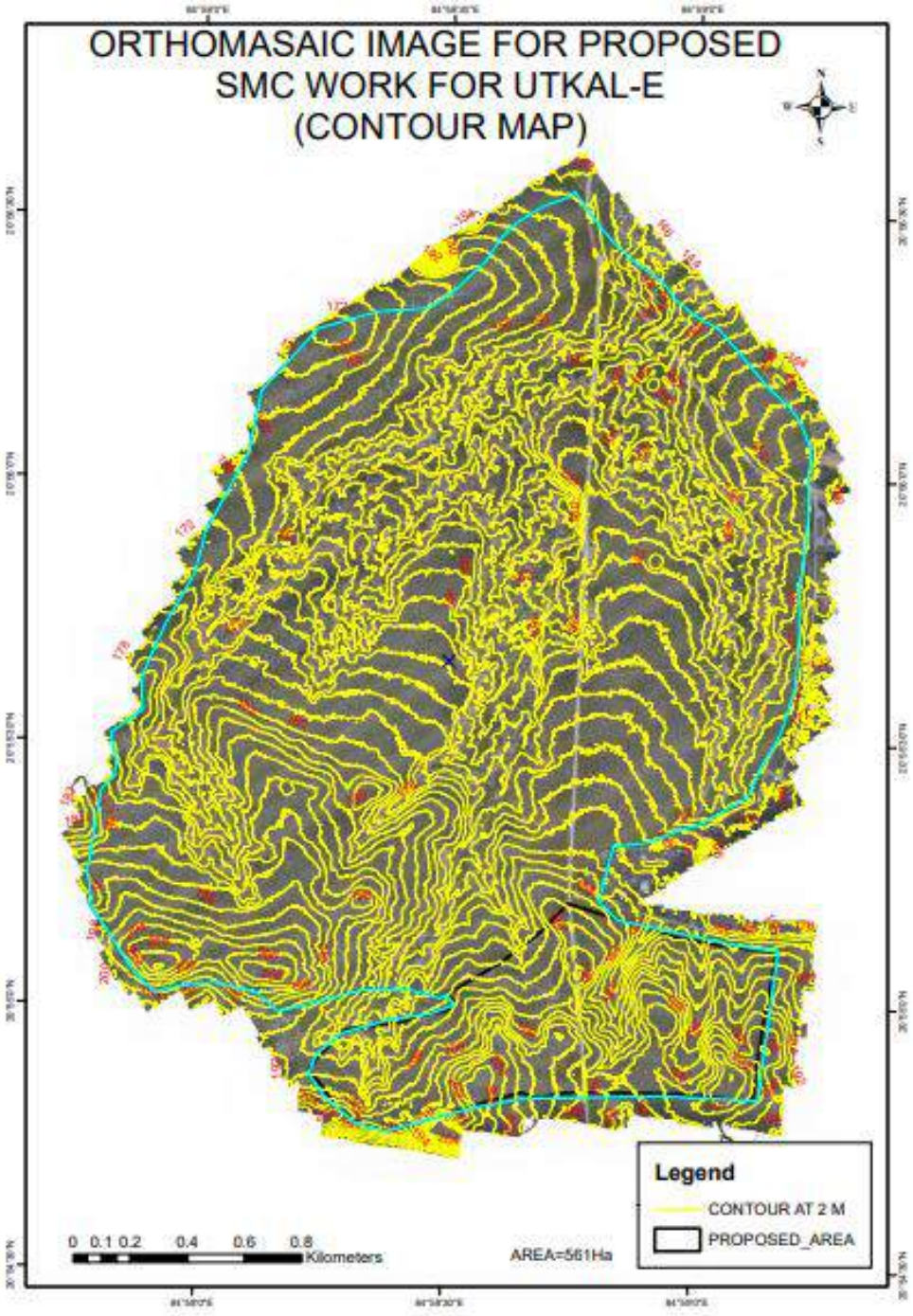
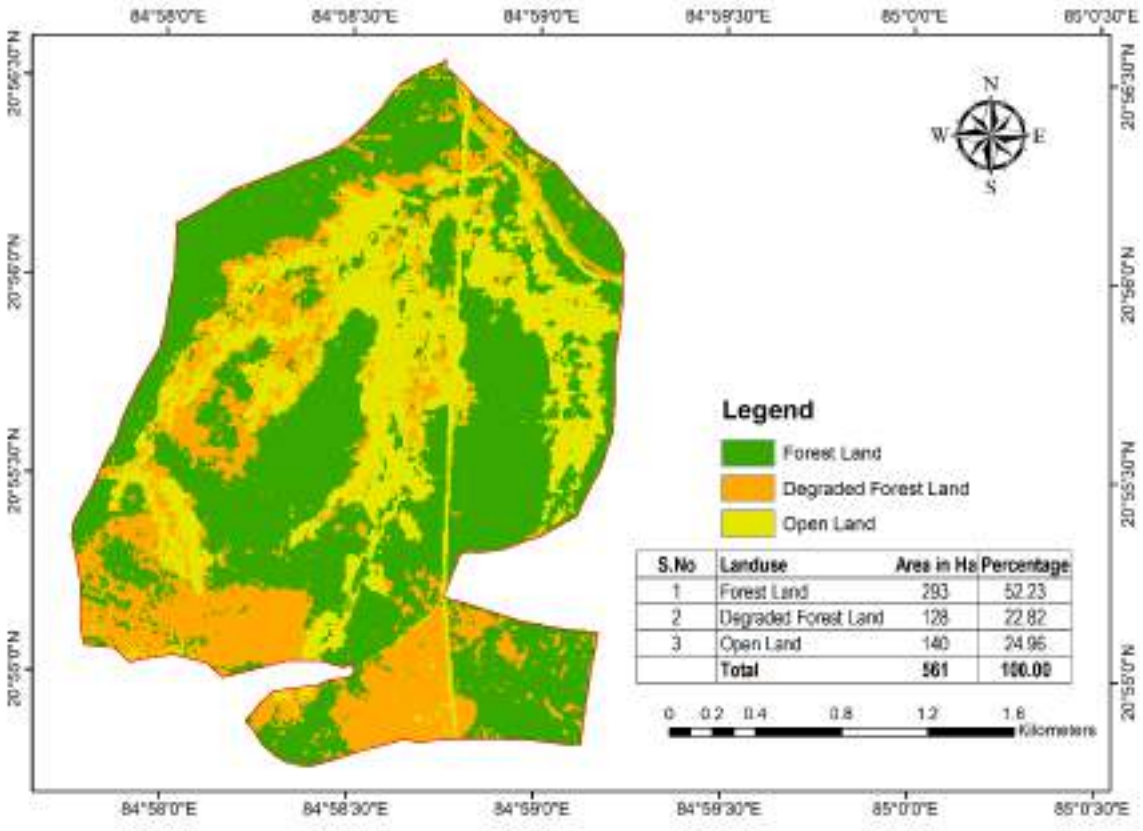


Fig 5.5: contour map of the study area

5.2 LAND USE OF STUDY AREA

The proposed area is 561 Ha of land which can be categorized into three categories based on signatures got through sentinel images (Fig-5.6). A total of 293 ha of land falls in the forest land category where some vegetation was available, 128 ha of land falls under degraded land area and 140 ha of land falls under the open land area where very less or no vegetation was available. Although in the study area seasonal streams were also present in this landuse ,it cannot be detected.



S.No	Landuse	Area in Ha	Percentage
1	Forest Land	293	52.23
2	Degraded Forest Land	128	22.82
3	Open Land	140	24.96
	Total	**561**	**100.00**

Fig-5.6 Landuse map of the study area using sentinel satellite image

The drainage map of the study area has been shown in fig-5.7. It can be depicted from the figure that the flow direction is from the south direction to the north direction. A total of three streams were present in the proposed study area.

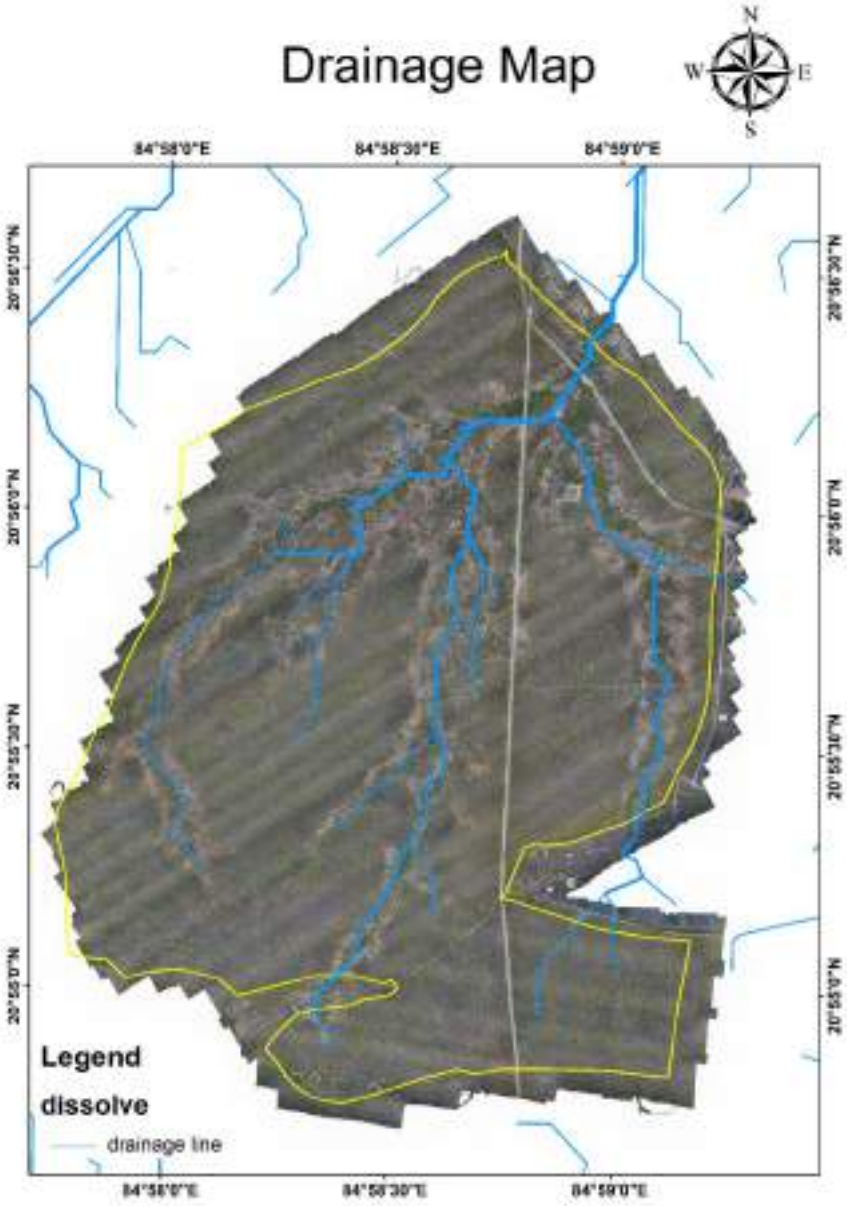


Fig-5.7: Drainage map of the study area

5.3 SOIL MOISTURE INDEX

5.3.1 INTRODUCTION

Soil moisture is a key parameter that directly or indirectly influences the water cycle. The existence of forest cover and agriculture production mainly depend on rainfed areas as well as irrigation practices of the area. Climate change and the trend of increasing temperatures have a significant impact on forest cover.

It is linked to various hydrological phenomena, such as drought, climate, and vegetation. The data collected for soil moisture analysis taken below the surface over the long term as well as higher temporal and spatial resolution data are valuable for assessing the extent and severity of drought quite accurately. Surface soil moisture is very sensitive and varies with space and time. Various studies have been done to assess soil moisture. Two methods of soil moisture measurement through remote sensing are based on the microwave part of the electo-magnetic spectrum and thermal, infrared observation.

In situ measurements can provide an accurate estimation of soil moisture, but they are both time-consuming and expensive, and only represent a small area (a few square decimeters). Nevertheless, a number of strategies can be adopted to upscale the spatially sparse ground-based observations, which are invaluable for calibrating and validating land surface models and satellite-based soil moisture retrievals.

The soil moisture index (SMI) is defined as the proportion of the difference between the current soil moisture and the permanent wilting point to the field capacity and the residual soil moisture. The index values range from 0 to 1 with 0 indicating extreme dry conditions and 1 indicating extreme wet conditions.

5.3.2 METHODOLOGY

The soil moisture index is based on empirical parameterization of the relationship between land surface temperature (LST) and normalized difference vegetation index (NDVI) (Figure 1) and calculated using Equation (5.1)

$$SMI = (LSTmax - LST)/(LSTmax - LST\text{min}) \qquad 5.1)$$

where $LSTmax$ and LSTmin are the maximum and minimum surface temperature for a given NDVI and LST is Land Surface Temperature. The surface temperature of a pixel for a given NDVI is derived using remote sensing data. $LSTmax$ and LSTmin are calculated using Equations (5.2) and (5.3), respectively.

$$LSTmax = a1 * NDVI + b1 \qquad 5.2)$$

$$LSTmin = a2 * NDVI + b2 \qquad 5.3)$$

where $a1$, $a2$, $b1$, and $b2$ are the empirical parameters obtained by the linear regression (*a* present slope and *b* present intercept) defining both warm and cold edges of the data. First step in SMI calculation is the conversion of digital number (DN) to spectral radiance (L W/$m2$/sr/µm) using Equation (5.4):

$$L = LSTmin + (((LSTmax - LSTmin)/(QCALmax - QCALmin)) * (DN - QCALmin)) \quad \text{---(5.4)}$$

where, $LSTmin$ and $LSTmax$ are spectral radiance calibration constants (Table 5.1); $QCALmax$ and $QCALmin$ are the highest and lowest quantized calibration pixel values, and DN is the Digital Number.

Table 5.1

Spectral radiance (Lmin and Lmax) values for thermal bands of Landsat imagery.(May-2022)

Landsat 5 (Band 6)		**Landsat 8 (Band 10 and 11)**	
Radiance maximum	Radiance minimum	Radiance maximum	Radiance minimum
1.238	15.303	0.1003	22.0018

Two inputs must be calculated (LST and NDVI) to be able to calculate $LSTmax$ and $LSTmin$. LST (K) is calculated using Landsat 5 and Landsat 8 Thermal bands using Equation (5.5):

$$LST = Tb/[1 + (\lambda * Tb/C2) * \ln(\varepsilon)] \quad (5.5)$$

where Tb (Equation (5.6)) is At-Satellite Brightness Temperature, λ is the wavelength of emitted radiance, $C2$ = 1.4388 * 10^{-2} m K and it is presented with Equation (5.7) and ε is emissivity (typically 0.95).

$$Tb = (K2/(\ln(K1 * \varepsilon/L + 1))) \quad (5.6)$$

where *K*1 is the sensor-dependent calibration constant 1 and *K*2 is the sensor-dependent calibration constant 2 (Table 5.2). E is emissivity (typically 0.95), and L is the spectral radiance.

$$C2 = h * c/s \quad (5.7)$$

where, h is Planck's constant = 6.626 × 10^{-34} J s; c is the velocity of light = 2.998 × 108 m/s, and s is the Boltzmann constant = 1.38 × 10^{-23} J/K.

Table 5.2

Landsat 5 and 8 thermal infrared (TIRS) thermal constant

Landsat 8 (Band 10)		**Landsat 8 (Band 11)**	
K1	K2	K1	K2
774.89	1321.08	480.89	1201.14

The ratio of the reflectivity differences for the NIR and the red band to their sum (NDVI) is calculated using Equation (5.8) :

NDVI = (NIR – Red)/(NIR + Red) (5.8)

The final step in the data collecting is the determination of empirical parameters by linear regression. To do so, statistical software was developed which was able to process the data for the same pixel from two raster sets, LST and NDVI.

5.3.3 RESULTS AND DISCUSSION

NDVI (Figure 5.8) and LST (Figure 5.9) are calculated based on essential data to obtain SMI calculation. NDVI values vary in the range of −1 to 1 where negative value indicate the absence of vegetation or poor vegetative cover, while positive values show dense and good vegetative cover. LST values are the temperature of the surface which is measured in °C. The SMI result is accessible with the values range within 0 to 1, where values close to 1 are regions with a lower vegetation cover and surface temperature which indicates that the surface has low infiltration and present a higher amount of soil moisture. the values close to 0 are the areas with a major vegetation cover and surface temperature and present a low level of soil moisture and increased infiltration capacity of the soil surface.

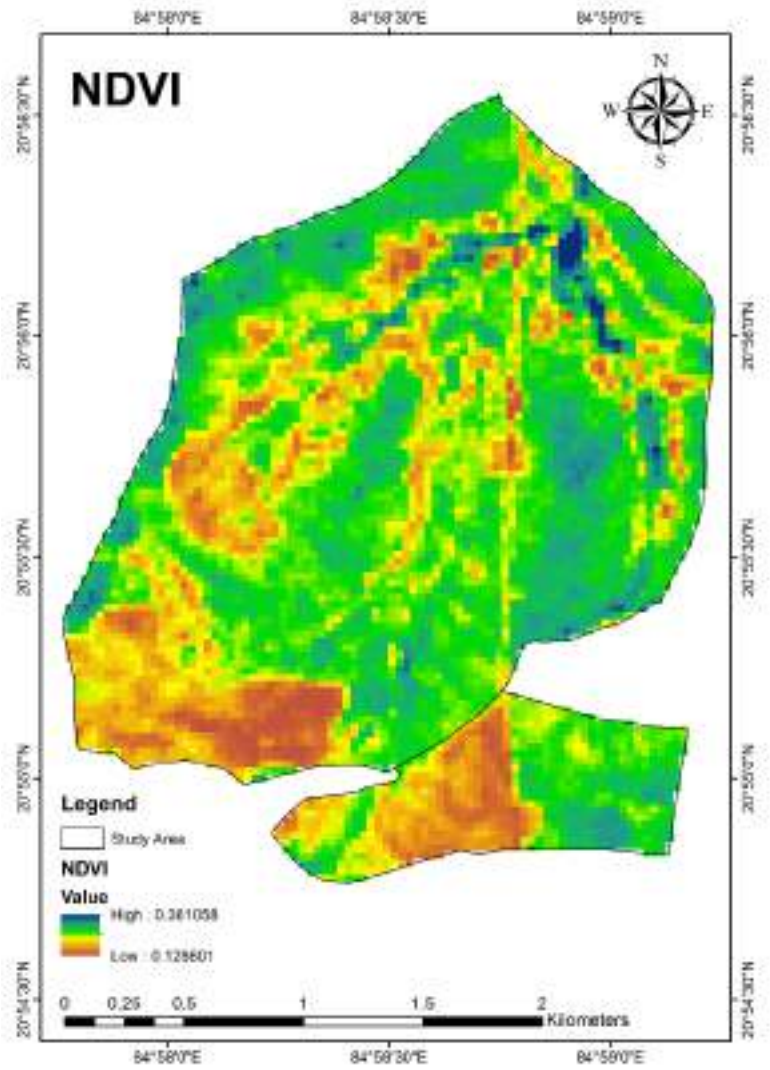


Figure 5.8: Normalized difference vegetation index (NDVI) map.

NDVI value in the study area is within the range of 0.12 to 0.36 and it is divided between the five classes as mentioned in Figure 5.8. LST value varies between a minimum of 28 °C and a maximum of 31 °C. The results of the soil moisture index map of May 2022 indicate the soil moisture index was in the range of 0.23 to 0.33 as classified in different color gradients. Most of the study area, as shown in Figure 5.10 (red and yellow color), has a value close to moisture stressed, which was highly affected by a water deficit. The values near 0.33 (green color) are degraded forest cover which has good moisture as compared to the rest of the land cover. The results concluded that nearly 70 percent of the area was close to 0.23, which indicates a moisture deficit in the offseason throughout the

study area. As per the index, value 1 represents a higher presence of water or moisture like such as waterbody like river or pond, and zero indicates minimum moisture content, such as dry areas. The soil moisture conservation activity must be done in those area.

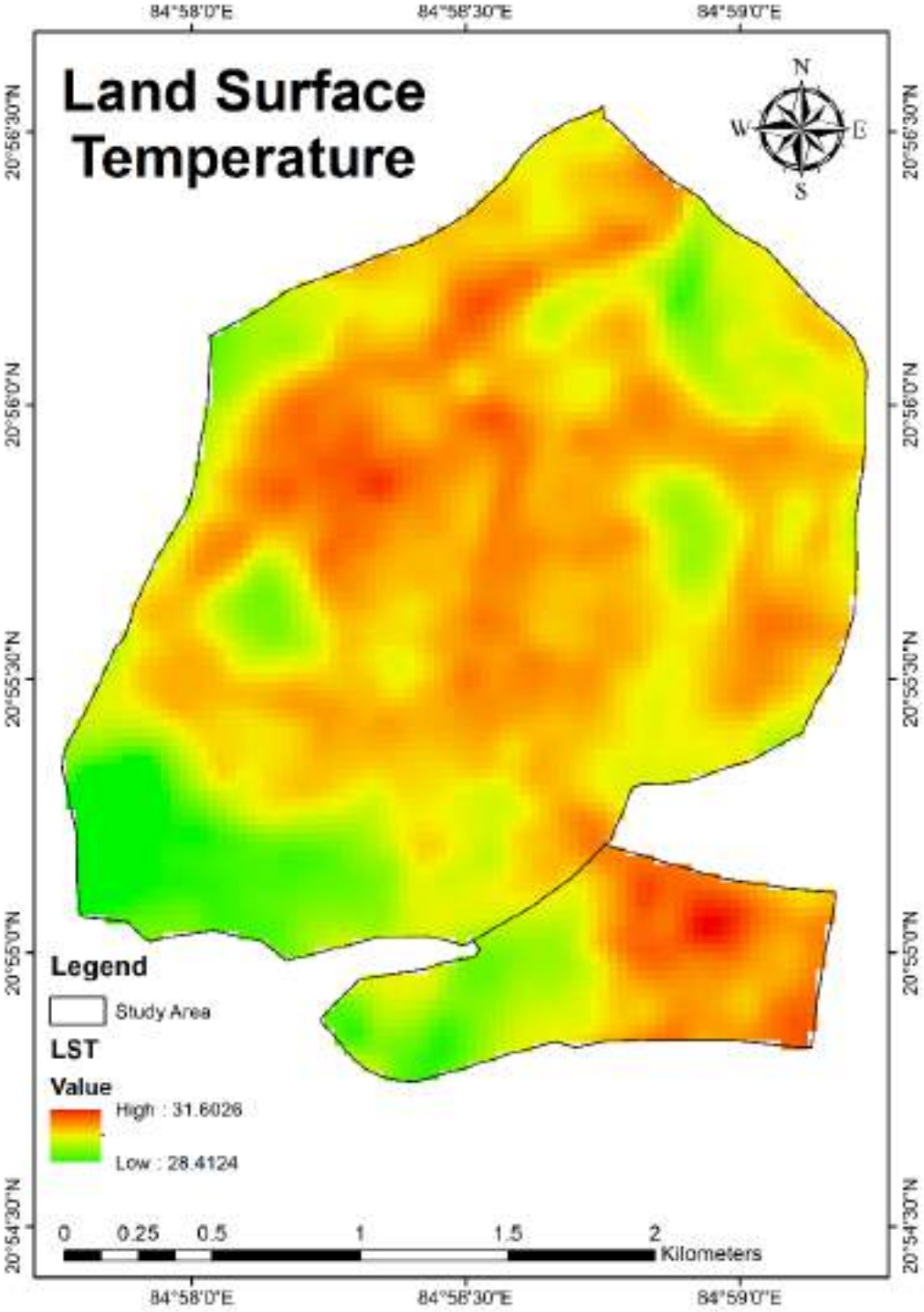


Figure 5.9: Land surface temperature (LST) map.

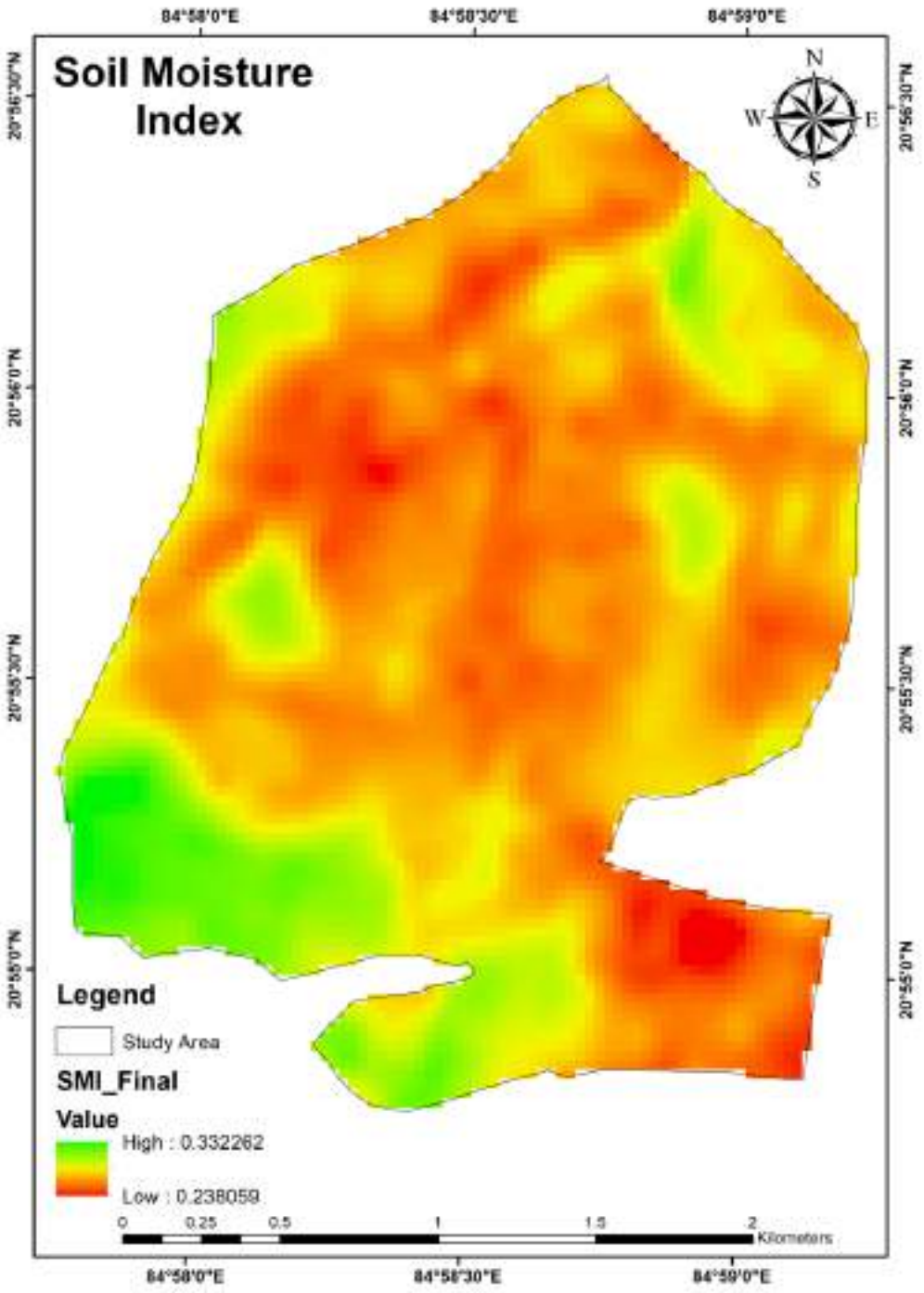


Figure 5.10.: Soil moisture index map of the study area.

