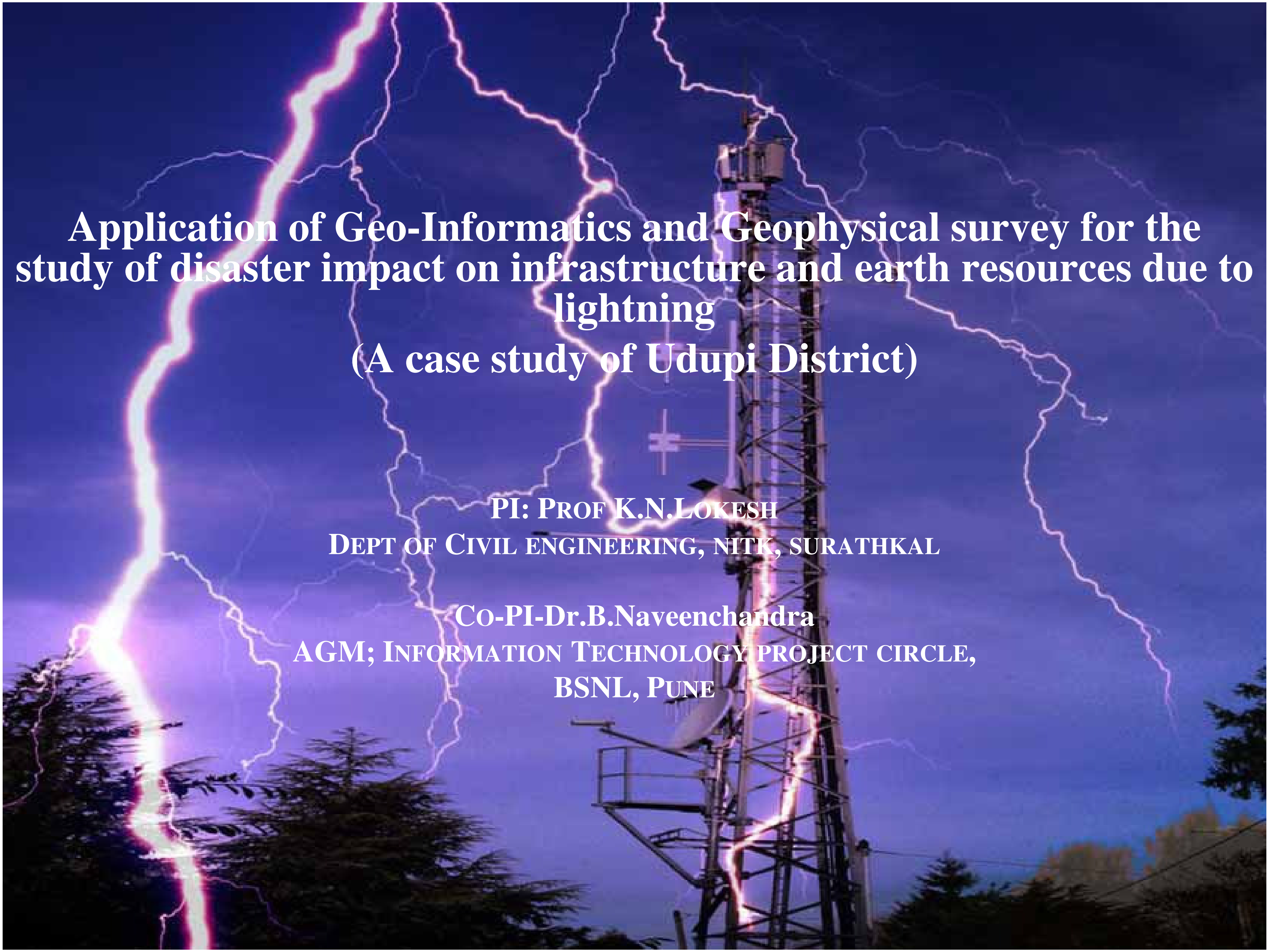

Application of Geo-Informatics and Geophysical survey for the study of disaster impact on infrastructure and earth resources due to lightning

(A case study of Udupi District)

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- Udupi district is a place of high lightning incidence occurring compared to most of the other parts in Karnataka

- Damages to Natural resources like tall trees, buildings, structures etc

- Telecom/power sites are badly affecting which causes huge loss to the department.

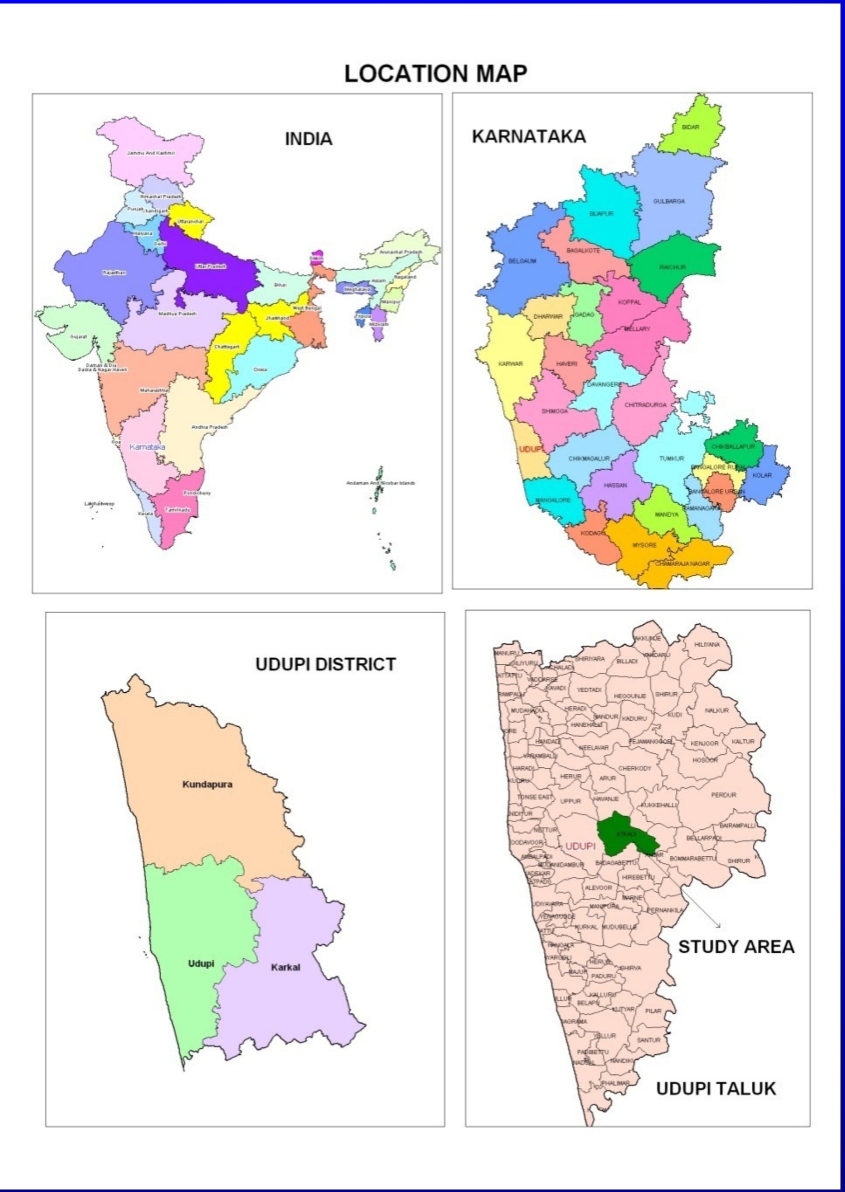
- The present state of affairs show that in a year the months April, May, October and November have relatively much higher lightning incidence.

