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कर्नाटक राज्य के उत्तर कन्नड जिले में भूआकृति संख्या 48J/1, 48J/2, 48J/6, 48J/7 और 48J/8 के कुछ हिस्सों में वृहद पैमाने पर (1:50,000) भूस्खलन संवेदनशीलता का मानचित्रण ।

(कार्य सत्र कोड सं:एल एस एम/एस आर/के.जी/2015/097)

कार्य सत्र: २०१५-१६

MACROSCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEETS NO. 48J/1, 48J/2, 48J/6, 48J/7, AND 48J/8, UTTAR KANNADA DISTRICT, KARNATAKA.

(FSP Code No: LSM/SR/KG/2015/097)
(F.S. 2015-16)

द्वारा/BY

नेहा कुमारी, भू-वैज्ञानिक
Neha Kumari, Geologist

तन्वी गुप्ता, भू-वैज्ञानिक
Tanvi Gupta, Geologist

परियोजना
Project

भूस्खलन संवेदनशीलता मानचित्रण
Landslide Susceptibility Mapping

राज्य इकाई: कर्नाटक व गोवा,
दक्षिणी क्षेत्र

State Unit: Karnataka and Goa
Southern Region

बेंगलुरू/ Bengaluru

2016

इस प्रतिवेदन का कोई भी भाग महानिदेशक, भारतीय भूवैज्ञानिक सर्वेक्षण से पूर्व में लिखित में अनुमति लिए बिना उद्धृत नहीं किया जाना है या प्रतिकृति नहीं बनाया जाना है।

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(FSP Code No: LSM/SR/KG/2015/097)

(Field Season: 2015-2016)

By

Neha Kumari, Geologist

and

Tanvi Gupta, Geologist

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कर्नाटक राज्य के उत्तर कन्नड जिले में भूआकृति संख्या 48J/1, 48J/2, 48J/6, 48J/7 और 48J/8 के कुछ हिस्सों में वृहद पैमाने पर (1: 50,000) भूस्खलन संवेदनशीलता का मानचित्रण ।

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(कार्य सत्र: २०१५-१६)

द्वारा

नेहा कुमारी, भू-वैज्ञानिक
और
तन्वी गुप्ता, भू-वैज्ञानिक

सारांश

कार्य सत्र २०१५-१६ के द्वारान कर्नाटक राज्य के उत्तर कन्न**ड** जिले में भू-आकृति संख्या 48J/1, 48J/2, 48J/6, 48J/7 और 48J/8 के कुछ हिस्सों में वृहद पैमाने पर (1: 50,000) भूस्खलन संवेदनशीलता का मानचित्रण 1376 वर्ग किलोमीटर क्षेत्र को कवर किया गया। अध्ययन क्षेत्र सरगुर समूह, प्रायद्वीपीय निसिक काम्प्लेक्स-I और पुराने ग्रेनिटोएड्स; बाबाबुदन और धारवाड सुपर समूह, आर्कियन उम्र के मैफिक- अल्ट्रामैफिक परिसर के चित्रदुर्ग समूह की चट्टानों को उजागर करता है। चट्टानों के धारवाड सुपर ग्रुप और प्रायद्वीपीय निसिक काम्प्लेक्स-I को पुराने ग्रेनिटोएड् अंतरवेदित कर रहे हैं, जिन्हें स्थानीय स्तर पर कारवार ग्रेनाइट के रूप में जाना जाता है। प्लाइओ - प्रोटेरोज़ोइक उम्र के डालराइट डाइक चट्टान इन सभी समूहों के चट्टानों में अंतरवेदित कर रहे हैं और सेनोज़ोइक उम्र के लेटराइट टोपी इन क्षेत्र में पायी जा रही हैं।

भौगौलिक दृष्टि से, क्षेत्र दो अनुदैर्ध्य वर्गों में बांटा गया है; पश्चिम तटीय मैदान की रोलिंग स्थलाकृति और पूर्वी भाग, जो पश्चिमी घाट की खड़ी चोटियों और घाटियों की श्रृंखला को दर्शाता है। 100 मीटर से कम ऊंचाई वाले निम्न, समतल शीर्ष लैटरिटिक पहाड़ी और पठार, कुमटा, होनावार और भटकल तालुकों के दक्षिणी तट में होने वाली भू-आकृतिक विशेषताएं है।

भू-कारक विषयगत नक्शे अर्थात भू-आकृति विज्ञान नक्शे, भूमि उपयोग व भूमि आवरण नक्शे, वक्रता नक्शे, ढाल उतराई नक्शे और भूस्खलन की घटनाओं/सूची नक्शे गूगल अर्थ आधारित उपग्रह चित्रण (सुदूर संवेदन) की सहायता से तैयार किया किये गए हैं । भू-सत्यापन/क्षेत्र अद्यतन और सभी विषयगत प्री फील्ड कार्यकलापों के नक्शे के सत्यापन के लिए किया गया। भूस्खलन के लिए 41 बिंदु भू-मापदंडों को कार्य क्षेत्र में दर्ज की गई हैं और अद्यतन भूस्खलन सूची डेटाबेस बनायीं गई हैं । जीआईएस मंच पर 50,000 पैमाने पर ऐ अच् पी आधारित गणितीय मॉडलिंग के प्रयोग आवश्यक डेटा सेट के साथ और अलग-अलग विषयों के भीतर भू- कारक कक्षाओं के लिए अंतिम विश्लेषणात्मक दर्ज़ा किये गए हैं ।

क्षेत्र के अधिकांश भाग नीच विच्छेदित ढलान के तदुपरांत अत्यधिक विच्छेदित ढलान में निहित है। ढलान के गठन सामग्री अर्थात अधिभार सामग्री अपक्षय चट्टान, लैटरिटिक और लेटराइट मिट्टी के हैं। व्यापक कटौती ढलान ढलानों पर अस्थिरता के लिए नियतात्मक मापदंड है; संपर्क में कटौती खंड वर्षा के कारण अपक्षय पर सप्रोलाइट के गठन और लिथोमर्ज का निर्माण किया है। लेटराइटजस्सून प्रक्रिया क्षेत्र की विशेषता है। लेटराइट दुरिक्रुस्त पठार शीर्ष और उजागर सतहों पर स्थित हैं और अस्थिर क्षेत्रों को स्थिरता प्रदान करते हैं। कई स्थानों पर ढाल संशोधन के कारण नीच विच्छेदित पहाड़ी ढलान की विफलता के लिए सड़क निर्माण और मानवीय हस्तक्षेप उत्तरदायी है। पहाड़ी ढलान जो विघात होने की प्रवृत्त रखता है ऐसे ढाल को दनुडेशनल ढाल के रूप में वर्गीकृत किया गया है।

41 सूत्री भू-कारक के साथ बड़े और छोटे आयाम की स्लाइड्स की ऐतिहासिक डेटाबेस पैदा करने के लिए दर्ज किया गया है। इसके अलावा स्लाइड से अस्थिर क्षेत्रों में व्यापक सड़क कटौती और संशोधित ढलान के तहत निपटान के रूप में चित्रित किया गया है, एवम संभव उपचारात्मक उपायों का सुझाव दिया है और गुणात्मक जोखिम मूल्यांकन किए गए हैं। क्षेत्र में अधिकांश स्लाइड् <=5 मी. के रोटेशनल और ट्रांसलेशनल विफलता के डेब्रिस स्लाइड हैं। राष्ट्रीय राजमार्ग (एनएच-17) के साथ भूस्खलन की घटनाओं का कारण बुनियादी ढांचे और विकास गतिविधि के लिए तीव्र ढलान कटौती है। बड़ा आयाम के दो प्रमुख मलबे स्लाइड काडवाड गांव क्षेत्र और 1 रॉक स्लाइड और 2 मलबे स्लाइड ससंवाड गांव क्षेत्र में लगभग कारवार शहर के 3 मी. उत्तर-पश्चिम और शेजवाड गांव के 1 मी.

पूर्वोत्तर में दर्ज किया गया है। टोपोशीट संख्या 48J/1 डेब्रिस स्लाइड मुद्राळी, बैटकॉल और अरगा गांव क्षेत्र में भी दर्ज किए गए हैं। एनएच-206 पर दर्ज किए गए डेब्रिस स्लाइडस मुख्य रूप से खड़ी ढलान खदान या निर्माण के उद्देश्यों के लिए किया ढलान संशोधिकरण हैं। टोपोशीट संख्या 48J/1 के दक्षिण गोवा के कुछ हिस्सों में दर्ज किया गया है। नीच विच्छेदित ढलान पर लेटराइट और ढीली लैटरिटिक उथले मलबे स्लाइड के जिम्मेदार कारक हैं। टोपोशीट संख्या 48J/6 में रोटेशनल से ट्रांसलेशनल डेब्रिस स्लाइड दर्ज किया गया है। अतिसंवेदनशील क्षेत्रो में अधिभार मोटाई >10 मीटर है। अधिकांश भूस्खलन 15 डिग्री से 35 डिग्री के कोण के बीच हुआ है और संशोधित खड़ी ढलान >45 डिग्री पर दर्ज किया गया है।

भूस्खलन संवेदनशीलता नक्शा, भू-कारक विषयगत नक्शे की मदद से ऐ अच् पी आधारित गणितीय मॉडलिंग नक्शे का डेटा एकीकरण के लिए ज्ञान आधारित एकीकरण, तकनीक-बहु स्तरीय सूचकांक ओवरले पद्धति का उपयोग करके तैयार किया गया है। सभी प्री फील्ड कार्यकलापों के नक्शे, अध्ययन क्षेत्र में सत्यापित और संकलित किये गए हैं फिर डिजीटल और विश्लेषण के लिए रास्टराइजड किये गए हैं ।उच्च मध्यम और कम अतिसंवेदनशील क्षेत्रों के साथ सहज भूस्खलन संवेदनशीलता नक्शे 50,000 पैमाने पर चित्रित किये गए हैं, ताकि भूस्खलन जोनेशन और पश्चिमी घाट के पहाड़ी इलाकों के जोखिम मूल्यांकन के लिए एक अग्रदूत के रूप में अध्ययन किए जा सके ।

MACROSCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEETS NO. 48J/1, 48J/2, 48J/6, 48J/7, AND 48J/8, UTTAR KANNADA DISTRICT, KARNATAKA

(Code No: LSM/SR/KG/2015/097)

(Field Season: 2015-2016)

By
Neha Kumari, Geologist
&
Tanvi Gupta, Geologist

ABSTRACT

Macroscale (1:50,000) Landslide Susceptibility mapping was carried out in Toposheets No. 48J/1, 48J/2, 48J/6, 48J/7 & 48J/8, Uttar Kannada District, Karnataka covering 1376 sq. km of area on 1:50,000 scale. The study area exposes the rocks of Sargur Group, Peninsular Gneissic Complex-I and older granitoids; Bababudan and Chitradurga Group of Dharwar Super Group, mafic-ultramafic complex of Archaean age. The Dharwar Super Group of rocks and Peninsular Gneissic Complex-I are intruded by older Granitoid locally referred as Karwar Granite. Basic intrusive like dolerite dykes of Palaeo-Proterozoic age are intruded in all these groups of rocks and laterite caps of Cenozoic age are occurring in the area.

Physiographically, the area is divided into two longitudinal sections, the coastal plain on the west showing rolling topography and the eastern part shows series of steep ridges and valleys of the Western Ghats. Low lateritic, flat-topped hills and plateaus, not exceeding 100 m are the geomorphic features occurring in the southern coast of Kumta, Honavar and Bhatkal taluks.

The geofactor thematic maps i.e. Geomorphology maps, Landuse and Landcover maps, Regolith Thickness maps, Slope Forming Material maps and Landslide incidences/inventory maps are prepared with the aid of Google Earth based Satellite imagery (RS data) and GIS tools and techniques. Ground truthing/field checks for updation and validation of all thematic pre-field maps was carried out in field. 41 point geo-parameters for

the landslides are recorded in the field and updated landslide inventory database is generated. GIS platform is used for AHP based mathematical modelling with necessary data sets for the final analytical rating for the geofactor classes in the individual thematic maps and within the individual geofactor themes on 1:50,000 scale.

Majority of the area lies in Lowly dissected slope, followed by Highly dissected slope. The slope forming material i.e. overburden material consists of weathered rock, laterite and lateritic soil. The extensive cut slope is the deterministic criteria for instability on slopes; at exposed cut section weathering due to rainfall has lead to the formation of saprolite and lithomarge on modified vertical cut slope of >45°. The area is characterized by lateralization process. The laterite duricrust on plateau top and exposed surfaces stabilizes the unstable zones; lowly dissected hill slope at many places is vulnerable to failure due to slope modification for road construction and anthropogenic interferences. The hill slope prone to multiple failures are categorised as Denudational slope.

The slides of large and small dimension with 41-point geoparameters are recorded for generating historic landslide inventory database. Apart from slides the unstable zones are delineated as extensive road cut and settlement under modified slope. The possible remedial measures are suggested and qualitative risk assessment is done. Majority of the slides in the area are shallow debris slide of rotational and translational failure of <=5m failure plane. The landslide incidences all along national highway (NH-17) shows perfect evidence of slope failure due to intense slope cut for infrastructure and development activity. 2 Major debris slides of larger dimensions are recorded at Kadwad village area and 1 rock slide and 2 debris slides are recorded at Sasanwad village area nearly 3km NW of Karwar town and 1km NE of Shejwad village. Debris slides are recorded at Mudarali, Baithkol and Arga village area that lies in Toposheet no. 48J/1. Debris slides are recorded all along NH-206 are shallow rotational failure induced primarily by vertical slope cut made for quarry or construction purposes. Debris slides are recorded in parts of south Goa of Toposheet no. 48J/1, are shallow debris slide occurring on laterite and loose lateritic soil on lowly dissected slope. Slides recorded in Toposheet no. 48J/6 are shallow translational to rotational debris slide. The risk prone susceptible area has overburden thickness of >10m. Majority of the slides have occurred between slope gradient 15° to 35° and on modified vertical cut slope of with slope angle>45°.

The landslide susceptibility map is prepared using knowledge-driven integration technique i.e. multi-class index overlay method for data integration of geofactor thematic maps incorporating AHP based mathematical modelling. All the Pre-field thematic maps are validated in the field, compiled, digitized and rasterised for analysis. The seamless landslide susceptibility maps with high, moderate and low susceptible areas are delineated and prepared on 1:50,000 scale for the study area as a precursor to the landslide hazard zonation and risk evaluation of the hilly terrains of Western Ghats.

भारतीय भूवैज्ञानिक सर्वेक्षण GEOLOGICAL SURVEY OF INDIA

MACROSCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEETS NO. 48J/1, 48J/2, 48J/6, 48J/7, AND 48J/8, UTTAR KANNADA DISTRICT, KARNATAKA

(Code No: LSM/SR/KG/2015/097)

(Field Season: 2015-2016)

By

Neha Kumari, Geologist

and

Tanvi Gupta, Geologist

I. INTRODUCTION

1.1 Background Information

Landslides, around the world, take a heavy toll on life and property every year. Indeed, they are one of the most causative factor to loss of life and aggregate national losses caused by natural disasters associated with earthquakes, severe storms and heavy rainfall in mountainous terrain. The landslide incidences in the hilly regions of Western Ghats in the districts of Kodagu, Chikmagalur, Hassan, Shimoga, Dakshin Kannada and Uttar Kannada in state of Karnataka are recorded. The heavy rainfall during peak rainy season is the triggering factor for landslides leading to the displacement of rocks and soils causing widespread damage to infrastructure such as rails, roads and loss of life and property.

As the frequent landslide occurrences has taken places in recent past in hilly terrains of Himalayas that has caused the national sorrow. Ministry of Mines, Government of India has taken up a nation-wide programme on "National Landslide Susceptibility Mapping" on 1:50,000 scale for delineating the landslide susceptible zones for the societal benefits.

GSI, being the nodal agency for landslide studies in India is generating the base data in the field of landslide hazard study on 1:50,000 scale. In this programme seamless "Landslide Susceptibility Map" for the entire nation is generated on priority basis where knowledge driven multi-class index overlay method for data integration and AHP (Analytical Hierarchical Process) technique are used. In AHP method site-specific/terrain-specific weights/ ratings systems are taken into account for data modelling and implemented with the aid of GIS and RS tools and techniques, incorporating necessary field inputs.