5.4 REVISED UNIVERSAL SOIL LOSS

5.4.1 SOIL EROSION PROCESS

Soil erosion is a quite complex phenomenon that is governed by some natural processes where the end result is decreased soil fertility, depleted water quality, and above all reduced crop yields or loss in vegetation. Biophysical factors that comprise soil, climate, ground cover, terrain, and their interactions modify the soil erosion process. Terrain characteristics that affect soil erosion include slope gradient, slope length, aspect, and shape. The runoff mechanism is greatly influenced by the slope gradient impact and aspect. As the slope gradient increases, the infiltration component reduces, and generated runoff runs down the slope, the end result is more erosion. Soil erosion is described as a natural geomorphic (both ends process whose occurrence on the land's surface is quite continuous, and above all, it is more frequent and well distributed. This is because the surface of the Earth is exposed to water, wind, ice action, and gravitational forces at various spatiotemporal scales. Soil erosion process is accelerated by anthropogenic perturbations and improper land use practices, whose impacts are felt on soil and environment. Farming, habitation, terracing, deforestation, and overgrazing are some of the activities which lead to increased soil erosion rates. Soil erosion process has three distinct phases: detachability, transportability, and deposition. Soil erosion process begins with detachment, where breakdown of soil particles occurs due to raindrop impact, shearing, and/or the drag force possessed by wind or even through forces that result from tillage activities. Detached soil particles are transported and thereafter get deposited as the force of the eroding agent subsides.

Water-induced soil erosion is reported to be the most extensive among the other soil erosion causes. This form of erosion is much dependent on land cover, surface gradient, and type of soil. Water erosion has a significant contribution to depletion of organic matter content and important soil nutrients; hence, the functionality of the soil is largely affected. According to Pimentel, farmlands are washed at a rate of between 10 and 40 tonnes, which is much more than the rate

of soil replacement. Water erosion has been identified as a worldwide problem because of the interrelationship between natural resources, population, and climate change.

5.4.2 SOIL EROSION MODELS

Soil erosion models make use of mathematical expressions so as to relate dominant parameters and processes that occur on land's surface. The parameters involved include terrain characteristics, soil properties, land use/land cover, and weather variables. Soil erosion models describe detachment, transport, and deposition phases, which comprise the soil erosion process. Soil erosion models serve as important tools for planning because they enable the prediction of soil loss. Above all, models create a clear understanding of the entire soil erosion phenomenon and the resulting impacts. However, the choice of appropriate models for a particular soil erosion study is based on the objectives, catchment characteristics, and data available on the model's efficiency. Consequently, models differ based on complexity, involved processes, and data required to calibrate and use the model. In this study empirical model Revised Universal Soil Loss Equation (RUSLE).

5.4.3 REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)

RUSLE model is a good example of an empirical model which is well recognized, widely accepted, and very much implemented in soil erosion studies. It is derived from the USLE model, and its application spans over 40 years. The model was designed and developed by a team of high-ranking scientists and some soil conservationists having vast experience in matters relating to soil erosion. It comprises mathematical equations that quantify the average soil loss on an annual basis at different geospatial scales. Many researchers had cited it as the best technology ever for estimation of soil loss in undisturbed areas characterized by overland flow, land surface experiencing disturbance, and recently or already reclaimed lands. Additionally, the model is very well applicable in ungauged catchments, its demand for data is quite moderate, and above all, it integrates well

with GIS enabling upscaling of the soil erosion process. The results of the RUSLE model are a representation of the sediment amount lost from a user-defined landscape. The superiority of the model is brought about by its prowess in accounting for different control management actions with minimal data requirements. The basic assumption that forms the foundation of the RUSLE model is that detachability and deposition processes are a function of sediment content. It is argued that until sediment load attains threshold capacity, soil detachment cannot occur. Therefore, the process of soil erosion is influenced by the flow carrying capacity and not by its source. Recent breakthroughs in spatial information technologies have augmented the prevailing methods in monitoring, analyzing, and above all managing resources. The spatial variation of soil erosion risk is brought about by heterogeneity in topography, geomorphology, geology, land cover, soil types, and land use. Such spatial variability of soil erosion parameters is easily and efficiently handled by geographic information systems (GIS). The trend has improved the accuracy, costs, and scales of application. The state-of-the-art technology geographic information system provides essential mapping interpolation techniques for creating a database that comprises input datasets for modeling soil erosion. Management of large datasets is made easier with the use of GIS; therefore, such spatial techniques provide a basis for the management of land upon the estimation of soil loss rates. In RUSLE, soil loss is predicted by converting the input data (rainfall data, soil data, digital elevation model, and land use) into a geographical information system format, following which it is implemented in the geospatial framework.

Many researchers worldwide have adopted this methodology to carry out soil erosion studies at different spatial scales. For instance, the following researchers studied soil loss in catchment areas by applying the RUSLE model, GIS, and remote sensing. The studies revealed that, apart from estimating soil erosion, the methodology was found to be satisfactory in identifying areas that had higher soil erosion risks. Further, geospatial tools facilitated the extraction of important information, which was deemed critical in implementing plans for soil conservation.

5.4.4 RUSLE Model Parameterization.

The model quantifies average annual soil loss (A) using five important factors, notably rainfall erosivity (R), soil erodibility (K), slope length and slope steepness (LS), cover management (C), and support practice (P).

$$A = R \times K \times LS \times C \times P \qquad (5.9)$$

Where, A is the mean annual soil loss in t/ha/yr, R is the rainfall erosivity (MJ mm/ha/yr), K is the soil erodibility factor (t-ha-h/ MJ/mm), LS is the slope length and slope steepness factor (dimensionless), C is the cover management factor (dimensionless), and P is the support practice factor (dimensionless).

Rainfall is a precondition for any form of water erosion to materialize. The amount and even intensity of rainfall are the two important attributes of rainfall. Waterborne erosion is more pronounced when the two rainfall attributes are on the higher side. The rainfall erosivity factor (R) quantifies the erosive power possessed by rainfall, and it much depends on the rainfall's intensity and amount. The R factor is expressed as the sum of EI-values for each particular storm for a year and averaged over long periods of time (more than 20 years) so as to accommodate discernible recurring rainfall patterns. The abbreviation EI refers to the product of energy and maximum intensity of rainfall in 30 minutes. The amount of soil loss is proportional to the product of the total storm's energy, E (MJ/ha), and the storm's maximum intensity in a time of 30 min, I30 (mm/h). The resulting product is known as the EI30 index or commonly as the storm erosivity index expressed in MJmm/ha/h. The storm erosivity index reflects the amalgamated effect of soil particle dislodgement and runoff transportability to cause net erosion. The mean of the annual sums for the period under consideration gives the rainfall erosivity factor (R factor). Different researchers have developed equations from which the R factor has been derived and applied in different regions. For India following equation(5.10) can be used:

$$R = 50 + 0.389 \text{ x } P \qquad (5.10)$$

Where, P is annual rainfall in mm

Table: 5.3 Annual rainfall as per IMD (30 year average)

DISTRICT	ANGUL (mm)
JANUARY	10.30
FEBRUARY	13.40
MARCH	21.10
APRIL	27.60
MAY	60.20
JUNE	209.40
JULY	326.10
AUGUST	357.40
SEPTEMBER	205.60
OCTOBER	79.20
NOVEMBER	14.70
DECEMBER	6.00
Mean_Annual	**1331.00**

5.4.5 SOIL ERODIBILITY FACTOR (K).

Different soils show varying degrees of resistance to water-related erosion. Soil erodibility is an essential requirement when estimating soil loss and also when implementing soil conservation activities. The characteristics of soil and its properties have a pronounced influence on soil erosion. There is effect is well represented by the soil erodibility factor. Hence, the K factor is affected by a variety of the soil's physicochemical properties. The K factor is simply defined as the inherent susceptibility of soil-to-soil erosion. The RUSLE model identifies the distribution of particle size, permeability, organic matter content, and structure of the soil as the critical physicochemical properties which affect erodibility. Quantitative determination of physicochemical properties of soils is carried out using conventional procedures in laboratories. Generally, soils that have low silt levels have less erodibility regardless of high fractions of both sand and clay. Different K factor algorithms have been developed and applied based on suitability and requirement (Table 5.4).

Table: 5.4: K-Factor for different soil type

Sl no	Type of soil	K - Factor
1	Sand	0.02
2	Low Clay	0.05

Sl no	Type of soil	K - Factor
3	High Clay	0.15
4	Sandy Soil	0.1-0.2
5	Silty Clay	0.26
6	Silty Loam	0.25-0.4
7	Silty Soil	0.4

5.4.6 TOPOGRAPHIC (LS) FACTOR

Slope length and slope steepness is the other main factor for estimating the soil loss which measures the sediment transport capacity of the flow. LS does not consider the 3D complexity of the topography but simply assumes soil loss increases with slope length and/or upslope contributing area. The LS- factor is calculated based on Eq. (5.11):

$$LS = \left(Flow Accumulation \times \frac{CellSize}{22.13} \right)^{0.4} \times \left(\frac{\sin(Slope)}{0.0896} \right)^{1.3} \quad \text{-- 5.11}$$

The slope length (L) and slope steepness (S) define the landscape's topography, which mostly influences the extent of soil erosion. L and S are the two most important parameters with regard to soil erosion modeling and most importantly when calculating the transporting power of surface runoff. The LS factor, therefore, combines the effects of slope length and slope steepness, both of which account for the landscape's topographical effects on erosion. Hence, terrain effects on erosion processes are accounted for by the LS factor within the RUSLE model. Soil erosion is noted to increase when both the slope angle and length increase. The is explains the sensitivity of terrain effects on soil erosion, and therefore determination of the LS factor needs to be accurate.

5.4.7 COVER MANAGEMENT FACTOR (C).

Vegetation cover ranks second behind terrain effects in influencing soil erosion rate. The parameters that define vegetation cover are mainly ground cover and plant canopy cover, respectively. Spatial distribution of vegetation cover fraction requires accurate estimation and is of utmost importance in soil erosion matters. Vegetation cover prevents the soil from the impact of raindrops by

dissipating the amount of energy they possess before reaching the soil surface. Moreover, vegetation cover intercepts rainfall, thereby encouraging more infiltration. In the RUSLE model, vegetation cover effects are accounted for by the cover management factor (C). The C factor is defined as the ratio of soil lost from cropped land under specified conditions to that lost from bare soil. It is much influenced by vegetation type, growth stage, and percent cover. The crop management factor is indicative of the influence of vegetation cover and specified management practices on soil erosion. The values have a range of between 0 and 1 depending on land cover types. C factor strongly relates to vegetation cover because it can be influenced by human beings to reduce erosion. The C factor is derived based on prior land uses, canopy shading factor, percent soil cover by crop remains, soil surface roughness, and above all soil moisture. Within the RUSLE model, the crop management factor is calculated using some empirical relationships that contain ground cover information. Satellite image information is an important input in the preparation of land cover maps, and as such, it has become an integral component in natural resources management. Traditionally, the C factor values have been spatially estimated by assigning values to land cover classes identified using remote sensing. Researchers have developed numerous methods for estimating the C factor based on normalized difference vegetation index (NDVI) for the assessment of soil loss using the RUSLE model. These methods make use of regression analysis to establish the correlation between C factor values (obtained from fieldwork or developed guide tables) and NDVI values obtained from remote sensing images. The regression equations (linear/ nonlinear) are generated by correlating NDVI values with corresponding C factor values (Eq-5.12).

$$\mathbf{C = 0.431 - 0.805\ NDVI} \qquad \textbf{--}\ 5.12$$

5.4.8 SUPPORT PRACTICE FACTOR (P)

The support practice (P) factor is regarded as one of the most uncertain factors of the RUSLE model. &e support practice factor relates strongly to the cover management

factor because both reflect positive impacts resulting from management interventions in controlling soil erosion. The two factors differ in that the support practice factor quantifies the effects of some implementation that targets reducing the runoff and eventual soil loss. The most common support practices include the use of contours, terraces, crop strips, grassed waterways, and cross-slope cultivation. The P factor is expressed as the ratio between the rate and the amount of soil lost when a specific support practice is used and similar soil loss when row farming is executed in an up-and downslope manner. Typical P factor values range between 0 and 1. A value of 1 corresponds to lands without any support practice (especially grasslands and bare lands), while values which approach 0 are indicative of lands under specified support practices. Lower P factor values are indicative of effectiveness in conservation practices.

Table:5.5

Values of Crop Management factor

	Cover %	**Factor**
1.	10	0.7
2.	20	0.5
3.	30	0.36
4.	40	0.26
5.	50	0.20
6.	60	0.15
7.	70	0.12
8.	80	0.10
9.	90	0.085
10.	100	0.075
11.	Waffle wall/ countering	0.45
12.	Grass	0.17
13.	Terracing	0.9

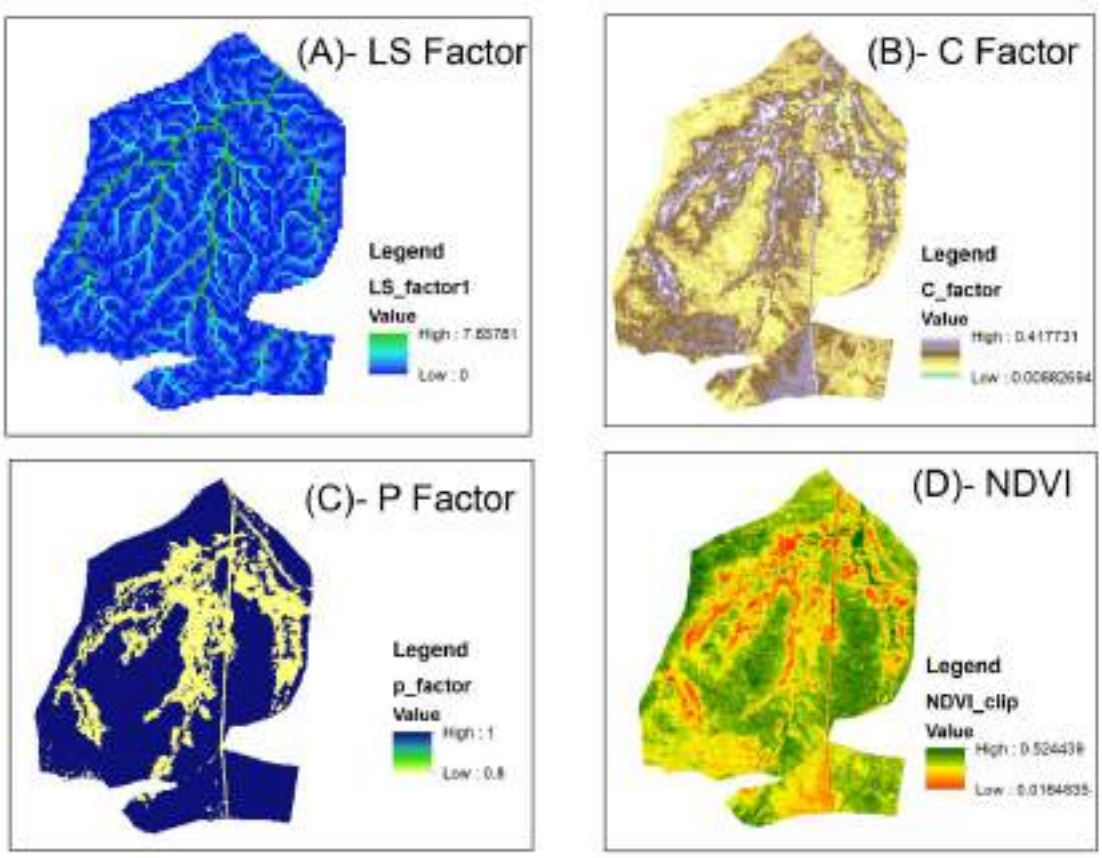


Fig 5.11 Derived factors for the study area

5.4.9 SOIL EROSION ESTIMATION.

The soil erosion severity map (Figure-5.12) was generated by overlaying all the parameter layers of RUSLE. Results indicated that the proposed area has a soil loss with a range of 0 to 311 t/ha/yr. Based on the soil erosion classification used, the estimated soil erosion was classified into four classes, namely, very slight (<5 t/ha), slight (5–15 t/ha), moderate (15-30 t/ha), sever (30-50 t/ha) and very severe (>50 t/ha) per annum. 52.66% of the area falls in the very slight erosion zone although 18 % area comes under the moderate to very severe erosion zone where conservation is required.

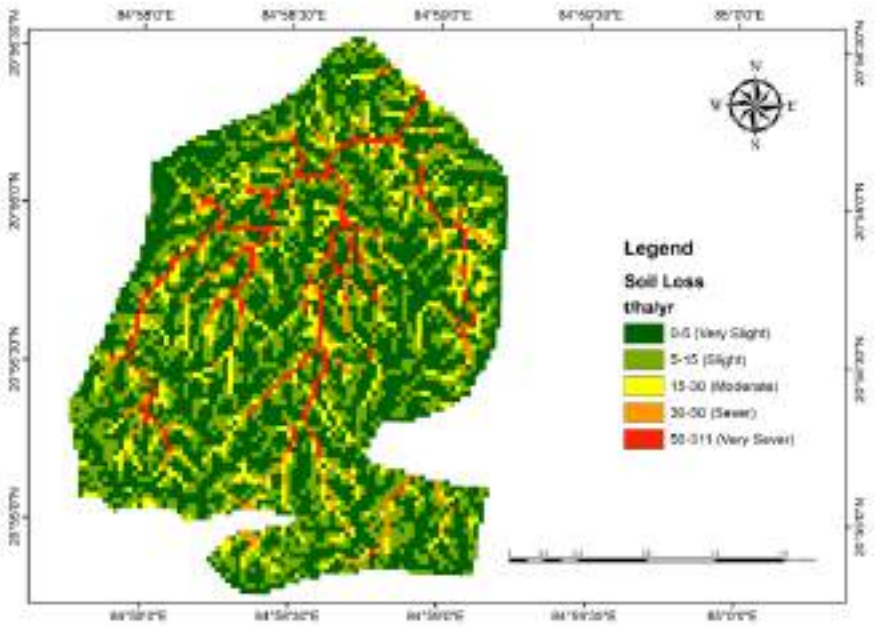


Fig 5.12 Soil loss from the study area

Table:5.6

Classification of soil loss from the study area

S.No.	Soil loss in t/ha/yr	Severity Zone	AREA in Ha	Percentage
1	0-5	Very Slight	298.80	52.66
2	6-15	Slight	165.42	29.16
3	16-30	Moderate	56.70	9.99
4	31-50	Sever	21.42	3.78
5	51-331	Very Sever	25.02	4.41
			567.36	100.00

CHAPTER-6

Mitigation Measures and Cost Estimation

CHAPTER-6

MITIGATION MEASURES AND COST ESTIMATION

6.1 MITIGATIVE MEASURES

There are three methods of SMC in the catchments, namely,

1. Agronomical Measures
2. Mechanical Measures
   - Catchment conservation works other than water harvesting structures: Those are implemented to minimize the soil erosion around the structures. In addition, those are also implemented to prolong the life span of water harvesting structures (check dams). Representative conservation works are as follows: Gully plugging works, contour trench works, terrace works, contour bunding works, mulching, plantation and filter strip works along the river, river/stream bank protection works etc.
   - Water harvesting structures: check dams (construction of embankment)

3. Non-structural measures: Land use regulation, public awareness for the forest, livelihood assistance/poverty alleviation, etc.

6.2 MECHANICAL MEASURES

I. Contour Bund: Contour bunds are mechanical barriers built across the slope for the safe diversion of excess runoff and retention of eroded soil. The land area in between the two bunds get levelled in due course of time. Due to the deposition of eroded soil along the bund, the latter takes the shape of a riser. These risers should be planted with grasses to check their erosion.

II. **Graded Bunds:** The graded bund is a small earthen bund with a slight grade constructed across the slope for safe disposal of runoff. The graded bunds are recommended up to to 10% slope for areas where annual rainfall exceeds 800 mm, particularly on clayey and black soils with poor drainage. However, the efficacy of graded bunds gets reduced gradually beyond the 4% slope. The purpose of grading is to reduce the velocity of runoff water, for in-situ conservation of rainwater, and to minimize soil erosion.

III. **Bench Terrace:** Bench terraces are flat beds constructed on the hills across the slope. The height of the riser should not be more than one meter and the width of the bench terrace depends on the degree of slope. The bench terraces are important because they promote uniform distribution of soil moisture, irrigation water, etc. and control soil erosion. The bench terrace may be table top (level), outward sloping or inward sloping, with or without mild longitudinal grades. On steep slopes, it is better to construct terraces on the foothills for agricultural crops when soil depth is more than one meter.

IV. **Half Moon terrace:** Half-moon terraces are semi-circular beds of appropriate diameter with a shape resembling a half-moon. These terraces are recommended for fruit trees or other plantation crops on steep slopes.

V. **Grassed Waterways:** Grasses are well-known for their soil binding characteristics. They are most effective in moderating the flow and reducing the erosive velocity of runoff water, particularly on the rolling topography. The runoff water moves with high velocity down the slope, carrying with it soil and nutrients. If some suitable grasses are planted on the runoff route or natural channels, the soil and nutrient losses can be reduced. These grassed waterways are laid on the natural drainage lines in the watershed. Stilling basins or water ponds are constructed *en route* at appropriate locations, with earthen and boulder pitched bunds for the retention of runoff water. By reducing the velocity of runoff water, erosion

losses can be minimized.

VI. **Water Harvesting Ponds:** Water harvesting structures can be dug out for retaining runoff water on a seasonal or perennial basis. These are generally constructed down the slope. Earthen dams should be used for retaining silt load at an appropriate location on the slope of a watershed. The water thus harvested or stored can be used for pisciculture and other purposes.

VII. **Conservation Bench Terraces (CBT):** These are used to stabilize the yield of rainfed - crops by inter-field water harvesting. A part of the field is leveled to retain the runoff originating from the rest of the field.

VIII. **Gully Control Structures:** Gully control structures are provided to (i) reduce the erosive velocity of runoff water, (ii) facilitate the establishment of vegetation, and (iii) provide protection at points that cannot be adequately protected by other methods. Loose boulder check-dams perform well in gullies that do not carry much runoff and it also helps in silt deposition, thereby helping the stabilization of gully beds. Permanent gully control strati-fifes are constructed to control the overfalls either at the gully head or in the gully bed. Erosion from the extending heads and sides of the gully and main channel are the major sources of sediment. There is also a need to construct diversion bunds to divert surplus water to water harvesting structures or to the grassed waterways.

IX. **Contour Trenches:** Contour trenches are dug out, piling up the dugout earth on the lower side of the trench, for trapping, sediment, and runoff at the early stage of their movement. These trenches also improve soil moisture and favor the quick growth of trees and grasses.

X. **Stream Bank and Torrents Control:** The vulnerable stream banks should be protected by providing spurs and retaining walls, etc. To control torrents, structures like bar-rages, paved channels, etc. need to be provided.

6.3 AGRONOMICAL MEASURES:

For preventing soil erosion on cultivated lands, proper choice of crops and cropping patterns is necessary, particularly on hill slopes. The protection through the vegetative shield, forest cover, grasses, crops and mulches, etc. are some important measures to prevent soil erosion. Such protection by absorbing the energy of rain impact prevents the loss of both water and soil. The following crop management practices can be useful in minimizing the erosion of soil and nutrients.

I. **Cropping Systems —** Crops with the ability to develop canopy quickly provide early protection to the soil. Inter-planting of erosion-resistant crops like cowpea, soybean, etc. are also useful. Strip cropping of erosion-resistant legumes along with cereals can conserve rainwater and reduce the velocity of runoff.

II. **Crop Geometry —** It is essential to manipulate the crop layout in the field in a manner that may prevent soil erosion. Closer spacing of rows across the slope can help in this regard.

III. **Contour Cultivation —** Contour cultivation reduces the runoff to a large extent, thereby reducing the soil and nutrient losses. Contour cultivation, as well as furrows and ridges, have been found useful.

IV. Low-intensity tillage favors the consolidation of soil through better structure, infiltration, and pore distribution. This imparts erosion resistance. A study of the conventional method of cultivation of maize 'with- zero tillage, with or without live mulch, has shown that runoff and soil losses are greatly reduced with low-intensity tillage.

V. **Grasses -** Grasses are perhaps the best friend of soil conservationists. Low and evenly distributed canopy and fibrous root systems with much binding capacity make grasses highly effective in controlling soil erosion. The performance of various grass species in controlling filling soil erosion and runoff losses at 9% and

11% slopes. The selection of grasses should be based on their production potential considering edaphic conditions and local preferences.

VI. **Mulching:** Mulching is the placement of any organic or inorganic material over the top of a soil surface to protect it. Some of the benefits include reduced soil erosion, less compaction, moisture conservation, increased control of soil temperature, and a reduction in weed growth.

6.4 CONTOUR TRENCH WORKS

6.4.1 OBJECTIVE/FUNCTION

The contour trench works are the method of constructing the trenches along the contour lines of the slope.The objectives of the trench works are to retain water and sediment on the slope, to increase the water infiltration, to improve local soil moisture, and as the result, to reduce the runoff discharge and sediment to the downstream watershed.

There are three (3) types of contour trenches, that is continuous trenches, and interrupted (line and staggered) trenches. The continuous contour trenches are essentially used for moisture conservation in low rainfall areas. The staggered trenches are commonly used in Forest, in consideration of the rainfall condition of the study area.

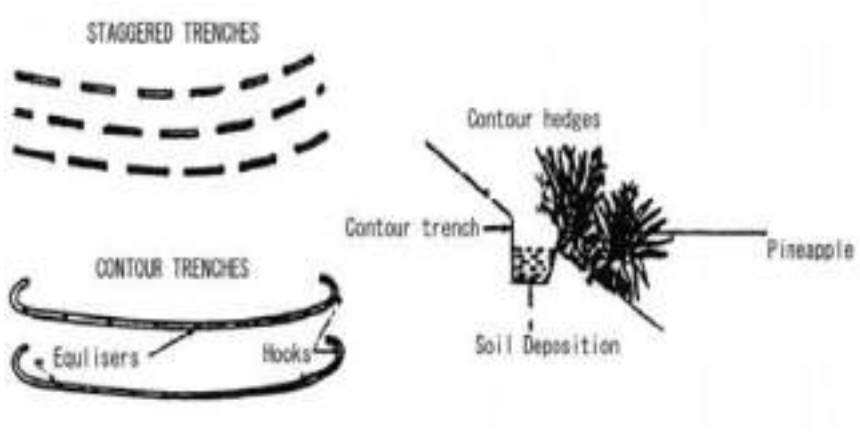


Fig. 6.1 Continuous and Staggered Contour Trenches

6.4.2 MULCHING

Mulching is an SMC practice in which a covering of cut grass, crop residues, or other organic materials is spread over the ground between rows of crops or around the trunks of trees. This practice helps to retain soil moisture to intercept the direct impact of raindrops on bare soil to reduce runoff and soil loss, to prevent weed growth, to reduce labor costs of weeding and enhance soil structure.

6.4.2.1 CLASSIFICATION OF MULCHES

(A) On the basis of organic matter

a. **Organic mulches:** Organic mulches can be made of naturally occurring various substances which contain organic matter in it. Common examples of organic mulching are bark clippings, grass clippings, compost, dry leaves, straw etc.

b. **Inorganic mulches:** Inorganic mulches are made up of inorganic substances which do not contains organic matter in it. Inorganic mulches include stones and gravels, polyethylene films, landscape materials, and rubbers.