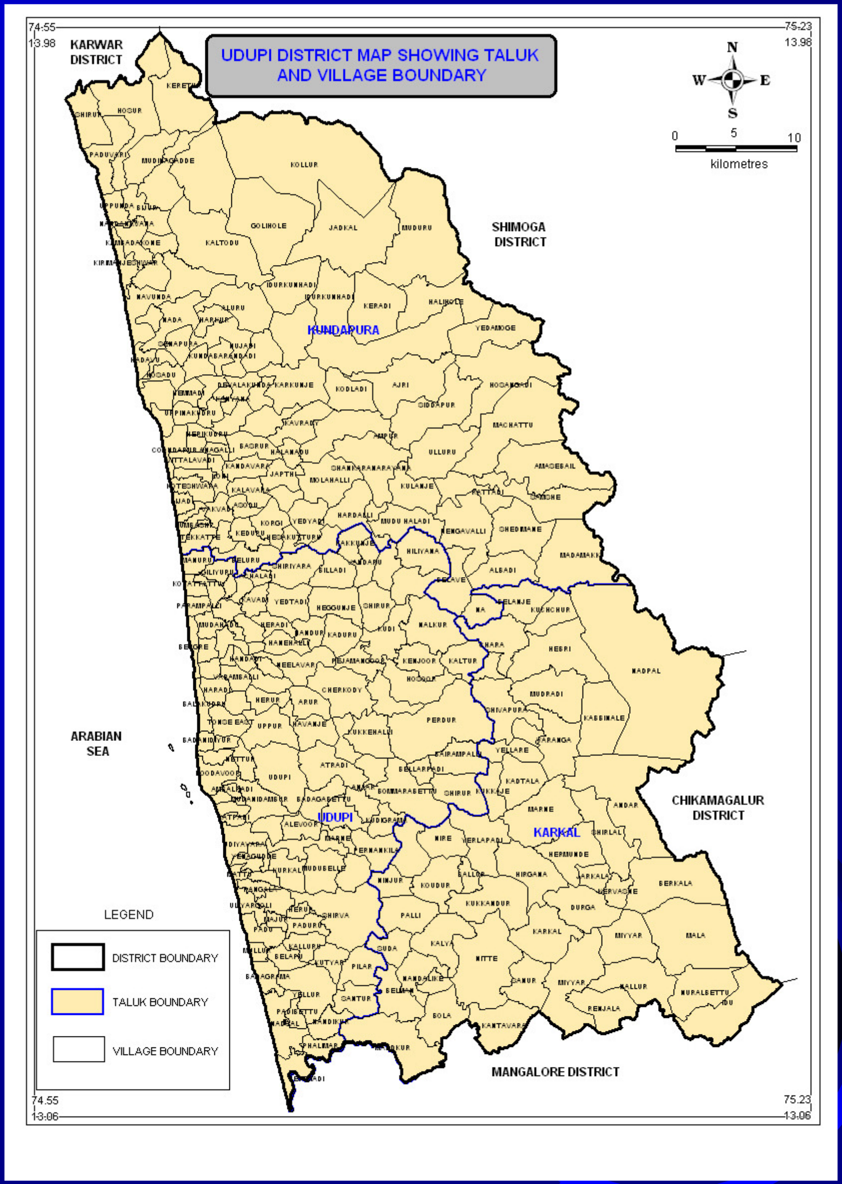
- The relatively severe impact of the hazard on the state and observed the very high casualty rates of 71 deaths, 112 injuries and 188 accidents per annum.




- Loss to telephone sector/Power sector is very high not only to the networked systems but also to the electronic equipment of telecom system.
- The infrastructure sites are constructed on the hill and on rock with sandy area which has high soil resistivity and it is difficult to improve the ground resistance to the standard (less than 0.5 ohms).

Study Area


LOCATION MAP
INDIA
KARNATAKA
UDUPI DISTRICT
Kundapura
Udupi
Karkal
STUDY AREA
UDUPI TALUK


UDUPI DISTRICT MAP SHOWING TALUK AND VILLAGE BOUNDARY
KARWAR DISTRICT
SHIMOGA DISTRICT
ARABIAN SEA
CHIKAMAGALUR DISTRICT
MANGALORE DISTRICT
KUNDAPURA
UDUPI
KARKAL
N
W
E
S
0
5
10
kilometres
LEGEND
DISTRICT BOUNDARY
TALUK BOUNDARY
VILLAGE BOUNDARY
74.55
13.98
75.23
13.06

Objectives

To understand the role of geology and soil type in lightning impact and to update the existing geological map by carrying out a detailed lithological, structural and soil mapping using Satellite imageries.

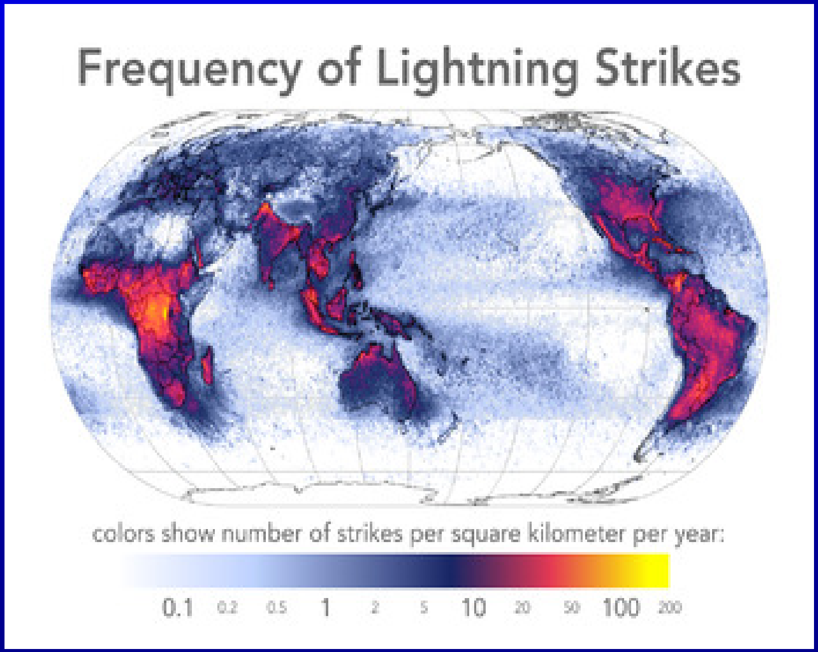
To conduct palaeomagnetic studies of the different lithologies and Natural Remanent Magnetisation directions of the rocks and their intensities.

To evaluate the application of electrical resistivity survey for the lightning disaster

GIS integration for analysis and modeling - to solve real world problems.

Overview of Selected Literatures

1. NASA (1998) Lightning strikes land more than water, according to the first three months' image data from NASA's Lightning Imaging Sensor (LIS). It is not just that most lightning occurs over land. From December 1997 through January 1998, LIS reported that 90 percent of lightning was over land as per NASA records



World Map showing lightning strike frequency (Source: NASA)

Investigators such as Boccippio *et al*., (2000); Williams and Stanfill (2002); Williams *et al*., (2002). have have shown that there is high variability between the distribution of lightning strikes over the ocean and land.

Williams *et al*., (2002). The land surface is asymmetrically heated faster than the ocean because of the lower thermal inertia and higher sensible heat flux over the land, illustrated by the higher Bowen ratio for land (0.2-1) compared to ocean (0.1).

Beringer and Tapper (2002), The surface energy balance, albedo, surface roughness, and the litho unit types are important factors in determining available energy and the partitioning of the energy fluxes over different surface types which are important characteristics in determining the microclimate and regional climate.

The intense currents of a lightning discharge create a fleeting with a very strong magnetic field.

When the lightning current passes through rock, soil, or metal, then these materials are magnetized permanently. This effect is known as lightning-induced remanent permanent magnetism, (LIRM).

These currents follow the least resistive path, often horizontally near the surface, sometimes vertically, where faults, ore bodies, or ground water offers a less resistive path.

Lightning-induced magnetic anomalies mapped in the ground, and analysis of magnetized materials confirms lightning was the source of the magnetization, which provides an estimate of the peak current of the lightning discharge.

Salminen *et al*., (2002) conducted palaeomagnetic studies of the different lithologies and they found that the NRM (Natural Remanent Magnetisation) directions of the rocks that post-date the impact event were randomly oriented. All the Archean granite-gneisses on the other hand were found to be randomly oriented and with much higher NRM intensities.

Carporzen *et al*., (2005) There is a possibility that lightning may be the cause of the high NRM's and random directions of magnetization in the granitic-gneisses. They explained these phenomena by suggesting that extremely intense randomly oriented magnetic fields were responsible for causing the randomization of the vectors and producing the high remanence associated with the Archaean rocks and it is clear that the highly erratic NRM directions could indicate that lightning might have been responsible.