Accordingly, during FS: 2015-16, total 1376 sq. km of area was taken up for "Landslide Susceptibility Mapping" in parts of Toposheets no. 48J/1, 48J/2, 48J/6, 48J/7 & 48J/8 of Uttar Kannada district, Karnataka on 1:50,000 scale vide FSP code: LSM/SR/KG/2015/097.

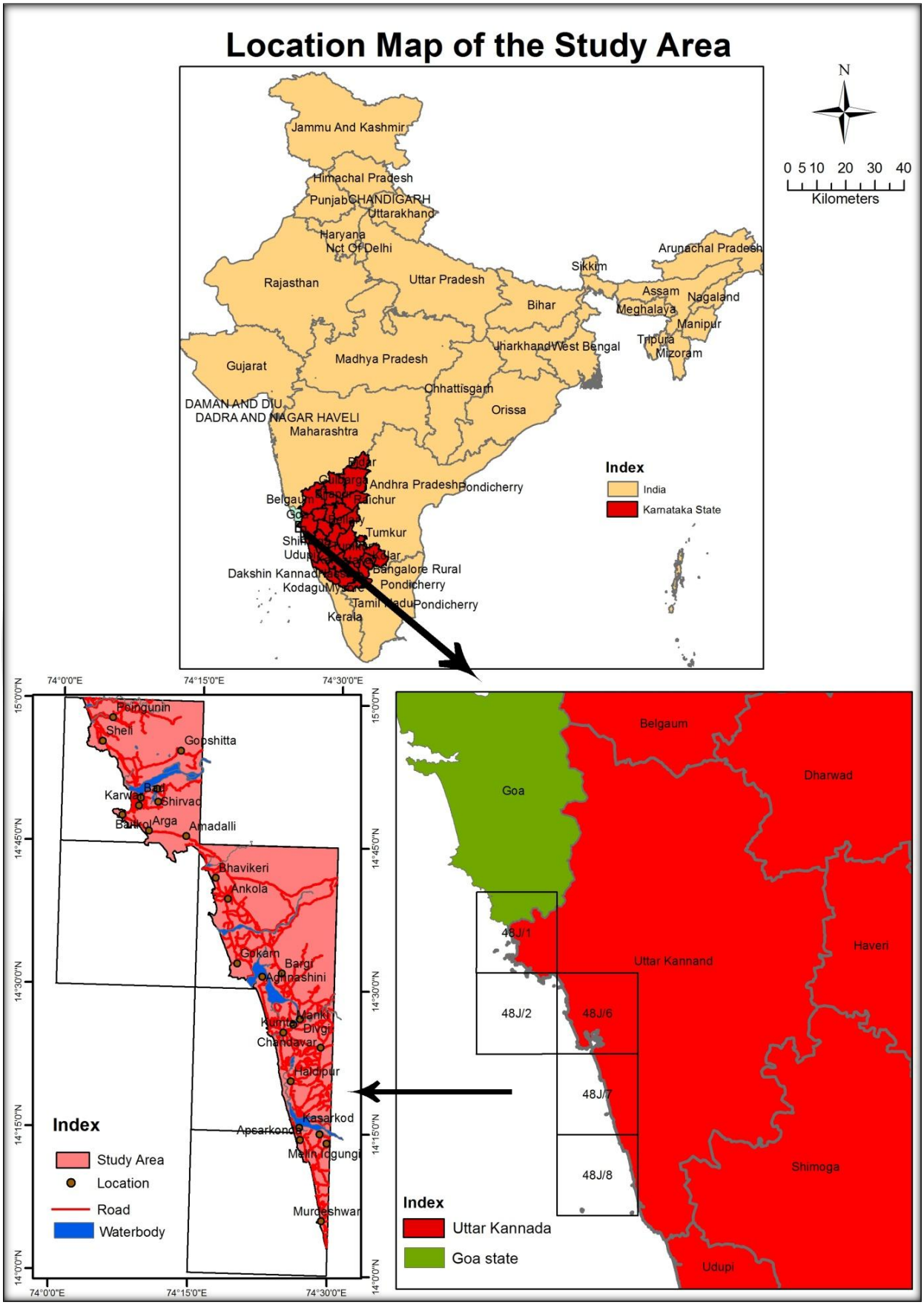
1.2 Study Area

Macroscale (1:50,000) "Landslide Susceptibility Mapping" was carried out in parts of Toposheets no. 48J/1, 48J/2, 48J/6, 48J/7 & 48J/8, Uttar Kannada district, Karnataka during FS: 15-16. The Uttar Kannada district is one of the biggest districts of Karnataka State. It is located in the north western part of the Karnataka state with geographical area of nearly 10,291 sq. km. It is bounded by Goa state, Belgaum district in the north, Dharwad district in the north east, Haveri district in east, Shimoga district in south east, Udupi district in south and remaining north west and south west parts of the district is surrounded by Arabian Sea. The district has a long coastal line of about 140 km. It lies between latitudes $13^0$55'N to $15^0$31'N and longitudes $74^0$05'E to $75^0$06'E. Uttar Kannada district has 11 taluks namely; Ankola, Bhatkal, Haliyyal, Honavar, Joida, Karwar, Kumta, Mundgod, Siddapur, Sirsi, and Yellapur. The city of Karwar is the administrative headquarter of the district.

The area mapped is bounded by latitudes 14°30'00"N to 15°00'00"N and longitudes 74°00'00"E to 74°15'00"E of Toposheets no. 48J/1 & 48J/2 covering parts of South Goa district of Goa and Uttar Kannada district of Karnataka, and area between latitudes 14°00'00"N and 14°45'00"N and longitudes 74°15'00"E and 74°30'00"E of Toposheets no. 48J/6, 48J/7 & 48J/8 of Uttar Kannada district, Karnataka.

The district headquarter Karwar is located around 500 km from Bangalore city on Panjim-Mangalore National Highway-17. The NH-17 passes through Bhatkal, Honnavar, Kumta, Ankola, and Karwar in N-S direction. The other important roads are state highways connecting Ankola-Hubli-Gadag and Honnavar-Shimoga-Bangalore. The famous Konkan railway passes through the western most part of the district in N-S direction connecting all the towns between Panvel (Bombay) and Trivendrum. All the taluk headquarters are well connected to district headquarter and all the villages are connected to taluk headquater by state highways and metalled roads. Interior places are connected by foot/cart tracks. The nearest rail head is located in Karwar and airport is situated in Mangalore **(Plate-1)**.

Plate-1


Location Map of the Study Area
N
0 5 10 20 30 40
Kilometers
Jammu And Kashmir
Himachal Pradesh
Punjab
CHANDIGARH
Uttarakhand
Haryana
Nct Of Delhi
Rajasthan
Uttar Pradesh
Sikkim
Arunachal Pradesh
Assam
Nagaland
Meghalaya
Manipur
Tripura
Mizoram
Bihar
JharkhandWest Bengal
Gujarat
Madhya Pradesh
Chhattisgarh
Orissa
DAMAN AND DIU
DADRA AND NAGAR HAVELI
Maharashtra
Andhra Pradesh
Pondicherry
Belgaum
Raichur
Tumkur
Bangalore Rural
Pondicherry
Kerala
Index
India
Karnataka State
74°0'0"E
74°15'0"E
74°30'0"E
15°0'0"N
14°45'0"N
14°30'0"N
14°15'0"N
14°0'0"N
Belgaum
Goa
Dharwad
Haveri
Uttar Kannand
Shimoga
Udupi
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48J/2
48J/6
48J/7
48J/8
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Haldipur
Kasarkod
Murdeshwar
Index
Study Area
Location
Road
Waterbody

1.3 Present Work

During the present work in Uttar Kannada district, Karnataka; total 1376 sq. km of the area has been mapped for "Landslide Susceptibility Mapping" on 1:50,000 scale with the following objectives:

i) To prepare Landslide inventory database using high resolution remote sensing data and field inputs.

ii) To prepare toposheet-wise (1:50,000 scale) spatial database for geofactors of landslides i.e. Landuse and Landcover map, Geomorphology map, Slope Forming Material map, Slope Morphometry (Slope, Curvature, and Aspect) map, Regolith Thickness map, Geo Hydrology: Drainage map and Landslide Inventory/Incidences map as input thematic maps.

iii) To prepare "Landslide Susceptibility Map" using knowledge-driven integration technique i.e. multi-class index overlay method for data integration of geofactor thematic maps on Arc GIS platform incorporating AHP based mathematical data modelling method for delineating high, medium and low susceptible zones based on LOFS rating and ranks.

The details of nature of work, quantum and achievements are mentioned in **(Table 1)**.

Table 1: Details of nature of work, quantum and achievements.

Nature of work	**Target F.S: 2015-16 in (sq. km)**	**Achievement F.S: 2015-16 in (sq. km)**
1.Pre field map preparation		
Preparation of Thematic maps (in GIS on scale 1:50000)		
a) Slope forming material map	1376 sq. km	1376 sq. km
b) Geomorphology and lineament map	1376 sq. km	1376 sq. km
c) Slope morphometry (slope, aspect & curvature) map	1376 sq. km	1376 sq. km
d) Landuse / Landcover map	1376 sq. km	1376 sq. km
e) Drainage map	1376 sq. km	1376 sq. km
f) Regolith thickness map	1376 sq. km	1376 sq. km
ii) Preparation of landslide inventory map	1376 sq. km	1376 sq. km
2.Field based studies		
i) Field checking of all thematic maps	1376 sq. km	1376 sq. km

ii) Field validation of landslide inventory and collection of recent and historic landslides	1376 sq. km	1376 sq. km
iii) Collection of landslide inventory and damage data as per 41 point geo - parametric sheet	As necessary	23 nos. (Landslides)
iv) Validation of landslide susceptibility map at important locations	1376 sq. km	1376 sq. km
3. Post field studies and modelling		
i) Updation of thematic and inventory maps in GIS	1376 sq. km	1376 sq. km
ii) Preparation of landslide susceptibility map in GIS	1376 sq. km	1376 sq. km
4.Collection of rainfall data	As necessary	collected

1.4 Physiography and Drainage

Physiographically, the study area can be divided into 3 distinct zones namely narrow and flat coastal zone in west, abruptly rising ridge zone and elevated flatter eastern zone. The taluks, which comprises the narrow flat coastal zone, are: Karwar, Ankola, Kumta, Honnavar and Bhatkal. The important physiographic feature of the study area is hill ranges of Western Ghats that forms the part of Ridge zone, runs north to south, parallel to the coast, which acts as a divide between the narrow coastal strip on western side and the adjoining hilly regions belonging to Sahyadri hill ranges. The taluks, which comprises the ridge zone, are Yellapur, western Sirsi, and western Siddapur. The flat eastern zone joins the Deccan plateau The taluks which comprises the elevated flatter eastern zone are Mundgod, eastern Sirsi and eastern Siddapur. The landmass of the district is situated between the elevations of 0 to 800 m above msl. The highest peak in the district is Darshangudda located 915 m msl and is near Goa state boarder.

The area lying in Toposheet no. 48J/1 is relatively hilly terrain with high peaks, and narrow valley plains in east-central part along the Kalinadi river and also along the coastal track adjoining the Arabian Sea. The highest elevation is 662 m above msl in north-eastern part whereas; the lowest elevation is 60 m above msl on the banks of Kalinadi River in east central part. The area covering Toposheet no. 48J/6 is a hilly terrain with forest cover whereas, the western margin is a coastal plain adjoining the Arabian Sea. The highest elevation is 56 m above msl in the western coastal margin at south of Gokarna. The area

covering Toposheet no. 48J/7 is physiographically divided into two longitudinal sections, the coastal plain on the west showing rolling topography and the eastern part shows series of steep ridges and valleys of the Western Ghats. The highest elevation is 232 m above msl in the south-eastern part and lowest elevation is 60 m above msl on the coastal plain at Halangadde.

The important rivers in the district are Sharavathi, Kali, Aghanashini, and Gangavali that forms the major sources of drainage system in Uttar Kannada district; illustrated in Drainage map (Plate-9). Kalinadi, Aghanashini and Tadri river is the major river flowing in northern part, Gangavalli river is flowing in the central part and, Sharavati river in the southern part of the study area. All these river flows from east to west and joins the Arabian Sea. All the rivers in the study are together with their tributaries exhibit dendritic drainage pattern and rivers are perennial/rain fed. In addition, there are numerous streams and nalas showing dendritic drainage pattern. The finest estuaries with tidal flats are present at the junction where rivers meet the Arabian Sea.

1.5 Climate and Rainfall

The Uttar Kannada district experiences tropical monsoon climate. Generally, the weather is hot and humid on the coastal areas throughout the year. The district falls under the hilly agro-climatic zone except for western parts of Karwar, Ankola, Kumta, Honnavar and Bhatkal taluks which falls under coastal agro-climatical zone. The Uttar Kannada district experiences temperature variation between 22^0C to 30^0C. The highest day time temperature rises up to 38^0C. The humidity is lowest during the dry season and highest during the monsoons. The climate is drier to the east of the Ghats except in the south-west monsoon season.

The rainfall is plentiful (average annual rainfall is 2741 mm), particularly in the coastal and Western Ghats region. The winds are predominantly south westerly during the summer monsoon and north-easterly during the winter monsoon. The year may broadly be classified into four seasons: the dry season is from January to February with clear and bright weather and hot weather from March to May. Thunderstorms are common in the month of May. The monsoon season is from June to September. This season yields around 75% (Halyal taluk) to 90% (Karwar taluk) of the annual rainfall. The period from October to December may be termed as the post monsoon season. On an average the district receives annually around 2750 mm rainfall, occurs in nearly 103 rainy days. The rainfall decreases from over 3230 mm in

west to less than 1207 mm in east. The coefficient of variability of pre-monsoon season rainfall is high indicating erratic rainfall. The same is the case during the post monsoon season. The variability is 30 to 40 % during the monsoon season, which is normal. The same is the case on an annual basis it being around 30%. July is the wettest month with normal monthly rainfall in all stations is recorded in excess of 300 mm. Annual rainfall in the district varies from 1176.8 mm in Mundgod taluk to around 4145.6 mm in Bhatkal taluk.

1.6 Soil Types

Along the coast, alluvial soil is occurring on western most parts of the area. Most of the area is covered by lateritic soil. On eastern parts, the lateritic soils changes to red loamy soils. The exposed soils of denuded hills got laterised through surface erosion, fine clay materials seeping down into the lower horizons leaving honey-combed iron rich, indurated surface laterite, a poor terrain for plant growth. The indurated surface laterite is an effective shield against landslides, except when deep vertical cuts are made exposing the soft clayey soil horizon beneath. Major portion of the district is covered by red lateritic and sandy, loamy soils.

The soil can be described as derivatives of the most ancient metamorphic rocks in India, which are rich in iron and manganese. The soils of the district are basically divide into two distinct zones based on topography; the coastal alluvial soil and the uphill lateritic soil. The lateritic soils are highly leached, reddish brown in colour, shallow to medium in depth and loamy in texture. These soils are found in the taluks of Karwar, Kumta, Honavar, Bhatkal. Red sandy loams soils are found in taluks of Sirsi, Yellapur, Karwar and Ankola poor in water holding capacity, and are therefore well drained, and acidic. In the coastal taluks there are numerous patches of land which contain saline soil of light yellow or brownish colour.

1.7 General Geology

The regional geology of Uttar Kannada district including study area exposes the rocks of Sargur Group, PG-I and older granitoids; Bababudan and Chitradurga Group of Dharwar Supergroup, mafic-ultramafic complex of Archaean age. The Dharwar Supergroup of rocks and PG-I are intruded by older Granitoid locally referred as Karwar Granite. Basic intrusive like dolerite dykes of Palaeo-Proterozoic age intrude all these group of rocks and laterite caps of Cenozoic age are also noticed in the area.

Older metamorphic of Sargur Group of rocks represented by number of enclaves within gneisses and granites and the enclaves are quartzite, amphibolite, iron formation, garnetiferous mica schist, talc-chlorite schist, kyanite-staurolite schist, silimanite-garnet schist, calc-silicate rock and ultramafics within Peninsular Gneissic Complex (PGC). In the study area amphilbolite and talc-chlorite schist occur as enclave within PGC. The amphibolites are dark grey in colour, fine to medium grained, massive and schistose, rich in hornblende and plagioclase. The talc-chlorite schist is grey to greenish, schistose, soft, consists of talc and chlorite. The Peninsular Gneiss of this region is a complex of migmatitic gneiss and granitoids and includes biotite gneiss, hornblende-biotite gneiss and hornblende gneiss.