(B) On the basis of living matter

a. **Natural mulches:** Natural mulches are generally made up of naturally occurring materials. Organic mulches are also known as natural mulches. No prerequisite for the replacement of natural mulches because it decomposes readily.

b. **Synthetic mulches:** Synthetic mulches are made of artificial non-living substances. Various types of synthetic mulch materials are available in the market for use in crop fields such as plastic films, plain and oiled paper, spun materials etc.

6.4.2.2 ORGANIC MULCHES

Organic mulches comprise materials like animal compost, grass clippings, straw of various crops, dried leaves, tree bark clippings and sawdust. It has an easily degradable capacity because nature of appealing slugs, insects, and worms that eat them and help them in rapid degradation, which results in the addition of some quantity of nutrient and organic material in the soil. Organic mulch has a large number of helpful features. Some of them are: soil moisture conservation by reducing the rate of evaporation, moderates soil temperature, lessening soil erosion, hindering the growth of weeds, cheers the growth of beneficial soil bio-organisms, and diminishing the blowout of soil-borne pathogens. Organic mulches after decomposition over time improve soil structure and increase the nutrient content of the soil. The illustration of different organic mulches and their usages are given below:

(A) Bark clippings

Bark clippings are long-lasting materials and permit appropriate aeration of the soil. It can be used properly in dry as well as wet regions and has more water holding capacity. In the wet region, if rain is too much the wood bark will reduce waterlogging condition after absorbing the excess water and if rain is too little, the wood bark will release the holding water, providing water to the plants in dry times also.

I. **Bark (hardwood):**

Hardwood bark clipping is the derivative of paper and timber industries and differs in sizes ranging from chips to bigger nuggets. It is mostly used nearby the shrubs and trees. Both colored and natural varieties of bark are obtainable. Colored varieties are generally a mixture of recycled wood waste comprising non-natural peroxides. Hardwood bark clippings have more nutrients than softwood but bark clippings are not effortlessly and plentifully available and also phytotoxicity is caused by some bark products. These barks are slightly alkaline in nature.

II. **Bark (softwood):**

It is similarly a derivative of the wood and paper industries. A common example is pine bark and it is commonly used under large shrubs and trees. It is somewhat acidic in behavior and takes more time to decay. These barks are obtainable in several sizes and generally applied to 2 to 4 inches of depth.

(B) Tree waste:

Generally, this mulch outcome from larger lumps of timbers. At the time of decomposition, the fresh tree chunks will utilize larger sums of nitrogen inside the soil. This type of mulch is specifically useful for making pathways.

(C) Leaf mulch:

Leaves are decent for mulching which is easily and profusely available**.** However, leaves are good for shielding inactive plants during the winter season by keeping them warm and it helps in starting germination throughout the winter season but they may be blown away even by the little speed of wind due to its lightweight. Bark, stone, or any other material which are useful in reducing wind speed, should be used to lessen these problems. It can be made at home by composting shredded leaves. Leaf mulch can be used in all types of gardens. Leaves infected with disease should be disposed instead of composting. The proper thickness of the leaf mulching is about 3 to 4 inches.

(D) Grass clippings:

Grass clippings are effortlessly and profusely available mulch materials in agriculture. It provides some quantity of nitrogen and organic material into

the soil if freshly incorporated in the soil. If green grass clippings are added to the soil, it can develop its root system and can create damage to the growth and development of crops. So, the use of dry grass is more favorable as mulch material. Grass clippings should be spread in thin layers for better results across perennial and vegetable beds and concave at the end of the growing season. Before adding extra layers let every layer dry. Grass clippings will mat if a thick layer of clipping is applied instead of thin layers. Grass clippings were taken from lawns which are treated with insecticides or herbicides never be used. It should apply at a depth of 2 to 3 inches.

(E) Composted animal manure:

The composted animal manure is an excellent choice for mulching material which advances the soil health, increases the population of microbes or bio-organisms, and adds nutrients to the soil. Compost is slightly acidic in nature. Compost does not have a better capability of weed suppression which is one noticeable drawback of composted animal manure. The use of fresh manure in crop fields sometimes results in the burning of plant roots. Before using as mulch manure should be well decomposed at temperatures between 54°C to 60 °C for a minimum of one week and 4 to 6 months of composting to eradicate potential disease micro-organisms. It is too used as mulching material in various nutrient-consuming florae like roses. 3-4 inches of depth is favorable for compost used as a mulch.

(F) Newspaper:

Newspaper mulching is helpful in adding some organic matter to the soil and controlling weeds. A thickness of 1 to 2 cm of newspaper sheet is required for mulching and the edge of the paper should be fastened with stones, gravel, pebbles, etc. Suppression of weed is done by the layers of white and black newspapers. Apply 2 to 3 layers of newspaper at a time

and cover it with leaf mulch or grass clippings or any other organic materials so that it cannot blow away by the winds. Newsprint will ultimately decay and can be merged into the soil.

(G) Straw mulches:

Some examples of straw mulches are groundnut shells, cotton shells, Straws of paddy and wheat, crop stubbles, etc. which are used as mulches for moisture conservation on the soil surface. Even though nutrient content is less in straw but soil converts more productive after the decomposition of straw mulches. Straw mulches reduce the amount and rate of evaporation and lessen the amount of energy captivated by the soil.

(H) Sawdust:

Sawdust is obtained from the wood and furniture-making industry and is very deprived of nutritive value. It is slowly decomposable. It is acidic in nature so it should not be used in acidic soils.

6.5 BENEFITS OF ORGANIC MULCHING

A vital role is played by organic mulch in reflecting solar radiation. It reduces the rate of evaporation and keeps soil cooler. Prevent germination and growth of weeds, lessens erosion of soil, reduces runoff, increases moisture-retaining power of the soil, improves infiltration and percolation of water, advances the soil condition, makes soil porous, and augments better growth of roots. It can also maintain the soil temperature.

6.6 INORGANIC MULCHES

Inorganic mulches are commonly used to obstruct the germination of weeds and are also used for decoration. Inorganic mulches like stones, gravel, and rocks do not decompose voluntarily, so they do not participate in improving soil conditions but bio-degradable and photo-degradable plastic mulches are readily decomposable and improve the soil condition as well after decomposition, because they are made from plant sugar or starches. Heat can be absorbed and reflected by rocks which are useful in dry and hot environmental conditions.

6.6.1 DISADVANTAGE OF INORGANIC MULCHING

Inorganic mulches, except in biodegradable plastic mulches, do not augment any nutrient in the soil because they do not decompose. In several cases, inorganic mulch will get damaged by the sun in several cases and starts looking damaged with time. It can increase the temperature of soil if established in large areas. Inorganic mulches like rubber may create harm to plants as it is toxic in nature.

6.7 SUGGESTIONS AND RECOMMENDATIONS

The soil of the proposed forest areas are having less organic content which results in less soil moisture. Therefore, it is proposed to use an agronomical measure like mulching from locally available materials like straw, dry leaves, stubble, or similar materials.

6.7.1 MECHANICAL MEASURES

A. **Contour Trench:** 14 number of trenches of size Lm x1m W × 0.6m D shall be constructed along the specified contour as shown in (Fig. 6.2). The details about the length and latitude and longitude of stating point and end point is given in table no-6.1.

Table: -6.1 Details of contour trenches with GPS location

S. No	Name	Length (m)	X_Start	Y_Start	X_End	Y_End
1	C-1	1100	84.9755	20.91677	84.986078	20.917354
2	C-2	990	84.9629	20.921265	84.971772	20.920597
3	C-3	820	84.9664	20.926382	84.973772	20.923889
4	C-4	430	84.9769	20.922148	84.980972	20.921881
5	C-5	965	84.9664	20.929795	84.975515	20.928183

S. No	Name	Length (m)	X_Start	Y_Start	X_End	Y_End
6	C-6	650	84.9789	20.927707	84.983931	20.924268
7	C-7	375	84.9848	20.923878	84.986705	20.926749
8	C-8	1250	84.9766	20.940687	84.970056	20.933421
9	C-9	120	84.9838	20.938303	84.982962	20.937562
10	C-10	165	84.9827	20.937194	84.981433	20.936273
11	C-11	490	84.9809	20.939111	84.97717	20.936406
12	C-12	495	84.9799	20.9328	84.983819	20.930293
13	C-13	165	84.9853	20.936721	84.98426	20.935689
14	C-14	740	84.9842	20.934958	84.985048	20.928429

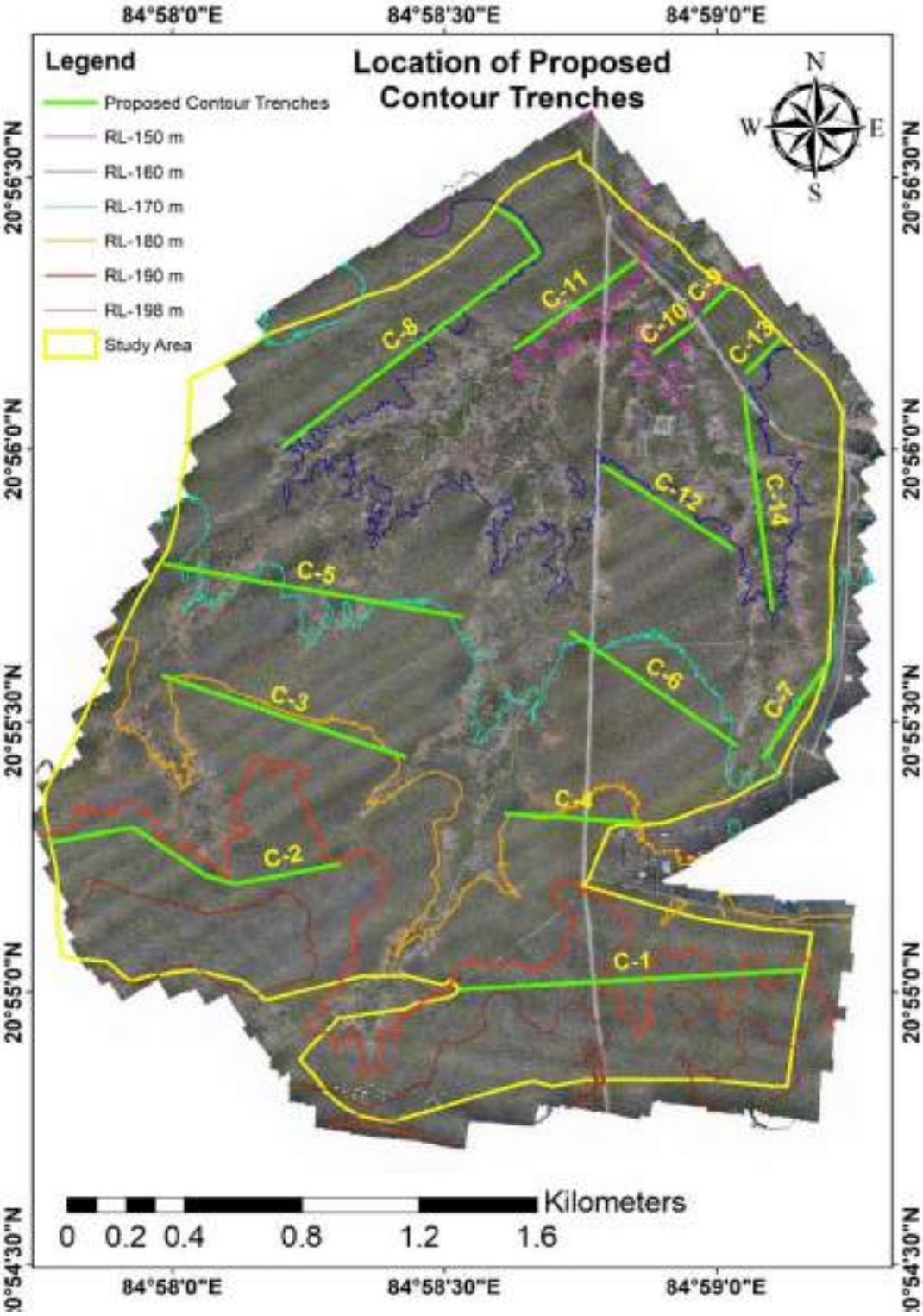


Fig 6.2: Figure showing proposed location of Contour trench

B. **Check Dam**: 18 nos. of check dam of size 15 m L × 0.5 m W × 0.6 m H and 2 nos. of check dam of size 15 m L × 0.5 m W × 1.0 m H shall be constructed across the stream at the location specified in table 6.4 and also shown in Fig.6.3.

Spacing between check dams:

The spacing of check dams should be so placed that, the line joining the top of the lower check dam and the bottom of the successive upper check dam gives the gradient. This gradient will give a non-erosive velocity of flow. This gradient is known as a compensation gradient. For general practice, the compensation gradient is taken as 3 to 5% of the slope. The horizontal distance between successive check dams is given by:

$$S = \frac{h \times 100}{(S_o - S_e)}$$

where,

S =spacing between two check dams

h =Height of check dam up to the notch

S_o=Existing bed slope in percentage

S_e=Establishing slope of the bed in percentage

Table-6.2: Calculation for spacing between the dam

Sl. No	Streams	Existing Slope (So) in %	Established Slope (Se) in %	Average height (h) in m	Spacing of Dam (S) in m
1.	Stream-1	1.5	1.3	0.6	300
2.	Stream-2	1.818182	1.6	0.6	370
3.	Stream-3	0.909091	0.8	0.6	550

In the study area three major streams are present for each streams calculation for

spacing between the dams are shown in table 6.2. In first, second and third stream spacing between the dams are required 300, 370 and 550 m.

Number of Check Dams

The number of check dams required is determined from the following formula:

number of check dams (N)

$$N = \frac{(a-b)}{H}$$

where,

a =total vertical distance between first and last dam in meters

$$b = \frac{S_e \times d}{100}$$

d =horizontal distance between first and last dam in meters

H=average height in meters

Table-6.3: Calculation for required number of Check Dam

S.No	Streams	Initial RL in m	Final RL in m	a in meters	Horizontal Distance in m	b	Number of Check Dam
1.	Stream-1	180	150	30	2000	26	7
2.	Stream-2	190	150	40	2200	35.2	6
3.	Stream-3	170	150	20	2200	17.6	4

Based on formula in equation, total 17 number of dams are required. Other than these 3 more check dams have been suggested at the exist point of the stream of study area.

Table-6.4: GPS location of the check Dam

S.No	Name	Length	Height	X_Centroid	Y_Centroid
1	CD1	15	0.6	84.966872	20.92377
2	CD2	15	0.6	84.965807	20.926333
3	CD3	15	0.6	84.967158	20.92856
4	CD4	15	0.6	84.968503	20.93034
5	CD5	15	0.6	84.970199	20.931722
6	CD6	15	0.6	84.972624	20.933726
7	CD7	15	0.6	84.975654	20.934601
8	CD8	15	0.6	84.973778	20.918219
9	CD9	15	0.6	84.975438	20.921228
10	CD10	15	0.6	84.977186	20.924383

S.No	Name	Length	Height	X_Centroid	Y_Centroid
11	CD11	15	0.6	84.978107	20.927669
12	CD12	15	0.6	84.978644	20.931047
13	CD13	15	0.6	84.978431	20.933621
14	CD14	15	0.6	84.984265	20.930948
15	CD15	15	0.6	84.982903	20.933184
16	CD16	15	0.6	84.981585	20.936599
17	CD17	15	0.6	84.98484	20.927018
18	CD18	15	0.6	84.981776	20.938098
19	CD19	15	1	84.979281	20.937119
20	CD20	15	1	84.977502	20.935367

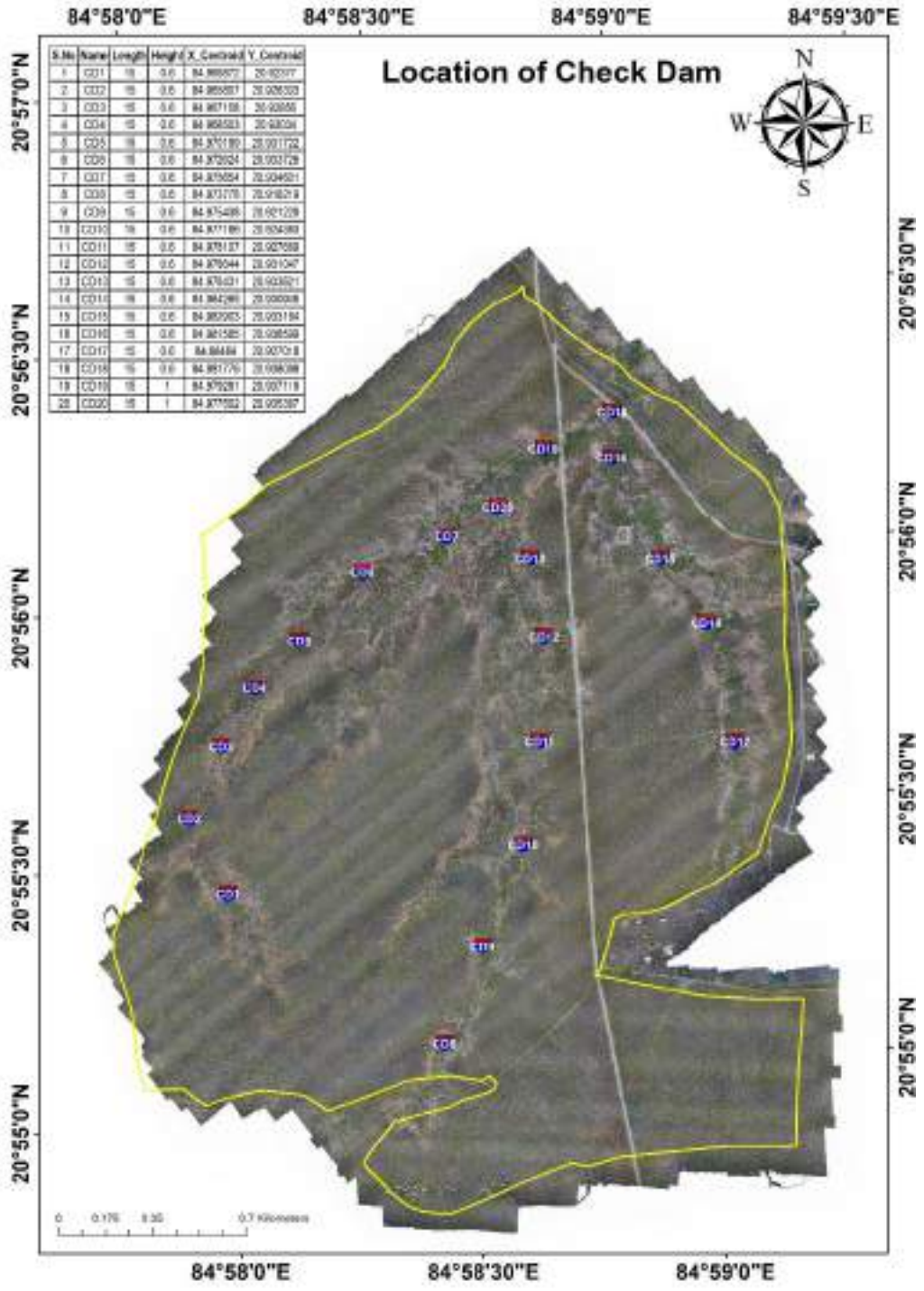


Fig 6.3: Figure showing proposed location of check dams

C. **Catch Pit/Recharge Pit**: A total of 13,440 Pit of size 2 m L × 1m W × 0.8 m D shall be constructed across the slope at a spacing of 5 m and vertical/cross interval of 100m approx. Typical arrangement of recharge pit has been shown in figure-6.4 (RP-1 Part to be done in the first year and RP-2 part to be done in the 2nd year).

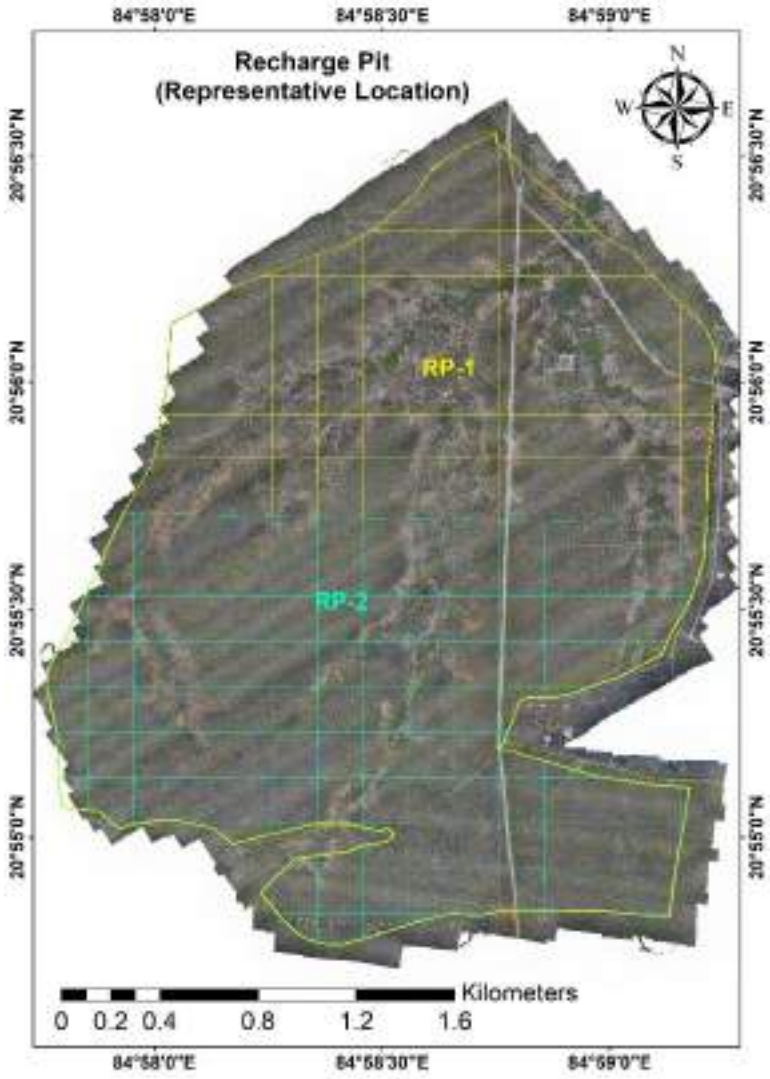


Fig 6.4 Figure showing typical arrangement of recharge pit (not to scale).

D. **Surface Pond**: Five nos. of surface pond with stone pitching of size 50 m L × 30 m W × 2.5 m D shall be constructed at the location specified in table 6.3 and also shown in Fig.6.5

Table: -6.3 Details of Ponds with GPS location

S.No.	Name	X_ Centroid	Y_ Centroid
1	P1	84.971367	20.932126
2	P2	84.980384	20.917316
3	P3	84.975782	20.92911
4	P4	84.984275	20.932097
5	P5	84.9765	20.937251

Design Criteria

Pond in study area has been suggested of capacity of 3300 cum capacity (free board of 30 cm). The total water collected in the proposed ponds through rainfall will be around 200 cum/year. The calculation has been shown in table 6.4

Table 6.4: Capacity of Proposed Ponds

Pond	C	A (in m2)	I (in m annually)	Q (m3/year)
P1	1.00	1500	0.1331	199.65
P2	1.00	1500	0.1331	199.65
P3	1.00	1500	0.1331	199.65
P4	1.00	1500	0.1331	199.65
P5	1.00	1500	0.1331	199.65

The rest water in pond will come through surface run-off from the micro-watershed. The calculation for each micro-watershed is given in table no- 6.5. Inlet for each is proposed

in south direction considering the slope of the micro-watershed. The excess water of micro watershed will join the stream through natural slope of the area.

Table 6.5: Water discharge from micro-watershed.