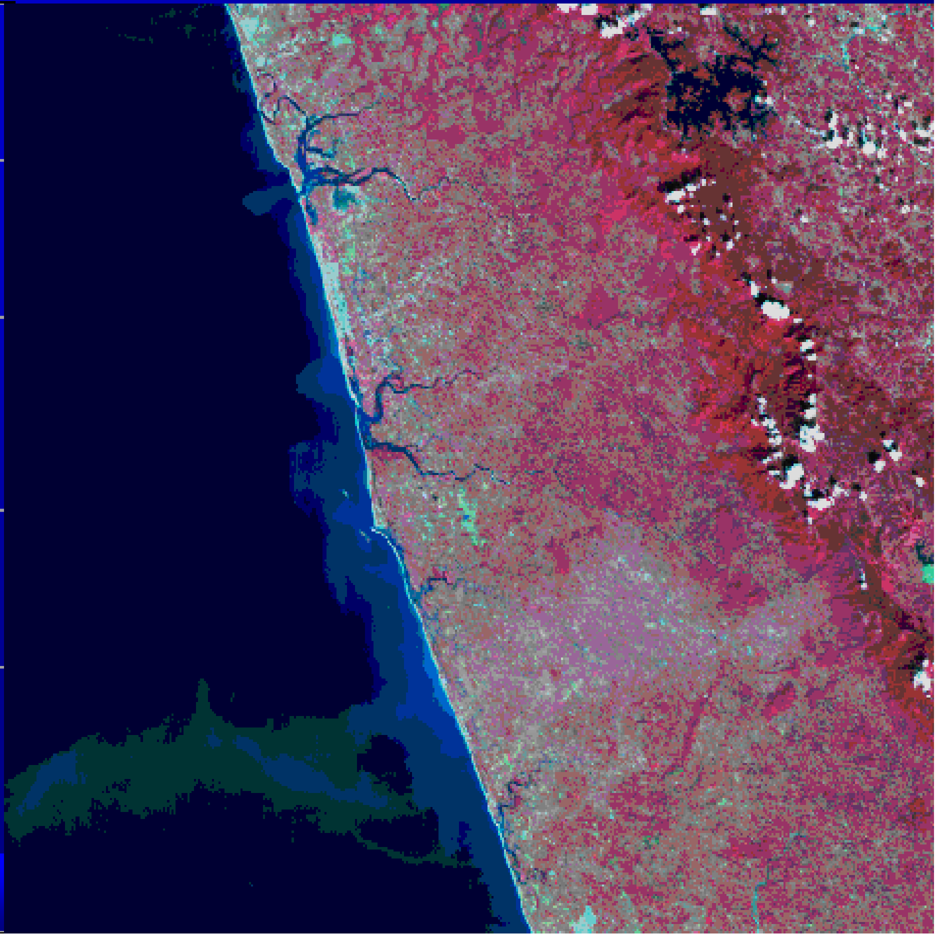
Remote Sensing - Imagery

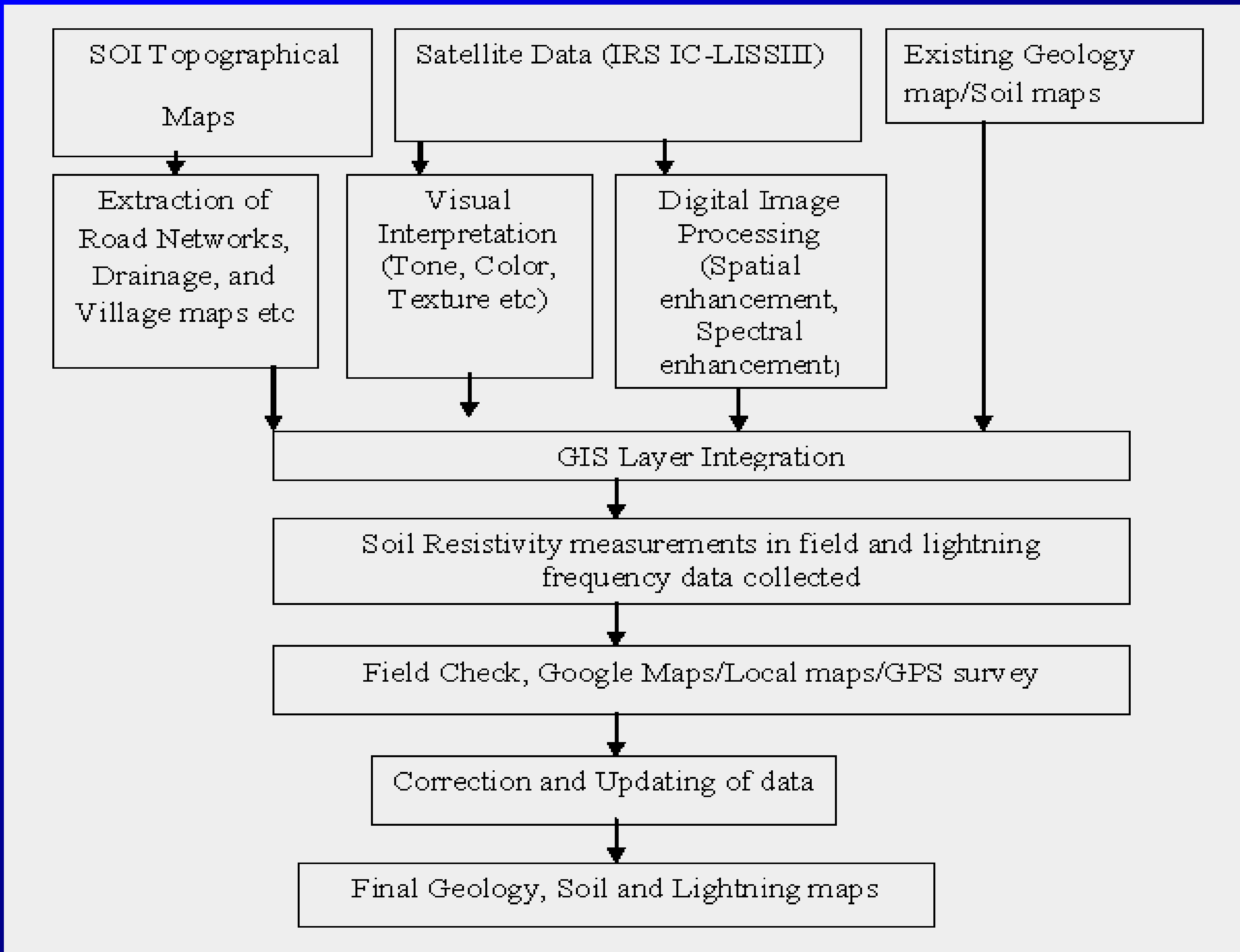
Remote Sensing digital data on CD-Rom will be used

IRS 1C/1D LISS III digital data

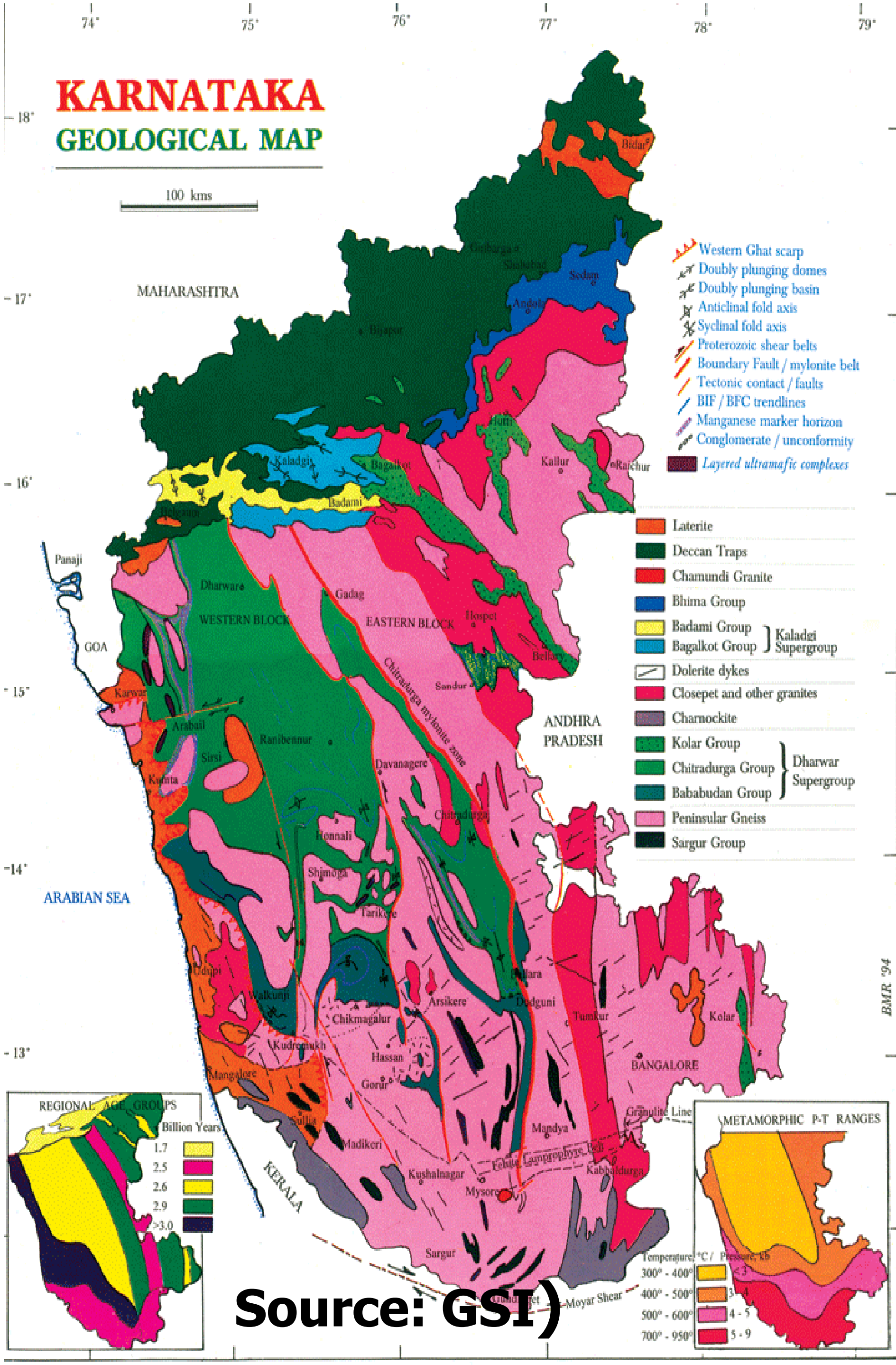
Sensor Characteristics

Sensor	LISS-III
Resolution	23.5 m
Swath	127 km (bands 2, 3, 4) 134 km (band 5 -MIR)
Repetitivity	25 days
Spectral Bands	0.52 - 059 microns (B2) 0.62 - 0.68 microns (B3) 0.77 - 0.86 microns(B4) 1.55 - 1.7 microns (B5