The Peninsular Gneissic Complex in the study area is represented by granitic gneiss and granodiorite gneiss. The granite gneiss is coarse grained, comprises of quartz, orthoclase, plagioclase feldspars, mica and hornblende show gneissic texture and at places with migmatitic structures. The Peninsular Gneiss is unconformably overlain by Dharwar Supergroup (Bababudan Group). Bababudan Group is represented by four formations namely a) Walkunje Formation b) Kudremukh Formation c) Kodachadri Formation and d) Narasiparvata Formation.

The Walkunje Formation represents the lower arenaceous and argillaceous member of the Bababudan Group. The Western Ghat Belt preserves an ideal succession of Bababudan Group, which is exposed in the mountainous region of Kudremukh, Agumbe and Kodachadri.

Bababudan Group of rocks locally referred as North Kanara Belt represented by Kudremukh Formation comprises of quartzite, hornblende-actinolite-chlorite schist and metabasalt. Chitradurga Group of rocks represented by Joldhal Formation (locally referred as Bisgod Formation) and Ranibennur Formation are exposed in the area. Kodachari Formation comprises of Banded magnetite quartzite and quartz-chlorite-sericite schist.

The Narasiparvata Formation comprises of acid porphyries, chlorite quartz schist and iron stones. Numerous dykes varying in texture from coarse to fine grained are reported from various localities. The Joldhal Formation consists of ortho-quartizite, limestone, dolomite, phyllite, manganese phyllite and banded magnetite quartzite (BMQ).

The Ranibennur Formation of Chitradurga Group consists of greywacke-argillite suite of rocks and banded ferruginous quartzite (BFQ). The layered mafic and ultramafic complexes are the intrusive bodies consists of peridotite, pyroxenite, gabbro, talc-chlorite schist and titano-vanadiferous magnetite bands.

The PGC is unconformably overlain by the Goa group (equivalent to Chitradurga group of Dharwar Super group) comprising of Barcem, Sanverdem, Bicholim and Vagari formations of low grade green schist facies. The Barcem and Bicholim formation are occurring in the study area.

The Barcem formation dominant in South Goa, comprises of Ortho-quartzite, thick piles of meta-basalt, met-acid volcanic (quartz porphyry, meta-dacite and tuffs) and quartz-chlorite amphibolite schist with bands of agglomerate.

The Bicholim formation consists of quartz chlorite biotite/ amphibolites schist with thin lenses of metabasalt, sills of metagabbro, carbonaceous and manganiferous cherts, quartzite, BIF, quartz sericite schist and magnesian limestone.In south Goa, the lower units of Bicholim formation are manganiferous. The BIF is intersected with Quartz-chlorite-biotite amphibolites schist, chert, quartzite, limestone and metavolcanics association showing pinching and swelling and correspond to 'Algoma type'.

The granitoids locally called as Karwar Granite is intruded into the Dharwar Supergroup of rocks is light grey, fine to coarse grained, hard, compact, with well developed gneissic texture at places and consist of quartz, orthoclase, plagioclase, biotite with lot of epidote and few specks of muscovite mica. All the rock types in the area have been traversed by the basic intrusive like dolerite dykes.

Laterite capping of Cenozoic age have composition varying from aluminous to ferruginous. The ferruginous laterite is rich in iron content. The laterite cover is extensive in the area between the coastal plains and the intermediate range of hills of the Western Ghats. Most of the coastal hills are lateritic (**Plate-2, Plate-3, Plate- 4, and Plate-5**).

1.8 Landuse and Landcover

As per statistics, around 80440.836 hectare of land of the study area is under forest cover out of total 150319.99 hectare of the land. The different landuse and landcover occurring in the area is Settlement, Barren, Sparse vegetation including Scrub land, Moderate vegetation, Thick vegetation, Swampy land, Cultivated land, Quarry i.e. rock quarry and laterite quarry, Fallow land, Saltpan, Barren sandy coast and Plantation like Coconut (Cocos nucifera), Betel nut (Areca catechu), Eucalyptus (Eucalyptus globules), Acacia (Acacia confuse), and Cashew (Anacardium occidentale). Cashew and Betel nut/Areca nut is the main cash crop grown in the area. Prawn farms and saltpans are major landuse practices in and around coastal areas.

1.9 Geomorphology

Geomorphologically, the area forms a part of Western Ghats and is characterise by a highly undulating rugged topography except for the narrow strip of coastal plains in the west and narrow valley plains between plateaus and hills. Extensive low lateritic, flat-topped hills and plateaus are occuring from Kumta-Honnavar-Apsarkonda. Coastal hills of Uttar Kannada broadly come under two categories: most of them exceeding 200 m high have granite as the main rock type, these hills characterise northern coastal stretches from Ankola to Karwar and low lateritic, flat-topped hills and plateaus, not exceeding 100 m are feature of the southern coast of Kumta, Honavar and Bhatkal taluks. Geomorphic units of marine depositional origin like beach sands, beach ridge are occurring near coast.

1.10 Data and Software used

Data used: Topographic sheets and OSM sheets (open series) of SOI Toposheets no. 48J/1, 48J/2, 48J/6, 48J/7 & 48J/8.

Softcopy of Geology map on 1:50,000 scale *(in jpg and shapefile (.shp) format; Source: GSI, M&C Division)*.

National Geomorphological and Lineament Map (NGLM data) on 1:50,000 scale *(Source: GSI and NRSC).*

Software used: Arc GIS 10.3, Google Earth *(Open source)*

Satellite Data used: Aster DEM (30 m resolution), Google Earth Satellite Imagery (multi-temporal data)

1.11 Methodology

Landslide susceptibility maps are prepared using AHP based modelling. In present study both probabilistic and heuristic-based method are used where the weightage is assigned to the causative factors/parameter based on weightage to landslide causal factors and where weightage given by expert in particular domain.

Methodology followed for generating landslide susceptibility map is mentioned below:

I. Pre-field thematic/geofactor map preparations (in GIS on 1:50000 scale)

Various geofactor thematic maps i.e. Landuse and Landcover Map, Geomorphology Map, Slope Forming Material Map, Regolith Thickness Map, Slope Morphometry (Slope,

Aspect, and Curvature) Map, Drainage Map, Landslide inventory Map are prepared. Different classes/categories within thematic maps are delineated and classified with the help of topographic sheets and Google earth based satellite imagery and map is prepared in Arc GIS platform.

- Slope forming material map are generated with the aid of Geomorphology, Lithology (from legacy map: Geology map) and Landuse and Landcover map as proxy thematic maps.
- Drainage and Slope Morphometry (Aspect, Curvature and Slope) map are DEM derivative map prepared from Aster DEM data of 30 m resolution which is resampled to 50 m resolution.
- Landslide inventory database is prepared with the help of multi-temporal data on Google earth imagery, historical and event based data are reported in old GSI reports and other relevant papers/articles.

II. Field based studies/Ground truthing

i) Ground truthing/ field checks of all geofactor thematic maps.
ii) Field validation of landslide inventory and collection of recent and historic landslides.
iii) Collection of landslide inventory and damage data as per 41 point geo-parametric sheet.
iv) Validation of landslide incidences at important locations.

III. Post field studies and modelling

i) Updation of thematic and landslide inventory maps in GIS platform.
ii) Pair wise correlation matrix calculation, determination of LOFS and Rank as per weightage/rating assigned to different thematic (causative factors) variables.
iii) AHP based modelling and overlay analysis of different thematic maps for the preparation of Landslide susceptibility map on 1:50,000 scale on GIS platform.

All the Pre-field thematic layers were updated and compiled after field validation. The thematic maps are rasterised for data modelling and analysis. To perform GIS analysis all the layers were projected in UTM (Zone 43N) taking WGS84 as spheroid and datum.

1.12 Acknowledgements

During the FS:15-16, the proposed landslide susceptibility mapping was carried out in the state of Karnataka for the societal benefit of national importance in this regard, I extend my sincere thanks to Shri B. D. Thappa, ADG & HOD, Southern Region, Shri R. K. Aggrawal, DDG & RMH-IV, Southern Region for their support, help & assistance. Thanks to Shri C. G. Hemantha Kumar, Dy. Director General, State Unit: Karnataka & Goa, GSI, Bengaluru for his support, and for imparting his valuable engineering knowledge and analytical skills in the field that helped in augmenting our field knowledge during his inspection visits to the field.

I dedicate my thanks to the Supervisory officer Shri J. Srihari, Director, EG Division, SU: Karnataka & Goa, GSI, Bengaluru for his guidance, co-operation, patience and for sharing his valuable knowledge at headquarter and during the field visit.

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Authors are also thankful to the residents of Uttar Kannada, district for rendering co-operation and sharing their experiences and past landslide incidences during the field work.

II. PREVIOUS WORK ON LANDSLIDE STUDIES

To update the database, an item pertaining to the landslide inventory along National Highway (NH) and State Highway (SH) roads in Western Ghat sections was taken up in Mission-IV under 'Engineering geology and Geotechnical investigation programme of GSI: Landslide Hazard Evaluation'. In order to implement the proposed action plan of the landslide hazard and risk mitigation, the landslide database for preparation of the future models, inventory of the landslides was carried out.

In the first phase of the inventory of landslides, the landslides along the National Highways (NH) and State Highways (SH) of the Western Ghat section in parts of Goa state and in parts of Karnataka state in Toposheets no. 48I/2, I/3, E/14, 15 & 16 and J/7, J/6, J/9, and L/13 was taken up during F.S. 2007-08 in order to develop a landslide database for future landslide zonation and modelling as a part of the action plan of the MHA on landslide Hazard and risk mitigation. A total of 64 incidences of landslides were studied along the ghat sections of NH/SH, the landslides recorded along NH-17 between Honavar-Kumta road section: 2 nos., along SH-95 between Karwar- Kumbarwada (Ansi ghat)-14 nos. and Arbail ghat along NH-63 between Yellapur- Ankola road-15 nos. reveals that most of the slides are shallow (<2m depth) debris slides/slumps**.**The slided material consists of boulders, rock fragments and colluvial deposits (A.K. Mishra et. al, 2010).

During the F.S. 2009-10, (K.V. Maruthi et. al, 2011) Landslide inventory was carried out along NH & SH of ghat roads in Chikmagalur, Coorg, Dakshina Kannada, Udupi and Shimoga Districts Karnataka was carried out along the Ghat roads of the Western Ghat in Coorg, Dakshina Kannada and Chikmagalur districts covering parts of toposheet nos .48 O/7, 8 & 11; 48P/ 7, 11&15 reveals that most of the landslides are shallow (<2m depth) debris slides/slumps. The cut slope height and angle plays a major role in all the slides as the sliding events from crown to toe are restricted between the cut slopes. It was observed that majority of the slides are restricted to the cut slopes having height more than 10 m and slope angle varying from 70°- 90°. The relative relief from the cut slope is low to moderate at all the section and varies from 5m to 20m with depth of overburden varying from 0.5-10 m and 110 incidences of landslides were studied.

The Landslide Hazard Zonation in Macrosacle (1:25,000 scale) were taken up during FS 2008-09 and FS 2009-2010 includes Charmudi ghat section from Charmudi to Kotigehara and Kotigehara to Kalasa, Dakshina Kannada and Chikmagalur districts of Karnataka and

Shiradi ghat section from Sakleshpur to Gundiya (Uppinangadi taluk) along with Sakleshpur-Subramanya road and railway sections, Hassan and Dakshina Kannada districts of Karnataka. Total 152 landslide incidences were studied in the area. During the investigation it is observed that majority of the landslides are debris or earth slumps and slides occurred due to cutting of the natural slope for making road (A.K. Mishra, U. K. Pradhan et. al, 2011).

During 2010-12, the landslide inventory was carried out by (K.V. Maruthi et. al, 2012) along the road-sections of the Western Ghat in Uttar Kannada and Chikmagalur districts covering parts of Toposheets no. 48 J/1, 6, 7, 10, 11, 14 & 15; 48 O/6, 7, 8 , 10,11 ,14 & 15. The study reveals that most of the landslides are shallow (<2m depth) debris slides/slumps with the height of the cut slope as well as the inclination playing a major role in triggering the slides as the slides are confined to cut-slopes between the Crown to Toe of the slope. The study also reveals that majority of the slides are restricted to the cut slopes having more than 10m elevation and quite a steep slope angle varying between 70° and 90^{0}. The relative relief from the cut-slope has also been low to moderate varying between 5m to 20m at all sections with relatively a heavy overburden varying from 0.5-10m. The following Ghat sections (SH and NH roads and main district roads) were covered recorded 18 landslides on NH-17 Karwar-Ankola road section, 15 landslides on Ankola- Kumta road section, 47 landslides on SH-69 Kumta-Sirsi road section, 11 landslides on SH-93 Sirsi- Siddapur road section, 38 landslides on SH-48 Kumta-Siddapur road section.

A detailed site specific study and post disaster study of the Karwad Landslide, Karwad taluk, Uttar Kannada was taken up by (K.V. Maruthi et. al, 2012) during the F.S. 2010-12 to understand of the slide characteristics, causative factors of landslide & suggested the remedial measures and similar investigation was carried out in Sasanwad Village, Karwar Taluk, Uttar Kannada district in June 2010 where landslides have occurred at about 3 km NW of Karwar .

During the F.S. 2012-13, the landslide inventory along the road-sections of the Western Ghat in North Goa and South Goa districts covering parts of Toposheet nos. 48 I/2 & 4; 48 E/13,14 & 15 along NH-17 road section was carried out. Slides recorded are shallow (<2m depth) debris slides/slumps The study also reveals that majority of the slides are restricted to the cut slopes having 5- 15m elevation and quite a steep slope angle varying between 700 and 900 at all sections with overburden varying from 0.5-4.0m (K.V. Maruthi et. al, 2013).

III. LANDSLIDE INVENTORY

3.3 Spatial distribution of landslides:

In order to implement the proposed action plan of NDMA on Landslide Hazard Risk Mitigation it is proposed to take up landslide inventory of Karnataka state as a precursor to the Landslide Hazard zonation and risk evaluation of the hilly terrains of Western Ghats. Landslide occurrences along the NH-17 running all along Toposheets no. 48J/1, 48J/2, 48J/6, 48J/7, and 48J/8 of the study area are mapped and recorded in landslide inventory datasheets, majority of the slide occurring in the area are shallow debris slides occurring on highly weathered rock, loose lateritic soil, saprolite and lithomarge. Intense weathering and development of pore pressure due to water percolation and saturation along weaker planes resulted in loss of shear strength and cohesion of slope forming material leading to slope failure. Majority of the slides are recorded on hill slope near river/major drainage. The landslide incidences all along NH-17 shows perfect evidence of slope failure due to intense slope cut for infrastructure and development activity resulted in rock/debris fall and slides. The granitic hills of Karwar coast are also posing potential landslide problems. The massive granitic rocks known as Karwar Granite occurring all along NH-17 covering toposheet no. 48J/1 are of fractured type having ample pockets and cracks with trapped soils. Heavy rainfall acts as triggering cause for landslide hazards in such hills. Pediment cutting and quarrying add to the risk factor. The large dimension rotational debris slide at karwad village is recorded that has posed causality in past. The overburden i.e. slope forming material in the entire study area is predominantly weathered rock, laterite and lateritic soil.

2 major debris slides are recorded at Kadwad village area, 3 slides one rock fall of larger dimension and other rock cum debris slide and third of debris slide within 100 m range are recorded on denudational hillslope at Sasanwad village area nearly 3 km NW of Karwar town and 1 km NE of Shejwad village, the possible cause for the landslides identified are the unfavourable joint pattern, seepage along voids in joints, poor drainage at toe part leading to planar failure along joints of the modified unstable slope. 2 debris slides are recorded at Mudarali, 6 debris slides are recorded at Baithkol, 1 debris slide are recorded at Arga village area. Total 10 debris slides are recorded at Mashen, Lolien, Peden, and Agasgalli village area in South Goa part of T.S no. 48J/1, all the slides recorded are shallow translational and

rotational debris slide occurring on laterite and loose lateritic soil on lowly dissected hillslope where slope is modified for settlement and road construction.

Based on field studies majority of the slides occurring along NH-17 from Kumta to Honavar in parts of T.S. no.48J/7 are vertical cut slope failures of vertical height of 5-10 m and >10 m made on mid slope for road widening purposes. Suitable remedial measures are suggested based on geoscientific causes for the slope failure. Total 10 debris slides are recorded along NH-206, 6 debris slide/slump at Murur, Urkeri, Kudbali village area near Haldipur; all the slides are shallow rotational vertical cut slope failures that are identified as risk prone slide susceptible zones.