Pond ID	**Runoff Coefficient (C)**	**Area of watershed (in m^2)**	**Rainfall (I) (in m annually)**	**Q (m^3/year)**
P1	0.30	847495	0.1331	33840.48
P2	0.30	304102	0.1331	12142.79
P3	0.30	116737	0.1331	4661.31
P4	0.30	601151	0.1331	24003.96
P5	0.30	204060	0.1331	8148.12

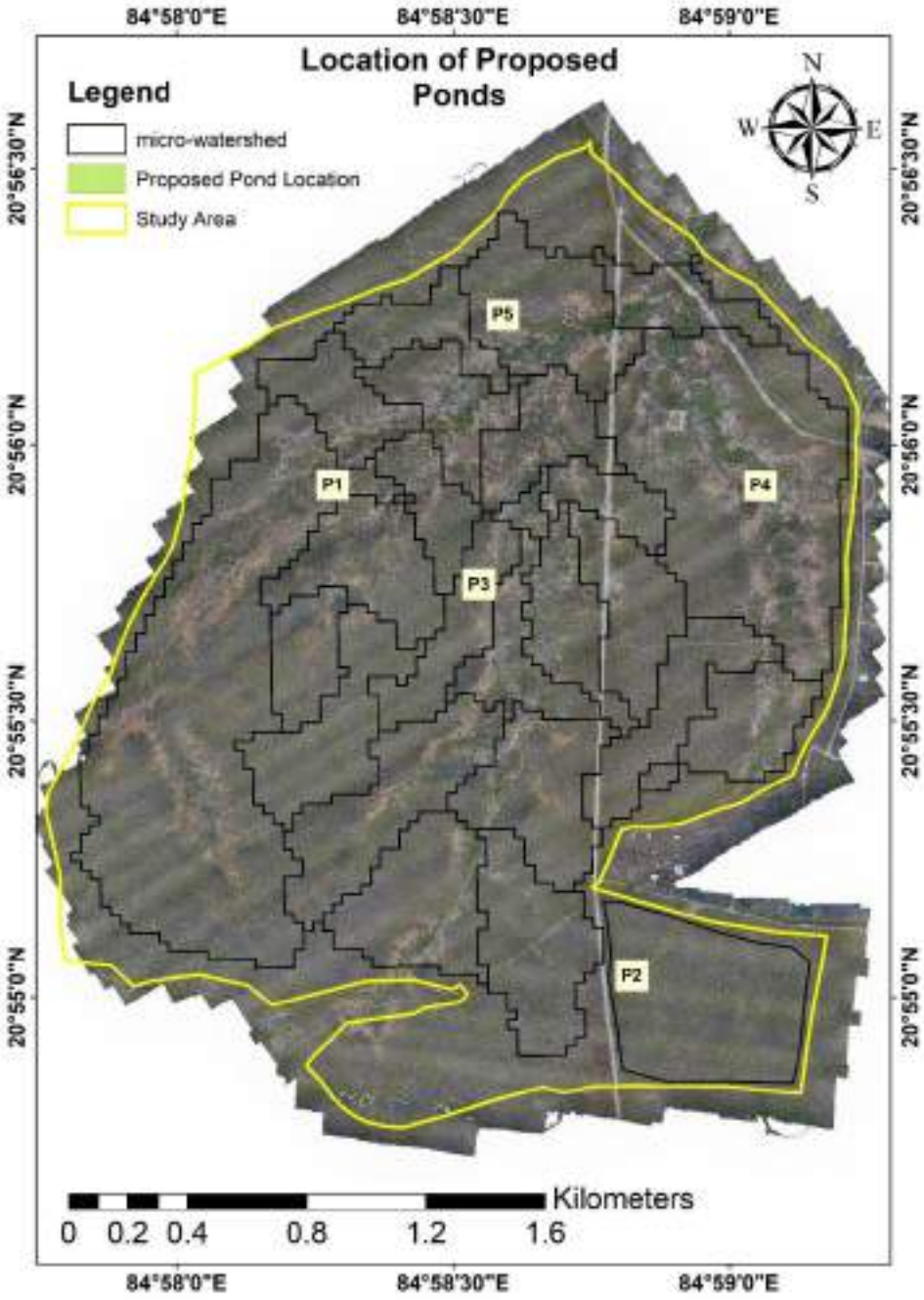


Fig 6.5: Figure showing proposed locations of Ponds

6.7.2 AGRONOMICAL MEASURES:

A. Mulching: Organic mulches comprising of materials like animal compost, cow dung, straw of various crops, dried leaves, or similar locally available material of 50 mm thickness shall be applied over an area of 185 ha land specified in table:6.6 and also shown in **Fig.6.6**

Table 6.6: Mulching Area

S.No	Name	Area in Ha
1	M1	122.19
2	M2	22.45
3	M3	40.29
	Total	**184.93**

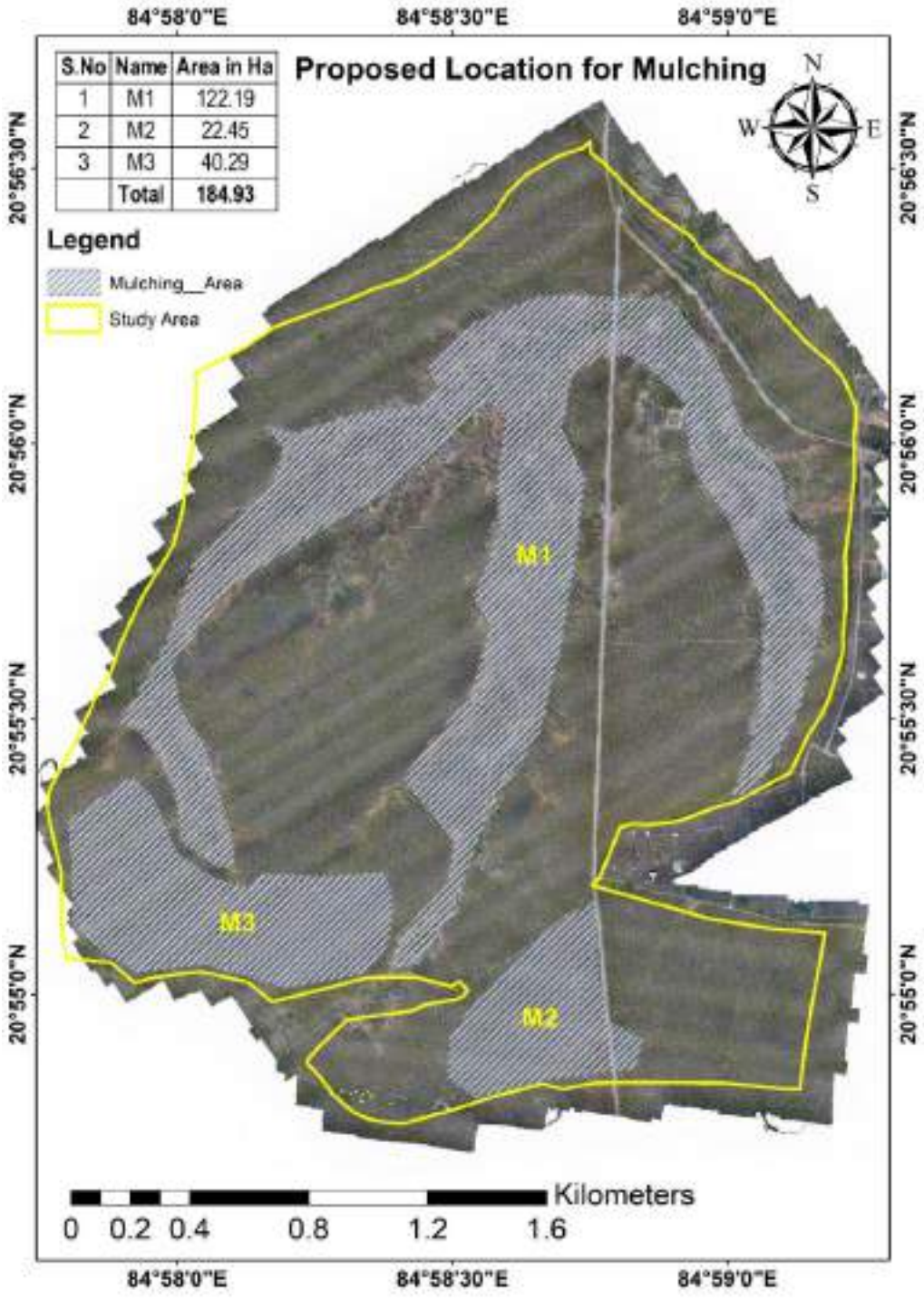


Fig 6.6: Figure showing the location of mulching

B. Grassing: Grassing with indigenous grass species over hatched area of degraded and open land as specified in **Fig.6.7**

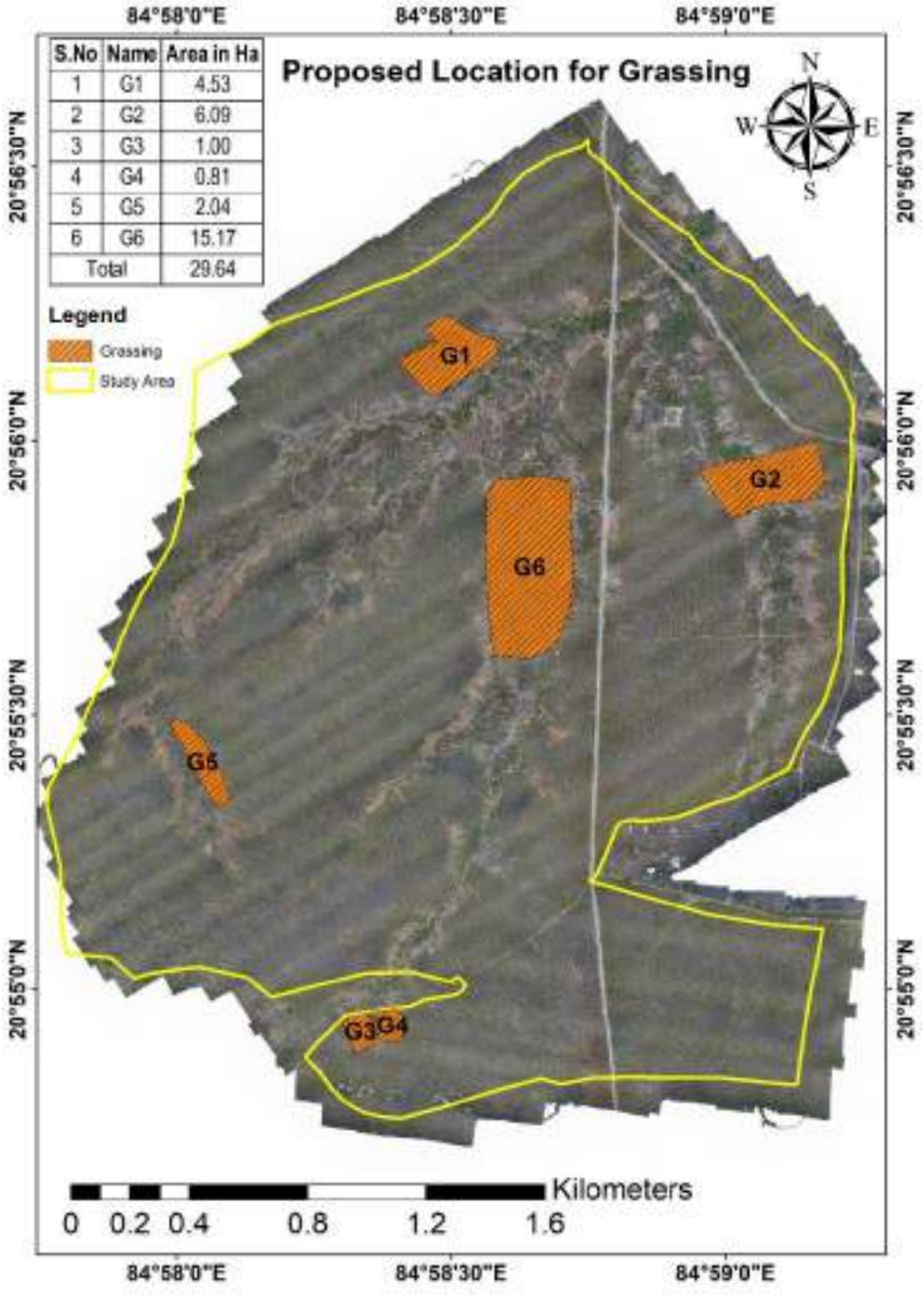


Fig 6.7: Figure showing the location of grassing

6.8 COST ESTIMATE

Table 6.7: Year wise Abstract of SMC Measures

Year wise Abstract of SMC Measures							
Sl No	Year	Total Cost for the SMC work	Maintenance of SMC structures @ 15%	Labour Cess @1%	Monitoring & Supervision @ 5% (in Rs)	Cost for Long Term Monitoring and Assessment	Total (Rs)
1	1st Year (2023-24)	29,703,729.30		297,037.29	1,485,186.47		31,485,953.06
2	2nd Year (2024-25)	28,482,074.28	4,678,337.36	331,604.12	1,658,020.58		35,150,036.34
3	3rd Year (2025-26)		9,398,180.93	93,981.81	469,909.05	2,500,000.00	12,462,071.79
4	4th Year (2026-27)		9,868,089.98	98,680.90	493,404.50		10,460,175.38
5	5th Year (2027-28)		10,361,494.48	103,614.94	518,074.72	2,756,250.00	13,739,434.15
6	6th Year (2027-28)		5,193,020.90	51,930.21	259,651.04		5,504,602.15
	Total	**58,185,803.58**	39499123.65	976,849.27	4,884,246.36	5,256,250.00	**108,802,272.86**

K. K. PANDA
Authorised Signatory
National Aluminium Company Ltd
Bhubaneswar-751013

Divisional Forest Officer
Angul Division

Approved.

Regional Chief Conservator
of Forests, Angul Circle.

Table 6.8: Year Wise Implementation Cost for Soil Moisture Conservation Measures

SN	Description	Item of Works	Unit	Quantity	Rate (DSR 2018)	Total Cost
	1st Year (2023-24)					
1	Contour Trench	Earth Work in Soil	Cum	1027.5	181.85	186,850.88
		Earth Work in Ordinary Rock	Cum	1027.5	352.45	362,142.38
2	Surface Pond	Earth Work in Soil	Cum	5625	181.85	1,022,906.25
		Earth Work in Ordinary Rock	Cum	5625	352.45	1,982,531.25
		Stone Pitching	SqMtr	1694.40	730.2	1,237,250.88
3	Catch Pit	Earth Work in Soil	Cum	5376	181.85	977,625.60
		Earth Work in Ordinary Rock	Cum	5376	352.45	1,894,771.20
4	Check Dams	Earth Work in Soil	Cum	31.5	181.85	5,728.28
		Earth Work in Ordinary Rock	Cum	31.5	352.45	11,102.18
		RCC below Plinth	Cum	45.00	7718.25	347,321.25
		RCC above Plinth	Cum	45.00	9306	418,770.00
		Reinforcement for RCC work of 37.5 Cum @ 100kg/Cum	Kg	9000.00	83.5	751,500.00
		Shuttering	SqMtr	360.00	609.3	219,348.00
5	Grassing	Grassing	SqMtr	150000.00	36.7	5,505,000.00
6	Mulching/ Manuring	Mulching	Cum	50000.00	96.15	4,807,500.00
		Manure	Cum	7500.00	229.95	1,724,625.00
		Manure Speading	Cum	7500.00	46.15	346,125.00
8	Survey/ Demarcation	Survey/Demarcation	L/s			200,000.00
	Sub Total (As on October 2018)					22,001,098.13
	Current Updated Cost (@ 24.836% WPI) -April 2022					27,465,306.00
	Escalation Cost for April 2023 assuming 5% increase					1,373,265.30
	Escalated Cost as on April 2023					28,838,571.30
	Contingencies @ 3%					865,158.00
	Sub Total for SMC Structure as on April 2023					29,703,729.30
	Labour Cess @1%					297,037.29
	Supervision & Monitoring , Evaluation & Documentation Cost @ 5%					1,485,186.47
	Grand- Total (For 1st Year)					**31,485,953.06**

SN	Description	Item of Works	Unit	Quantity	Rate (DSR 2018)	Total Cost
	2nd Year (2024-25)					
9	Contour Trench	Earth Work in Soil	Cum	1599.00	181.85	290,778.15
		Earth Work in Ordinary Rock	Cum	1599.00	352.45	563,568.00
10	Surface Pond	Earth Work in Soil	Cum	3750	181.85	681,937.50
		Earth Work in Ordinary Rock	Cum	3750	352.45	1,321,687.50
		Stone Pitching	SqMtr	1129.60	730.2	824,834.00
11	Catch Pit	Earth Work in Soil	Cum	5376	181.85	977,625.60
		Earth Work in Ordinary Rock	Cum	5376	352.45	1,894,771.00
12	Check Dams	Earth Work in Soil	Cum	31.5	181.85	5,728.28
		Earth Work in Ordinary Rock	Cum	31.5	352.45	11,102.18
		RCC below Plinth	Cum	45.00	7718.25	347,321.25
		RCC above Plinth	Cum	51.00	9306	474,606.00
		Reinforcement for RCC work of 37.5 Cum @ 100kg/Cum	Kg	9600.00	83.5	801,600.00
		Shuttering	SqMtr	384.00	609.3	233,971.20
13	Grassing	Grassing	SqMtr	150000.00	36.7	5,505,000.00
14	Mulching	Mulching	Cum	42500.00	96.15	4,086,375.00
		Manure	Cum	7500.00	229.95	1,724,625.00
		Manure Spreading	Cum	7500.00	46.15	346,125.00
	Sub Total As on October 2018					20,091,655
	Current Updated Cost (@ 24.836% WPI)-April 2022					25,081,632.00
	Escalation Cost for April 2023 assuming 5% increase					1,254,081.60
	Escalated Cost as on April 2023					26,335,713.60
	Escalation Cost for April 2024 assuming 5% increase					1,316,785.68
	Escalated Cost as on April 2024					27,652,499.28
	Contingencies @ 3%					829,575.00
	Total Cost for SMC Structure for 2nd Year					28,482,074.28
	Maintenance of SMC structures @ 15% of initial year cost					4,678,337.36
	Supervision & Monitoring , Evaluation & Documentation Cost @ 5%					1,658,020.58
	Labour Cess @1%					331,604.12
	Grand Total (For 2nd Year)					35,150,036.34

SN	Description	Item of Works	Unit	Quantity	Rate (DSR 2018)	Total Cost
	3rd Year (2025-26)					
	Maintenance of SMC structures @ 15% of initial year cost		L/s			4,912,254.23
	Maintenance of SMC structures @ 15% of Second year cost		L/s			4,485,926.70
	Sub Total (A)					9,398,180.93
	Labour Cess @1%					93,981.81
	Supervision & Monitoring, Evaluation & Documentation Cost @ 5%					469,909.05
	Grand Total (For 3nd Year)					**9,962,071.79**
	4th Year (2026-27)					
	Maintenance of SMC structures @ 15% of initial year cost		L/s			5,157,866.94
	Maintenance of SMC structures @ 15% of Second year cost		L/s			4,710,223.03
	Sub Total (A)					9,868,089.98
	Labour Cess @1%					98,680.90
	Supervision & Monitoring , Evaluation & Documentation Cost @ 5%					493,404.50
	Grand Total (For 4th Year)					**10,460,175.38**
	5th Year (2027-28)					
	Maintenance of SMC structures @ 15% of initial year cost		L/s			5,415,760.29
	Maintenance of SMC structures @ 15% of Second year cost		L/s			4,945,734.19
	Sub Total (A)					10,361,494.48
	Labour Cess @1%					103,614.94
	Supervision & Monitoring , Evaluation & Documentation Cost @ 5%					518,074.72
	Grand Total (For 5th Year)					**10,983,184.15**
	6th Year (2028-29)					
	Maintenance of SMC structures @ 15% of Second year cost		L/s			**5,193,020.90**
	Labour Cess @1%					**51,930.21**
	Supervision & Monitoring , Evaluation & Documentation Cost @ 5%					**259,651.04**
	Grand Total (For 6th Year)					**5,504,602.15**

Table No. 6.9: Cost of the Proposed monitoring Mechanism:

Sl No.	Parameters	Frequency	Year of Monitoring	Cost Per Year
A	Land use cover of the study area.	Yearly	3rd and 5th Year	12,00000/-
B	Soil Moisture Index of the area.	Yearly	3rd and 5th Year	5,00,000/-
C	Analysis of soil quality parameters	Yearly	3rd and 5th Year	3,00,000/-
D	Report Preparation	Yearly	3rd and 5th Year	5,00,000/-
			Cost for 3rd Year	**25,00,000/-**
			Cost for 5th Year	**2,756,250/-**
			Total Cost for Monitoring	**5,256,250/-**

Table 6.10: Proposed Estimate for Soil Moisture Conservation

S. No.	Description	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	Earth work in excavation by mechanical means (Hydraulic excavator)/manual means over areas (exceeding 30 cm in depth, 1.5 m in width as well as 10 sqm on plan) including getting out and disposal of excavated earth lead upto 50 m and lift upto 1.5 m, as directed by Engineer-in-charge. All kinds of soil	Cum	22816.50	181.85	4149180.53
2	Earth work in excavation by mechanical means (Hydraulic excavator)/ manual means over areas (exceeding 30 cm in depth, 1.5 m in width as well as 10 sqm on plan) including getting out and disposal of excavated earth lead upto 50 m and lift upto 1.5 m, as directed by Engineer-incharge.	Cum	22816.50	352.45	8041675.43
3	Dry stone pitching 22.5 cm thick including supply of stones and preparing surface complete.	Sqm	2824.00	730.20	2062084.80
4	Providing and laying in position specified grade of reinforced cement concrete, excluding the cost of centering, shuttering, finishing and reinforcement - All work up to plinth level : 1:1.5:3 (1 cement : 1.5 coarse sand (zone-III): 3 graded stone aggregate 20 mm nominal size)	Cum	90.00	7718.25	694642.50

S. No.	Description	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
5	Reinforced cement concrete work in walls (any thickness), including attached pilasters, buttresses, plinth and string courses, fillets, columns, pillars, piers, abutments, posts and struts etc. above plinth level up to floor five level, excluding cost of centering, shuttering, finishing and reinforcement : 1:1.5:3 (1 cement : 1.5 coarse sand(zone-III) : 3 graded stone aggregate 20 mm nominal size)	Cum	96.00	9306.00	893376.00
6	Steel reinforcement for R.C.C. work including straightening, cutting, bending, placing in position and binding all complete	Kg	18600.00	83.50	1553100.00
7	Centering and shuttering including strutting, propping etc. and removal of form for : Walls (any thickness) including attached pilasters, butteresses, plinth and string courses etc.	Sqm	744.00	609.30	453319.20
8	Providing & laying Selection no. 1 grass turf with earth 50mm to 60mm thickness of existing ground prepared with proper level and ramming with required tools wooden and than rolling the surface with light roller make the surface smoothen and light watering the same including maintenance for 30 days or more till the grass establish properly, as per direction of officer in charge	Sqm	300000.00	36.70	11010000.00
9	Mulching of land using cow dung/dry leaves/straw or similar items as per direction of officer in charge	Cum	92500.00	96.15	8893875.00
10	Supplying and stacking at site dump manure from approved source, including carriage upto 5 km lead complete	Cum	15000.00	229.95	3449250.00
11	Spreading of sludge, dump manure and/or good earth in required thickness as per direction of officer-in-charge (cost of sludge, dump manure and/ or good earth to be paid separately).	Cum	15000.00	46.15	692250.00
12	Survey/demarcation cost	LS			200000.00
	TOTAL as on October 2018:				**42092753.00**
	Current Updated Cost as on April 2022				**52546937.00**
	Contingencies @3%				**1576409.00**
	GRAND TOTAL				**54123346.00**

Note: Estimate is based on DSOR 2018		
	WPI as on October 2018	122
	WPI as on April 2022	152.3
	% Increase	24.836

Table 6.11: Detailed calculation of Items proposed

Sl. No.	Description	Nos.	Length	Breadth	Depth	Quantity	Unit
	Earthwork						
	Contour trench	1.00	1100.00	1.00	0.60	660.00	
		1.00	990.00	1.00	0.60	594.00	
		1.00	820.00	1.00	0.60	492.00	
		1.00	430.00	1.00	0.60	258.00	
		1.00	965.00	1.00	0.60	579.00	
		1.00	650.00	1.00	0.60	390.00	
		1.00	375.00	1.00	0.60	225.00	
		1.00	1250.00	1.00	0.60	750.00	
		1.00	120.00	1.00	0.60	72.00	
		1.00	165.00	1.00	0.60	99.00	
		1.00	490.00	1.00	0.60	294.00	
		1.00	495.00	1.00	0.60	297.00	
		1.00	165.00	1.00	0.60	99.00	
		1.00	740.00	1.00	0.60	444.00	
	Catch Pit	13440.00	2.00	1.00	0.80	21504.00	
	Surface Pond	5.00	50.00	30.00	2.50	18750.00	
	Check Dam	20.00	15.00	0.70	0.60	126.00	
					Total	45633.00	
					Say	**45633.00**	**Cum**
1	Earthwork in soil	50 % of	45633.00			**22816.50**	**Cum**
2	Earthwork in ordinary rock	50 % of	45633.00			**22816.50**	**Cum**
3	Stone pitching						
	Surface Pond	10.00	50.00	3.53		1765.00	**Sqm**
		10.00	30.00	3.53		1059.00	**Sqm**
					Total	**2824.00**	**Sqm**
4	RCC below plinth						
	Check Dam	20.00	15.00	0.50	0.60	**90.00**	**Cum**
					Total	**90.00**	**Cum**

Sl. No.	Description	Nos.	Length	Breadth	Depth	Quantity	Unit
5	RCC above plinth						
	Check Dam	18.00	15.00	0.50	0.60	**81.00**	**Cum**
		2.00	15.00	0.50	1.00	**15.00**	**Cum**
					Total	**96.00**	**Cum**
6	Reinforcement for R.C.C. work	186 m3 @	100 kg/m^3		=	**18600.00**	**Kg**
7	Shuttering						
	Check Dam	36.00	15.00	1.20		**648.00**	**Sqm**
		4.00	15.00	1.60		**96.00**	**Sqm**
					Total	**744.00**	**Sqm**
8	Grassing						
	As shown in map				**Total**	30.00	Hectare
						300000.00	**Sqm**
9	Mulching						
	As per Map shown		1850000.00	0.05		**92500.00**	**Cum**
10	Manure		300000.00	0.05		**15000.00**	**Cum**
11	Manure Spreading		300000.00	0.05		**15000.00**	**Cum**

Table 6.12: Calendar program for the proposed activities for 1st year

S.No.	Description	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	Earth work in excavation by mechanical means (Hydraulic excavator)/manual means over areas (exceeding 30 cm in depth, 1.5 m in width as well as 10 sqm on plan) including getting out and disposal of excavated earth lead upto 50 m and lift upto 1.5 m, as directed by Engineer-in-charge. All kinds of soil	Cum	12060.00	181.85	2193111.00
2	Earth work in excavation by mechanical means (Hydraulic excavator)/ manual means over areas (exceeding 30 cm in depth, 1.5 m in width as well as 10 sqm on plan) including getting out and disposal of excavated earth lead upto 50 m and lift upto 1.5 m, as directed by Engineer-incharge.	Cum	12060.00	352.45	4250547.00
3	Dry stone pitching 22.5 cm thick including supply of stones and preparing surface complete.	Sqm	1694.40	730.20	1237250.88
4	Providing and laying in position specified grade of reinforced cement concrete, excluding the cost of centering, shuttering, finishing and reinforcement - All work up to plinth level : 1:1.5:3 (1 cement : 1.5 coarse sand (zone-III): 3 graded stone aggregate 20 mm nominal size)	Cum	45.00	7718.25	347321.25
5	Reinforced cement concrete work in walls (any thickness), including attached pilasters, buttresses, plinth and string courses, fillets, columns, pillars, piers, abutments, posts and struts etc. above plinth level up to floor five level, excluding cost of centering, shuttering, finishing and reinforcement : 1:1.5:3 (1 cement : 1.5 coarse sand(zone-III) : 3 graded stone aggregate 20 mm nominal size)	Cum	45.00	9306.00	418770.00
6	Steel reinforcement for R.C.C. work including straightening, cutting, bending, placing in position and binding all complete	Kg	9000.00	83.50	751500.00

S.No.	Description	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
7	Centering and shuttering including strutting, propping etc. and removal of form for : Walls (any thickness) including attached pilasters, butteresses, plinth and string courses etc.	Sqm	360.00	609.30	219348.00
8	Providing & laying Selection no. 1 grass turf with earth 50mm to 60mm thickness of existing ground prepared with proper level and ramming with required tools wooden and than rolling the surface with light roller make the surface smoothen and light watering the same including maintenance for 30 days or more till the grass establish properly,as per direction of officer in charge	Sqm	150000.00	36.70	5505000.00
9	Mulching of land using cow dung/dry leaves/straw or similar items as per direction of officer in charge	Cum	50000.00	96.15	4807500.00
10	Supplying and stacking at site dump manure from approved source, including carriage upto 5 km lead complete	Cum	7500.00	229.95	1724625.00
11	Spreading of sludge, dump manure and/or good earth in required thickness as per direction of officer-in-charge (cost of sludge, dump manure and/ or good earth to be paid separately).	Cum	7500.00	46.15	346125.00
13	Survey/demarcation cost	LS			200000.00
	TOTAL as on October 2018:				**22001098.00**
	Current Updated Cost				**27465306.00**
	Contingencies @3%				**823960.00**
	GRAND TOTAL as on April 2022				**28289266.00**
	Escalation Cost for April 2023 assuming 5% increase				**1414464.00**
	Escalated Cost as on 01.04.2023				**29703730.00**

Note: Estimate is based on DSOR 2018

WPI as on October 2018	122
WPI as on April 2022	152.3
% Increase	24.836

Table 6.13: Detailed calculation of Items proposed for 1st Year

Sl. No.	Description	Nos.	Length	Breadth	Depth	Quantity	Unit
	Earthwork						
	Contour trench	1.00	1250.00	1.00	0.60	750.00	
		1.00	120.00	1.00	0.60	72.00	
		1.00	165.00	1.00	0.60	99.00	
		1.00	490.00	1.00	0.60	294.00	
		1.00	495.00	1.00	0.60	297.00	
		1.00	165.00	1.00	0.60	99.00	
		1.00	740.00	1.00	0.60	444.00	
	Catch Pit	6720.00	2.00	1.00	0.80	10752.00	
	Surface Pond	3.00	50.00	30.00	2.50	11250.00	
	Check Dam	10.00	15.00	0.70	0.60	63.00	
					Total	24120.00	
					Say	**24120.00**	**Cum**
1	Earthwork in soil	50 % of	24120.00			**12060.00**	**Cum**
2	Earthwork in ordinary rock	50 % of	24120.00			**12060.00**	**Cum**
3	Stone pitching						
	Surface Pond	6.00	50.00	3.53		1059.00	**Sqm**
		6.00	30.00	3.53		635.40	**Sqm**
					Total	**1694.40**	**Sqm**
4	RCC below plinth						
	Check Dam	10.00	15.00	0.50	0.60	**45.00**	**Cum**
		.			**Total**	**45.00**	**Cum**
5	RCC above plinth						
	Check Dam	10.00	15.00	0.50	0.60	**45.00**	**Cum**
					Total	**45.00**	**Cum**
6	Reinforcement for R.C.C. work	90 m3 @	100 kg/m3		=	**9000.00**	**Kg**
7	Shuttering						