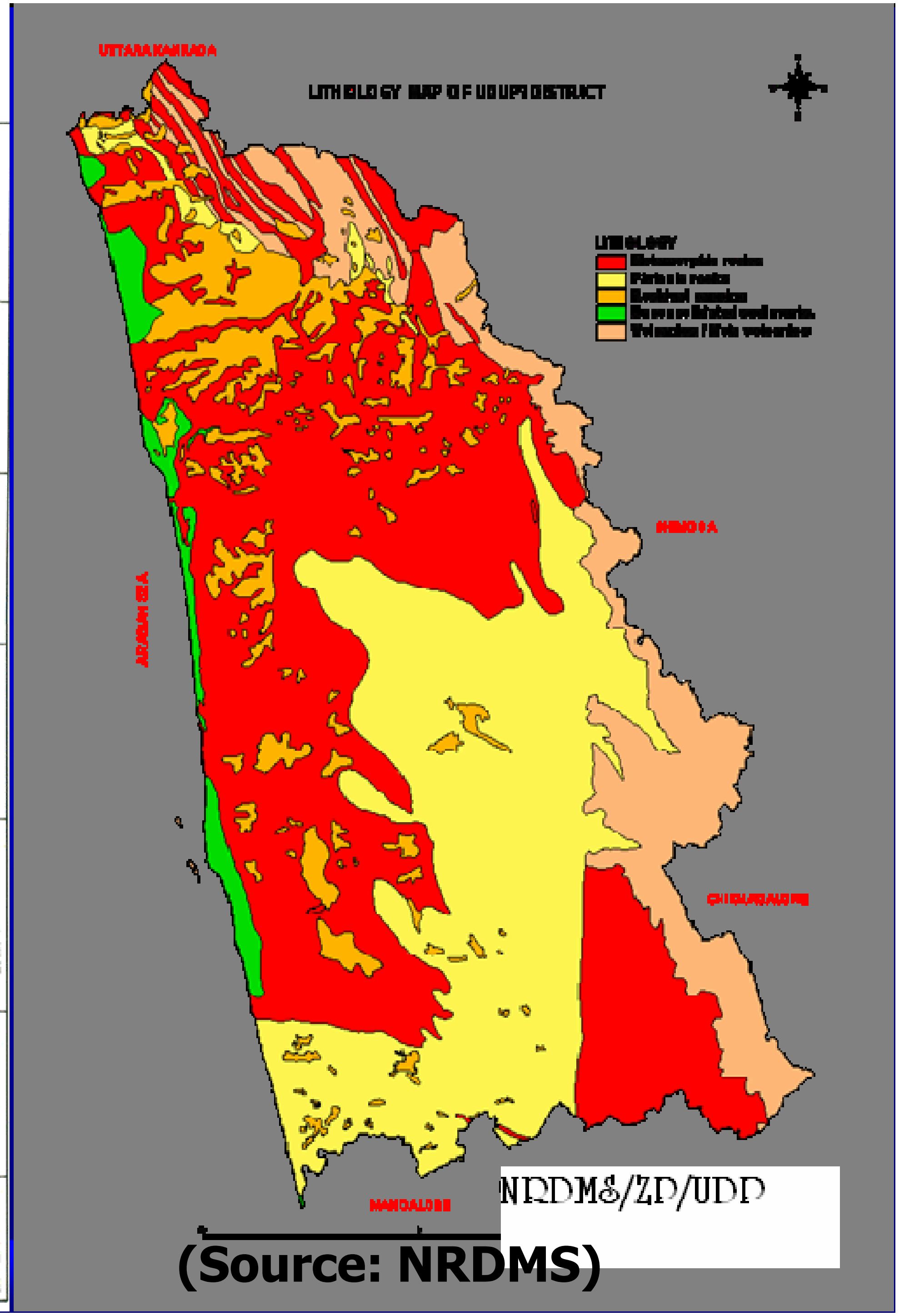



SOI Topographical Maps
Satellite Data (IRS IC-LISSIII)
Existing Geology map/Soil maps
Extraction of Road Networks, Drainage, and Village maps etc
Visual Interpretation (Tone, Color, Texture etc)
Digital Image Processing (Spatial enhancement, Spectral enhancement)
GIS Layer Integration
Soil Resistivity measurements in field and lightning frequency data collected
Field Check, Google Maps/Local maps/GPS survey
Correction and Updating of data
Final Geology, Soil and Lightning maps

Geology and Soil survey constitutes a valuable resource inventory linked with the survival of life on the earth. The technological advancements in the field of remote sensing and Geographical Information System have been a boon for such surveys.



Source: GSI)



(Source: NRDMS)

Visual Interpretation

Recognition elements like tone, color, texture, pattern, shape, size and associated features will help in delineating the lithological units.

Tone	Probable rock type
white	Quartzite, gravel sand, sandstones etc
Light grey	Granite, gneiss, sandy soils
Medium grey	Limestone, dolomite clay, shale, charnockite, gabbro, amphibolite
Dark grey	Dolerite, pyroxenite, norite etc.

Texture	Probable Rock Types
Blocky or coarse	Porphyritic granites and syenites
Fine	Dunite, dolerite, amphibolite
Medium	Granite, gneiss, charnockite, khondalite
Banded	Gneisses, bedded sandstone, shales.

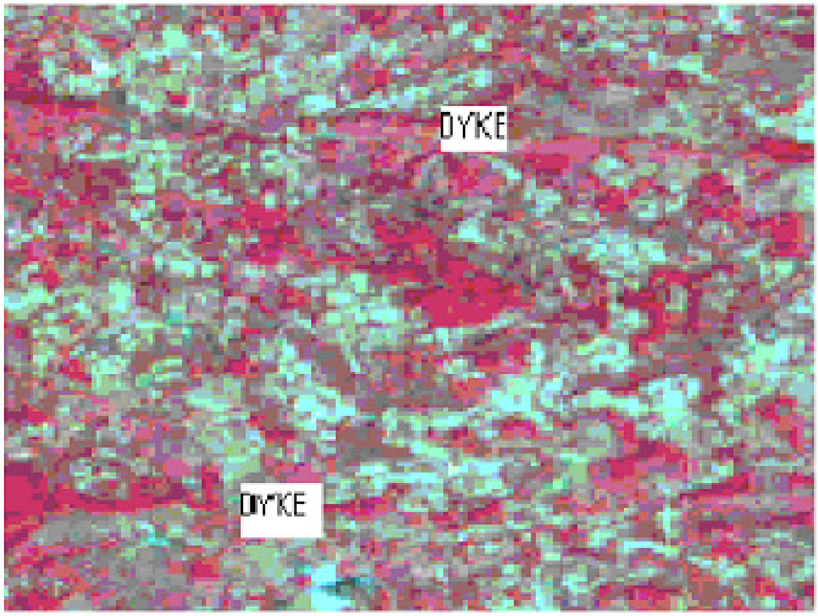
Digital Image Processing

- Each technique of digital processing will give some separated information.

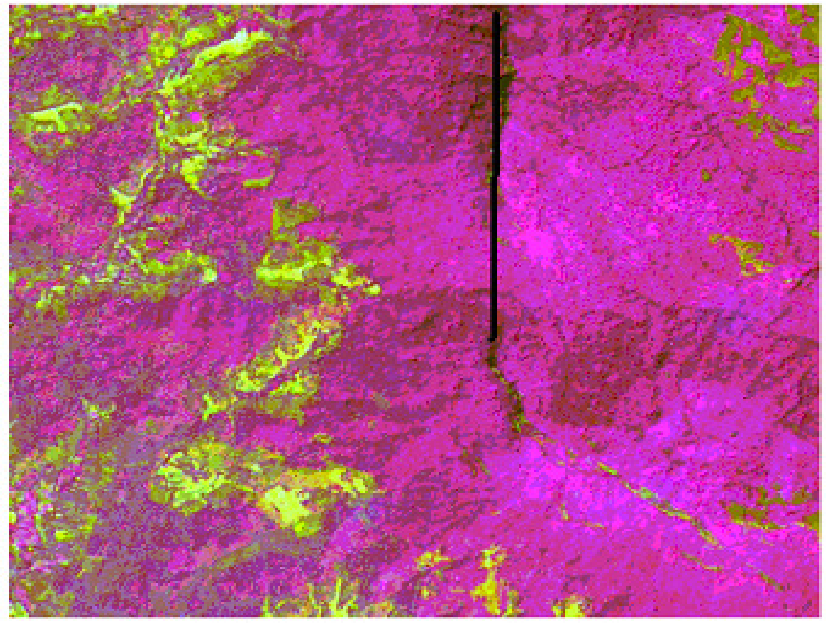
- Band Composite imagery with selected bands and difference color and filtering techniques is useful to enhance the lithological unit and tectonic features.

- Principal Components is also useful for delineate lineament (PC1) and lithological unit (PC2, PC3). With difference data from digital process, the visual interpretation brought out more detail information compare to the result from one kind of image.