2 debris slides are recorded at Aghanasani village area in part of T.S no. 48J/6; the slides recorded are shallow debris slide occurring on laterite and loose lateritic soil of >10m overburden thickness. Total 5 debris slides of large and small dimensions are recorded in and around Tadri village area of toposheet no.48J/6 and geoscientific causes for the slides are slope destabilization due to anthropogenic activities.

4 debris slides of shallow translational to rotational failure are recorded in Apsarkonda village area in parts of toposheet no. 48J/8. Although at few places retaining wall are constructed with weep holes for proper drainage to avoid failure due to water saturation and slope stabilization still the area is under high risk zone having settlements in downslope. At many places short term remedial measures are adopted for avoiding causalities where vertical cut slope is stabilized by grading the high height retaining wall.

3.3.1. Landslide along the road sections:

1. Landslides recorded along NH-17 Karwar-Ankola road section:

Total 18 landslides are recorded along 29 km stretch of the ghat section. The majority of slides were found to be debris slides and slumps caused mainly due to tampering of the natural slope for road construction. The slides are shallow debris slide with less than 2m depth. The general slope angle varies from 25° to 35°. The slopes are moderately vegetated. The overburden thickness varies from 1-5m and consists of soil and weathered rock. The cut slope angle is 70° to 80° with vertical cut of 10-15m. Geologically, the area comprises of weathered granite. The vertical cut slopes for road construction have increased the instability of the hill slopes. The loose and non-cohesive material formed due to prolonged weathering failed due to increase in pore water pressure during heavy rain during monsoon.

a) Location: The slide is located at latitude 14°26′40.21″N and longitude 74°26′57.11″E lies in Survey of India Toposheet no. 48J/7 along NH-17 road section.

Slide Description: The slide is classified as composite slide, which is shallow rock cum debris slide/fall. The overburden material consists of weathered rock and laterite and the upslope gradient is low. The geoscientific causes of slope failure are the seepage along closely spaced joints and the basic dyke body is concordant with granite rock. So, planner faiure along joints are seen. The head part in present condition is metasatble. The prolonged weathering and rainfall is the triggering factor for the slide. The overburden type is laterite and weathered granite rock with overburden thickness of 4.5m. The rock has three sets of joints E-W, N-S, N30°E. The dimension of the slide is 40m length, 16m width, run out distance 40m and height of 4.5m. The slope angle varies from 20°-25°. The slope forming material consists of unconsolidated weathered granite. The geological set up of area shows that the basic intrusive body is underlain on granite. The sliding surface indicates rotational as well as planner failure along joint. The slide is progressive, enlarging and widening in nature.

Causes: Unscientific way of cutting of slope and removal of material for construction by local people. Unfavourable orientation of joints in rocks has lead to slope failure.

Remedial measures: Slope gradation is required for slope stabilization.

Remarks: Though the slope failure is anthropogenic but rainfall is the triggering factor for the advancement of slide that may lead to loss of life, livestock and property.

b) Location: The slide is located at latitude 14°26′22.78″N and longitude 74°25′54.63″E lies in Survey of India Toposheet no 48J/7 along NH-17.

Slide description: The slide is classified as a shallow debris slide/fall. The debris consists of boulders/chunks of laterite and loose lateritic soil occurring on denudational hillslope covered with dense scrub. The underlying rock type is granite which has undergone prolonged lateritization leading to the formation of laterite. The slided area has an overburden type is laterite and weathered granite rock and lateritic soil with thickness of 8-10m. The head condition is metastable due to unscientific way of cutting of slope and removal of material for construction by local people. The slide is 22m length, 23.2m width, run out distance 40m and height of 5.5m. The slope amount varies from 20°-25°.

The sliding surface indicates rotational failure of slope. The slide is enlarging and widening in nature.

Remedial measures: Laterite quarry is in progress the vertical cut slope should be made gentle i.e. slope modification is required further benches should be made for prohibiting unconsolidated material from falling downslope.

Remarks: Though the slope failure is anthropogenic but rainfall in near future will be the triggering factor for the advancement of slide that may lead to loss of life, livestock and property. Settlement and building nearby is in risk zone as the slope direction is towards the road.

(c) Location: The slide is located at latitude 14°28′49.06″N and longitude 74°26′16.08″E lies in Survey of India Toposheet no. 48J/7 along NH-17.

Slide Description: The slide is classified as a shallow debris slide/fall. The debris consists of boulders/chunks of laterite and loose lateritic soil occurring on denudational hillslope covered with dense scrub. The underlying rock type is granite which has undergone prolonged lateritization leading to the formation of laterite. The slided area has an overburden type is lateritic soil with thickness of nearly 12 to 13m. The head condition is unstable due to unscientific way of cutting of slope and removal of material. The slide is 34m length, 53m width, run out distance 28.5m and height of 4.5m. The slope amount varies from 20°-25°. The slope forming material consists of unconsolidated weathered granite. The sliding surface indicates rotational failure of slope. The slide is enlarging and widening in nature.

Remedial measures: Retaining wall of 8 m height and 69m width made of dimension stone of basic dyke body has been constructed for the stabilization but the slide has occurred on road above the retaining wall needs stabilization. Benches should be made after slope gradation at shorter interval i.e. more no. of benches of lesser vertical height should be made for overburden support for slope stabilization on vertical road cut surface. On benches anchoring grasses should be grown to hold the loose unconsolidated material from sudden failure.

Remarks: Though the slope failure is anthropogenic but rainfall in near future will be the triggering factor for the advancement of slide that may lead to loss of life, livestock and property.

d) Location: The slide is located at latitude 14°30′48.56″ N and longitude 74°24′40.02″ E in Survey of India Toposheet no. 48J/6 along NH-17.

Slide description: The slide is classified as a shallow debris slide/fall. The debris consists of boulders/chunks of laterite and loose lateritic soil occurring on denudational hillslope covered with dense scrub. The underlying rock type is granite which has undergone prolonged lateritization leading to the formation of laterite and lateritic soil. The overburden type is lateritic soil with thickness of nearly 12 to 13m. The head condition is unstable and cracks are very much prominent. The width of slide is about 49m. The slope angle is 20°-25°.The sliding surface indicates rotational failure of slope along weak fractures and cracks. The slide is single, enlarging and widening in nature.

Causes: Anthropogenic, the vertical cut is made for the road construction for infrastructure and development activities. The modified slope that is vertical without gradation of slope has leads to vertical road cut failure along the weaker planes i.e. along fractures and cracks.

Remedial measures: Benches should be made after slope gradation at shorter interval i.e. more no. of benches of lesser vertical height should be made for overcoming overburden that can fail by its own weight suddenly due to slope instability. On benches anchoring grasses should be grown to hold the loose unconsolidated material from sudden failure. Although the vertical cut slope is stabilized by making benches.

Remarks: Though the slope failure is anthropogenic but rainfall in near future will be the triggering factor for the advancement of slide that may lead to loss of life, livestock and property.

2. Major Landslides recorded along NH-206 and Honavar road section:

The majority of the slides were found to be debris slides. The slides are shallow with less than 2m depth. The general slope angle varies from 25° to 35°.The slopes are moderately vegetated. The overburden thickness varies from 1-5m and consists of soil and weathered rock. The cut slope angle is 70° to 80° with height varying from 2-15m. The cut slopes have failed due to heavy rain in the ghat section during monsoon. Geologically the area comprises of weathered granite, gneisses and laterite.

3. Landslides recorded along Kumta to Murur road section:

The majority of slides are shallow debris slide on lowly dissected hillslope having sparse vegetation and moderate vegetation cover. The slope failure in the area is anthropogenic due to slope modified for the construction of road and unscientific way of removal of material that has lead to instability of the slope. The overburden thickness is 5-10m and material involved is laterite and lateritic soil.

4. Landslide recorded in Karwad village Area:

Location: The landslide is located at Kadwad village (14º50′35.6″N latitude and 74º10′ 36.4″E longitude in toposheet no. 48J/1) nearly 6 km northwest of Karwar.

Slide description: The slide is deep seated (depth of failure > 20m) nature of rotational debris slides. The maximum length reported is 270m, width 80m and depth 10m, so classified as classified as a 'Large slide' (>20,000 sq.m area) and as per the rate of movement, the slide was also classified as a 'very fast slide'. The litho-unit exposed at the site is mainly laterite (as capping) over granite. The laterite is vesicular in nature with tubular cavities. The granite is mostly weathered. The ferruginous/lateritsed soil and lithomarge clay are the other litho-constituents. The slope angle is more than 40° and cut slope angle is very steep (>80°), unstable slope condition might have resulted in slope failure.

Remedial measures: Gradation of the slope is required and benches should be made for stability. Apart from this, plantation on slope is suggested for anchoring unconsolidated loose material on slopes from sudden fall during rainy season.

Remarks: The railway track is situated very close to the slide area, if remedies are not adopted effectively, still the chances of slope failure can't be neglected as the area is under unstable zone and risk is for loss of life and property.

5. Landslide recorded in Sasanwad village Area:

Location: The Sasanwad landslide site (latitude 14º49′19.63″N and longitude 74º10′17.83″E) confined to Survey of India Toposheet No. 48J/1 is nearly 3 km NW of Karwar town.

Slide description: As per observation, the Slide No-1 is a 'Rock fall' wherein both planar and wedge failures are noticed. The planar failure appears to have occurred along the joint trending N70^{0}W dipping 20^0 towards NE. The wedge failure appears to have occurred along intersect of joints N50°W/ dipping vertical and N40^{0}E/dipping 78^{0}NW. The Slide No-2 is a 'Composite slide' wherein both 'Rock fall' and 'Debris slide' are seen. The planar failure might have occurred along the joint trending N50^{0}W/dipping 45^{0}NE. The high rainfall might have enabled removal of the weathered material along these planes by infiltration and the fluid might have acted as a lubricant causing reduction in the resisting force, resulting in slope failure. The Slide No-3 classified as a 'Debris slide' and the planar failure appears to have occurred along the joint trending N55^{0}W/ dipping 42^{0}NE.

Remedial measures: Rock bolting for the exposed rocks with wire mesh. Gradation of crown part required.

Remarks: Construction of retaining structure at toe has been done. Drainage at toe part is done.

6. Landslide recorded in Urkeri village Area:

Location: The slide is located at latitude 14°23′22.27″ N and longitude 74°25′54.15″ E lies in Survey of India toposheet no. 48J/7 at Urkeri village nearly 4.5km from Kumta road (NH-17).

Slide description: The slide is classified as shallow Debris slide leading to rotational failure of slope. The overburden material consists of laterite and loose lateritic soil and the upslope gradient is low. The geoscientific cause of failure is has perfect evidence of anthropogenic causes that has lead slope modification for settlement and road construction. The railway line passing by has definitely has set instability. The vertical cut made is >10m. The crown of 8.5m in present condition is metastable and the runoff distance is 21.2m. The area 122m from slide location is marked as highly unstable zone. The slide is enlarging and widening in nature.

Causes: Unscientific way of cutting of slope and removal of material for settlement and construction purposes.

Remedial measures: slope gradation is required for slope stabilization.

Remarks: Though the slope failure is anthropogenic but rainfall in near future will be the triggering factor for the advancement of slide that may lead to loss of life, livestock and property. The settlement at down slope must be removed to prevent the casualty, in past two houses were submerged in the debris reported by localite.

3.3.2 Slides on Natural Slope

As per the landslide incidences on the study area is concerned, majority i.e. more than 95% of the slides are anthropogenic, occurring on modified natural slope , the vertical extensive cut slope of 70°-90° has failed due to slope instability and triggered by rainfall and weathering phenomenon. Geomorphologically, the area is relatively hilly terrain with reserved forest whereas the western margin is a coastal plain adjoining the Arabian Sea, whereas narrow valley plains are associated with dissected hill slope. Low lateritic, flat-topped hills and plateaus, not exceeding 100 m are feature of the southern coast of Kumta, Honnavar and Bhatkal taluks. The area has natural slides at few places basically due to nala erosion. The spatial distributions of natural slides in the area are described below:

(a) Location: The slide is located near Binaga on NH-17(T.S. no.48J/1) at latitude 14º46′ 15.8″N latitude and 74º08′10.4″E longitude.

Slide Description: The slide is classified as a shallow debris slide leading to rotational failure. The debris consists of boulders/chunks weathered rock and loose soil soil occurring on denudational hillslope covered with dense scrub. The underlying rock type is granite /granitoid. The head condition is metastable due to unscientific way of cutting of slope and removal of material for construction. The slide is 15m length, 19m width, run out distance 10m and height of 5.5m. The slope amount varies from 20°-25°. The sliding surface indicates rotational failure of slope. The slide is enlarging and widening in nature.

Remedial measures: As per the ground condition it seems that the slope failure at initial stage was anthropogenic due to excavation and excavation later stage the rainfall induced further weathering due to the seepage and widening of gaps within the joint planes and weak fracture zone that thas intiated slide of such nature.

Remarks: Though the retaining wall with draining holes of 1-2m is constructed at toe parts are made for providing proper drainage at toe part still for long term remedy the height of the retaining wall should made high with respect to the vertical slide and volume of debris if fails. Futher at hilltop building should be removed for preventing damage.

(b) Location: The slide is present near Binaga on NH-17 (T.S. no. 48J/1) at latitude 14º47′ 31.12″N latitude and 74º06′52.10″E longitude at road diversion.

Slide description: The slide is classified as a shallow debris slide leading to rotational failure. The debris consists of boulders/chunks weathered rock and loose soil occurring on denudational hillslope covered with dense scrub. The underlying rock type is granite /granitoid. The head condition is meta-stable due to unscientific way of cutting of slope for road construction. Adjacent areas are unstable and slides are recorded. The surface is likely to fail along weaker planar joint surface facing towards the road.

Remedial measures: The high height road divider made up of highly fractured and jointed basic dyke rock may slip along widening of joints in near future by weathering and seepage along joins and fractures. So, stabilization techniques like rock bolting, netting and fencing can be done for trapping the loose boulders from falling down directly that may lead to loss of life, property and blockage of roadways. The unstable rocky diversion pillar can be removed as long term remedies.

Remarks: The unfavourable orientation of joints and sliding surface towards the road are dangerous to man and material as the roadways are busy National highway, the life line roadway for communications.

(c) Location: The slide is located at latitude 14°21′27.89″ N and longitude 74°25′05.52″ E lies in Survey of India toposheet no. 48J/7 at Svarnagadde village Kumta road (NH-17).

Slide description: The slide is classified as shallow Debris slide leading to translational failure of slope. The overburden material consists of laterite, loose lateritic soil & weathered rock, which has fallen downslope and the upslope gradient is low. The geoscientific cause of failure is has perfect evidence of anthropogenic causes that has lead to slope modification.The slide has occurred in 6-7 years back, at present it is metastable zone where material movement and advancement is in downslope direction, Total vertical height is 14.7m and crown height is 8m, crown cracks are visible.

Remarks: The settlement on the footslope of hill is at danger; though the benches are made still the zone is unstable due to human interference. The area within 140m range is highly unstable zone.

(d) Location: The slide is located at latitude 14°36′11.04″ N and longitude 74°22′49.67″ E lies in Survey of India toposheet no. 48J/7 at Kodsani village area on NH-17.

Slide description: The slide is classified as naturally occurring, deep rotational debris slide having gentle upslope. The slide is palaeo-slide induced by nala erosion, where the crown cracks are visible, the slide dimension is 44m width, height 8-10m, and runoff 30m, the overburden material consists of laterite, loose lateritic soil, saprolite which has fallen downslope. The slide has occurred in 6-7 years back, at present it is metastable zone where material movement and advancement is in downslope direction, and crown cracks are visible. The plantation on slope has contributed stabilization to an extent.

Remarks: Still the area is unstable and slope is susceptible and prone to failure if triggered by rainfall.

(e) Landslide recorded in Aghanashani river catchment Area:

The Aghanashani river catchment and the village in and around the are susceptible for failure, 5 no. of debris slide of shallow translational in nature is noticed the causes are slope modification and high degree of weathering activities on hillslope ,the overburden type is lateritic in-situ soil and weathered rock, The causes involved is anthropogenic basically slope modified for the construction. Large dimension, deep translational to rotational slide is identified in this area which is a natural slide occurred due to increased pore water pressure that has lead to weathering and erosion by naturally occurring nala in nearby area.