Sl. No.	Description	Nos.	Length	Breadth	Depth	Quantity	Unit
	Check Dam	20.00	15.00	1.20		**360.00**	**Sqm**
					Total	**360.00**	**Sqm**
8	Grassing						
	As shown in map				**Total**	15.00	Hectare
						150000.00	**Sqm**
9	Mulching						
	As per Map shown		1000000.00	0.05		**50000.00**	**Cum**
10	Manure		150000.00	0.05		**7500.00**	**Cum**
11	Manure Spreading		150000.00	0.05		**7500.00**	**Cum**

Table 6.14: Calendar program for the proposed activities for 2nd year

S.No.	Description	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	Earth work in excavation by mechanical means (Hydraulic excavator)/manual means over areas (exceeding 30 cm in depth, 1.5 m in width as well as 10 sqm on plan) including getting out and disposal of excavated earth lead upto 50 m and lift upto 1.5 m, as directed by Engineer-in-charge. All kinds of soil	Cum	10756.50	181.85	1956069.53
2	Earth work in excavation by mechanical means (Hydraulic excavator)/ manual means over areas (exceeding 30 cm in depth, 1.5 m in width as well as 10 sqm on plan) including getting out and disposal of excavated earth lead upto 50 m and lift upto 1.5 m, as directed by Engineer-incharge.	Cum	10756.50	352.45	3791128.43
3	Dry stone pitching 22.5 cm thick including supply of stones and preparing surface complete.	Sqm	1129.60	730.20	824833.92
4	Providing and laying in position specified grade of reinforced cement concrete, excluding the cost of centering, shuttering, finishing and reinforcement - All work up to plinth level : 1:1.5:3 (1 cement : 1.5 coarse sand (zone-III): 3 graded stone aggregate 20 mm nominal size)	Cum	45.00	7718.25	347321.25
5	Reinforced cement concrete work in walls (any thickness), including attached pilasters, buttresses, plinth and string courses, fillets, columns, pillars, piers, abutments, posts and struts etc. above plinth level up to floor five level, excluding cost of centering, shuttering, finishing and reinforcement : 1:1.5:3 (1 cement : 1.5 coarse sand(zone-III) : 3 graded stone aggregate 20 mm nominal size)	Cum	51.00	9306.00	474606.00
6	Steel reinforcement for R.C.C. work including straightening, cutting, bending, placing in position and binding all complete	Kg	9600.00	83.50	801600.00
7	Centering and shuttering including strutting, propping etc. and removal of form for : Walls (any thickness) including attached pilasters, butteresses, plinth and string courses etc.	Sqm	384.00	609.30	233971.20

S.No.	Description	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
8	Providing & laying Selection no. 1 grass turf with earth 50mm to 60mm thickness of existing ground prepared with proper level and ramming with required tools wooden and than rolling the surface with light roller make the surface smoothen and light watering the same including maintenance for 30 days or more till the grass establish properly,as per direction of officer in charge	Sqm	150000.00	36.70	5505000.00
9	Mulching of land using cow dung/dry leaves/straw or similar items as per direction of officer in charge	Cum	42500.00	96.15	4086375.00
10	Supplying and stacking at site dump manure from approved source, including carriage upto 5 km lead complete	Cum	7500.00	229.95	1724625.00
11	Spreading of sludge, dump manure and/or good earth in required thickness as per direction of officer-in-charge (cost of sludge, dump manure and/ or good earth to be paid separately).	Cum	7500.00	46.15	346125.00
	TOTAL as on October 2018:				**20091655.00**
	Current Updated Cost				**25081632.00**
	Contingencies @3%				**752449.00**
	GRAND TOTAL as on 01.04.2022				**25834081.00**
	Escalation Cost for 01.04.2023 assuming 5% increase				**1291705.00**
	Escalated Cost as on 01.04.2023				**27125786.00**
	Escalation Cost for 01.04.2024 assuming 5% increase				**1356290.00**
	Escalated Cost as on 01.04.2024				**28482076.00**

Note: Estimate is based on DSOR 2018

WPI as on October 2018	122
WPI as on April 2022	152.3
% Increase	24.836

Table 6.15: Detailed calculation of Items proposed for 2nd year

S. No.	Description	Nos.	Length	Breadth	Depth	Quantity	Unit
	Earthwork						
	Contour trench	1.00	1100.00	1.00	0.60	660.00	
		1.00	990.00	1.00	0.60	594.00	
		1.00	820.00	1.00	0.60	492.00	
		1.00	430.00	1.00	0.60	258.00	
		1.00	965.00	1.00	0.60	579.00	
		1.00	650.00	1.00	0.60	390.00	
		1.00	375.00	1.00	0.60	225.00	
	Catch Pit	6720.00	2.00	1.00	0.80	10752.00	
	Surface Pond	2.00	50.00	30.00	2.50	7500.00	
	Check Dam	10.00	15.00	0.70	0.60	63.00	
					Total	21513.00	
					Say	**21513.00**	**Cum**
1	Earthwork in soil	50 % of	21513.00			**10756.50**	**Cum**
2	Earthwork in ordinary rock	50 % of	21513.00			**10756.50**	**Cum**
3	Stone pitching						
	Surface Pond	4.00	50.00	3.53		706.00	**Sqm**
		4.00	30.00	3.53		423.60	**Sqm**
					Total	**1129.60**	**Sqm**
4	RCC below plinth						
	Check Dam	10.00	15.00	0.50	0.60	**45.00**	**Cum**
					Total	**45.00**	**Cum**
		.					
5	RCC above plinth						
	Check Dam	8.00	15.00	0.50	0.60	**36.00**	**Cum**
		2.00	15.00	0.50	1.00	**15.00**	**Cum**
					Total	**51.00**	**Cum**
6	Reinforcement for R.C.C. work	96 m^3 @ 100 kg/m^3			=	**9600.00**	**Kg**

S. No.	Description	Nos.	Length	Breadth	Depth	Quantity	Unit
7	Shuttering						
	Check Dam	16.00	15.00	1.20		**288.00**	**Sqm**
		4.00	15.00	1.60		**96.00**	**Sqm**
					Total	**384.00**	**Sqm**
8	Grassing						
	As shown in map				**Total**	15.00	Hectare
						150000.00	**Sqm**
9	Mulching						
	As per Map shown		850000.00	0.05		**42500.00**	**Cum**
10	Manure		150000.00	0.05		**7500.00**	**Cum**
11	Manure Spreading		150000.00	0.05		**7500.00**	**Cum**

CHAPTER-7

Long Term Monitoring and Assessment of the Proposed Mitigative Measures

CHAPTER-7

LONG TERM MONITORING AND ASSESSMENT OF THE PROPOSED MITIGATIVE MEASURES

7.1 PROPOSED MITIGATIVE MEASURES

Based on the field visits, soil sample analysis, Drone Survey based Orthomosaic image and contour map of the area, following Mechanical and Agronomical mitigation measures have been suggested to increase moisture level of the study area:

1. Contour Trenches
2. Check Dams
3. Catch Pit/Recharge Pit
4. Surface Pond
5. Mulching:
6. Grassing

7.1.1 CONTOUR TRENCHES

Contour Trench: 14 number of trenches of size Lm x1m W × 0.6m D shall be constructed along the specified contour as shown in (Fig. 6.2). The details about the length and latitude and longitude of stating point and end point is given in table no-7.1.

Table No.-7.1 Details of contour trenches with GPS location

S. No	Name	Length (m)	X_Start	Y_Start	X_End	Y_End
1	C-1	1100	84.9755	20.91677	84.986078	20.917354
2	C-2	990	84.9629	20.921265	84.971772	20.920597
3	C-3	820	84.9664	20.926382	84.973772	20.923889

S. No	Name	Length (m)	X_Start	Y_Start	X_End	Y_End
4	C-4	430	84.9769	20.922148	84.980972	20.921881
5	C-5	965	84.9664	20.929795	84.975515	20.928183
6	C-6	650	84.9789	20.927707	84.983931	20.924268
7	C-7	375	84.9848	20.923878	84.986705	20.926749
8	C-8	1250	84.9766	20.940687	84.970056	20.933421
9	C-9	120	84.9838	20.938303	84.982962	20.937562
10	C-10	165	84.9827	20.937194	84.981433	20.936273
11	C-11	490	84.9809	20.939111	84.97717	20.936406
12	C-12	495	84.9799	20.9328	84.983819	20.930293
13	C-13	165	84.9853	20.936721	84.98426	20.935689
14	C-14	740	84.9842	20.934958	84.985048	20.928429

7.1.2 CHECK DAM

- **18 nos.** of check dam of size 15 m L × 0.5 m W × 0.6 m H and **2 nos.** of check dam of size 15 m L × 0.5 m W × 1.0 m H shall be constructed across the stream.

Table No.- 7.2 Details of Check Dams with GPS location

S.No	Name	Length	Height	X_Centroid	Y_Centroid
1	CD1	15	0.6	84.966872	20.92377
2	CD2	15	0.6	84.965807	20.926333
3	CD3	15	0.6	84.967158	20.92856
4	CD4	15	0.6	84.968503	20.93034
5	CD5	15	0.6	84.970199	20.931722
6	CD6	15	0.6	84.972624	20.933726
7	CD7	15	0.6	84.975654	20.934601
8	CD8	15	0.6	84.973778	20.918219
9	CD9	15	0.6	84.975438	20.921228
10	CD10	15	0.6	84.977186	20.924383
11	CD11	15	0.6	84.978107	20.927669
12	CD12	15	0.6	84.978644	20.931047
13	CD13	15	0.6	84.978431	20.933621
14	CD14	15	0.6	84.984265	20.930948
15	CD15	15	0.6	84.982903	20.933184
16	CD16	15	0.6	84.981585	20.936599
17	CD17	15	0.6	84.98484	20.927018
18	CD18	15	0.6	84.981776	20.938098
19	CD19	15	1	84.979281	20.937119
20	CD20	15	1	84.977502	20.935367

7.1.3 CATCH PIT/RECHARGE PIT

Catch Pit/Recharge Pit: A total of 13,440 Pit of size 2 m L × 1m W × 0.8 m D to be constructed across the slope at a spacing of 5 m and vertical/cross interval of 100m approx.

7.1.4 SURFACE POND

Surface Pond: Five nos. of surface pond with stone pitching of size 50 m L × 30 m W × 2.5 m D shall be constructed at the location specified in table 7.3:

Table: -7.3 Details of Ponds with GPS location

S.No.	Name	X_ Centroid	Y_ Centroid
1	P1	84.971367	20.932126
2	P2	84.980384	20.917316
3	P3	84.975782	20.92911
4	P4	84.984275	20.932097
5	P5	84.9765	20.937251

7.1.4 MULCHING

Mulching: Organic mulches comprising of materials like animal compost, cow dung, straw of various crops, dried leaves, or similar locally available material of 50 mm thickness shall be applied over an area of 185 ha land specified in table:7.4:

Table 7.4: Mulching Area

S. No	Name	Area in Ha
1.	M1	122.19
2.	M2	22.45
3.	M3	40.29
	Total	**184.93**

7.1.6 GRASSING

- Grassing with indigenous grass species over area of 29.64 ha of the degraded and open area.

7.2 EXPECTED OUTCOME IN THE STUDY AREA AFTER IMPLEMENTATION OF THE PROPOSED CONTROL MEASURES

I. After construction of contour trenches, Percolation pit, Check Dams, and Surface ponds, the soil moisture content in the study area will increase.

II. During the soil testing of the study area, different nutrients like Organic Carbon, Phosphorus, Potash Nitrogen etc were found deficient.

III. After the implementation of the proposed Agronomic control measures like Mulching and Grassing the water holding capacity of the study area will increase. It will also help in the improvement in soil quality parameters.

IV. The land use of the study area will change due to increase in moisture content and increase in soil fertility which further will increase the green cover.

V. The above mechanical (Contour trenches & Check Dam) and agronomical control (Grassing) measures will help in the control soil erosion.

VI. The proposed control measures will help in the improvement of the soil moisture index of the degraded forest area.

7.3 MONITORING MECHANISM FOR PROGRESS OF THE OUTCOMES

For preparation of the Soil Moisture Conservation (SMC) report, following studies were done:

7.3.1 LAND USE OF STUDY AREA

The proposed area is 561 Ha of land which can be categorized into three categories based on signatures got through sentinel images. A total of 293 ha of land falls in the forest land category where some vegetation was available, 128 ha of land falls under degraded land area and 140 ha of land falls under the open land area where very less or no vegetation was available. Although in the study area seasonal streams were also present in this landuse, it cannot be detected.

Table No. 7.5 Land use of the Study area

Sl. No.	Land Use	Area in Ha	Percentage
1.	Forest Land	293	52.23
2.	Degraded Forest Land	128	22.82
3.	Open Land	140	24.96
	Total	**561**	**100**

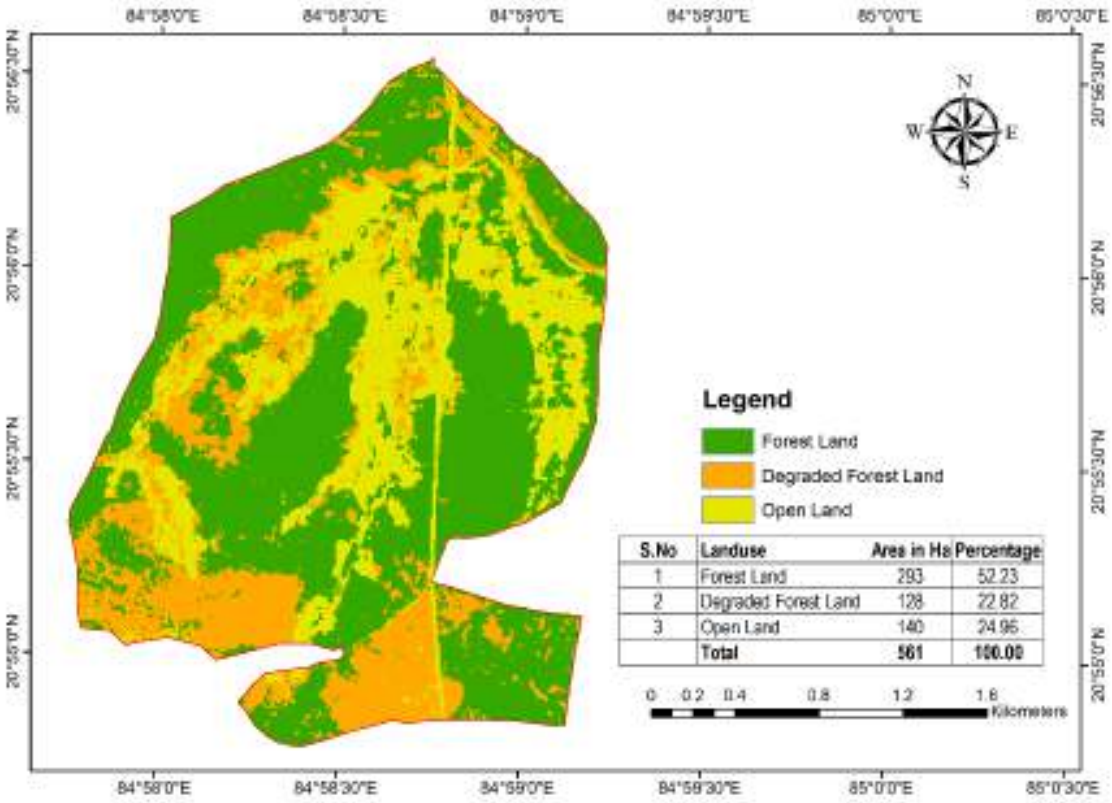


Fig-7.1 Land use map of the study area using sentinel satellite image

7.3. 2 SOIL MOISTURE INDEX

Soil moisture is a key parameter that directly or indirectly influences the water cycle. The existence of forest cover and agriculture production mainly depend on rainfed areas as well as irrigation practices of the area. Climate change and the trend of increasing temperatures have a significant impact on forest cover. It is linked to various hydrological phenomena, such as drought, climate, and vegetation. The data collected for soil moisture analysis taken below the surface over the long term as well as higher temporal and spatial resolution data are valuable for assessing the extent and severity of drought quite accurately. Surface soil moisture is very sensitive and varies with space and time. Various studies have been done to assess soil moisture.

In situ measurements can provide an accurate estimation of soil moisture, but they are both time-consuming and expensive, and only represent a small area (a few square decimeters). Nevertheless, a number of strategies can be adopted to upscale the spatially sparse ground-based observations, which are invaluable for calibrating and validating land surface models and satellite-based soil moisture retrievals.

The soil moisture index (SMI) is defined as the proportion of the difference between the current soil moisture and the permanent wilting point to the field capacity and the residual soil moisture. The index values range from 0 to 1 with 0 indicating extreme dry conditions and 1 indicating extreme wet conditions. Presently, 80 % of study area is under water stressed. On applying proposed interventions, the soil moisture of area will increase. This will be monitored by the satellite image in subsequent years.

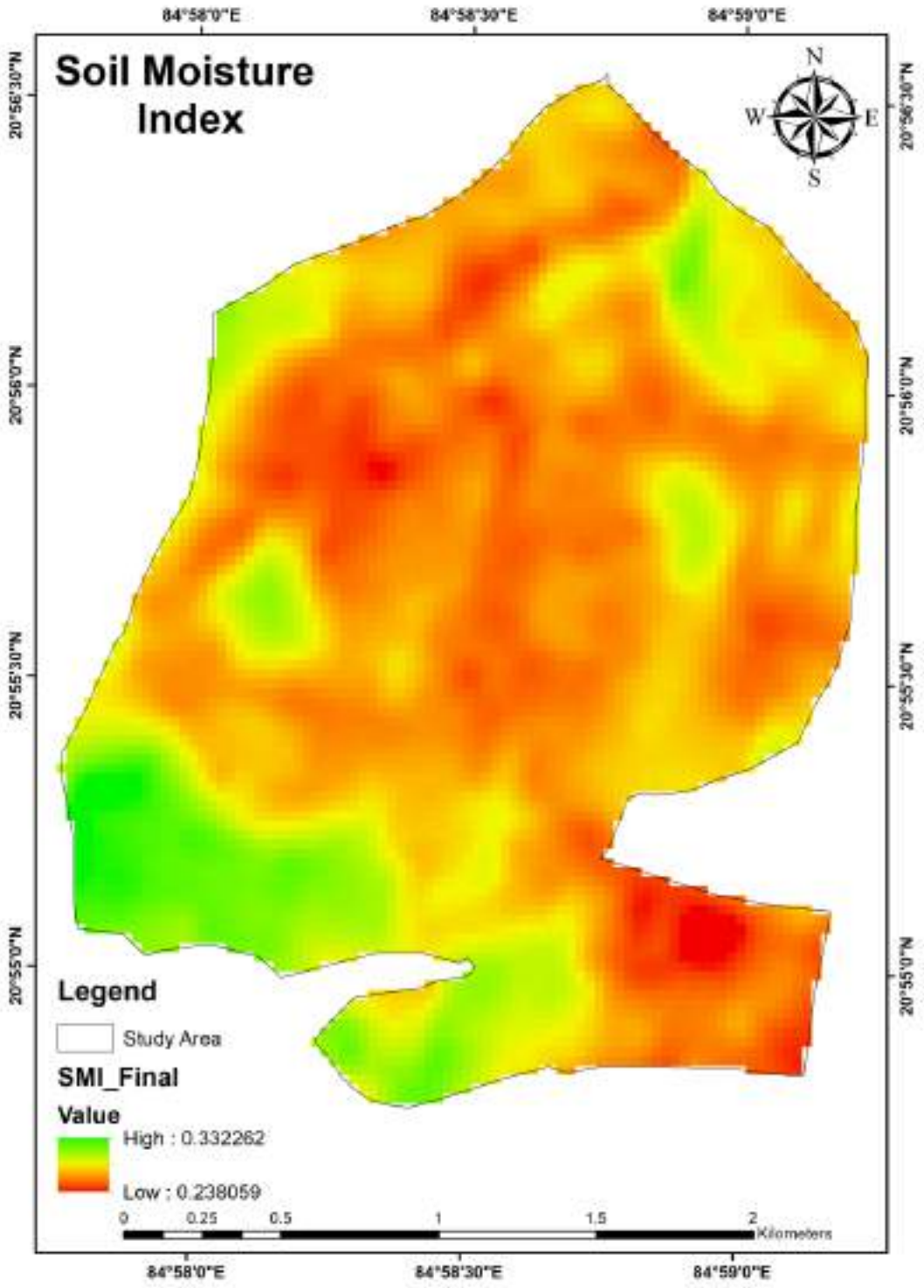


Figure 7.2.: Soil moisture index map of the study area.

7.3.2 ANALYSIS OF SOIL QUALITY PARAMETERS:

The highlights of some of the parameters as depicted in analytical results presented in Tables – 5.2 to 5.4 are given hereunder:

(i) Texture

The texture of the soils was Sandy Clay, Clay, Loam and Sandy Clay Loam and Sandy loam.

(ii) pH

The pH of the soils ranged between 4.68 to 6.34.

(iii) Electrical Conductivity

The electrical conductivity varied from 1.42 to 1.92 dS/cm at $20^{O}C$.

(iv) Organic Carbon

The organic carbon ranged between 0.39 to 0.91 %. Organic carbon is one of the important characteristics of the soil represents for fixation of nitrogen and survival of the various macro and microorganisms. It has been found in the range of poor quality the degraded forest land.

(v) Phosphorus as P_2O_5

The concentration of Phosphorous varied between 5.72 to 17.85 Kg/ha.

(vi) Potash as K_2O

The concentration of Potash ranged between 116.8 to 162.48 Kg/ha.

(vii) Nitrogen as N

The concentration of Nitrogen varied between 86 to 166 Kg/ha.

7.4 PARAMETERS REQUIRED TO BE MONITORED FOR MEASURING THE EFFECTIVENESS OF THE PROPOSED CONTROLLED MEASURES:

The following parameters are required to be monitored for measuring the effectiveness of the proposed controlled measures:

A. Land use cover of the study area.

B. Soil Moisture Index of the area.

C. Analysis of soil quality parameters

Table No. 7.6 Monitoring Frequency and Time Line:

Sl No.	Parameters	Frequency	Year of Monitoring	Remarks
A	Land use cover of the study area.	Yearly	3rd and 5th Year	Season – Pre-Monsoon
B	Soil Moisture Index of the area.	Yearly	3rd and 5th Year	Season – Pre-Monsoon
C	Analysis of soil quality parameters	Yearly	3rd and 5th Year	Season – Pre-Monsoon

The result of the above parameters monitored for measuring the effectiveness of the proposed controlled measures may be compared with the baseline data of the study area.

The work of the monitoring the effectiveness of the proposed controlled measures may be carried out by the reputed organization dully accredited by Quality Council of India (QCI-NABET). The laboratory work may be carried out by NABL accredited /Central Pollution Control Board (CPCB) recognized laboratory.

The estimated cost for the same is as given in the Table below:

Table No. 7.7: Cost of the Proposed monitoring Mechanism:

Sl No.	Parameters	Frequency	Year of Monitoring	Cost Per Year
A	Land use cover of the study area.	Yearly	3rd and 5th Year	12,00000/-
B	Soil Moisture Index of the area.	Yearly	3rd and 5th Year	5,00,000/-
C	Analysis of soil quality parameters	Yearly	3rd and 5th Year	3,00,000/-
D	Report Preparation	Yearly	3rd and 5th Year	5,00,000/-
			Cost for 3rd Year	**25,00,000/-**
			Cost for 5th Year	**2,756,250/-**
			Total Cost for Monitoring	**52,56,250/-**

CHAPTER-8

Disclosure of the Consultant Engaged

CHAPTER-8
DISCLOSURE OF THE CONSULTANT ENGAGED

About CMPDI

FIG. – 8.1 CMPDI Corporate Office, Ranchi

Central Mine Planning & Design Institute Limited (CMPDIL) is a Government of India enterprise having its corporate headquarters at Ranchi in India. It is a fully owned subsidiary of Coal India Limited (CIL) and a Schedule – B Company. It is a Mini Ratna (Category I) company since June, 2019. CMPDI is also an ISO 9001: 2015 certified since 28th March, 2017. There are seven Regional Institutes (Asansol, Dhanbad, Ranchi, Nagpur, Bilaspur, Singrauli & Bhubaneswar) headed by Regional Directors. The highest authority of CMPDI is Chairman cum Managing Director (CMD).

Its registered Corporate office is situated at Gondwana Place, Kanke Road, Ranchi-834 008, a capital city of Jharkhand state. It operates through seven strategically located Regional Institutes over six states territories of India.

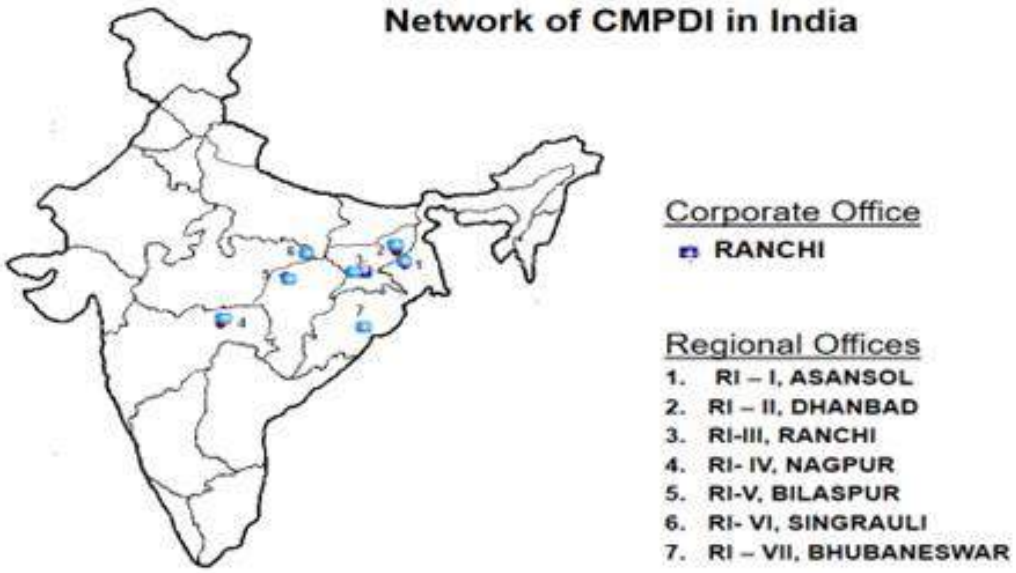


FIG. – 8.2 Locations of Regional Institute of CMPDI

Details of all the seven institutes including its corporate office are given as below:

Sl. No.	Offices	Addresses		Tel / Fax
		Postal	Website	
1	Corporate, Ranchi	Gondwana Place, Kanke Road, Ranchi-834 008, Jharkhand	http://www.cmpdi.co.in	+91 651 2230483, 2230116 / +91 651 2231447, 2232249
2	Regional Institute-I, Asansol	West End, GT Road. Asansol-713 301, West Bengal.	http://www.cmpdi.co.in	+91 341 2253504 / +91 341 2250935
3	Regional Institute-II, Dhanbad	Koyala Bhawan, Koyla Nagar, Dhanbad-826 005, Jharkhand	http://www.cmpdi.co.in	+91 326 2230789, 2230850, 2230103, 2230105/+9132 6 2265575

Sl. No.	Offices	Addresses		Tel / Fax
		Postal	Website	
4	Regional Institute-III, Ranchi	Gondwana Place, Kanke Road, Ranchi-834 008, Jharkhand	http://www.cmpdi.co.in	+91 6512231506 / +91 651 2231501
5	Regional Institute-IV, Nagpur	Kasturba Nagar, Jaripatka, Nagpur- 440 014, Maharashtra.	http://www.cmpdi.co.in	+91 0712 2642134 / +91 0712 2643231
6	Regional Institute-V, Bilaspur	SECL Complex, Seepat Road, Bilapur, Chhattisgarh.	http://www.cmpdi.co.in	+91 7752 246482 / +91 7752 246481
7	Regional Institute-VI, Singrauli	CWS Colony, P.O. Jayant Colliery, Sidhi-486 890, Madhya Pradesh.	http://www.cmpdi.co.in	+91 7805 222172 / +91 7805 277600
8	Regional Institute-VII, Bhubaneshwar	Samantapuri, Near Janta Maidan, Bhubaneshwar-751 013, Orissa.	http://www.cmpdi.co.in	+91 0674 2394760, 2394357, / +91 0674 2395128

All the above regional institutes are dedicated to rendering services to seven subsidiaries of the CIL as flows:

Sl. No.	Institutes	Dedicated to
1	Regional Institute-I, Asansol	Eastern Coal fields Ltd.(ECL)
2	Regional Institute-II, Dhanbad	Bharat Coking Coal Ltd.(BCCL)
3	Regional Institute-III, Ranchi	Central Coalfields Ltd(CCL)
4	Regional Institute-IV, Nagpur	Western Coalfields Ltd(WCL)
5	Regional Institute-V, Bilaspur	South Eastern Coalfields Ltd(SECL)
6	Regional Institute-VI, Singrauli	Northern Coalfields Ltd.(NCL)
7	Regional Institute-VII, Bhubaneshwar	Mahanadi Coalfields Ltd(MCL)

CMPDI (HQ.) Ranchi renders services to NEC & Non-CIL clients and specialized assignments for both CIL & non-CIL clients.