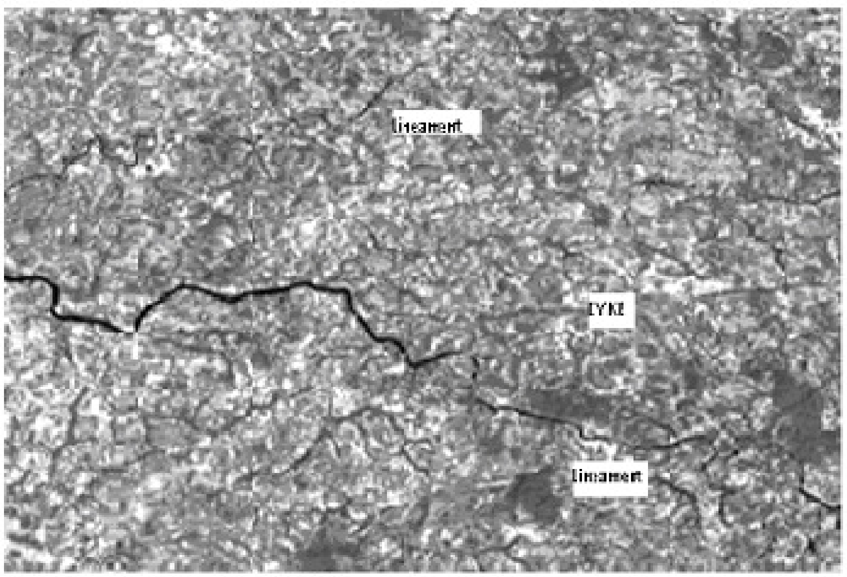
- Spectral characteristic of rock has been identified by vegetable reflectance using filtering technique, and a number of lineament has been enhanced. Result of filtering technique shows mainly five generation of lineament which has been distinguished using edge enhancement, Laplacian filter(3x3) with different direction).



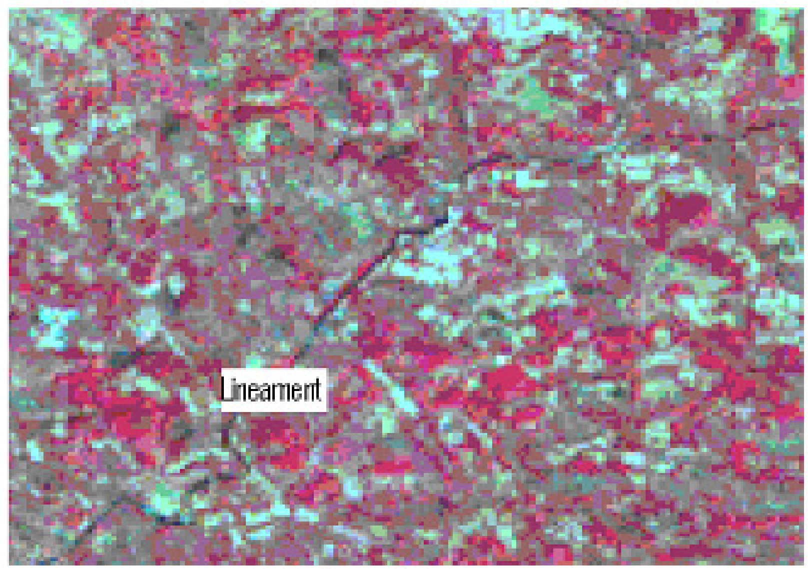
High Pass Filter



Principal Component Analysis



Edge Enhancement



FCC Band Ratio

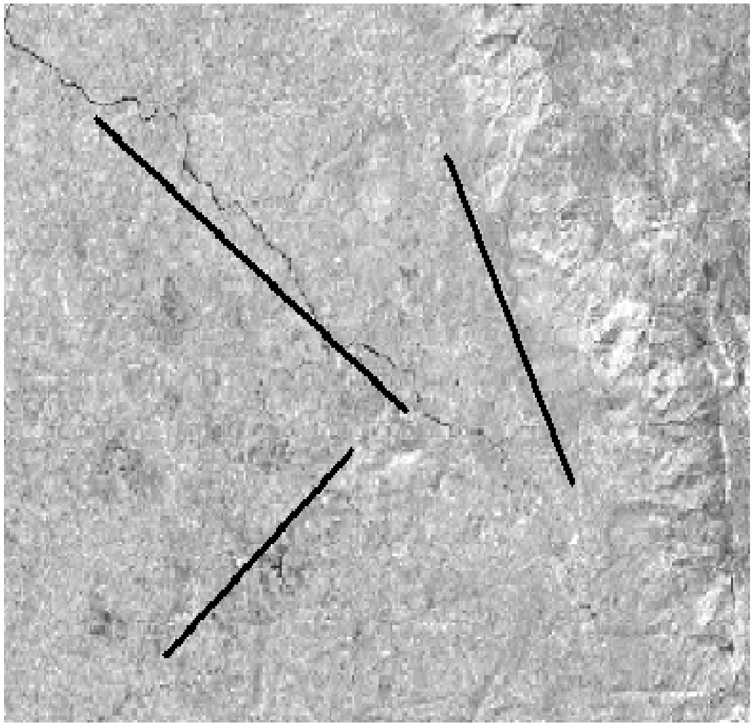
FCC of band ratioed images for identification of geological units by various digital image techniques

PC analysis is a statistical technique widely used in RS to choose the suitable bands and to show spectral differences which helps to display clearly the correlation of the spectral values between different channels.

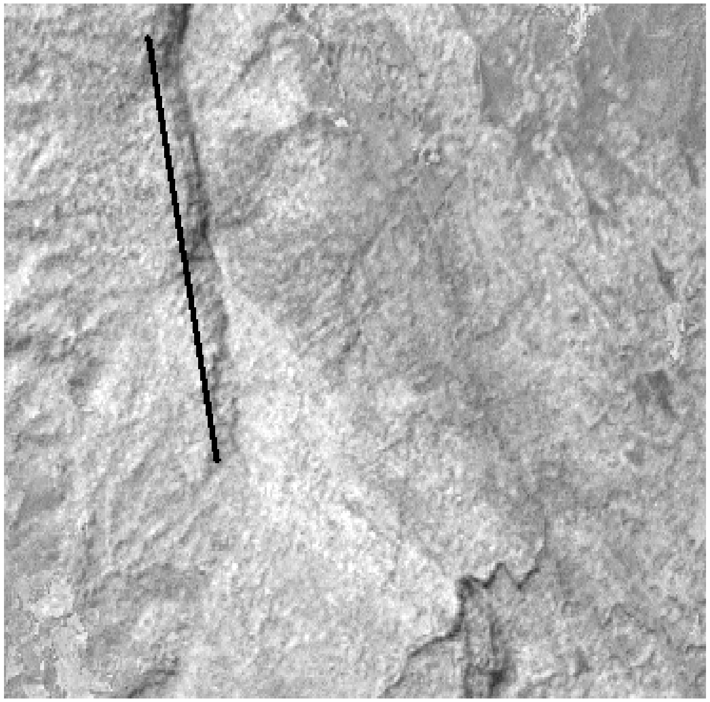
	DN	PC1	PC2	PC3	PC4
B1	255	64	64	67	72
B2	133	24	23	26	32
B3	250	26	24	22	38
B4	153	85	98	93	83
B1/B2	1.92	2.67	2.78	2.35	2.25
B1/ B3	1.02	2.46	2.46	2.78	1.89
B1/ B4	1.95	8.00	4.57	6.78	3.13
B2/ B3	0.53	0.92	0.95	1.18	0.84
B2/ B4	0.87	0.24	0.23	0.28	0.38
B4/ B3	0.55	0.48	0.30	0.49	0.60
B4/ B2	1.02	3.00	1.64	2.89	1.39

The digital processing of satellite data, especially the ratioed images of PC1/PC3 displayed more detail on alluvial formation along the river system. Whereas in the ratioed images of PC4/PC3, the difference between granites, laterites, gneisses, dolerite dykes and coastal sediments are very clear

The filtering technique is commonly used to (i) restore imagery, (ii) enhance the images for visual interpretation and (iii) extract features using local spatial frequency.