Location: The slide is located at latitude 14°30′15.83″ N and longitude 74°21′43.64″ E and latitude 14°30′14.78″ N and longitude 74°21′41.87″ E lies in Survey of India toposheet no. 48J/7 at Berkori village/near Kilubele village area in and around Aghanashani river catchment area.

Slide description: One large dimension and other small dimension slides are recorded. Smaller slide the vertical cut made is >10m. The crown is unstable. The area is sparsely

vegetated and the slope forming material is fractured and jointed laterite which is likely to fail during heavy rainfall by seepage along joints the width of slide is 54m. At adjacent places 14°30′14.78”N and 74°21′41.87”E, large dimension slide is recorded having crown height 6.5m , 13m vertical height, width 57.7m and 27m runout distance.The vertical profile section has laterite, saprolite and lithomarge and weathered rock. The slope is disturbed by human interferences.

(g) Landslide recorded in and around Haldipur village area:

Location: The slide is located at latitude 14°21′14.21″N and longitude 74°25′56.03″E near Holegadde village.

Slide description: The debris slide is deep translational to rotational failure. The slope forming material is laterite to lateritic soil. The crown height is 7m and crown cracks are visible, the nature of the slide is enlarging and advancing, vertical height is 15m, and the width is 64m.The sliding area is highly unstable and the downslope settlement , community hall and temple are at high risk.

Remarks: The settlement, temple and community hall should be removed to the safer site and slope treatment through plantation/afforestation are required on the slope, other way the slope angle should be modified for the stability.

(h) Landslides recorded at Apsarkonda village area:

6 debris slides are recorded at lowly dissected slope at Apsarkonda village area. The overburden thickness varies from 10-15m and material involved in sliding surface is weathered rock, laterite and in-situ soil. The failure surface is shallow rotational to translational, the slope failure is observed along the road section. 2 large sides are recorded at 14°14′12.4″N/74°26′48.81″E, where 60.4 m width and 2.5m high retaining wall was constructed. At 14°14′18.68″N/ 74°26′ 54.95″E 49.6m width and 3m high retaining wall supported with proper drainage chute are constructed as remedial measure for preventing casualties.

IV. LANDSLIDE SUSCEPTIBILITY ANALYSIS

4.1 Background

Landslide occurrence in any terrain is governed by various factors associated which are site/terrain specific so multivariate analysis is required to serve the purpose different geofactor themes are taken into consideration which includes i) Physical state of slope/slope morphometric parameters such as slope gradient, slope aspect, and slope curvature, ii) Lithology or physical characteristics of slope forming material iii) spatial variation in thickness of slope forming material/Regolith, iv) Geomorphic features, v) Geology and rock structure: orientation of planar/linear discontinuities in the rock mass in relation to topography, vi) Drainage and, vii) Land use/Landcover including road and other physical features mappable at 1:50,000 scale. Based on the estimation of above pre-disposing geofactors, the following preparatory factors and its possible factor classes are considered for preparation geofactor databases for the GIS-based analysis of susceptibility to landsliding.

4.2. Selection of preparatory factors

As per data model is concerned, some of the geofactor themes are categorical (e.g., geomorphology, aspect etc.) and others represent continuous data (e.g., slope, elevation etc.) These spatial geo-factor maps are prepared using various source data and employing different mapping techniques:

(i) Geomorphology Maps: The source data for preparation of Geomorphology map is National Geomorphological and Lineament mapping on 1:50,000 scale and Google Earth Based Satellite Imagery on 1:50,000 scale. The pre-field Geomorphology maps are validated and augmented in the field and necessary correction and updation in geomorphic features are made.

(ii) Landuse/ Landcover Maps: The source data for preparation of Landuse/ Landcover map is toposheet and Google Earth Based Satellite Imagery on 1:50,000 scale. The pre-field Landuse/Landcover maps are validated and augmented in the field and necessary correction and updation in geomorphic features are made.

(iii) Slope Morphometry Maps: The Slope, Aspect and Curvature maps are Aster DEM derived continuous data, prepared from Aster DEM data of 30m resolution on 1:50,000 scale.

(iv) Slope Forming Material Maps: The pre-field maps are prepared taking into account geomorphology, geology, and landuse/landcover maps and updated based on field observations further with the remote sensing data in inaccessible sites and geology map of the area on 1:50,000 scale and the information is substantiate by different litho-units.

(v) Regolith Thickness Maps: The maps are prepared with help of overburden thickness data collected on the field, slope forming material map and NGLM data.

(vi) Road and Waterbodies: Primary source data is topographic map sheet/Google Earth Imagery.

4.3 Geofactor Themes

The geofactor thematic maps prepared for landslide susceptibilty analysis are mentioned below:

4.3.1 Slope Morphometry (Slope, Aspect, Curvature) Maps:

Raster maps of Slope (**Plate-6**), Aspect (**Plate-8**), and curvature (**Plate-7**) are DEM derivative geofactor maps generated from Satellite data Aster DEM of 30m resolution resampled to with 50m spatial resolution using spatial Analyst/ 3D Analyst Module of ArcGIS software, all the above thematic rasters is generated.

Slope Angle Map **(Plate-6)** are classified into 5 classes; <15°, 15°-25°, 25°-35°, 35°-45°, >45° based on slope gradient, slope is deterministic geofactor class governing the failure plane. The hillslope in the area is gentle that varies between 25°-35° whereas vertical cut at places has modified the slope angle from 70° to 90°.

Slope Curvature Map **(Plate-7)** shows negative and positive curvature values that represent concave and convex upward slopes respectively which are believed to have strong spatial correlation with landslides mapped/ inventoried in an area and zero curvature shows flat surface.

Geofactor theme aspect are categorised into 12 classes namely NNE, NE, ENE, ESE, SE, SSE, SSW, SW, WSW, WNW, NW & NNW. Raster map of Aspect **(Plate-8)** are generated for analysing the Slope Morphometry .The computed aspect values is a categorical data, discretized into 12 classes using 30^{o} intervals from Aster DEM (Continuous data) of 30m resolution resampled to 50m resolution. Aspect parameter is not taken into consideration in the analysis.

4.3.2 Landuse/Landcover Maps:

Pre-field landuse and landcover map is prepared through visual interpretation of Google Earth Imagery (multi-temporal real time datasets) and validated during field traverses. This thematic map is classified into some standard land use/ cover classes (**Plate-10, Plate-11, Plate-12**). The landuse and landcover categories classified and their geographical distribution in percentage is illustrated in (**Table 2**) are as follows: Settlement (3.14%), Barren (4.28%), Sparse Vegetation (5.94%), Moderate Vegetation (17.14%), Thick vegetation (36.66%), Swamp (2.23%), Cultivation (15.11%), Quarry (0.08%), Fallow land (2.12%), Extensive Slope Cut (0.08%), Settlement on modified Slope (0.25%), Low Height Plantation (LHP) (0.003%), High Height Plantation (HHP) (5.66%), Barren sand (1.86%), Salt pan (0.95%), Water bodies (4.504%). The major flora categorised under High Height Plantation (HHP) are Coconut (Cocos nucifera), Betel Nut (Areca catechu), Eucalyptus (Eucalyptus globules) and Acacia (Acacia confuse) whereas, Cashew (Anacardium occidentale) are categorised in Low Height Plantation (LHP) are grown in Uttar Kannada District.

4.3.3 Geomorphology Maps:

National Geomorphological and Lineament Map (NGLM) of GSI and NRSC has already produced 1:50K base geomorphology map of the entire country, which is used as source maps for geomorphology theme for use in landslide susceptibility mapping as one of the categorical geofactor thematic database. The geomorphic features are mapped mostly through visual interpretation of Satellite imagery with limited field checks. The NGLM data is substantiated by reclassifying the existing geomorphic features. Detailed mapping is done to further update through adequate field validation making it more useful as an evidential layer for landslide susceptibility (**Plate-14, Plate-15, Plate-16**).

The different geomorphological features and categories identified in the area and their geographical distribution as per statistics (**Table 3**) indicates that the Highly Dissected Slope covering 11.08% of the hillslope, 24.18% of the area is covered by Lowly dissected slope, 2.029% & 0.01% of the area are Hilltop and Ridge top respectively, 0.056% of area covers Denudational slope, 29.838% area is under Pediment Pediplain complex, 0.659% of the study area is piedmont slope, Mound covers 0.307 of the study area .80% of the total study area is Valley fills, 1.96% of the area is plateau top, 10.54% area is Rolling plain , Tidal flat is 0.10% of the area ,.83% of the area is beach,

whereas 2.467% of the area is coastal plain & 10.52% area is alluvial plain. Waterbody (river, reservoirs) contributes 4.67% of the total area mapped.

4.3.4 Slope Forming Material Maps:

Another important categorical data is the geofactor theme is the slope forming material which categorizes areas into discerning types of material occurring on slope, starting from exposed different litho-units and overburden material. The primary source maps used for the preparation of such slope forming material map are 1:50K Geology Map, 1:50K Geomorphology maps, Landuse/ Landcover and Slope maps. The field-based knowledge/ inputs on characteristics of exposed rock masses, their weathering details, types of overburden material, depths etc, are then combined with the above source maps and subsequently, a slope forming material map can be derived as an important geofactor thematic map for use in the landslide susceptibility analysis.

Since, on macro scale (1:50,000), it is generally difficult to classify susceptibility maps solely based on landslide types (e.g., debris and rock slides), the preparation of such a detailed and classified slope forming material map and use the same as an input thematic map in the landslide susceptibility analysis instead of using general geology map would always be highly relevant. In the above exercise, all the source maps are used as proxies because the spatial distribution of soil/overburden and its thickness is controlled by erosion processes and slope morphometry. Using landforms as proxies, we first prepared a subjective soil/overburden thickness map, since those proxies can easily be mapped on 1:50,000 scales using remote sensing data. Then the same is modified further using thickness data obtained from the field. In the study area the slope forming material classes are identified as in-situ soil, weathered rock, rock, transported soil and alluvium (**Plate-17, Plate-18, Plate-19**).

4.3.4 Regolith Thickness Maps:

The Regolith Thickness map is prepared on the basis of field observation in the study area.The variation in the thickness of soil/regolith was observed to be very erratic. Regolith, here, means material (in-situ or transported), including soil and weathered mass, lying over the fresh country rock. The thickness depends on a large variety of factors, one important being the local variation in terrain morphology; and therefore prediction of the thickness of regolith over a large area is extremely difficult. Ideally, for thickness

modelling, a large number of observations (such as drill holes, outcrops or geophysical measurements) are required. However, at a catchment scale, this approach is difficult to implement. Given the above limitations, Regolith thickness map was prepared based on field observations and value judgement. Assessment of depth of regolith at different sites was made by studying the exposures along the road, streams, landslide scars and from bore holes/well. The overburden thickness varies from <0.5m, 0-5m, 5-10m, 10-15m. Majority of the debris slides are occurring where overburden thickness is 5-10m and 10-15m (**Plate-20, Plate-21, Plate-22**).

4.3.5 Structure and Drainage

Structures, particularly joint and fracture play an important role in defining distribution of landslides. The presence of joint and their orientation has large influence in causing landslides particularly the rock failures during rainfall. The seepage along weaker planes builds pore pressure resulting in shattering of rocks such sliding surfaces are highly prone to failure. Concerning geohydrological parameters, the different order of streams are extracted and classified as first st order, second order and higher order streams from Aster DEM data of 50m using Strahler's (1957) ordering system. It is observed that 1st order streams cause only limited erosion including shallow landslides. So, drainage is not considered as significant parameter for landslide susceptibility mapping (Plate-9). Drainage map is extracted from Aster DEM data (50m resolution). Different order of streams i.e. 1^{st} Order, 2^{nd} Order, 3^{rd} Order and 4^{th} Order streams are extracted in GIS platform using spatial analyst tool.

4.4 LANDSLIDE SUSCEPTIBILITY ANALYSIS

Landslide susceptibility is a quantitative or qualitative estimate of the spatial distribution of landslides, which exist or potentially may occur in an area. Although it is expected that landslide will occur more frequently in the most susceptible areas, however, in the susceptibility analysis, no time frame and magnitude of event are explicitly taken into account. A susceptibility map therefore gives only the qualitative or quantitative estimation that the mapping unit (e.g., a pixel, slope unit or facet) will be affected by a future landslide. "Landslide Susceptibility Analysis" is carried out on the basis of AHP

method for spatial prediction of landslide-prone areas and the final susceptible map of the area is demarcated or classified as low, moderate and highly susceptible areas where likelihood of landslide occurrences in near future is expected.

4.4.1 Methodology

Due to the certain limitation/constrain in present ground condition and lack of sufficient landslide datasets for data driven modelling in such a situation empirically derived terrain-specific ratings and weights can pose problems. Hence, Analytical Hierarchy Processes are considered useful for the preparation and generation of landslide susceptibility map.

Different methods of predictive mapping of landslide susceptibility are adopted because landsliding has complex interactions with several geo-environmental spatial factors. The cardinal aim of landslide susceptibility mapping is to identify locations where future landslides are likely to occur, based on the fundamental assumption that spatial factors that caused present and past landslides are likely to cause similar landslides in the future. Several knowledge-driven (heuristic) and data-driven or empirical methods of mapping landslide susceptibility are available in the literature which make use of indirect or direct spatial relations between landsliding of a certain type and relevant spatial factors.

Knowledge-driven/ Heuristic methods of landslide susceptibility can either be direct or indirect. In indirect heuristic methods, individual factors are assigned specified weight values or ratings that are solely based on subjective criteria (Hansen, 1984; BIS, 1998). In the latter method, specified factor weights are considered regardless of the existing landslide inventory maps and variations in terrain conditions. The use of unique weight values for the factor in different geomorphological/geological environments. However, the most important aspect of any predictive mapping is the validation. Validating the landslide susceptibility maps by mere physically overlapping the landslide incidence map over landslide susceptibility map is only trivial and cannot quantitatively assess the actual performance of any predictive model. Predictive modelling of susceptibility to landsliding aims to make an estimate at every location in a study area of the future occurrence of such landslides based on known occurrence of landslides. The analysis thus assumes that the relations between spatial factors and past landslides are relevant to the occurrence of future landslides. Therefore, to effectively model the landsliding phenomenon, landslide

incidences, controlling geofactors, their mutual importance in influencing landslides is taken into account.

Methodology of landslide susceptibility mapping is divided into the following main themes:

- **Identification and preparation of its landslide inventory database and maps in GIS:** Landslides, its types and failure mechanisms are the basic and fundamental parameters required by any analyst for carrying out landslide susceptibility analysis. For this, availability of a complete landslide inventory in an area is a prime pre-requisite. To accomplish this task, landslide inventory mapping using all sorts of available and past source information such as archival data, old maps/ reports, very high-resolution remote sensing data and adequate fieldwork are carried out and landslide inventory database is generated and landslide inventory map is generated.
- **Role of geofactors in landsliding and preparation of its related GIS-based database.**
- **Empirical selection or spatial association analysis between various geofactors and landslides for determining both ratings of factor classes and weights of the geofactor themes:** Several empirical techniques are available in the literature for selection and weighting of geofactors using landslide inventory data through which spatial association analyses between prevalent landslides and different types of geofactor maps are carried out in a GIS. The purpose of accomplishing such quantitative spatial association analyses in any predictive modeling of landslide susceptibility is to select and use only the good predictors, which are the spatial geofactors that exhibit positive spatial associations with existing landslides. After selection of such predictors, the next step is to objectively determine their inter-predictor weights and then combine the selected predictors with their weights in a suitable susceptibility model like Weighted Multiclass Index Overlay
- **GIS-based modeling for integration of selected and weighted geofactor maps for preparation of landslide susceptibility scores, validation and classification of landslide susceptibility score maps into qualitative maps showing varying degree of landslide susceptibility.**

4.4.2 Selection of mapping unit

After the selection of appropriate preparatory factors, the next step was the selection of mapping units for the GIS based susceptibility analysis. The 1376 km^2 study area was converted into an equal-area grid by rasterizing the geofactor vector map using a 50m ×

50m pixel size. The Dem derivative maps are extracted from Aster DEM of 30 m resolution resampled to 50 m resolution for the overlay analysis of different thematic maps. Therefore, in this work, a pixel was selected as the basic mapping unit for the susceptibility modelling so, that the smallest landslide can be represented by a single pixel of 50m × 50m resolution.

4.5 Methods of Susceptibility Analysis

The flow diagram (**Figure-1**) showing the methodology followed in the current study for calculation of factor class ratings and inter-predictor weights of factor maps using pairwise comparison matrix developed by Saaty, 1977.