Establishment background

The company was formerly known as Coal Mines Authority Limited. And, the Central Mine Planning & Design Institute Limited (herein after called as CMPDI) is a planning & design division of Coal India Limited (hereinafter called as CIL) as per Memorandum of Association of the company. The CIL is a holding company since November 01, 1975, and the CMPDIL is one of its subsidiaries since then. It is under Ministry of Coal, Government of India.

Strength & Resources

Manpower

CMPDI has total Manpower 2977 (832 Executives , 2145 Non Executives) as on 01.05.2022. It has multidisciplinary technical executive professionals who combine innovation and initiative to deliver faster and effective solutions in planning, implementation and management of projects.

Resources

CMPDI is equipped with modern laboratory facilities for undertaking various analytical works to supplement its services. It has well equipped network of six environmental laboratories located in various coalfields to regularly monitor air, water, Soil and noise parameters. **The Environment Laboratory at Ranchi is accredited with NABL (National Accreditation Board for Testing and Calibration Laboratories).** The environment lab is also having recognition of CPCB since 1997 and also working under ISO-9001:2015 Certification. Besides its own strength, CMPDI has access to the vast resources with its principal, CIL, India's largest coal producer and a **Maharatna Company**.

Fig: 8.3 Environment Laboratory at CMPDI HQ, Ranchi

Recognition

CMPDI is recognized as preferred consultant by Indian and overseas clients, United Nation agencies and international financial institutions, and the company is registered with

- World Bank
- Asian Development Bank
- African Development Bank
- United Nations Development Programme

Main Functional area

The main functional area of the CMPDI is to provide adequate and up-to-date planning, design and technological supports to the CIL and its coal producing subsidiaries to enable them to produce the planned quantity of coal efficiently and economically with due attention to safety, conservation, quality and environment. In addition to these, CMPDI also provides necessary consultancy for clients outside the CIL in India and abroad. The Quality Management System of CMPDI, Ranchi is certified under international standard-ISO 9001:2015, Services covered under are as follows:

1. Consultancy in Mineral Exploration and Environmental Management.
2. Planning & Design in Mining, Civil & Architectural Engineering, Coal Preparation & Utilization, Electrical & Mechanical Engineering, Mining Electronics, Geomatics and Mine Construction.
3. Laboratory testing facilities for the above.
4. Technical & Management Training in Mineral & Mining Sector.

Nature of consultancy rendered

CMPDI has been offering services in the fields enumerated in table below:

Sl.No.	Services offered
1	Exploration & Resource Evaluation
2	Mine Planning & Design Services
3	Infrastructures Engineering
4	Environmental Services
5	Beneficiation Services

Sl.No.	Services offered
6	Management Services
7	Specialized Services
8	Laboratory Services
9	ITC in Mining
10	Research & Development

Exploration & resource Evaluation

New generation exploration technology coupled with skilled manpower has made CMPDI a twenty first century leader in mineral exploration, deposit modeling, resource evaluation, resource management, mining geology, hydro-geological & geophysical studies, engineering geological investigations, etc. Services rendered under this head are described in brief :

Sl. No.	Subheads of Services	Services rendered in
1	Geological Support for mining	Production support or mine development drilling and prediction of faults and pinch / wash outs
		Delineation of roof / floor and dirt bands
2	Drilling	Coring-Diamond rotary drills up to a capacity of 1280 m depth
		Non-coring-Direct rotary and DTH drills for hydro-geological investigations, dewatering, etc.
3	Deposit modelling	Using geo-statistical and geological software packages including MINEX and in-house developed CEMPGEODOC and SASLINT software
4	Resource Evaluation	Deposits of coal, lignite, manganese, iron ore (magnetite and hematite), phosphorite, coal bed methane, etc.
5	Resource Management	Strategic planning for future exploration depending upon market demand.
		Updating of reserve / resource of individual blocks or coalfields.
6	Hydro-geological studies	Systematic ground water investigations.
		Mining hydro-geological studies.

Sl. No.	Subheads of Services	Services rendered in
7	Geo-engineering works	Determination of strength properties of rocks and coal and RQD (Rock Quality Designation) to assess strength characteristics of strata.
8	Master Planning for assessment of resource potential-with respect to CBM (Coal Bed Methane) globally an emerging environment friendly alternate energy source.	Creation of data packages of potential CBM blocks
		Resource evaluation of CBM / CMM / AMM.
		Formulation of policy guidelines for harnessing CB resources.
		Implementation of CIL-ONGC Consortiums venture in developing CBM in coalfields.

To provide quality services, CMPDI is effectively utilizing technology like remote sensing, combination drilling (coring and non-coring), multi-probe geophysical borehole logging, seismic refraction survey, etc.

CMPDI has already undertaken over 500 integrated exploration projects in varying geological and terrain conditions.

Mine Planning & Design Services

CMPDI is a premier consultant in open pit and underground mine planning & design in coal, lignite and other minerals. It has prepared more than 950 mining project reports with individual capacity up to 70 Million tonne per annum. CMPDI uses advance software like MINEX for resource modeling, mine planning and scheduling of open cast and underground mine projects. It has helped its subsidiaries to achieve unprecedented production growth from open cast mines in their organizations. Its experience in mechanized underground mining technology spans exploitation of coal seams from 1.00 m to 20 m thickness, at different gradients from flat to 75^0; with soft to extremely hard coal; liable to spontaneous heating and gassiness and under varying roof strata conditions. Services offered to are manifold and are enumerated briefly blow:

Sl No.	Services Offered
1	Master planning of coalfield
2	Perspective planning
3	Conceptual engineering studies
4	Techno-economic feasibility studies
5	Detailed project reports
6	Detailed engineering with working drawings
7	Mine ventilation and transport planning
8	Operational planning
9	Mining plans for mining lease
10	Mine capacity assessment
11	Performance analysis of equipment
12	Prediction of surface subsidence through numerical modeling software.
13	Geo-physical logging, Seismic survey, Resistivity survey etc.

Infrastructure Engineering

CMPDI provides engineering logistic or support services for development of infrastructure. It has developed multi-disciplinary engineering skills for implementing projects of various complexities. In particular, it has offered complete planning and design services for architectural planning, civil, structural, electrical and mechanical engineering in various projects; important of them are enumerated here:

Sl No.	Services Offered
1	Planning of large capacity, high speed bulk material handling plants.
2	Turnkey execution of coal handling plants.
3	Planning of high voltage sub-stations.
4	Planning of workshops of various types and capacities.
5	Township planning including roads, water supply, water supply system, drainage, water / sewerage treatment plants and detailed planning and design of all township infrastructure.
6	Site selection for pit head thermal power plants based on remote sensing data.
7	Rail corridor alignment through remote sensing

8	Techno-economic feasibility study of captive power plants based on pulverized coal and FBC technology.

Environmental Services

CMPDI holds a position of eminence in the field of environmental planning, impact assessment, management and environmental engineering in coal and other sectors. **CMPDI is accredited by National Board of Education and Training (NABET), an organ of Quality Council of India (QCI), New Delhi as an EIA consulting organization for four sectors namely Mining of Minerals including opencast/underground mining, Offshore and Onshore oil and Gas exploration, development & production, Thermal power plants and Coal Washeries.** CMPDI has prepared more than 600 EMPs for coal mining projects (incl. washery & clusters) and obtained Environment Clearance for more than 450 projects. Also, CMPDI has prepared Mine Closure Plans for more than 425.

Environmental Services Rendered by CMPDI:

- Environmental Impact Assessment/ Environmental Management Plan
- Regional Environmental Management Plan
- Routine Environmental Monitoring and Base data generation.
- Planning & design of Sewage Treatment Plants (STPs)
- Design of Effluent Treatment Plants (ETPs) for coal projects
- Schemes for Rainwater Harvesting
- Environmental Statements (Audit Report)
- S&T / R&D studies
- Final Mine Closure Plan for UG & OC projects
- OB Dump Reclamation Action Plan for OC projects
- Study of Environmental Problems of Eco-Sensitive Regions
- Studies related to disposal of fly ash in abandoned mines

A few of the new areas in which CMPDI has diversified are environmental & hydrogeological studies for disposal of fly ash, development of air quality model,

bio-treatment of industrial effluents, carrying capacity base development planning, watershed modeling and rain water harvesting. Services offered with respect to environmental quality; monitoring, engineering, management and planning are briefly given as below:

Sl. No.	Subheads of Services	Services rendered
1	Environmental Monitoring	Air quality
		Water quality
		Noise level
		Soil Quality
		Micro-meteorological studies
		Stack monitoring
2	Environmental Laboratory facilities	**Air Analysis:**
		Suspended Particulate Matter Respirable Particulate Matter (PM_{10}& $PM_{2.5}$) Oxides of Sulphur (SOx) Oxides of Nitrogen (NOx) Carbon Monoxide (CO) Total Hydro Carbon (C_nH_n) Total Dust (Settleable)
		Water Analysis:
		Physical Parameter - pH, Colour, Temp, Turbidity Suspended Solids, Dissolved Solids, etc. Chemical and Biological (BOD, COD, Heavy Metals and trace elements as per statutory requirement)
		Soil: Soil Texture, Porosity, Bulk Density, pH Elect. Conductivity, Water holding capacity, Infiltration Rate Cation Exchange Capacity, Organic Carbon, Phosphorous, Potash Nitrogen etc.
		Noise:
		Noise Intensity Survey Leq Value of Noise
3	Environmental Engineering	Water treatment plants
		Industrial / Municipal effluent treatment and recycling plants
		Hazardous waste disposal site engineering
		Municipal effluent disposal site engineering
4	Natural Resource management	Land use planning
		Rain water harvesting
		Watershed management plans

Sl. No.	Subheads of Services	Services rendered
5	Regional planning	Regional environment management plans
		Regional environment status plans
6	Environment Assessment plans	Environment Assessment plans
7	Special studies	Review of existing mining and environment policies, legislations, standards and mechanisms for monitoring compliance, institutional strengthening for regulatory and counterpart institutions.
		Study of environmental problems and action plan for restoration of environmental quality. Mine closure planning.

Beneficiation Services

CMPDI specializes in planning, design and construction of new washeries and modification of existing washeries for coal and mineral beneficiation. Services with respect to beneficiation offered to are given as below:

Sl No.	Services Offered to for
1	Planning of coal and mineral beneficiation plants.
2	Preparation of feasibility / project reports including macro level analysis, washability studies, environmental impact assessment and techno-economic analysis.
3	Technical studies, performance evaluation and operation & maintenance related consultancy for existing washeries.
4	Pilot scale studies and trials.

Management Services

Following descript management services enumerated in table below, have been offered by CMPDI to different organizations or bodies.

Sl. No.	Subheads of Services	Services rendered for
1	Coal Investment promotion Services	Assistance to Government of India in identification and assessment of coal mining properties for investments through private sector participation.
2	Quality Management Services	Consultancy for implementation, certification and maintenance of ISO 9001 Quality Management System and its industry specific translations
3	Human Resource Management	Creating knowledge and skill based workforce, CMPDI through its Staff Training College (STC) imparts training to its clients' personnel. Under UNDP, CMPDI has trained professionals from Nigeria, Sultanate of Oman and North Korea. Through its STC it has organized training programmes under five major categories such as (i) Technical (ii) Managerial (iii) Computer application, (iv) Quality Skills, (v) Quality System, etc. It has also organized & conducted off-campus training programmes with respect to Quality System at various subsidiaries of the CIL

CMPDI diversified into management system consultancy in 1998. While continuing to provide consultancy for ISO 9001 Quality Management System (QMS) and ISO 14000 Environmental Management System (EMS), it made forays into consultancy for ISO 17025:2017 (Testing and calibrating laboratories) under consultancy scope as:

- Creation of Management system.
- Providing training support.
- Implementation, certification and post certification support.

Specialized Services

With a view to catering to specific requirements of clients, CMPDI has been providing field oriented specialized services to its clients. Descript services rendered under this category have been remote sensing, terrestrial survey, blasting, ventilation design & gas assessment in underground mines, energy

audit and non-destructive testing. Main services rendered are described in brief here:

Sl. No.	Subheads of Services	Services rendered in
1	Geomatics	Geomatics services in mining sector ranging from topographical survey, base line data generation and monitoring of land use / land cover for environmental management, water resource survey and coal mine fire mapping. It has also imparted expertise services in the fields of remote sensing applications, terrain mapping, co-relation survey for underground mines, GPS / GIS survey, cartography and digital image processing.
2	Blasting	Carrying out controlled blasting & ground vibration study, vibration monitoring, fragmentation improvement studies, random sampling and testing of explosive and accessories and performance evaluation of new explosives with sophisticated testing equipment in both coal and non-coal sectors.
3	Non-destructive Testing (NDT)	Services for Non-destructive testing of components of machinery, installations and other structural elements have been provided on site during periodic maintenance to avoid accidental failure.
4	Ventilation and Gas Survey	CMPDI has been offering services for ventilation monitoring, planning and design of ventilation system including gas assessment and testing for underground mines.
5	Energy Audit	CMPDI is empaneled as an accredited energy auditor with Govt. of West Bengal and Petroleum Conservation Research Association (PCRA) under ministry of Petroleum and Natural Gas, Govt. of India. Over 130 reports on electrical and diesel energy conservation have been prepared.
6	Inspection Services	CMPDI has been rendering pre-dispatch third party inspection services for plants and equipment at the manufacturers workstations for materials procured by its clients.
7	Captive power plants	Reports on optimum utilization, conceptual notes and tender documents.

Laboratory Services

CMPDI has well-equipped laboratories for carrying out investigations and analysis for geo-chemical, petrography, coal washability and geo-mechanic

properties.

For coal and lignite characterization, CMPDI has laboratories with highly skilled manpower and state of art equipment. The data generated by these laboratories form basis for characterization and grading of coal in exploration, mine feasibility reports, washery designs and down-stream utilization. Brief description of Laboratory Services rendered by CMPDI is given as below:

Sl. No.	Subheads of Services	Services rendered in
1.	Environment Laboratory	CMPDI has a well-equipped environmental laboratory to undertake the entire spectrum of environmental studies. The environmental laboratory is recognized by NABL & Central Pollution Control Board, Ministry of Environment & Forests, Government of India and accredited with ISO-9001:2015 certification.
2	Geo-chemical Laboratory	CMPDI has been rendering geo-chemical analysis like proximate & ultimate analysis, GCV determination of coal and lignite and other special tests through microprocessor based automatic calorimeter and analyzer.
3	Petrographic Laboratory	CMPDI has been carrying out evaluation for hydro carbons, oil shales and coal bed methane for coal coke and source rock through sophisticated microscopes, identifying mineral phases in coal, rocks and metals through X-Ray diffractometer, and Micro-area analysis & cleat studies for CBM through Scanning Electron Microscope accredited by International Committee for Coal and Organic Petrology (ICCP).
4	Mining Laboratory	CMPDI has been determining physico-mechanical properties of rocks for design inputs for mine planning and other technical services and undertaking testing of roof supports and building materials for design support systems for underground workings.
5	Washery Laboratory	CMPDI has been determining washability characteristics of course, small and fine coal and shattering & pulverizing characteristics of coal for assistance in planning and design of coal beneficiation plants.

ITC Services in Mining

CMPDI has been gearing up itself fully meet challenges of IT sector requisite for mining industries as per IT implementation scheme with a view to revolutionizing

mining industry and mining operations in coming years. IT services provided by CMPDI have been as tabulated here:

Sl No.	Services Offered to for
1	Mine communication and mine safety systems
2	Establishing internet and internet facilities
3	Real time fleet management system for large opencast mines using GIS & GPS.
4	Land information system using enterprise GIS.

R & D Services

The Research & Development activities in coal and lignite is being administered through the Scientific Advisory Committee (SSRC) with Secretary (Coal) as its Chairman. The committee is entrusted with the task of planning, budgeting and overseeing the implementation of R & D programme in coal & lignite sector and also for application of research findings. And, CMPDI is the Nodal Agency to coordinate S & T / R &D activities in coal and lignite Sector and assist SSRC in areas mentioned herein after.

CMPDI applied research and development in the field of mining, beneficiation, utilization, environment, exploration, etc. serving as nodal agency for all S & T schemes funded by Ministry of Coal and R & D schemes funded by R & D Board of the CIL (constituted in August 1995). Field oriented research projects including transfer and absorption of new technology concerning main areas of coal research have been as follows:

- Production, productivity and safety.
- Coal beneficiation and utilization.
- Environment and Ecology.

ANNEXURES

ANNEXURE-1

File No.8-07/2020-FC

Government of India
Ministry of Environment, Forests and Climate Change
Forest Conservation Division

Indira Paryavaran Bhawan,
Aliganj, Jor Bag Road,
New Delhi - 110003.

Dated: 12th March, 2020

To,

The Addl. Secretary (Forests),
Government of Odisha,
Bhubaneswar.

Sub: Proposal seeking prior approval of the Central Government under Section-2 of the Forest (Conservation) Act, 1980 for non-forestry use of 169.1779 ha of forest land in favour of M/s NALCO for Utkal E Opencast Coal Mining Project in Angul District (Odisha) – reg.

Sir,

I am directed to refer to the Government of Odisha's letter No. 10F(Cons) 105/2020-9681/F&E dated 25.06.2020 on the above subject seeking prior approval of the Central Government under Section 2 of the Forest (Conservation) Act, 1980 and letter no. 18235/9F(MG)-308/2020 dated 16.10.2020 forwarding additional information as sought by the Ministry vide its letter of even number dated 12.07.2020 and to say that the proposal has been examined by the Forest Advisory Committee constituted by the Central Government under Section-3 of the aforesaid Act.

After careful examination of the proposal of the State Government and on the basis of the recommendations of the Forest Advisory Committee, and approval of the same by the competent authority of the MoEF&CC, New Delhi, the Central Government hereby accords 'in-principle' approval under Section - 2 of the Forest (Conservation) Act, 1980 for **non-forestry use of 156.1779 ha of forest land out of originally proposed 169.1779 ha of forest land in favour of M/s NALCO for Utkal E Opencast Coal Mining Project in Angul District (Odisha)** subject to fulfilment of the following conditions:

A. Conditions which need to be complied prior to handing over of forest land by the State Forest Department and compliance is to be submitted prior to Stage-II approval

1. **Compensatory Afforestation:**

i. *The proposal for CA on notified degraded forest under the management control of the Forest Department was accepted. Nodal Officer shall give a certificate that no afforestation/plantation has been taken up under any plan / programme /scheme on the proposed CA land in the last ten years. However, given the fact that Talcher coal mining area involves very large forest area and the same would need to be properly compensated, future forest diversion proposals in the area will be accepted with CA on degraded notified forest area on the following conditions:*

a. *State Government issues a certificate that degraded forest land outside notified forests is not available for CA purpose, and*

File No.8-07/2020-FC

b. *Nodal Officer certifies that no afforestation/ plantation has been taken up under any plan/programme /scheme in the degraded notified forest area proposed for CA in the last ten years.*
2. The cost of compensatory afforestation at the prevailing wage rates as per compensatory afforestation scheme and the cost of survey, demarcation and erection of permanent pillars, if required on the CA land, shall be deposited in advance with the Forest Department by the user agency. The CA will be maintained for 10 years. The scheme may include appropriate provision for anticipated cost increase for works scheduled for subsequent years;
3. *The KML files of diverted area, the CA areas, the proposed SMC treatment area and the WLMP area shall be uploaded on the e-Green watch portal with all requisite details prior to Stage II approval;*
4. Compensatory levies to be realized from the User Agency under the project shall be transferred/ deposited, through e-challan, in to the account of CAMPA pertaining to the State concerned through **e-portal** (https://parivesh.nic.in/);
5. *The revised Mining plan having duly incorporated progressive mine closure Plan with backfilling details year wise and financial expenditure to be incurred annually, shall be submitted as part of the compliance report of the conditions of Stage-I approval. The rehabilitated forest area after closure of mining operations shall be handed over to the State Forest Department for sustainable forest management in the future;*
6. *Noting that the proposed area is contiguous to Reserve Forests, and heavy mechanised coal mining and transport will have significant impact both on the wildlife of the area and the overall soil-moisture condition that in turn will affect the health of flora in both short and long-term, proper wildlife and soil-moisture conservation (SMC) measures in the adjoining areas along with their long-term monitoring, are necessary. The user agency shall contribute towards cost of the SMC Plan duly approved by State Forest Dept. The User Agency will also contribute towards duly approved Site-specific Wildlife Conservation Plan and Regional Wildlife Management Plan of the adjoining area at the revised rate. The Plan shall include specific conservation measures for RET flora and fauna species.* All compensatory levies to be realized from the user agency in compliance of aforementioned approved plans shall be deposited into the account of CAMPA;
7. *Approved R&R plan shall be submitted. Noting that collection of forest products from forests in the area is an important and significant component of livelihoods of the people in the area and that the same will be affected due to loss of forest on account of mining, the R&R Plan shall include components for compensating the loss of such forest-based income including augmenting it through village level forest-based enterprises;*
8. The User Agency shall transfer the funds towards the cost of Net Present Value (NPV) of the forest land being diverted under this proposal from the User Agency as per the orders of the Hon'ble Supreme Court of India dated 28.03.2008, 24.04.2008 and 09.05.2008 in Writ Petition (Civil) No. 202/1995 and the guidelines issued by this Ministry vide its letter No. 5-3/2007-FC dated 05.02.2009 through online portal of CAMPA account of the State Concerned;
9. *Thirteen (13) ha of forest land proposed to be used for Office, R.S. and other infrastructure, is not allowed as part of this proposal;*
12. User agency either himself or through the State Forest Department shall undertake gap planting and soil & moisture conservation activities to

File No.8-07/2020-FC

restock and rejuvenate the degraded open forests (having crown density less than 0.40), if any, located in the area within 100 meter from outer perimeter of the mining lease. The plan for plantation and SMC activities will be prepared and submitted to MoEF &CC before Stage-II Clearance;

13. The User Agency shall prepare a list of existing village tanks and other water bodies with GPS co-ordinates located within five km from the mine lease boundary. This list is to be duly verified by the concerned Divisional Forest Officer. The User Agency shall regularly undertake desilting of these village tanks and other water bodies so as to mitigate the impact of siltation of such tanks/water bodies. A detailed approved plan for desilting of identified ponds and water bodies to be prepared in consultation with forest department and shall be submitted to MoEF & CC before Stage-II approval;
14. *Afforestation on degraded forest land to be selected elsewhere, measuring one and a half times the area under safety zone, shall also be done at the project cost under the supervisions of the State Forest Department. The degraded forest land (DFL) so selected will be informed to the MoEF & CC with shape files before Stage-II approval and afforestation will be done within three years from the date of Stage-II clearance and maintained thereafter in accordance with the approved Plan in consultation with the State Forest Department;*
15. **Safety Zone Management**: Following activities, at project cost, shall be undertaken by the user agency for the management of safety zone as per relevant guidelines issued by the Ministry's guidelines:

i. User agency shall ensure demarcation of safety zone (7.5 meter strip all along the inner boundary of the mining lease area), and its fencing, protection and regeneration by erecting adequate number of 6 feet high RCC boundary pillars inscribed with DGPS coordinates with barbed wire fencing and deploying adequate number of watchers under the supervision of the. State Forest Department;
ii. Boundary of the safety zone of the mining lease, adjacent to habitation/roads, should be properly fenced by the user agency;
iii. Safety zone shall be maintained as green belt around mining lease and to ensure dense canopy in the area, regeneration shall be taken up in this area by the user agency at project cost under the supervision of the State Forest Department; and
iv. The State Government and the user agency shall ensure that safety zone is maintained as per the prescribed norms;

16. The cost of felling of trees shall be deposited by the User Agency with the State Forest Department;
17. State Government shall complete settlement of rights, in term of the Scheduled Tribes and Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, if any, on the forest land to be diverted and submit the documentary evidence as prescribed by this Ministry's letter No. 11-9/1998-FC (Pt.) dated 03.08.2009 read with 05.07.2013, in support thereof; and
18. The compliance report shall be uploaded on **e-portal** (https://parivesh.nic.in/).