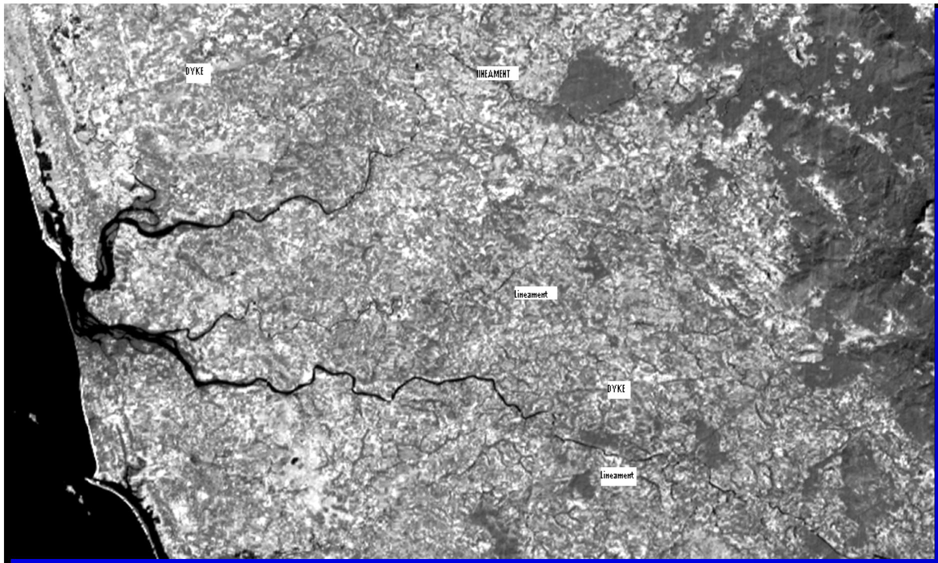


High Pass Filter

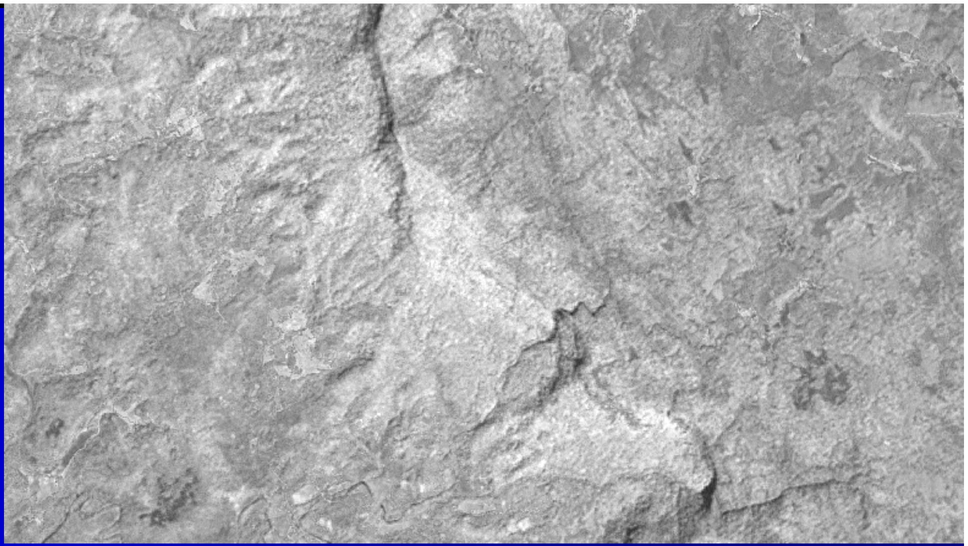


Edge Enhancement

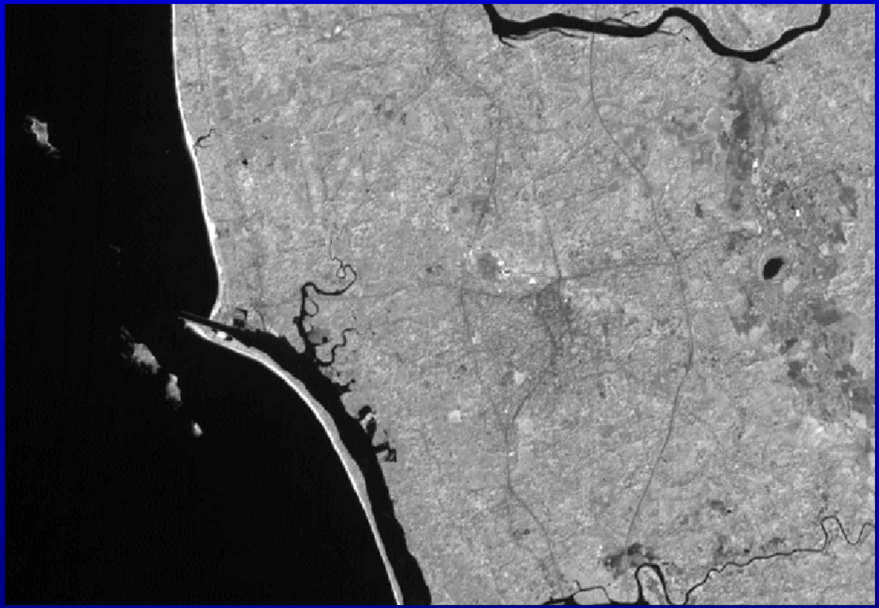
Showing the trend of major lineaments. Some of these lineaments are faults and are clearly observed in the digitally processed satellite images



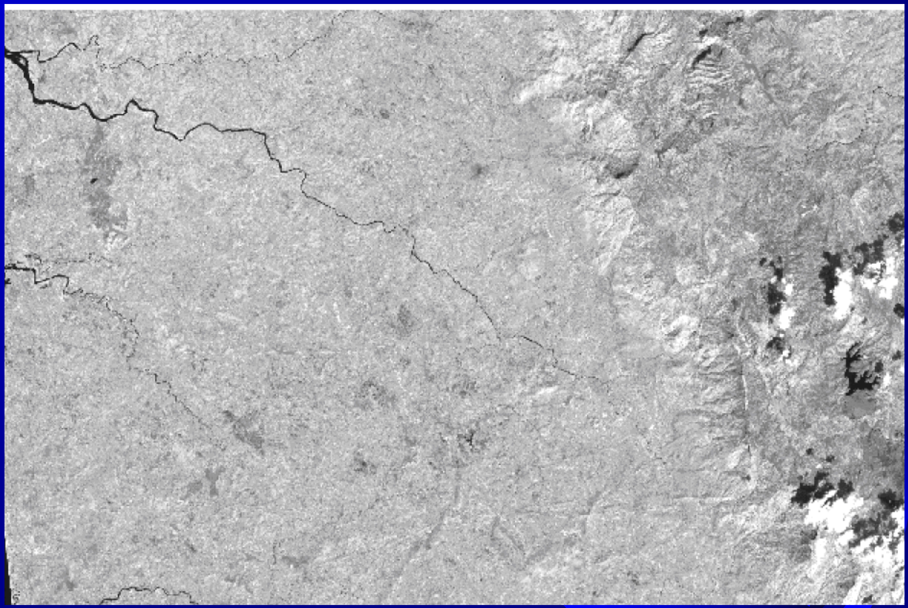
Showing the trend of major lineaments (Some of these lineaments are faults and are clearly observed in the digitally processed satellite images)



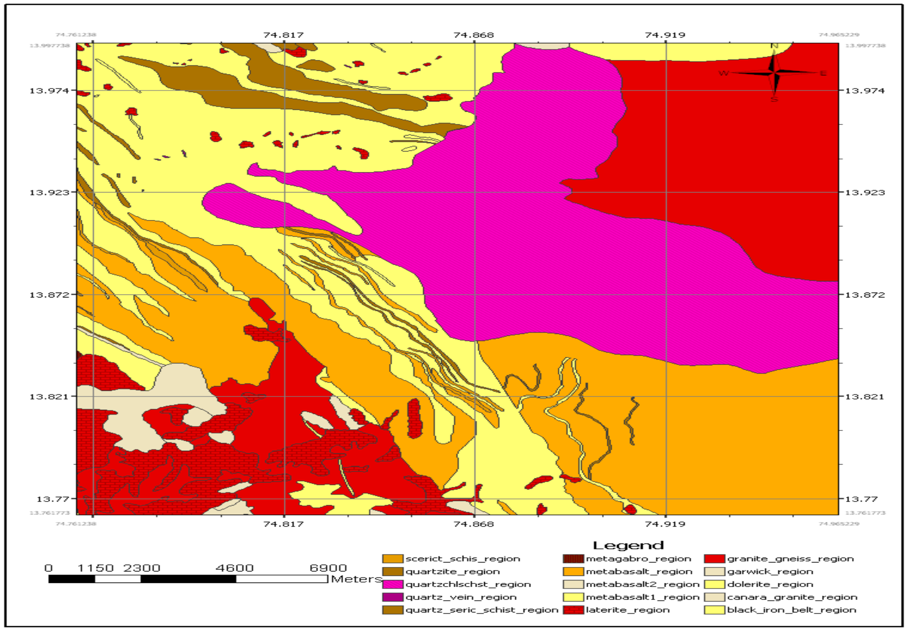
Showing the trend of major lineaments of inaccessible terrains (Some of these lineaments are faults and are clearly observed in the digitally processed satellite images)