1. **Analysis for selection and weighting of geofactors (heuristic/ knowledge-driven AHP method)**
   a. Empirical landslide-dependent analysis for determining terrain-specific ratings and weights of geofactors.
   b. Analysis and discussion about spatial association between each geofactor and observed landslides in the study area.
2. **Data integration and landslide susceptibility mapping**
   a. Data integration procedure - e.g., Weighted Multi-class Index Overlay.
   b. Data validation.
   c. Classification and preparation of qualitative landslide susceptibility maps.
   d. Usability of landslide susceptibility maps and information with specific recommendations.
3. **Data Modelling using Analytic Hierarchy Process (AHP):**

   The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making approach and was originally developed by Prof. Thomas L. Saaty (1977). It is an effective tool for dealing with complex decision making, and may aid the decision maker to set priorities and make the best decision. By reducing complex decisions to a series of pair wise comparisons, and then synthesizing the results, the AHP helps to capture both subjective and objective aspects of a decision. In addition, the AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thus reducing the bias in the decision making process. The Analytical Hierarchy Process-AHP provides measures of judgement consistency, derives priorities among criteria and alternatives, and simplifies preference ratings among decision criteria using pair wise

comparisons to establish priorities among the elements to obtain the set of overall or weights for achieving, evaluating and checking the consistency of judgements.

4. Classification of the Landslide Susceptibility Map into High, Moderate and Low Susceptible zones.

The basic procedures followed are described below:

1. Develop the ratings for each decision alternative for each criterion by • developing a pair wise comparison matrix for each criterion • normalizing the resulting matrix • averaging the values in each row to get the corresponding rating • calculating and checking the consistency ratio.

2. Calculate the weighted average rating for each decision alternative and choose the one with the highest score.

Step 1: Pair wise comparison matrix

The criteria in the row are being compared to the criteria in the column.

Step 2: Normalization

This step is to normalize the matrix by totalling the numbers in each column. Each entry in the column is then divided by the column sum to yield its normalized score. The sum of each column is 1.

Step 3: Consistency analysis

Now, calculate the consistency ratio is calculated and value is checked. The purpose for doing this is to make sure that the original preference ratings were consistent

There are 3 steps to arrive at the consistency ratio:

1. Calculate the consistency measure
2. Calculate the consistency index (CI).
3. Calculate the consistency ratio (CI/RI where RI is a random index).

$$\mathbf{CI = \lambda max - n / n - 1}$$

$$\mathbf{CR = CI / RI}$$

To calculate the consistency measure, we can take advantage of Excel's matrix multiplication function = MMULT()

Approximation of the Consistency Index

1. Multiply each column of the pair wise comparison matrix by the corresponding weight.
2. Divide of sum of the row entries by the corresponding weight.
3. Compute the average of the values from step 2, denote it by λmax.
4. The approximate CI = λmax - n / n – 1

Consistency Ratio (CR)

CR = CI / RI

Random Index (RI)

The CI of a randomly-generated pair wise comparison matrix

n	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.46

Notes: n = order of matrix, Random inconsistency indices for n = 10 (Saaty, 1980)

In the AHP method, the scale range 1–9 is assumed. The standard preference scale was used by Miller is as follows:

Preference Level	**Numerical Value**
Equally Preferred	1
Equally to Moderately Preferred	2
Moderately Preferred	3
Moderately to Strongly Preferred	4
Strongly Preferred	5
Strongly to Very Strongly Preferred	6
Very Strongly Preferred	7
Very Strongly to Extremely Preferred	8
Extremely Preferred	9

1. The calculation of the ratings for each factor classes and weights of each factor maps was performed in excel. Based on pair wise matrix comparison of each factor class for all geo-factor thematic maps, calculation of Eigen values, fraction rate values and Landslide Occurrence Favourability Score (LOFS) rating was obtained.

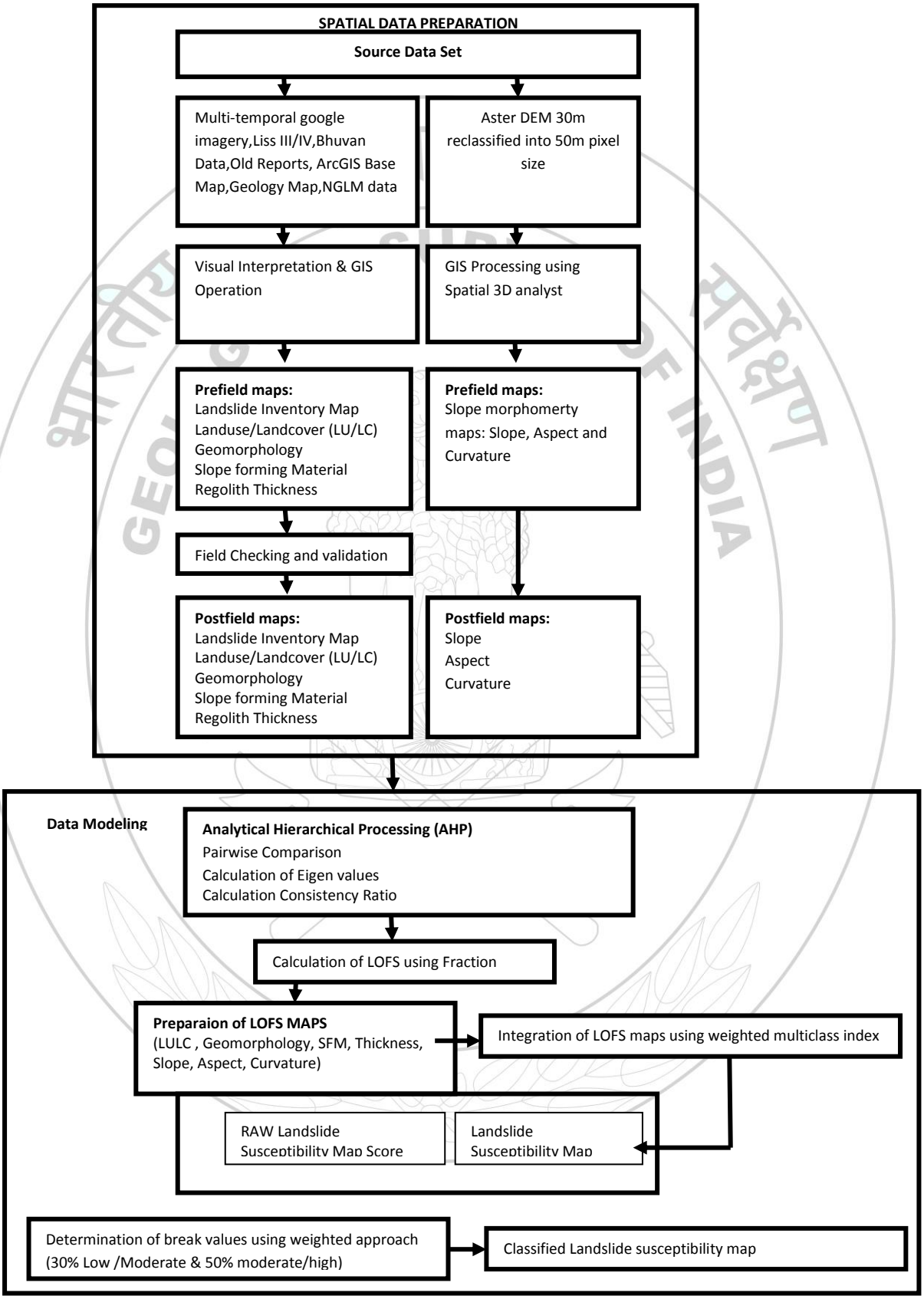
2. **Table 4 to Table 9** provides the calculated LOFS ratings of all classes of six geo-factor thematic maps. The excel table is joined with the factor maps using "Table Join & Relate" function in Arc GIS.

3. Using the “Lookup” function in Reclassify tool of Arc GIS, LOFS rating map was generated for each thematic geo-factor maps, showing the spatial distribution of LOFS values.

4. Using “Map Algebra” function of Spatial Analyst Tool in Arc GIS rating maps were combined together to obtain landslide susceptibility score maps.

5. Classification break values were determined on the basis of logic of providing mutual comparison expert-driven ranking to sub-divide the score map. Considering rank value of ‘5’ in a scale of ‘0 to 9’ has higher likelihood in influencing landslides which comes after 50% of absolute difference values, similarly rank value of ‘≤3’ has least likelihood in influencing landslides comes after 30% of absolute difference value. Hence, 50% cut-off margin or weightage was used to determine the break raster value between “Moderate” and “High” susceptibility classes, while 30% cut-off margin or weightage was used between “Low” and “Moderate” susceptibility classes.

Figure-1: Flow diagram showing methodology for Landslide Susceptibility Mapping



V. LANDSLIDE SUSCEPTIBILITY MAP

5.1 Susceptibility Maps

The Landslide Susceptibility maps (**Plate-23 to Plate-26**) of Toposheets no. 48J/1, 48J/2, 48J/6, 48J/7 and 48J/8 in parts of Uttar Kannada district, Karnataka are generated using Weighted Multiclass Index Overlay method of data integration and AHP based mathematical modeling. The susceptibility is expressed in terms of the knowledge driven method based on weightage assigned and rating of the geofactor classes and geofactor maps under the given geo-environmental conditions. About 93.30% of the areas are grouped in low susceptibility class, 6.64% of the areas are grouped in moderately susceptible class and .06% areas are grouped in highly susceptible class. The susceptibility map in general indicates that the road cut section, quarry section and toe parts of hillslope are moderately susceptible, whereas the high susceptible area is steep mid slopes.

The susceptibility map indicates that the area in and around Shelli, Mashen, Mobar Karai, Borus, Tamanen, and Jadigadde near Konkan raiway line of toposheet no. 48J/1 on Lowly dissected foot slope is identified as meta-stable and moderately susceptible zone. The denudational hill in karwad village area is demarcated as highly susceptible zone. The area all along NH-17 from Ankola-Kumta road section are slide susceptible zones. The slides are rock and debris slide of progressive nature.

In parts of Toposheet no. 48J/6 in Harvada village area on NH-17, Navgadde, Agsur, Badigon on NH-63 (Ankola-Yellapur road) are moderately susceptible zone. Kogre, Hichkad, Belshe, Hegre, Sagadgiri village area adjacent to river are moderately susceptible zones. The areas along Konkan railway track on other side of NH-17 in and around Belshe are demarcated as moderately susceptible zone. Belamber area at coast is moderately susceptible zone. The area in and around Torke, Hegle village are slide prone area identified as moderately susceptible zone. The area in and around Kagal and Aghnashani village area are weathering prone area surrounded by Aghnashani river, the catchment area is vulnerable zone hence the area is moderately susceptible. The Karmane Gudda is moderately susceptible zone due to Konkan railway track is constructed by cutting the toe part of the hillslope. Guddadevara Betta, in and around Harvada areas north of Ankola are also moderately susceptible to sliding. Kattinakkal at north-eastern parts of toposheet no. 48J/6 are demarcated as moderately susceptible zone. About 2 km south of Bargi, the area is identified as moderately susceptible zones on either side of NH-17 and Konkan Railway track. Moderately susceptible area is delineated towards NNE of Ankola along NH-63 (Ankola-

Yellapur road) in and around Navgadde and Sitegadde village. In south eastern part of topposheet no. 48J/6 Kadakoda, Gundabala, Arulu, Boli village areas are moderately to highly susceptible zone.

In parts of toposheet no. 48J/7, the area in around Divgi, Mirjan, Antravalli, Murur, Kallabbe, Aralli, Baskeri, Upple Gudda, Kodigadde, Habgaleti, Kelginkeri area in the central part, Sokkanmakki, Chitrag 2.3 km from Kumta, Malarmakki, Bangarmakki, Mugve, in and around Baskeri is moderately susceptible to sliding, whereas isolated places in and around Haldipur, Swarnagadde, Holegadde, Urkeri village and NH-206 are moderately susceptible zones. Remaining areas are almost stable. Majority of the slide are shallow rotational debris slide where the overburden and rock masses are laterite and lateritic soil; however the area having weathered rock and in-situ soil as slope forming material has undergone translational slope failure. The sliding area has overburden thickness of >10m.

The area around Apsarkonda, Kelagnur village in NW part and Hebbarhittal, Melin Idgubji, Kelagin Idgunji in NE part of Toposheet no. 48J/8 and south of Manki on NH-17 are moderately susceptible to sliding as the area has undergone prolonged weathering and the hills are of denudational in nature. Plain areas are low susceptible zone. Mavinasag Betta, north of Bailur and Bedarkere village are moderately susceptible whereas few places at the hill slope are highly susceptible and demarcated as unstable zone.

The investigation in the area reveals that causes of the landslide are anthropogenic where natural factor plays a role for landsliding. The slides are advancing, widening and progressive in nature. Instability of any slope increases over a period of time due to various factors like rainfall, slope modification (road cut for infrastructure and development activities), Quarry, quality and density of slope forming material, weathering depth and conditions, ground water table variation etc. affecting independently or simultaneously. Rainfall in an area is a triggering factor that decreases the normal shearing resistance because of increase pore water pressure due to water saturation causing slope failure. Extrinsic fators responsible for sliding surface are surface erosion, weathering, water percolation and saturation along the cut slope and crest loading. Intrinsic factors responsible are loose in-situ soil, and moisture content.The slides are enlarging and progressive, the instability propagates sideways parallel to the slope contours. The instability propagates upslope even in retrogressive slide. Progressive failure that starts at the top of slope and progress downward and retrogressive slide failure that starts at the base of a slope and retrogress upward are observed in study area at several landslide locations.

VI. CONCLUSIONS AND RECOMMENDATIONS

1. More than 98% of the slides are shallow rotational debris slide of overburden thickness <5m with slope angle 15°-35° and vertical cut of slope angle 70°-90°.
2. The slides are mainly anthropogenic and are triggered by anthropogenic activities/human interference with the natural slope. The main causes of landslides and slope failure in the study area is toe cutting of hill slope for the construction of road, modification for slope for human settlement.
3. The vulnerability of deposited low lateritic hills to landslides increases if such deposits have taken place along the river courses or estuarine regions, causing capillary rise of water from beneath and descend of rain water through fissures and holes formed by rotten tree stumps or through joints and fractures in rocks. Rainfall is a triggering factor that reduces the shear resistance of the slope forming material due increased pore water pressure leading to failure of slope.
4. The presence of highly weathered rock mass, saprolite and lithomaric clay greatly reduces shearing resistance of underlying rock units during rainy season.
5. Unscientific way of quarry, pediment cutting, toe cutting of hill slope, soil removal and stripping of vegetation destabilizes the slope, hence increases the risk. Above practices in the area has modified the natural slope for road construction, infrastructure development, human settlement, plantation and mining activities.
6. Cut slope angle and height plays a major role in all the slides. Cut slope height was included as a factor as this is found to be a major cause of the slides and the sliding events crown and toe are restricted between the cut slopes. Prograding of the slide is more towards both the flanks rather than towards back of the crown. The sliding is more in convex turns of the road than concave sections.
7. The slides occurring on laterite are rotational in nature the leading side of the first inverted wedge is created by rotational failure. Rotational landsliding dominate during the acceleration and deceleration phases when the failure zone is advancing slowly.
8. Heavy rainfall during monsoon is contributing factor favourable for intense weathering of rocks causing appreciable decrease in their shearing resistance and cohesive strength.
9. Majority of the slides observed are debris slides. Debris slides were mainly noticed in lateritic hills and plateau on Kumta-Murur road section which is having maximum number of debris slides/slumps of small cut slope height and almost vertical to sub vertical slope angle.

10. The new slides are advancing, progressive and widening in nature due to pronounced weathering and leaching activity at cut section.
11. Majority of the slides are small in dimension of the slides observed were having less than 30 m in length, width respectively. Interesting to notice that almost all slides are shallow depth with less than 2m and cut slope heights ranging between 5 m and 15 m with nearly vertical slope angle.
12. Slope forming material/overburden material consists of weathered granite or gneiss, schistose rock, loose lateritic soil are prone to sliding.
13. Majority of the slides observed have Cut slope angle and height plays a major role in landsliding. Prograding of the slide is more towards both the flanks rather than towards back of the crown.
14. The laterite quarry in the area has resulted in slope failure at exposed cut section. The high degree of water saturation and pore water pressure has resulted in formation of saprolite and lithomarge clay that has induced the failure on the sliding plane. The quarry section on lateritic hill is playing a major role in increasing the landslides incidences.
15. The indurated surface laterite is an effective shield against landslides, except when deep vertical cuts are made exposing the soft clayey soil horizon beneath.