B. **Conditions which need to be complied on field after handing over of forest land to the user agency by the State Forest Department but the compliance in form of undertaking shall be submitted prior to Stage-II approval**

File No.8-07/2020-FC

1. Legal status of the diverted forest land shall remain unchanged;
2. Compensatory afforestation over degraded forest land, double in extent to the forest land being diverted, shall be raised by the State Forest Department at the project cost within three years from the date of grant of Stage - II approval;
3. At the time of payment of the Net Present Value (NPV) at the present rate, the user agency shall furnish an undertaking to pay the additional amount of NPV, if so determined, as per the final decision of the Hon'ble Supreme Court of India;
4. *Trees should be felled in phased manner as per the requirement in the approved Mining Plan with prior permission of DFO, Angul;*
5. The user agency shall explore the possibility of translocation of maximum number of trees identified to be felled and shall ensure that any tree felling shall be done only when it is unavoidable and that too under strict supervision of the State Forest Department.
6. The User Agency shall undertake mining in a phased manner after taking due care for reclamation of the mined over area. The concurrent reclamation plan as per the approved mining plan shall be executed by the User Agency from the very first year, and an annual report on implementation thereof shall be submitted to the Nodal Officer, Forest (Conservation) Act, 1980, in the concerned State Government and the concerned Regional Office of the Ministry. If it is found from the annual report that the activities indicated in the concurrent reclamation plan are not being executed by the User Agency, the Nodal Officer or the concern Addl. Principle Chief Conservator of Forests (Central) may direct that the mining activities shall remain suspended till such time, such reclamation activities area satisfactorily executed.
7. *The User Agency shall comply with the Hon'ble Supreme Court order on re-grassing, and re-grass the mining area and any other areas which may have been disturbed due to mining to restore them to a condition which is fit for growth of fodder, flora, fauna, etc. in a timely manner;*
8. *Talcher coalfield area is one of the largest in the country. Already a large number of operational leases/coal blocks, and many other allocations/ approvals are underway in the area. Their cumulative effect on the overall forest and wildlife cover in the area could be significant. Further, overall increase in ambient air temperature and forest-fire susceptibility in coal mining areas has been generally observed around the world. Such cumulative impact could be better reduced /mitigated if synergistic action is taken by different coal block operators. Therefore, a multidisciplinary committee may be formed by the Ministry to make a visit to the Talcher coalfield area and suggest integrated action on infrastructure and mining development in forest and wildlife friendly manner. The committee may also suggest site specific mitigation measures. The visit of the committee shall be facilitated by the State Government. The committee shall submit its report in next two months. It is clarified that submission of the report by the committee shall not be a pre-condition for compliance of the in-principle approval of the instant proposal. However, the User Agency shall give an undertaking that any specific condition/measure suggested by the committee for the instant proposal, and approved by this Ministry, shall be complied by them during the course of the lease operation;*
9. Period of diversion of the said forest land under this approval shall be for a period co-terminus with the period of the mining lease proposed to be granted

File No.8-07/2020-FC

under the Mines and Minerals (Development and Regulation) Act, 1957, as amended and the Rules framed there-under;

10. The User Agency shall obtain the Environment Clearance as per the provisions of the Environmental (Protection) Act, 1986, if required;
11. No labour camp shall be established on the forest land and the User Agency shall provide fuels preferably alternate fuels to the labourers and the staff working at the site so as to avoid any damage and pressure on the nearby forest areas;
12. Following activities, as per approved plan / schemes, shall be undertaken by the User Agency under the supervision of the State Forest Department:
    i. Mitigative measures to minimize soil erosion and choking of stream shall be implemented within a period of three year with effect from the issue of Stage-II clearance in accordance with the approved Plan in consultation with the State Forest Department.
    ii. Planting of adequate drought hardy plant species and sowing of seeds, in the appropriate area within the mining lease to arrest soil erosion in accordance with the approved scheme;
    iii. Construction of check dams, retention /toe walls to arrest sliding down of the excavated material along the contour in accordance with the approved scheme;
    iv. Stabilize the overburden dumps by appropriate grading/benching, in accordance with the approved scheme, so as to ensure that angles of repose at any given place is less than 28o; and
    v. No damage shall be caused to the top-soil and the user agency will follow the top soil management plan.
13. The boundary of the diverted forest land, mining lease and safety zone, as applicable, shall be demarcated on ground at the project cost, by erecting four feet high reinforced cement concrete pillars, each inscribed with its serial number, distance from pillar to pillar and GPS coordinates;
14. The layout plan of the mining plan/ proposal shall not be changed without the prior approval of the Central Government and the forest land shall not be used for any purpose other than that specified in the proposal;
15. The forest land proposed to be diverted shall under no circumstances be transferred to any other agency, department or person without prior approval of the Central Government;
16. No damage to the flora and fauna of the adjoining area shall be caused;
17. The User Agency shall submit the annual self -compliance report in respect of the above stated conditions to the State Government, concerned Regional Office and to this Ministry by the end of March every year regularly;
18. Any other condition that the concerned Regional Office of this Ministry may stipulate with the approval of competent authority in the interest of conservation, protection and development of forests & wildlife; and
19. The user agency shall comply all the provisions of the all Acts, Rules, Regulations, Guidelines, Hon'ble Court Order (s) and NGT Order (s) pertaining to this project, if any, for the time being in force, as applicable to the project.
20. Violation of any of these conditions will amount to violation of Forest (Conservation) Act, 1980 and action would be taken as prescribed in para 1.21 of Chapter 1 of the Handbook of comprehensive guidelines of Forest (Conservation) Act, 1980 as issued by this Ministry's letter No. 5-2/2017-FC dated 28.03.2019.

File No.8-07/2020-FC

After receipt of compliance report on fulfilment of the conditions mentioned above, the proposal shall be considered for final approval under Section-2 of the Forest (Conservation) Act, 1980. Transfer of forest land shall not be affected till final approval is granted by the Central Government in this regard.

Yours faithfully,
Sd/-
(Sandeep Sharma)
Assistant Inspector General of Forests

Copy to:

1. The PCCF (HoFF), State Forest Department, Government of Odisha, Bhubaneswar
2. The PCCF & Nodal Officer (FCA), O/o PCCF, State Forest Department, Government of Odisha, Bhubaneswar
3. The Regional Officer (Central), Integrated Regional Office of MoEF&CC at Bhubaneswar
4. User Agency
5. Monitoring Cell, FC Division, MoEF&CC, New Delhi
6. Guard File

ANNEXURE-2

Comments of DFO, Angul on the Draft SMC Report

OFFICE OF THE DIVISIONAL FOREST OFFICER ; ANGUL DIVISION:ANGUL.

Letter No. 4030 /110/DRP/2021/Dated. 07.6.22

To

Sri Tapan Pattnaik (GGM Coal Mines & Project) .
National Aluminium Company Ltd.
Coal Mines Division S&P Complex, Angul.

Sub:- Proposal seeking prior approval of Central Government under section 2 of the Forest (Conservation) Act, 1980 for diversion of 169.1779 ha. of forest land of Utkal -'E' Coal Mines in Angul District by National Aluminium Company Ltd. Reg. **:- Submission the draft report on Soil Moisture Conservation Plan (SMC).**

Ref: - 1. Proposal No. FP/OR/Mining/41142/2019
2. No. 8-07/2020-FC dt. 12.03.2021 GoI, MoEF & CC.
3. Your Letter No. 089/2022 dt. 04.06.2022.

Sir,

With reference to the above cited letter on the subject, it is to inform that the Govt. of India MOEF & CC vide their letter No. 8-07/2020-FC dt. 12/15 .03.2021 have accorded in principle approval under section -2 of the Forest (Conservation) Act ,1980 **for non forestry use of 156.1779 ha of forest land out of originally proposed 169.1779 ha of forest land in favour of M/s Nalco for Utkal –E Coal mining project in Angul District (Odisha).**

In view of the above, you are requested to suggest the following observations are being made for Soil Moisture Conservation Plan (SMC) prepared by M/s CMPID.

1. Though soil moisture index map of study area on V-14 page shows around 80% of study area under moisture stress and conservation activity have been recommended for this area on V-13 page, treatment is only suggested for open area.

2. Suggested Counter trenches are not along the contour but along east west direction crossing drains and elevations.

3. It is evident from the soil sample data that soil is deficient in a number of nutrients, particularly phosphorus. Grassing of 60% of open area without any soil treatment and without recommendation for future maintenance is most likely to fail.

4. Five number of Water bodies have been suggested without analysing their catchment and siltation load. On that basis, size and de-siltation schedule can be recommended in the plan.

5. While recommending check dams, top-down approach should be followed. Five number of check-dams may not be sufficient. A series of check dams along the drains may be explored.

6 Monitoring, supervision charges, contractor profits have not been included in the plan and estimates.

7 Calendar of operation detailed were estimates including labour less, excavation cost, contingency etc. are to be included in detailed project report.

Further, you are requested to provide spatial data (GPS location) of various activates such as catchment pits, Counter trench water bodies etc. while mentioning their alignment, length, spacing etc for effective implementation of your recommendation on field.

Hence, you are requested to fix a suitable date in consultation with this office for finalization of Soil Moisture Conservation Plan (SMC) for taking further action at this end.

Yours faithfully,

Divisional Forest Officer
Angul Division

Memo No. 4031 / Dated. 07.6.22

Copy forwarded to the General Manager (tech) National Aluminium Company Ltd. Bhubaneswar for information and necessary action. He is requested to attend the meeting for discussion of the above purpose.

Divisional Forest Officer
Angul Division

Memo No. 4032 / Dated. 07.6.22

Copy forwarded to the Regional Chief Conservator of Forests, Angul Circle for favour of kind information and necessary action.

Divisional Forest Officer
Angul Division.

Memo No. 4033 / Dated. 07.6.22

Copy forwarded to the Principal Chief Conservator of Forests, FD&NO, FC Act O/O the Principal Chief Conservator of Forests, Odisha Bhubaneswar for favour of kind information and necessary action.

Divisional Forest Officer
Angul Division

ANNEXURE-3

Comments of DFO, Angul on the SMC Report on the Power Point Presentation made on 07.07.2022

OFFICE OF THE DIVISIONAL FOREST OFFICER: ANGUL DIVISION:ANGUL.

Letter No. 4860 /110/DRP/2022/Dated 8/7/22

To

Sri Tapan Pattnaik,
GGM (Coal Mines & Project), NALCO.

Sub: - Proposal seeking prior approval of the Central Government under Section-2 of the Forest (Conservation) Act, 1980 for non-forestry use of 169.1779 ha of forest land in favour of M/s NALCO for Utkal E Opencast Coal Mining Project in Angul District (Odisha)-reg. :- **power point presentation**.

Ref: - Your Letter No. 100 dt. 16.06.2022 & This Office Memo No. 4708 dt. 04.07.2022.

Sir,

With reference to the above cited Letter No. on the captioned subject, it is to inform you that a power point presentation was held on **07.07.2022 (Thursday) at. 03.00 P.M** in the conference hall of Regional Chief Conservator of Forests, Angul, Circle, Angul in presence of Regional Chief Conservator of Forests, Angul Circle, Angul, Divisional Forest Officer, Angul and User Agency showing maps, location of project and details of various interventions, monitoring and assessment mechanism along with expected outcomes of the Soil & Moisture Conservation Plan. During discussion the following observations has been pointed out are given below.

i) 1% of the labour cess is to be explicitly included in the cost estimates as required under the Building and Other Construction Workers' Welfare Cess Act, 1966.

ii) Drainage Line Treatment should follow the top-down approach along the stream taking into consideration their longitudinal profiles and it should be planned in saturation mode.

iii) As APO 2022-23 has already been approved and is under operation, the commencement year for the SMC plan should be 2023-24. Escalation cost should accordingly be included accordingly for the first year and all subsequent years.

iv) Maps should be provided in at least 1:5000 scale showing GPS locations, general topography as it will be useful for the implementation of the plan.

v) GPS locations of the interventions should be included in the table format in the plan.

vi) A chapter on long term monitoring and assessment should be included in the plan mentioning at least the followings –

Expected outcome of the plan.

Monitoring Mechanism for progress of the above outcomes.

Plan Review and revision Procedure: Parameters based on which plan is to be reviewed and revised periodically.

In view of the above, you are requested to revise the SMC plan accordingly and re-submit as the observation made above for taking further action.

Yours faithfully,

8.7.22

Divisional Forest Officer
~~2~~ Angul Division.

Memo No. 4861 / Dated. 8.7.22

Copy forwarded to the Regional Chief Conservator of Forests, Angul Circle for favour of kind information and necessary action with reference to this office Memo No. 4709 dt. 04.07.2022..

8.7.22

Divisional Forest Officer
~~2~~ Angul Division.