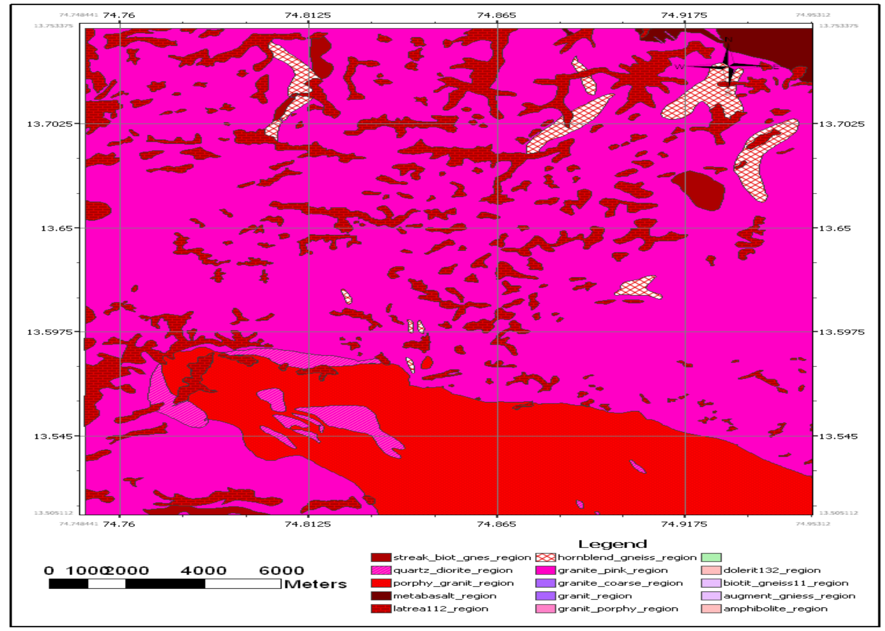


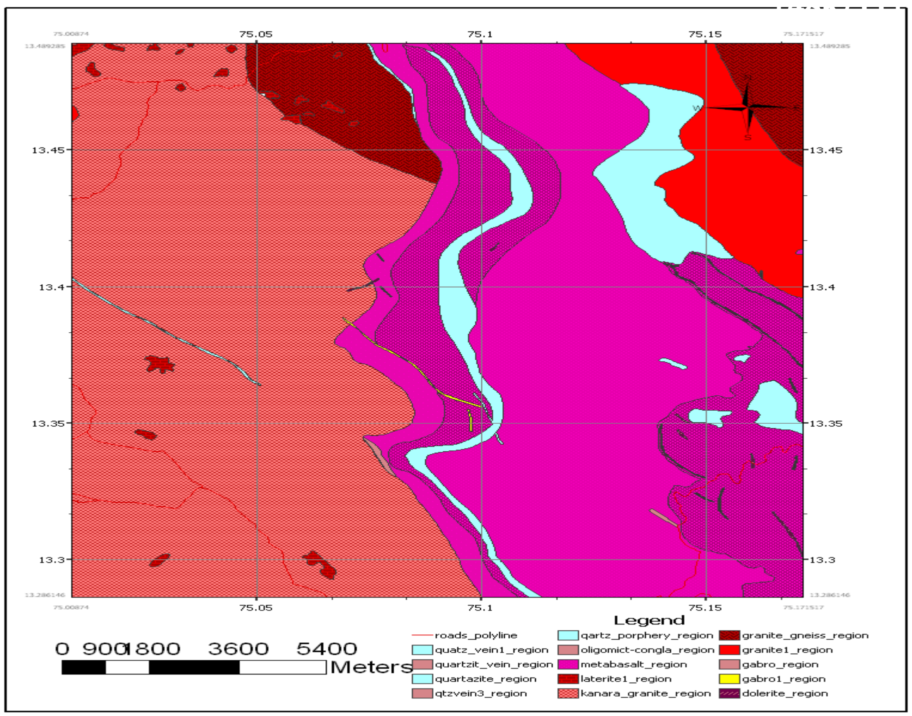
Road and railway network separated out easily using different wavelength of the electromagnetic spectrum (Contrast stretched IRS LISS-III Band-3 data clearly differentiating the linear features and lineaments)

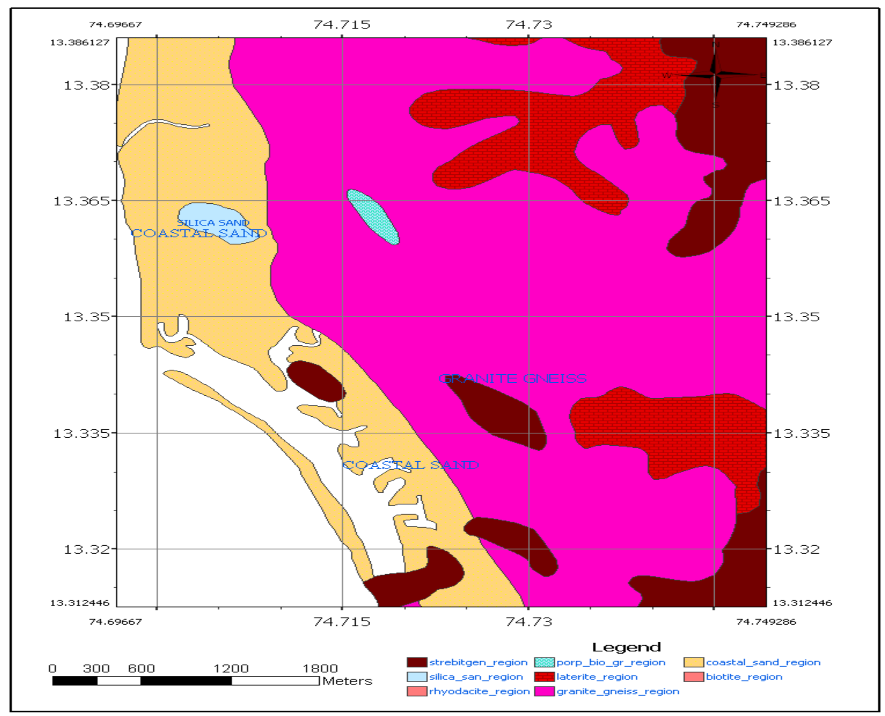


Digitally processed IRS PAN Data showing the straight river courses, shift in the alignment of ridges, abrupt ending of the Western Ghats in a linear fashion (All these indicate the study area is tectonically very active)


Legend
scerict_schis_region
quartzite_region
quartzchlschst_region
quartz_vein_region
quartz_seric_schist_region
metagabro_region
metabasalt_region
metabasalt2_region
metabasalt1_region
laterite_region
granite_gneiss_region
garwick_region
dolerite_region
canara_granite_region
black_iron_belt_region
0 1150 2300 4600 6900 Meters


Legend
streak_biot_gnes_region
quartz_diorite_region
porphy_granit_region
metabasalt_region
latrea112_region
hornblend_gneiss_region
granite_pink_region
granite_coarse_region
granit_region
granit_porphy_region
dolerit132_region
biotit_gneiss11_region
augment_gniess_region
amphibolite_region
0 1000 2000 4000 6000 Meters


Legend
roads_polyline
quatz_vein1_region
quartzit_vein_region
quartazite_region
qtzvein3_region
qartz_porphery_region
oligomict-congla_region
metabasalt_region
laterite1_region
kanara_granite_region
granite_gneiss_region
granite1_region
gabro_region
gabro1_region
dolerite_region
0 900 1800 3600 5400 Meters


SILICA SAND
COASTAL SAND
GRANITE GNEISS
COASTAL SAND
Legend
strebitgen_region
silica_san_region
rhyodacite_region
porp_bio_gr_region
laterite_region
granite_gneiss_region
coastal_sand_region
biotite_region
0 300 600 1200 1800 Meters

Peninsular gneiss exposures near Pajaka, Udupi showing alternate bands of felsic and mafic mineral assemblage

Gneissic rock exposures near Karkala

Soil mapping

Soil survey provides an accurate and scientific inventory of different soils, their kind and nature, and extent of distribution so that one can make prediction about their characters and potentialities.

Karnataka state has been divided into ten agro-climatic zones based on climate, soil, crops and topography.

These zones are further divided into six major regions.

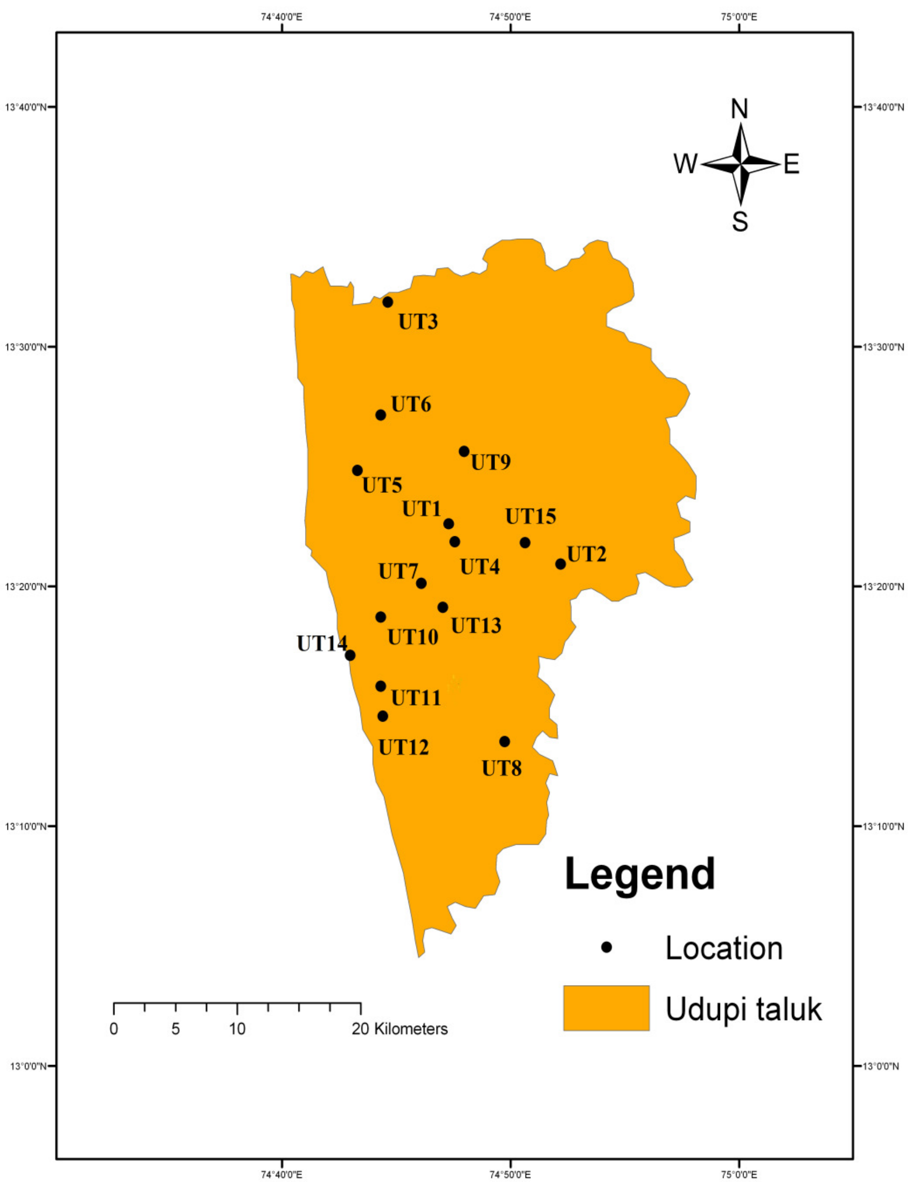
The Udupi District falls under coastal zone and region VI.