RECOMMENDATIONS:

1. Management of drainages is not properly carried out in the study area. Blockage of drainage is observed in 60% of the slided area. Water from uphill slope may be diverted in the following ways in order to minimize sliding.

   i. Provision of contour drainage above the crown of landslides,
   ii. Catch water drains in the sections,
   iii. Inserting horizontal perforated pipes in to the slopes will act as weep holes in the vertical slopes and thus reducing the pore pressure by draining out the excess water. This is to be given at suitable interval observing the type of lithology, soil and overburden and the weathering depth.

2. Vertical cut slopes should be avoided in future to reduce the risk of sliding.
3. Retaining structures like retaining wall, stone pitching and gabion wall are recommended as per the site condition.

4. The unscientific way of removal of material for construction purposes is to be avoided. Abandoned quarry pits should be packed or depending upon the ground condition and the degree of slope modified it is recommended to make benches for slope stabilization.

5. Restoration of vegetation cover: A replanting programme should be undertaken giving priority for strong and deep rooted species which check erosion and withstand water-logging may be considered for lower slopes bordering the estuarine areas. Middle and upper slopes in landslide prone areas should be planted with tree having lower biomass but stronger and deeper root networks. High biomass trees are likely to cause the weight of the overburden precipitating slope failures in future.

6. Regulations on slope cutting and quarrying: Indiscriminate slope cuttings have to be strictly regulated and engineering solutions such as protective walls/embankments to be made where ever required.
7. Quarrying for stones and soils are to be strictly limited to the specified localities where there is no threat of landslides.

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LOCALITY INDEX

Locality Name	Latitude	Longitude	T.S No.
Adlur	N14° 40' 30.264"	E74° 23' 2.669"	48J/6
Aedophond	N14° 59' 35.231"	E74° 5' 41.776"	48J/1
Aghnashini	N14° 31' 17.387"	E74° 22' 12.630"	48J/6
Agsur	N14° 40' 31.218"	E74° 23' 43.238"	48J/6
Agsurkoppa	N14° 39' 45.925"	E74° 24' 15.573"	48J/6
Aligadde	N14° 48' 6.954"	E74° 7' 21.977"	48J/1
Alvedande	N14° 25' 9.599"	E74° 23' 53.826"	48J/7
Amadalli	N14° 45' 49.060"	E74° 13' 31.620"	48J/1
Andle	N14° 35' 29.457"	E74° 23' 4.340"	48J/6
Angadi	N14° 53' 41.681"	E74° 7' 37.904"	48J/1
Ankola	N14° 39' 21.795"	E74° 18' 14.951"	48J/6
Antravalli	N14° 28' 23.424"	E74° 28' 14.112"	48J/7
Apsarkonda	N14° 14' 13.470"	E74° 26' 46.464"	48J/8
Arali	N14° 17' 52.668"	E74° 28' 22.057"	48J/7
Arga	N14° 46' 16.913"	E74° 9' 30.593"	48J/1
Bad	N14° 49' 42.458"	E74° 8' 29.890"	48J/1
Bailur	N14° 7' 35.950"	E74° 29' 21.404"	48J/8
Baitkol	N14° 47' 52.371"	E74° 6' 35.098"	48J/1
Baleguli	N14° 41' 36.130"	E74° 18' 38.131"	48J/6
Bargi	N14° 31' 40.694"	E74° 24' 17.379"	48J/6
Baskeri	N14° 18' 7.569"	E74° 28' 56.311"	48J/7
Belekeri	N14° 42' 34.090"	E74° 16' 23.115"	48J/6
Bellur	N14° 49' 50.527"	E74° 14' 42.809"	48J/1
Belshe	N14° 37' 13.718"	E74° 20' 50.715"	48J/6
Beroli	N14° 16' 27.998"	E74° 29' 36.514"	48J/7
Bhavikeri	N14° 41' 31.335"	E74° 16' 51.661"	48J/6
Binaga	N14° 47' 11.442"	E74° 7' 42.119"	48J/1
Borus	N14° 57' 41.053"	E74° 5' 38.942"	48J/1
Chandavar	N14° 24' 0.461"	E74° 28' 43.122"	48J/7
Chendiya	N14° 46' 2.910"	E74° 11' 33.510"	48J/1
Chikkoli	N14° 25' 57.430"	E74° 25' 50.823"	48J/7
Chitragi	N14° 25' 55.989"	E74° 24' 17.966"	48J/7
Divgi	N14° 26' 54.973"	E74° 26' 24.102"	48J/7
Gokarn	N14° 32' 36.741"	E74° 19' 25.802"	48J/6
Gopshitta	N14° 54' 46.687"	E74° 12' 41.549"	48J/1
Haldipur	N14° 20' 23.223"	E74° 25' 36.248"	48J/7
Halekeri	N14° 38' 55.921"	E74° 29' 39.137"	48J/7
Harvada	N14° 44' 12.933"	E74° 16' 14.508"	48J/6
Hattikeri	N14° 43' 8.643"	E74° 17' 45.870"	48J/6
Hegde	N14° 28' 12.067"	E74° 25' 21.370"	48J/6
Hegre	N14° 35' 16.929"	E74° 19' 5.621"	48J/7
Hichkad	N14° 36' 49.342"	E74° 20' 19.054"	48J/6
Hillur	N14° 39' 38.935"	E74° 28' 19.130"	48J/6
Hiregutti	N14° 34' 0.463"	E74° 23' 27.635"	48J/6
Hirehittal	N14° 3' 24.793"	E74° 29' 56.286"	48J/6

Locality Name	Latitude	Longitude	T.S No.
Holegadde	N14° 22' 26.703"	E74° 25' 7.236"	48J/8
Honavar	N14° 16' 50.106"	E74° 26' 24.590"	48J/7
Honnalli	N14° 40' 40.645"	E74° 26' 10.206"	48J/7
Hoskeri	N14° 28' 9.547"	E74° 23' 40.710"	48J/6
Hosur	N14° 35' 48.241"	E74° 23' 1.007"	48J/7
Islampur	N14° 40' 13.748"	E74° 18' 44.872"	48J/6
Kadvad	N14° 50' 42.379"	E74° 10' 15.518"	48J/1
Kagal	N14° 30' 12.867"	E74° 21' 59.093"	48J/6
Kallabbe	N14° 26' 58.427"	E74° 29' 31.500"	48J/7
Karai	N14° 58' 0.103"	E74° 3' 36.362"	48J/1
Kargal	N14° 57' 38.958"	E74° 7' 37.517"	48J/7
Karki	N14° 18' 36.369"	E74° 27' 19.565"	48J/1
Karkimakki	N14° 26' 45.018"	E74° 27' 56.133"	48J/8
Karwar	N14° 48' 54.160"	E74° 8' 18.992"	48J/7
Kasarkod	N14° 15' 30.948"	E74° 26' 38.994"	48J/8
Katgal	N14° 28' 40.021"	E74° 29' 26.788"	48J/6
Kelagin Idgungi	N14° 14' 53.473"	E74° 28' 50.361"	48J/1
Keni	N14° 40' 14.246"	E74° 17' 15.594"	48J/6
Khotigoan	N14° 57' 24.431"	E74° 6' 14.527"	48J/7
Kodsani	N14° 36' 7.178"	E74° 23' 18.110"	48J/7
Kudehalli	N14° 27' 45.387"	E74° 29' 26.146"	48J/6
Kudle	N14° 31' 47.569"	E74° 19' 6.243"	48J/7
Kujalli	N14° 24' 22.103"	E74° 27' 21.140"	48J/7
Kumta	N14° 25' 29.985"	E74° 24' 38.194"	48J/7
Lolien	N14° 56' 39.577"	E74° 4' 13.028"	48J/1
Lukkeri	N14° 27' 47.273"	E74° 23' 56.924"	48J/7
Majali	N14° 53' 45.561"	E74° 6' 36.138"	48J/1
Makheri	N14° 49' 2.375"	E74° 9' 57.692"	48J/1
Malkod	N14° 15' 3.600"	E74° 28' 50.432"	48J/7
Manki	N14° 26' 19.710"	E74° 25' 41.925"	48J/7
Mashen	N14° 57' 39.086"	E74° 3' 13.246"	48J/1
Mastikatte	N14° 41' 12.522"	E74° 27' 40.281"	48J/6
Masur	N14° 28' 28.574"	E74° 23' 36.850"	48J/7
Melin Idgungi	N14° 13' 54.748"	E74° 29' 37.528"	48J/8
Mirjan	N14° 28' 58.629"	E74° 25' 37.392"	48J/7
Mudga	N14° 45' 13.591"	E74° 14' 22.061"	48J/1
Mudgeri	N14° 38' 13.765"	E74° 28' 49.981"	48J/1
Mugli	N14° 12' 45.672"	E74° 27' 20.815"	48J/8
Mugve	N14° 17' 36.881"	E74° 29' 0.975"	48J/7
Mundgod	N14° 31' 23.846"	E74° 20' 21.844"	48J/6
Mundrali	N14° 50' 50.955"	E74° 10' 55.658"	48J/1
Murdeshwar	N14° 5' 44.716"	E74° 29' 15.806"	48J/8
Murur	N14° 26' 27.264"	E74° 28' 26.639"	48J/7
Navayatkeri	N14° 5' 58.933"	E74° 29' 40.502"	48J/8
Navgadde	N14° 41' 19.835"	E74° 22' 12.731"	48J/6
Nilkod	N14° 29' 21.186"	E74° 27' 15.429"	48J/7
Nillkere	N14° 13' 15.478"	E74° 27' 46.024"	48J/8

Locality Name	Latitude	Longitude	T.S No.
Patnen	N14° 59' 50.292"	E74° 2' 27.016"	48J/1
Peden	N14° 56' 14.303"	E74° 4' 43.058"	48J/1
Poingunin	N14° 58' 46.391"	E74° 4' 25.735"	48J/1
Polen	N14° 58' 17.565"	E74° 3' 37.394"	48J/1
San Mudageri	N14° 54' 17.491"	E74° 7' 14.626"	48J/1
Sankoli	N14° 19' 56.311"	E74° 26' 41.963"	48J/7
Shedgeri	N14° 40' 5.377"	E74° 19' 9.970"	48J/6
Shejebag	N14° 53' 50.384"	E74° 6' 56.879"	48J/1
Shejvada	N14° 48' 42.465"	E74° 9' 31.008"	48J/1
Sheli	N14° 55' 33.706"	E74° 4' 13.721"	48J/1
Shilli	N14° 28' 14.677"	E74° 27' 33.123"	48J/7
Shingalen	N14° 59' 56.984"	E74° 3' 5.583"	48J/1
Shirur	N14° 36' 11.484"	E74° 21' 15.590"	48J/6
Shirvad	N14° 49' 20.629"	E74° 10' 22.542"	48J/1
Siddapur	N14° 49' 29.295"	E74° 10' 18.970"	48J/1
Siddar	N14° 51' 26.442"	E74° 13' 32.337"	48J/1
Sokkanmakki	N14° 25' 8.832"	E74° 25' 42.731"	48J/7
Svarnagadde	N14° 21' 26.764"	E74° 25' 8.645"	48J/7
Tadri	N14° 31' 24.622"	E74° 21' 1.684"	48J/6
Talagere	N14° 29' 1.812"	E74° 26' 16.241"	48J/7
Talagod	N14° 23' 27.249"	E74° 25' 44.040"	48J/7
Talmakki	N14° 10' 5.457"	E74° 28' 56.066"	48J/8
Torke	N14° 33' 30.115"	E74° 21' 3.354"	48J/6
Ulage	N14° 52' 53.364"	E74° 14' 39.723"	48J/1
Upple	N14° 21' 2.177"	E74° 28' 28.374"	48J/7
Urkeri	N14° 23' 12.920"	E74° 26' 2.534"	48J/7

ANNEXURE-I

GEO-PARAMETRIC LANDSLIDE INVENTORY DATASHEETS

	Location	TS no.	Lattitude			Longitude			Dist.	Dimension of slide				Type of slide	Overburden material	Overburden thickness(m)	Triggering factor	Geoscientific causes	Remedial measures	Qualitative Risk Assessment Remarks
Slide No			Deg	Min	Sec	Deg	Min	Sec		Length(m)	Width(m)	Height(m)	Run out Distance							
KA-001	South GOA/1.2 km from Lolien village	48J/1	14	56	27.8	74	4	22.79	South Goa	11m	16.5m	2m	6.6m	debris slide	weathered rock and insitu soil	5-10m	rainfall/ anthropogenic	weathering	slope gradation required	risk to life and property
KA-002	South GOA/1.2 km from Lolien village	48J/1	14	56	27.4	74	4	23.74	South Goa	13m	34.5m	9m	5m	3 multiple debris slides	weathered rock and insitu soil	5-10m	rainfall/ anthropogenic	vertical cut made	slope gradation required	risk to life and property
KA-003	South GOA/Lolien village	48J/1	14	56	48.3	74	4	6.73	South Goa	21m	25.5m	3m	16.5m	debris slide	Laterite and Lateritic soil	5-10m	anthropogenic	slope modification/ human interferences	slope treatment required	risk to life and property
KA-004	South GOA/Agasgalli village	48J/1	14	57	14.7	74	3	41.1	South Goa	18m	30m	12m	4m	debris slide	weathered rock, laterite and lateritic soil	5-10m	rainfall/ anthropogenic	road cut leading to destablization and modification of slope angle	retaining wall with draining chutes constructed	downslope settlement, risk to life and property
KA-005	South GOA/Agas Village	48J/1	14	57	16.6	74	3	40.91	South Goa	30m	30m	3m	20m	debris slide	weathered rock soil and laterite	10-15m	rainfall/ anthropogenic	weathering	slope gradation required	temple nearby is at risk, settlement at downslope are at risk, danger to life and property
KA-006	South GOA/2km from mashen	48J/1	14	57	26.3	74	3	36.28	South Goa	22m	9.6m	3.2m	17.9m	4 debris slide	laterite and lateritic soil	5-10m	rainfall	failure along fracture plane	slope modification required	downslope settlement is at risk
KA-007	South GOA/mashen village	48J/1	14	57	35.8	74	3	15.58	South Goa	19m	8m	2.8m	16m	4 debris slide	weathered rock, laterite and lateritic soil	5-10m	rainfall/ anthropogenic	weathering	retaining wall of 30m width constructed	temple and settlement are at risk
KA-008	South GOA/on Nh-17 1.5 km fromTamanen village	48J/1	14	58	0.4	74	4	39.97	South Goa	32m	27m	3.5m	19m	debris slide	Laterite and Lateritic soil	5.5m VH	rainfall	vertical cut slope failure, weathering along fracture plane	plantation on destablized slope required	life and property is at risk
KA-009	South GOA	48J/1	14	57	57	74	4	46.87	South Goa	35m	30.2m	9.5m	41m	debris slide/denudational hillslope	Laterite and Lateritic soil	10-15m	rainfall	vertical cut slope failure, weathering along fracture plane	plantation on destablized slope required	life and property is at risk
KA-010	South GOA	48J/1	14	59	52.1	74	4	3.41	South Goa	18m	12m	1.5m	16.5m	debris slide	laterite and weathered rock	10-15m	rainfall/ anthropogenic	weathering along fracture and weaker plane	plantation on destablized slope required	life and property is at risk
KA-011	South GOA/shelli village	48J/1	14	56	19.1	74	3	59.56	South Goa	7.5m	5.5m	1.5m	6.2m	2debris slump slide/denudational hillslope	Laterite and Lateritic soil	0-5m	rainfall/ anthropogenic	weathering and seepage along fracture and weaker plane	slope gradation required	life and property is at risk
KA-012	Chendiye village	48J/1	14	45	42	74	11	29.66	UK	28m	35.6m	1.2m	25m	Shallow translational Debris slide	weathered rock and insitu soil	0-5m	Natural/Rainfall	Nala erosion by first order stream, highly weathered, fractured and jointed rock and human interfernces	Slope stabilization by plantation on natural slope	unstable zone, moderate risk to man and material
KA-013	Chendiye village	48J/1	14	45	58.2	74	11	17.62	UK	19m	15m	2.5m	14.8m	Shallow translational composite slide	weathered rock and insitu soil	0-5m	Natural/Rainfall	Nala erosion by first order stream, highly weathered, fractured and jointed rock and human interfernces	Slope stabilization by plantation on natural slope	unstable zone, moderate risk to man and material
KA-014	near binaga on NH-17	48J/1	14	46	53.3	74	8	10.01	UK	15m	19m	4m	10m	Shallow rotational debris slide	weathered rock and insitu soil	0-5m	Anthropogenic	slope modification for road construction	High height retaining wall should be constructed, although low height retaining wall is constructed	Risk to life and property
KA-015	near binaga diversion on NH-17	48J/1	14	47	28.1	74	6	59.23	UK	8m	17.6m	2.25m	6m	weathered rock/highly jointed and fractured	Weathered rock	0-5m	Anthropogenic	slope modification for road construction	plantation on destablized slope required	life and property is at risk
KA-016	DC office/aligadde	48J/1	14	48	13.2	74	7	30.61	UK	25m	32m	2.5m	22.5m	debris slide	weathered rock+scree	0-5m	Anthropogenic	slope modification for road construction	plantation on destablized slope required	life and property is at risk
KA-017	Shirwad village/sasanwad village	48J/1	14	50	5.7	74	10	37.36	UK	30m	70m	3m	2m	composite slide	weathered rock	0-5m	Anthropogenic	road cut failure	Retaining wall is constructed with draining holes for proper drainage	life and property is at risk
KA-018	Baithkol port	48J/1	14	48	13.3	74	6	50.55	UK	45m	25.6m	3.5m	40.6m	debris cum rock slide	weathered rock	0-5m	Anthropogenic	Rainfall, highly jointed rock	Retaining wall is constructed with draining holes for proper drainage	risk to life and property
KA-019	Baithkol port	48J/1	14	48	4.26	74	6	44.64	UK	18m	25m	3m	15m	weathered rock(2 rock cum debris slide)	weathered rock and insitu soil	0-5m	Anthropogenic	Rainfall/ weathered , jonted and fractured rock	retaining wall should be constructed	life and property is at risk