Plates

PLATE-1: TOPOSHEET MAP

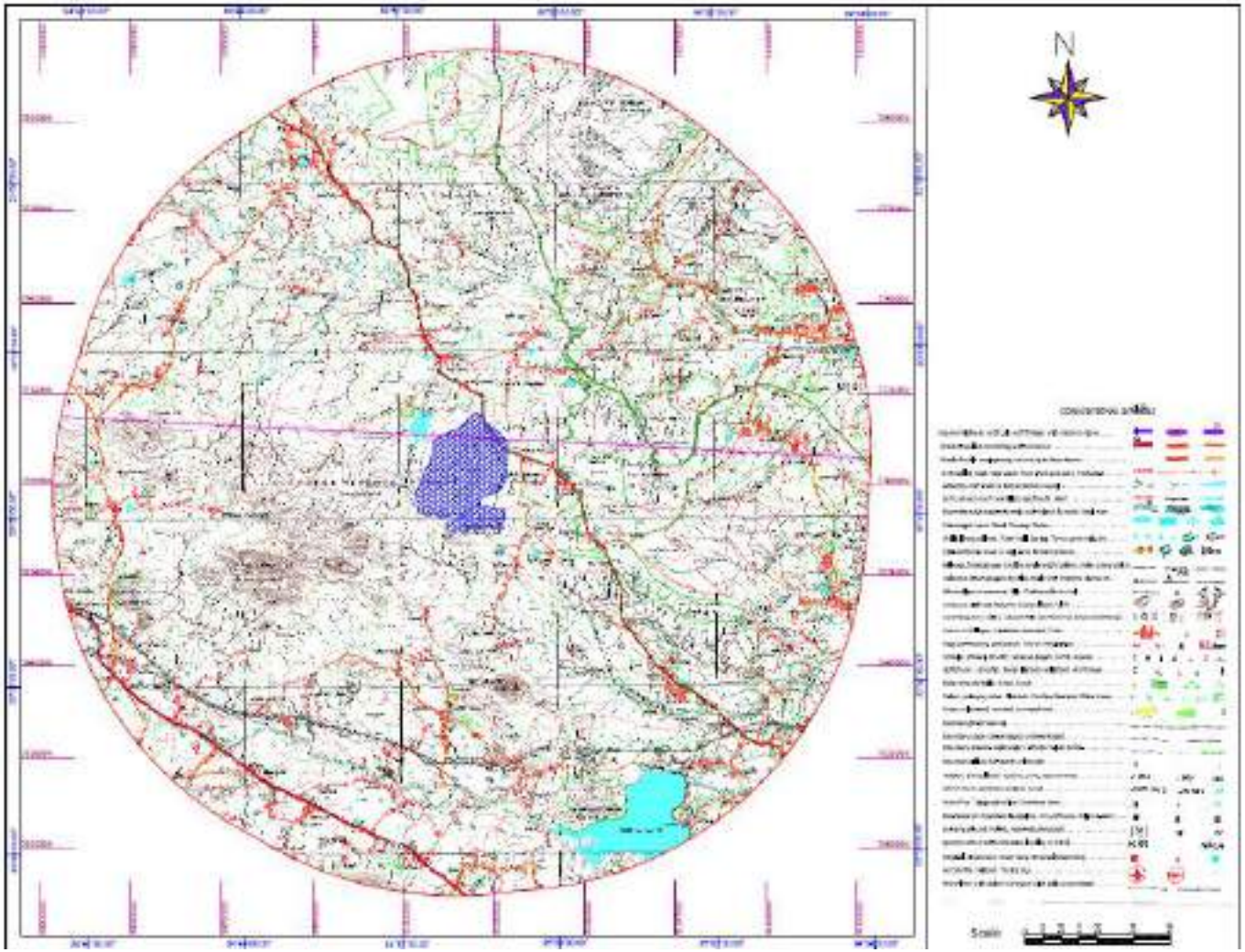


PLATE-2: STUDY AREA MAP

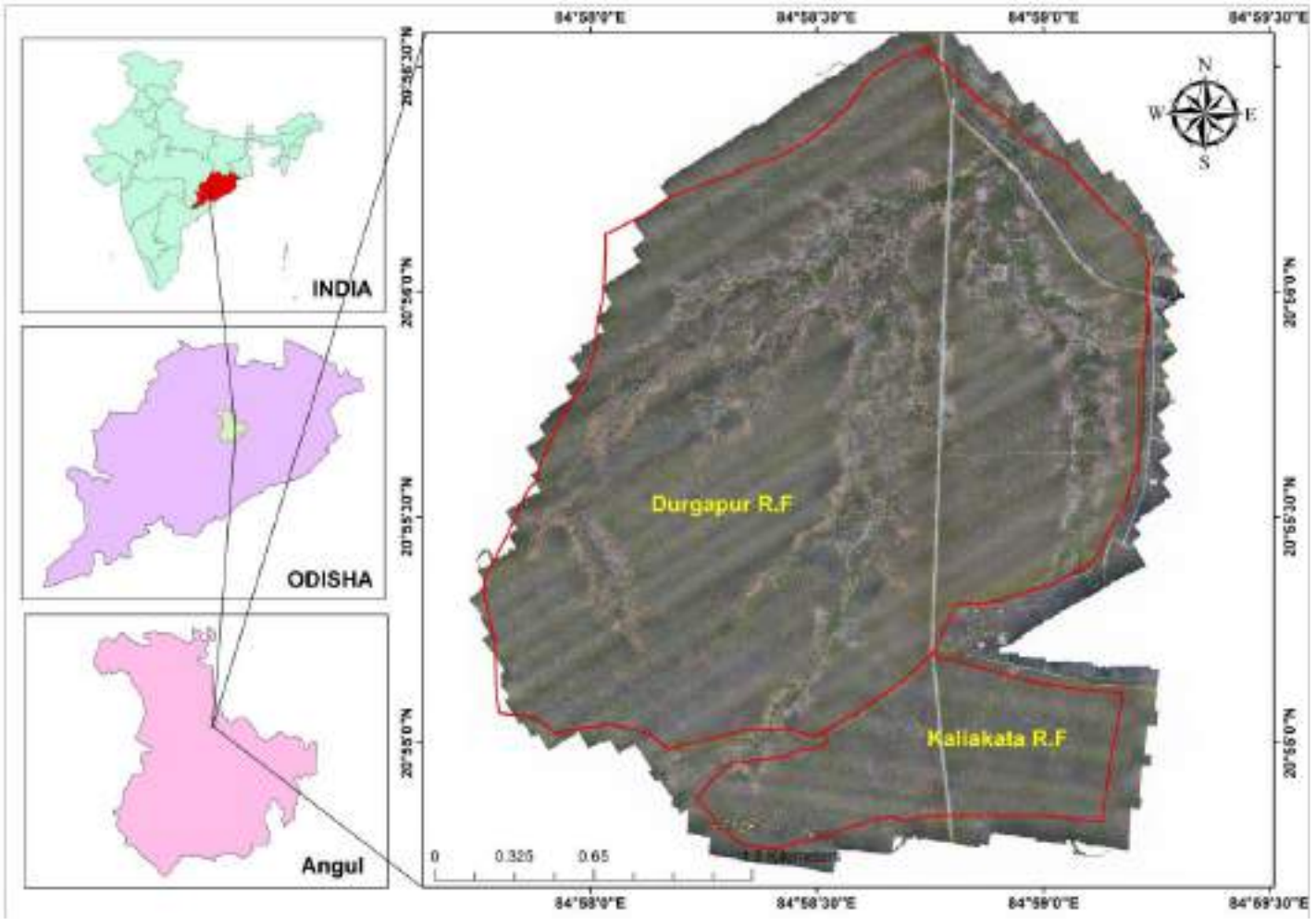


PLATE-3: ORTHOMOSIC IMAGE

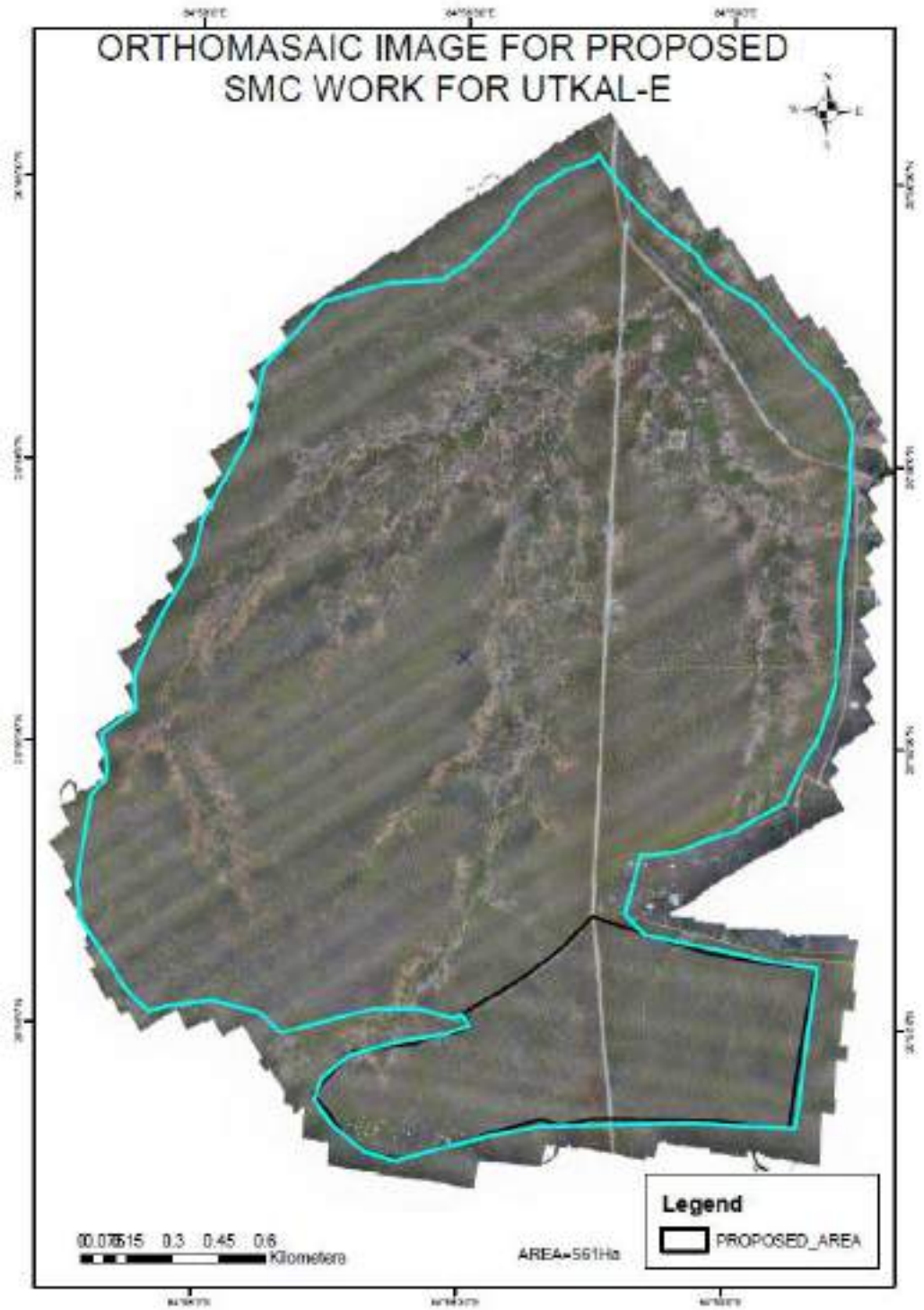


PLATE-4 CONTOUR MAP

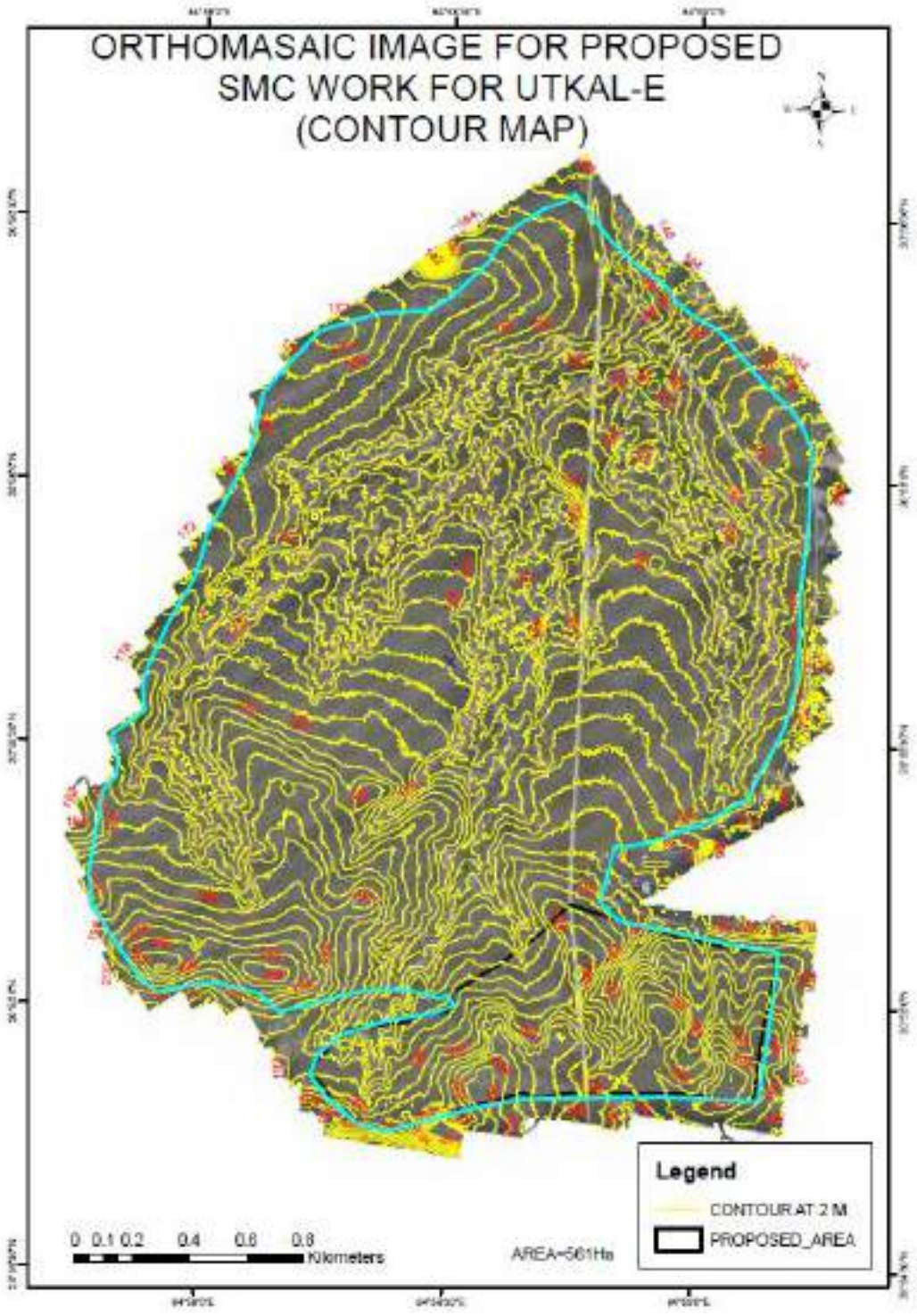


PLATE-5 LOCATION OF PROPOSED CONTOUR TRENCHES

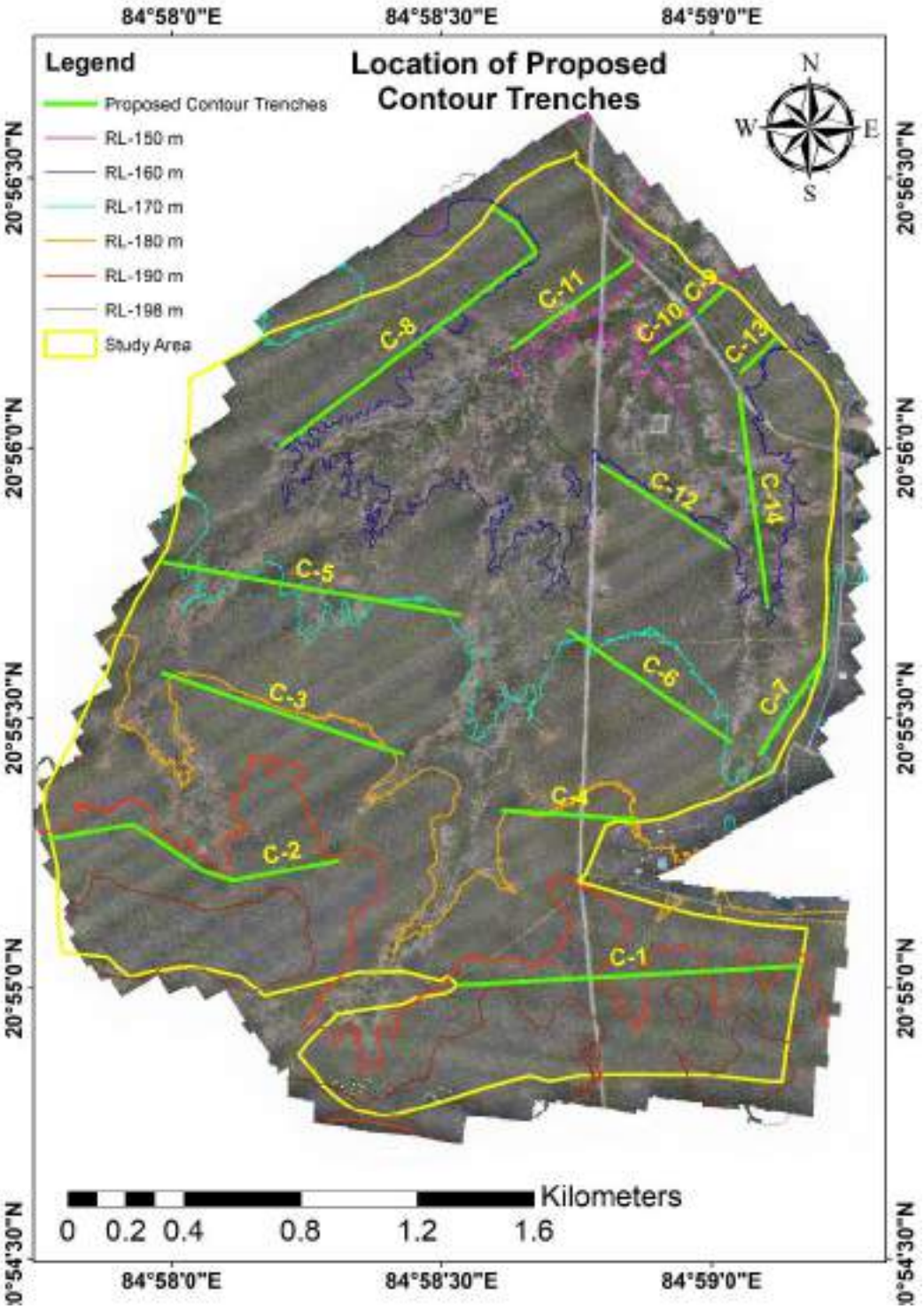


PLATE-6 PROPOSED LOCATION FOR GRASSING

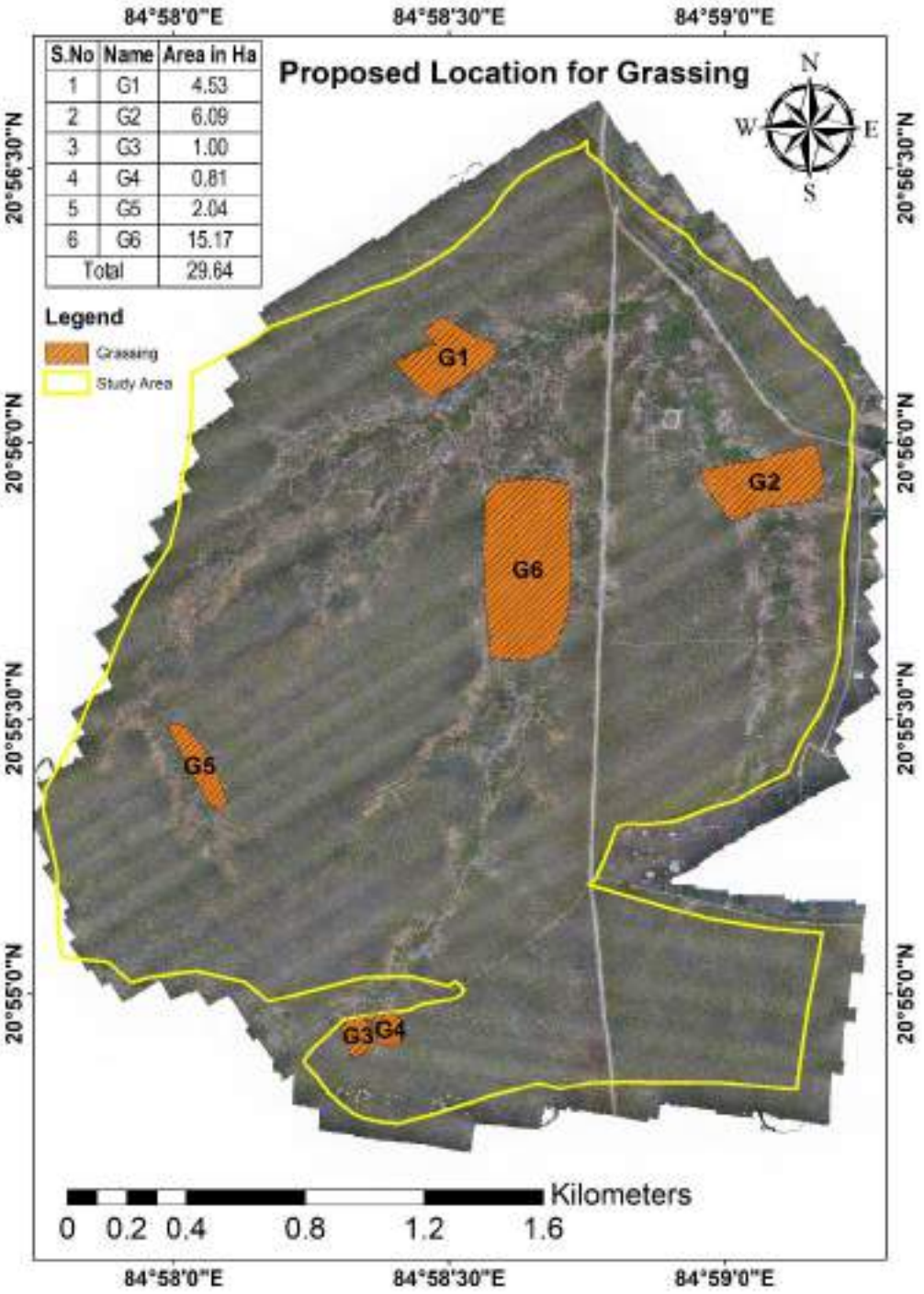


PLATE-7 PROPOSED LOCATION FOR MULCHING

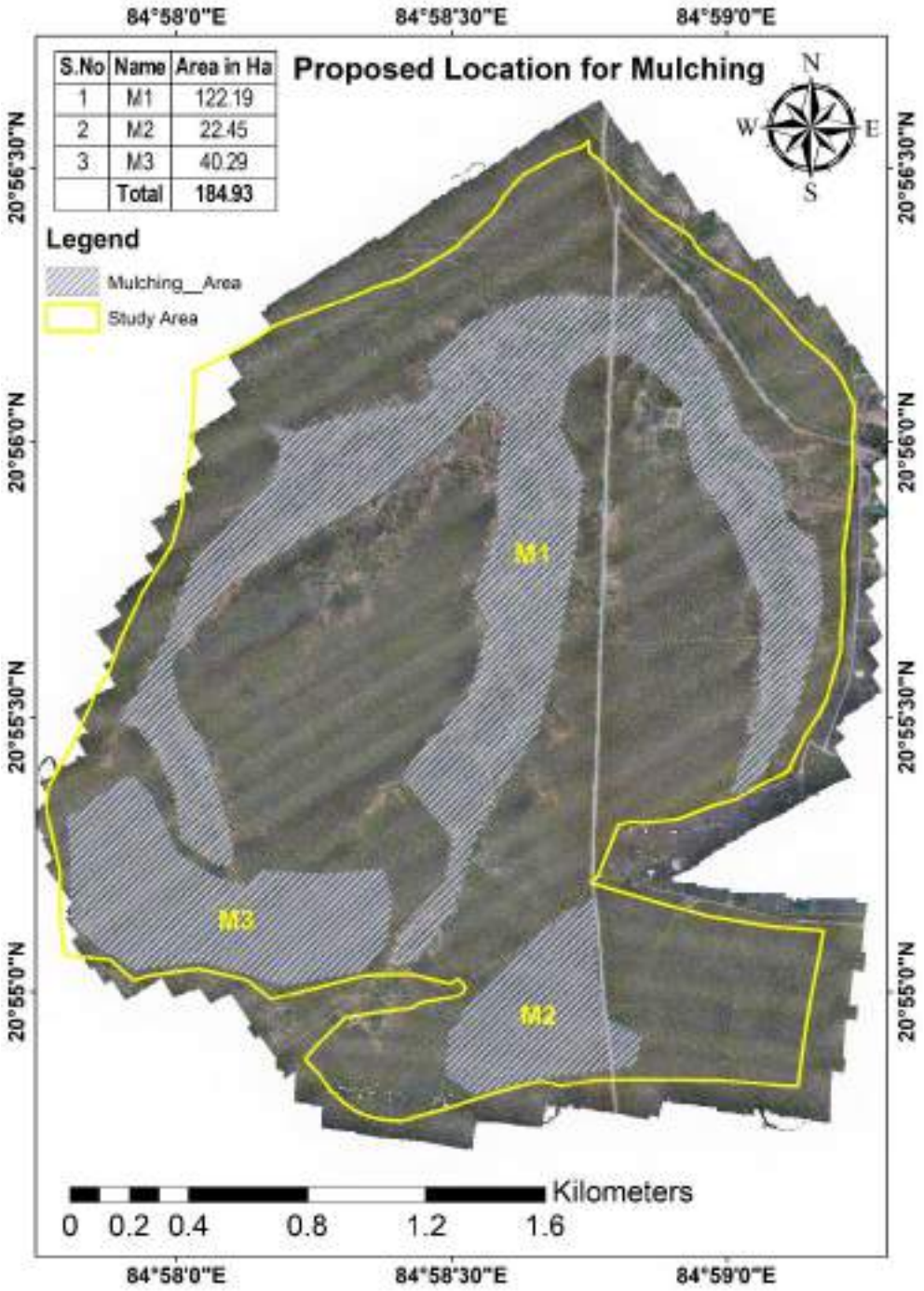
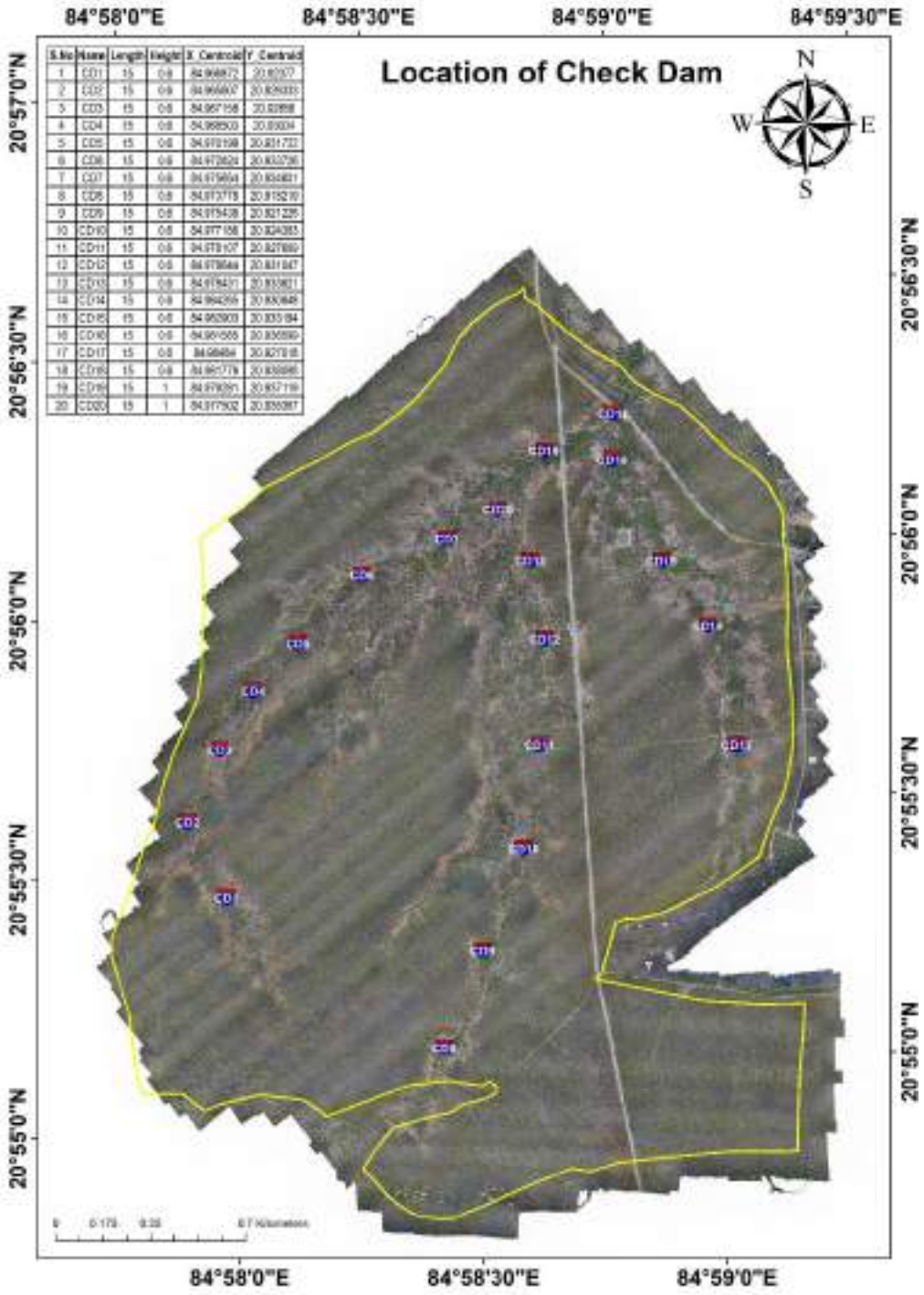
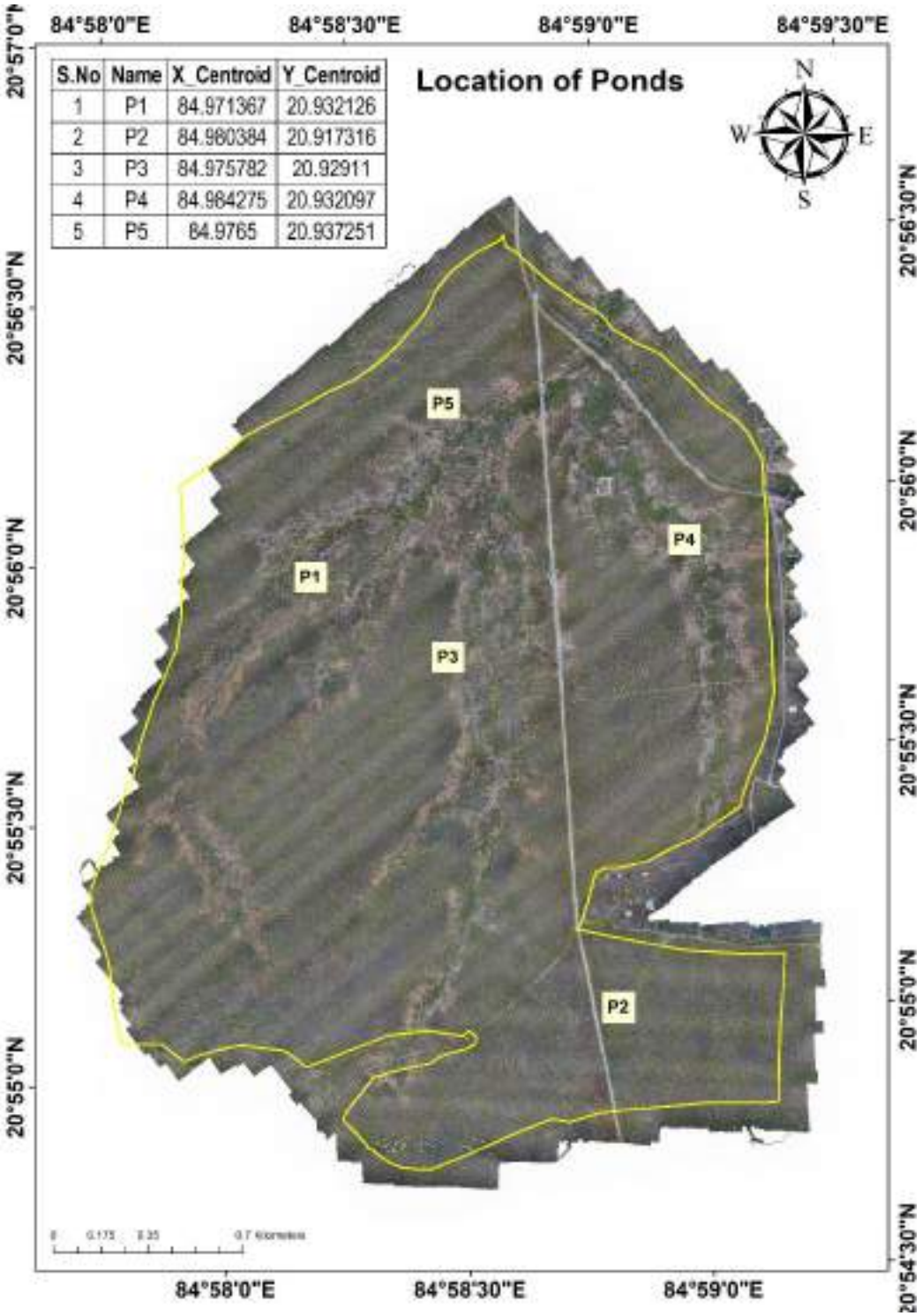


PLATE-8 LOCATION OF PROPOSED CHECK DAMS



S.No	Name	Length	Height	X_Centroid	Y_Centroid
1	CD1	15	0.6	84.966872	20.82327
2	CD2	15	0.6	84.966807	20.829333
3	CD3	15	0.6	84.967158	20.83958
4	CD4	15	0.6	84.968503	20.83934
5	CD5	15	0.6	84.970198	20.831733
6	CD6	15	0.6	84.973624	20.832736
7	CD7	15	0.6	84.975654	20.834831
8	CD8	15	0.6	84.972778	20.8152
9	CD9	15	0.6	84.975438	20.821235
10	CD10	15	0.6	84.977158	20.824383
11	CD11	15	0.6	84.978107	20.827883
12	CD12	15	0.6	84.979644	20.831847
13	CD13	15	0.6	84.979431	20.833821
14	CD14	15	0.6	84.984355	20.836648
15	CD15	15	0.6	84.982803	20.833184
16	CD16	15	0.6	84.981555	20.835592
17	CD17	15	0.6	84.98484	20.827218
18	CD18	15	0.6	84.981778	20.839585
19	CD19	15	1	84.979391	20.857119
20	CD20	15	1	84.977902	20.859287

PLATE-9 LOCATION OF PROPOSED PONDS



S.No	Name	X_Centroid	Y_Centroid
1	P1	84.971367	20.932126
2	P2	84.980384	20.917316
3	P3	84.975782	20.92911
4	P4	84.984275	20.932097
5	P5	84.9765	20.937251

PLATE-10 Recharge Pit (Representative Location)

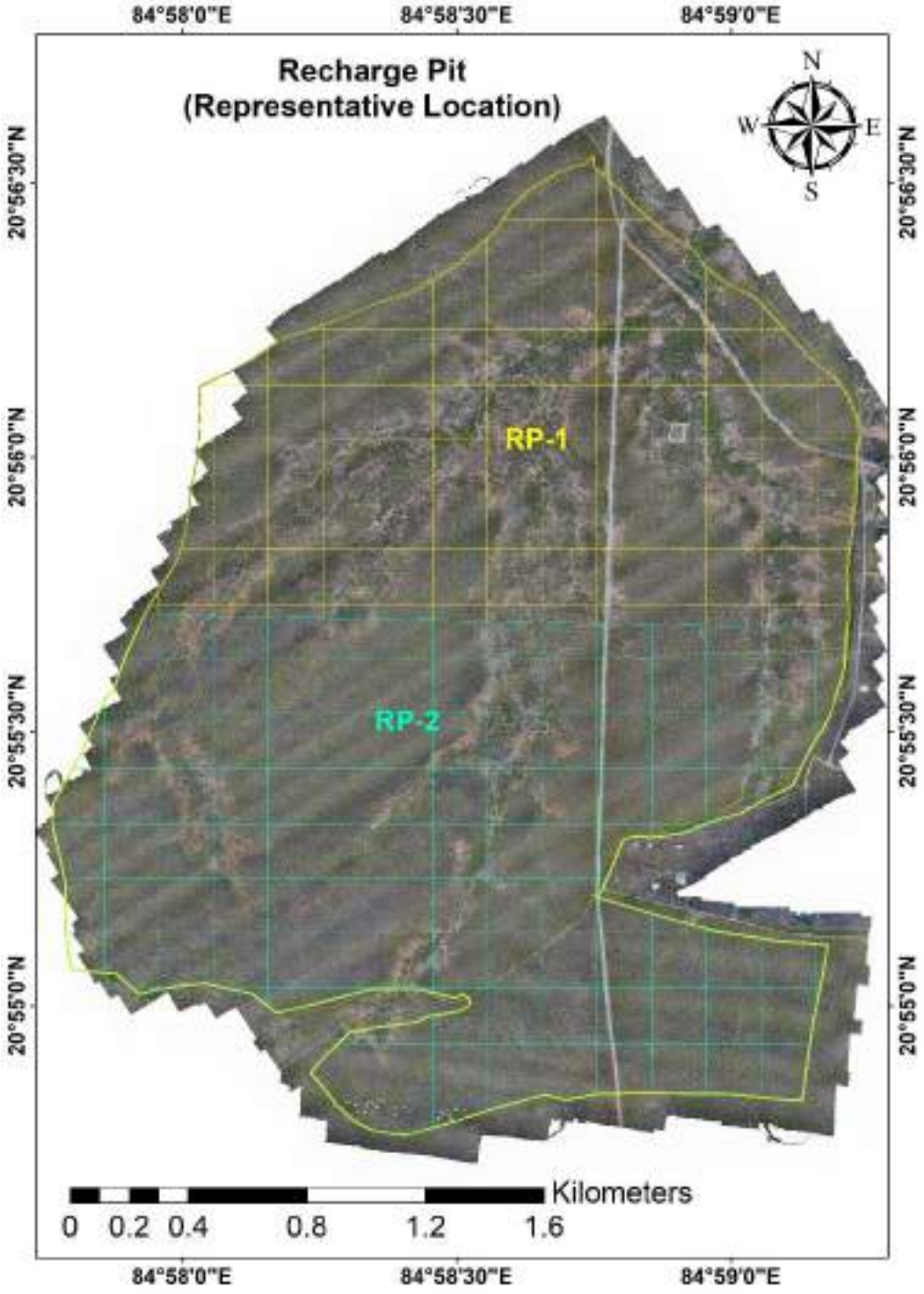
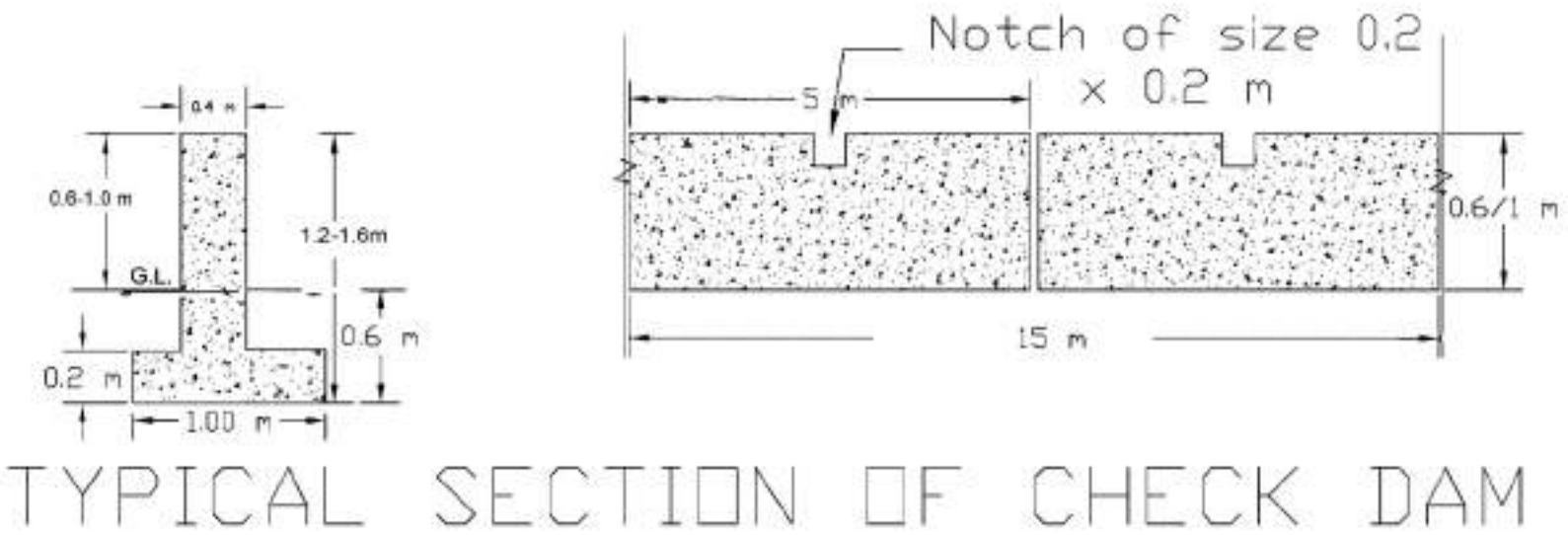
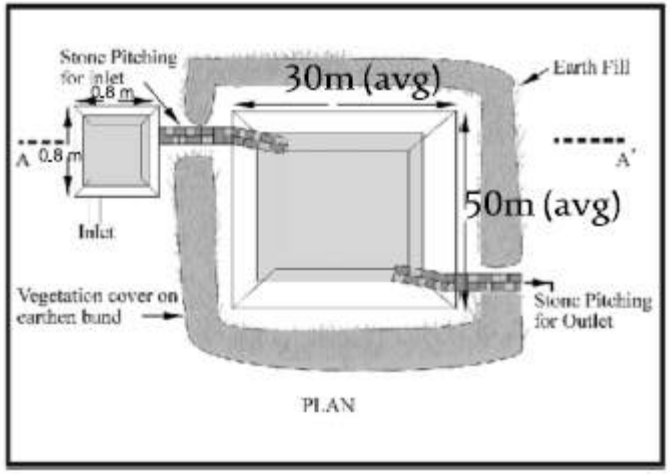


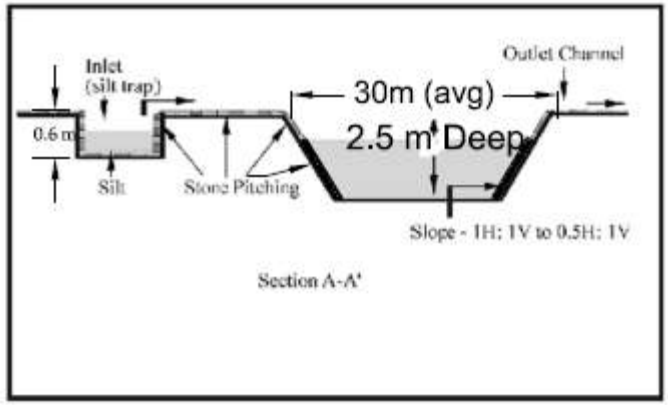
PLATE-11 TYPICAL SECTION OF CHECK DAM



TYPICAL SECTION OF CHECK DAM

PLATE- 12: TYPICAL SECTION OF SURFACE POND





TYPICAL SECTION OF SURFACE POND