Five major types of soils namely alluvial soils, lateritic soils, red loamy soils, laterite gravelly soils and mountain soils are encountered in the region VI.

ELECTRICAL RESISTIVITY

- Electrical resistivity is a measure of how much the soil resists the flow of electricity.
- It is a critical factor in design of systems that rely on passing current through the Earth's surface.
- Knowledge of the soil resistivity and how it varies with depth in the soil is necessary to design the grounding system in an electrical substation.
- It is needed for design of grounding (earthing) electrodes for high-voltage direct current transmission systems.
- The soil resistivity value is subject to great variation, due to moisture, temperature and chemical content.

ELECTRICAL RESISTIVITY SURVEY OF UDUPI TALUK



Location	VES No.	Type of curves	No. of Layers
Saralabettu	UT1	QH	4
Kondadi	UT2	QH	4
Kolkebailu	UT3	QH	4
Manipal	UT4	H	3
Kalianapura	UT5	H	3
Brahmavara	UT6	H	3
Kukkikatte	UT7	Q	3
Shirva	UT8	QH	4
Aroor	UT9	KH	4
Udiyavara	UT10	QH	4
Pangala	UT11	KH	4
Kaup	UT12	H	3
Alevoor	UT13	KH	4
Mattu	UT14	H	3
Athradi	UT15	KH	4

Geo-electrical sections based on the sounding curves

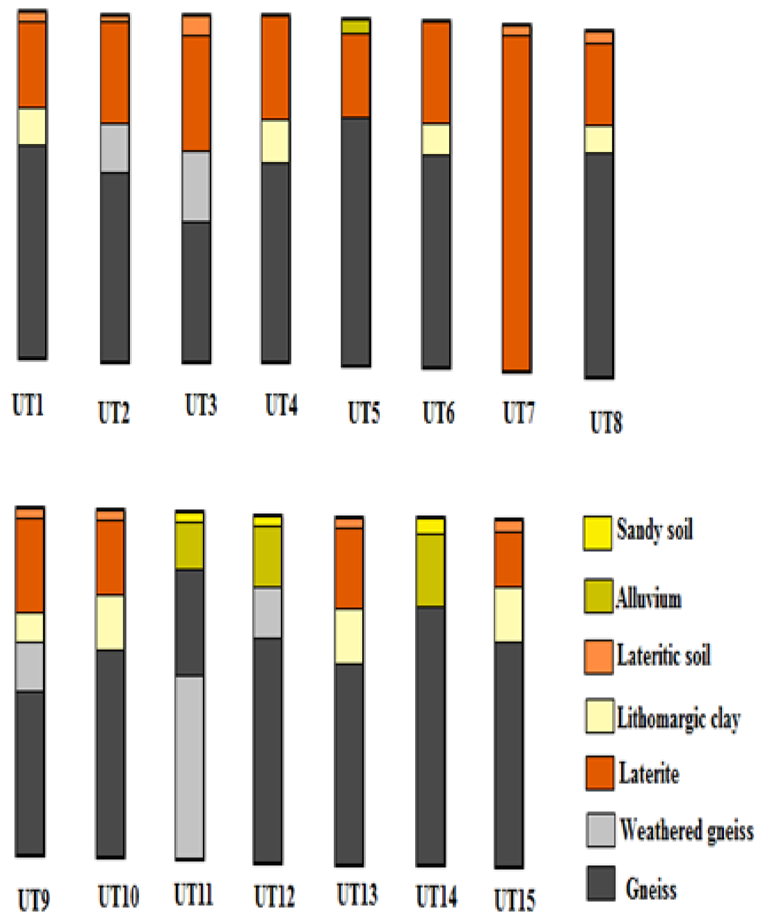


Fig. 12 Geo-electrical sections of Udupi taluk (Narayana and Lokesh, 2000a)

- Saralabettu (UT1): The topmost layer is lateritic soil with resistivity values ranging from 4400 to 5800 Ωm and thickness of 1.7 m. The resistivity of second layer varies from 1100 to 1650 Ωm and thickness of 8 m, this layer corresponds to laterite. The third layer corresponds to lithomargic clay with resistivity values ranging from 80 to 115 Ωm which is underlain by gneiss of high resistivity values.

- Kondadi (UT2): The topmost layer is lateritic soil with resistivity values ranging from 4000 to 6300 Ωm and thickness of 1 m. The resistivity of second layer varies from 1500 to 6600 Ωm and thickness of 3.7 m, this layer corresponds to laterite. The third layer corresponds to weathered gneiss which is underlain by gneiss of high resistivity values.

- Kolkebailu (UT3): The topmost layer is lateritic soil with resistivity values ranging from 4100 to 8000 Ωm and thickness of 2 m. The resistivity of second layer varies from 750 to 4800 Ωm and thickness of 8 m, this layer corresponds to laterite. The third layer corresponds to weathered gneiss which is underlain by gneiss of high resistivity values.

Resistivities and thickness of Soils of Mobile sites in Udupi District													
Name of mobile site	Lati	Long	No. of Layers	Resistivity of Layers in Ohm-m					Thickness of Layers in meters				
				1	2	3	4	5	1	2	3	4	5
UDUPI T/E	13.3291	74.7622	3	45	32	∞			1	1.5			
UDUPI M/W	13.3408	74.7483	3	98	48	∞			1.3	3.2			
ADI UDUPI	13.3481	74.7283	4	3100	705	160	∞	∞	0.8	1.7	26		
KADIYALI	13.3467	74.7567	4	1900	1000	400	∞	∞	0.5	8.5	41		
MALPE	13.3483	74.7086	5	30	120	30	300	90	1	5	10	40	
COONDAPOOR	13.6314	74.6919	5	350	3500	850	160	∞	1	9	12	9	
HEMMADY	13.6794	74.7033	3	95	35	∞			1.2	8			
HIRIADKA	13.3511	74.8639	5	4100	4800	6000	110	∞	1.2	2.3	45	14	
HERGA	13.3569	74.8039	3	6000	1000	∞			2	20			
MOODUBELLE	13.2797	74.8261	3	7000	1000	∞			2	18			
PERDOOR	13.3808	74.9014	3	7000	1300	∞			2	18			
MANDARTHI	13.4983	74.8122	5	900	3800	160	3	∞	1	1.2	1.8	34	
GANGOLLI	13.6544	74.6692	4	14	40	9.5	∞		1	3	19		
ANEGUDDE	13.5661	74.7003	4	240	46	7.5	∞		0.5	3.3	19		
BASRUR	13.6219	74.7289	4	250	39	8	∞		0.8	2	17		
SALIGRAMA	13.4994	74.7106	3	14	7	∞			2	18			

Resistivities and thicknesses of different layers as interpreted from sounding curves from different localities lateritic terrain.

Location	Types of Curves	Resistivity of Layers in Ohm-m					Thickness of Layers in meters				
		1	2	3	4	5	1	2	3	4	5
Manipal (ML)	H	1400	68	α			12	40.8			
Shirva (SV1)	QH	4100	2500	120	α		1.1	4.9	34		
Shirva (SV2)	QH	1800	1700	180	α		1.1	5.9	39		
Kallianpura (KP1)	H	2900	45	α			5	5			
kallianpura (KP2)	H	430	74	α			8.5	10.5			
Udiyavara (UV)	QH	4200	2000	190	α		1.5	5.5	7		
Kukkikatte (KK)	Q	2000	3300	α			1.2	8.8			
Aroor (A1)	KH	1600	1880	150	α		0.5	4.5	9.5		
aroor (A2)	KHA	420	870	75	102	α	1.3	4.7	7	16	
Alevoor (AL)	KH	1200	1380	410	α		1.2	8.3	14.5		
Brahmavara (B)	H	2200	250	α			6	49			
Kuap (K)	QHK	1700	1300	100	2700	40	2	8	3	15	40

SUMMARY

- Laterite, lithomargic clay, gneiss and alluvium are the major litho-units in the Udupi region.
- The top layer (mainly soil) with resistivity values ranging from 10 to 3100 Ωm and thickness ranging from 0.5m to 3m corresponds to the soil layer.
- Resistivities of laterites normally varies between 750 to 1500 Ωm with a normal thickness of 4 m to 12 m.
- Laterite is underlain by lithomaric of 25 to 100 Ωm resistivity.
- Lithomargic clay is underlain by gneisses of high resistivity values responsible for more lightning strikes on these areas.

1. The normal range of resistivity of gneiss is 300 to infinity.
2. The depth of bed rock is not uniform in Udupi taluk.
3. Good exposures of gneisses are observed at Manipal, Karkala, Ajjarkad and Ambalpady region where observed more lightning intensity
4. Soil Resistivity survey helps to delineate regions/sites which are highly prone to lightning effect.
5. The study reveals that there is a need for further scientific investigations of terrains in Udupi district with high resolution MSS satellite images and extensive geophysical surveys.

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