ANNEXURE-I

GEO-PARAMETRIC LANDSLIDE INVENTORY DATASHEETS

Slide No	Location	TS no.	Latitude			Longitude			Dist.	Dimension of slide				Type of slide	Overburden material	Overburden thickness(m)	Triggering factor	Geoscientific causes	Remedial measures	Qualitative Risk Assessment Remarks
			Deg	Min	Sec	Deg	Min	Sec		Length(m)	Width(m)	Height(m)	Run out Distance							
KA-020	Mudarali village	48J/1	14	50	48.8	74	10	58.48	UK	27m	26m	2.5m	25m	Shallow rotational debris slide	weathered rock and insitu soil	0-5m	Anthropogenic	Rainfall and road cut	retaining wall with draining holes are constructed, plantation on disturbed slope will impart stability	life and property is at risk
KA-021	Mudarali village	48J/1	14	50	48	74	10	59	UK	14m	9.5m	1.5m	12.4m	Shallow rotational multiple debris slide (2 slide)	weathered rock and insitu soil	0-5m	Anthropogenic	Rainfall and road cut	Retaining wall with chute drains to arrest rain water percolation from slide area	life and property is at risk
KA-022	Mudarali village	48J/1	14	50	59.6	74	10	44.52	UK	17m	14.6m	3m	14m	2 debris slump slide within 50m range and 1 rock fall	weathered rock and insitu soil	0-5m	Anthropogenic	weathering activity, seepage along weaker plane	retaining wall should be constructed	life and property is at risk
KA-023	200 m Mudarali village	48J/1	14	50	48.8	74	10	58.48	UK	65m	70m	3m	55m	Shallow rotational debris slide	weathered rock and insitu soil	0-5m	Anthropogenic	Rainfall and excavation for construction	slope gradation required	life and property is at risk
KA-024	Siddar/Sakalvadda village	48J/1	14	51	26.6	74	13	50.04	UK	12m	17m	1.8m	8.6m	Shallow rotational debris slide(3 slide)	weathered rock and insitu soil	0-5m	Anthropogenic	Rainfall /seepage through fractured and jointed weaker plane	slope gradation required	life and property is at risk
KA-025	near siddar village	48J/1	14	15	12.9	74	13	2.81	UK	19m	17m	1.3m	10m	debris slump slide(2 slide)	weathered rock and insitu soil	0-5m	Anthropogenic	Rainfall	slope gradation required and plantation on slope required	life and property is at risk
KA-026	near Arga village	48J/1	14	46	14.3	74	9	49.02	UK	12m	13.5m	2m	13m	Shallow translational failure	weathered rock and insitu soil	0-5m	Natural	Rainfall /seepage through fractured and jointed weaker plane	Nala erosion/plantation on disturbed slope	downslope settlement at risk
KA-027	Govt. school Arga	48J/1	14	46	18.3	74	9	44.21	UK	7.5m	4m	2.25m	3.8m	Shallow translational failure (4 slide)	weathered rock and insitu soil	0-5m	Anthropogenic	Weathering phenomenon	slope gradation	risk to life, school nearby area
KA-028	kolage	48J/1	14	52	25.1	74	8	10.38	UK	6m	7m	2m	14m	composite debris slide (2 slide)	weathered rock and insitu soil	0-5m	Anthropogenic/human interfernces/ quarry	Weathering phenomenon	rock bolting required	risk to communication line
KA-029	1 km from arga govt.colledge NH-17	48J/1	14	46	51.2	74	8	47.58	UK	8m	11m	2.8m	7m	2 debris slide	weathered rock and insitu soil	0-5m	Anthropogenic	seepage along joint and fracture	rock bolting required	risk to communication line
KA-030	Savantvada on main road	48J/1	14	53	11.9	74	9	54.12	UK	13.5m	15m	1.25m	12.3m	debris slide/scar mark	weathered rock and insitu soil	0-5m	Anthropogenic	road cut failure	slope gradation required	risk to life
KA-031	Savantvada on main road	48J/1	14	54	1.8	74	11	50.22	UK	13m	14.5m	2m	9m	highly weathered rock	weathered rock and insitu soil	0-5m	Anthropogenic	road cut failure	slope gradation required	risk to life
KA-032	Binaga Hebble, NH-17	48J/1	14	47	26.1	74	6	54.96	UK	7m	4m	2m	30m	debris slide/scree fall	weathered rock	0-5m	Anthropogenic	road cut failure	rock bolting required	risk to communication line
KA-033	Karwad slide1	48J/1	14	50	34.6	74	10	36.54	UK	15m	100m	5m	3m	Deep rotational debris slide	weathered rock, laterite and in-situ soil	0-5m	Anthropogenic	removal of material for railway line construction, shear failure of vertical cut slope due to water saturation	slope gradation required	risk to life and property
KA-034	Gopshitta on main road	48J/1	14	54	32.1	74	12	14.58	UK	5.7m	9m	2.8m	5m	2 debris slide/weathered rock	weathered rock and insitu soil	0-5m	Anthropogenic	road cut failure	slope gradation required	risk to life and property
KA-035	Grijabai sail institute of technology	48J/1	14	54	42.9	74	6	4.92	UK	19m	46.6m	2.5m	16m	debris slide (2 slide)	weathered rock and insitu soil	0-5m	Anthropogenic	rainfall and weathering activity, vertical cut made for construction, unscientific way of excavation	slope gradation required	risk to life, hostel should be removed
KA-036	Grijabai sail institute of technology	48J/1	14	54	38.8	74	5	54.67	UK	15m	15m	1.5m	13m	Rotational debris slide	weathered rock and insitu soil	0-5m	Anthropogenic	rainfall and weathering activity, vertical cut made for construction, unscientific way of excavation, nala at toe portion	plantation on natural slope required	risk to life and property
KA-037	Ganesh nagar/near temple	48J/1	14	53	4.38	74	8	30.32	UK	24m	13.6m	3.7m	20m	debris slide	weathered rock	0-5m	Anthropogenic	rainfall, seepage along joint and fracture	plantation on slope and slope gradation required	risk to temple nearby

ANNEXURE-I

GEO-PARAMETRIC LANDSLIDE INVENTORY DATASHEETS

Slide No	Location	TS no.	Lattitude	Longitude	Dist.	Dimension of slide								Type of slide	Overburden material	Overburden thickness(m)	Triggering factor	Geoscientific causes	Remedial measures	Qualitative Risk Assessment Remarks
			Deg	Min	Sec	Deg	Min	Sec		Length(m)	Width(m)	Height(m)	Run out Distance							
KA-038	NH-63 on Yellapur road near Navagadde Halla	48J/6	14	41	27.2	74	20	37.38	UK	6m	6m	2.5m	4.5	composite slide (Rock cum debris (2 slide), 2 debris slide)	weathered rock	<0.5m	Anthropogenic/Rainfall	Seepage along joints and fracture along road cut, toe erosion by water	Rock bolting required , proper drainage at toe part is required	Danger to life and property
KA-039	Ulvare village	48J/6	14	35	40.3	74	22	5.4	UK	3.8m	16m	3.5m	7m	debris slide	insitu soil	0-5m	Anthropogenic/Rainfall	slope gradation required	risk to life	Danger to life and property
KA-040	Bolukante village	48J/6	14	35	35.5	74	21	36.78	UK	4.5m	16m	3m	9m	debris slide	laterite and lateritic soil	0-5m	Anthropogenic/Rainfall	weathering and water saturation during rainfall on exposed cut section	risk to life	Danger to life and property
KA-041	Bolukante village	48J/6	14	35	29.6	74	21	32.58	UK	3m	7m	1.6m	5m	debris slide	weathered rock and insitu soil	0-5m	Anthropogenic/Rainfall	weathering and water saturation during rainfall on exposed cut section	plantation on destablized slope is required	Danger to life and property
KA-042	2 km from Bolukante village	48J/6	14	35	45.3	74	21	9.72	UK	8m	6m	2.5	5m	debris slide (3 slide)	lateritic soil	0-5m	Anthropogenic/Rainfall	weathering and water saturation during rainfall on exposed cut section	risk to life	Danger to life and property
KA-043	NH-63 on Yellapur road	48J/6	14	41	17.3	74	21	16.2	UK	14m	7m	2m	11m	composite debris slide	weathered rock and insitu soil	0-5m	Anthropogenic road cut failure/Rainfall	weathering along road cut section	Slope gradation required	risk to communication line
KA-044	NH-63 on Yellapur road near Navagadde Halla	48J/6	14	41	17.9	74	21	11.82	UK	6.6m	13m	2.8	6m	rock fall	rock	<0.5m	Anthropogenic road cut failure/Rainfall	planar failure along weaker plane, Seepage along joints and fracture along road cut	rock bolting required	risk to communication line
KA-045	NH-63 on Yellapur road	48J/6	14	41	6.96	74	22	34.32	UK	5m	6m	2m	3m	debris slide	weathered rock	0-5m	Anthropogenic road cut failure/Rainfall	road cut failure	slope modification required	risk to communication line
KA-046	NH-17 on ankola-karwar road/Islampur	48J/6	14	40	19.3	74	18	38.76	UK	6m	19m	3m	5m	debris slide	weathered granite	0-5m	Anthropogenic road cut failure/Rainfall	weathering and road cut failure	slope modification required	risk to communication line
KA-047	NH-17 on ankola-kumta road	48J/6	14	30	48.6	74	24	40.02	UK	15m	49m	2.5m	10m	debris slide	laterite and lateritic soil	10-15m	anthropogenic	road cut failure	gradation on benches required	risk to communication and electric power line
KA-048	NH-17 on ankola-kumta road near Shirur village	48J/6	14	36	5.14	74	22	1.8	UK	12m	81m	3m	8m	debris slide	weatherd rock and lateritic soil	5-10m	Natural	drainge and water saturation/ rainfall/cut slope failure	retaining wall is constructed/plantation on loose material on slope is required	risk to life and property
KA-049	NH-17 on ankola-kumta road near Shirur village	48J/6	14	36	7.23	74	22	4.47	UK	83m	46m	3m	78.6m	debris slide	weatherd rock and soil	5-10m	anthropogenic	unscientific way of removal of material and slope modification by making vertical road cut, seepage along weaker plane	retaining wall should be constructed with proper drainage at toe portion, large volume of loose debris should be removed	risk to life and property
KA-050	NH-17 on ankola-karwar road/Islampur	48J/6	14	40	20	74	18	40.38	UK	7m	10.5m	3m	9m	debris slide	weatherd rock and soil	0-5m	Anthropogenic/Rainfall	road cut failure	Slope gradation required	risk to life and property
KA-051	NH-17 near Handigade village	48J/6	14	36	54.2	74	21	27.66	UK	4.8m	5m	2.8m	5m	Rock slide	weatherd rock and soil	0-5m	Anthropogenic/Rainfall	road cut failure leading to failure along joints and fracture, seepage aand water saturation through fracture zone	rock bolting required	risk to life and property
KA-052	NH-17 near Handigade village	48J/6	14	36	48.1	74	21	26.76	UK	5m	6.2m	2.5m	2m	2 debris slide	weatherd rock and soil	0-5m	Anthropogenic/Rainfall	road cut failure/toe erosion	Slope gradation required	risk to life and property
KA-053	NH-17 near Handigade village	48J/6	14	36	48.5	74	21	26.82	UK	6m	4m	1.8m	4m	debris slump/slide	weatherd rock and soil	0-5m	Anthropogenic/Rainfall	road cut failure/toe erosion	Slope gradation required	risk to life and property
KA-054	NH-17 near Handigade village	48J/6	14	36	49.5	74	21	28.62	UK	7m	7m	2m	6m	debris slide	weatherd rock and soil	0-5m	Anthropogenic/Rainfall	road cut failure/toe erosion	plantation on destablized slope is required	risk to life and property
KA-055	Shirur village near railway track	48J/6	14	36	14.4	74	21	27.9	UK	5.7m	10m	2m	3.5m	debris slide	weatherd rock and soil	0-5m	Anthropogenic/Rainfall	Seepage along joints and fracture , weathering phenomenon	Slope gradation required	risk to life and property
KA-056	NH-17 near Handigade village	48J/6	14	36	31.5	74	21	36.66	UK	9.3m	31m	1.6m	8m	rock/debris slide/topple	Laterite, weatherd rock and soil	5-10m	Anthropogenic/Rainfall	road cut failure	Slope gradation required	risk to life and property

ANNEXURE-I

GEO-PARAMETRIC LANDSLIDE INVENTORY DATASHEETS

Slide No	Location	TS no.	Latitude			Longitude			Dist.	Dimension of slide				Type of slide	Overburden material	Overburden thickness(m)	Triggering factor	Geoscientific causes	Remedial measures	Qualitative Risk Assessment Remarks
			Deg	Min	Sec	Deg	Min	Sec		Length(m)	Width(m)	Height(m)	Run out Distance							
KA-057	NH-17 near Handigade village	48J/6	14	36	30.5	74	21	38.52	UK	8m	9m	1.5m	4m	debris slump/slide	weatherd rock and soil	5-10m	Anthropogenic/Rainfall	road cut failure	Slope gradation required	risk to life and property
KA-058	NH-17 near Handigade village	48J/6	14	36	20	74	21	42.72	UK	4.6m	8m	2m	5m	debris slide	weatherd rock and soil	5-10m	Anthropogenic/Rainfall	road cut failure	Slope gradation required	risk to life and property
KA-059	NH-17 near Handigade village	48J/6	14	36	21.8	74	21	42.84	UK	6m	8m	2.5m	9m	rock fall	granite	10-15m	Anthropogenic/Rainfall	road cut failure, seepage along fractured and jointed	Slope gradation required	risk to life and property
KA-060	NH-17 near Sirur village	48J/6	14	36	7.62	74	21	49.2	UK	3m	9m	2m	5m	debris soil	weatherd rock+soil	5-10m	Anthropogenic/Rainfall	road cut failure, seepage along fractured and jointed	Slope gradation required	risk to life and property
KA-061	NH-17 near Kurigadde village	48J/6	14	32	17.1	74	23	55.44	UK	5.6m	3.5m	18m	4m	debris slide	laterite, weathered rock, insitu soil	0-5m	Anthropogenic/Rainfall	road cut failure, seepage along fractured and jointed	Slope gradation required	risk to life and property
KA-062	on NH-17 2km from Bergi	48J/6	14	31	4.56	74	24	34.32	UK	7m	12.5m	3.8m	3.4m	2 debris slide	insitu soil	0-5m	Anthropogenic/Rainfall	road cut failure, seepage along fractured and jointed	Slope gradation required	risk to life and property
KA-063	on NH-17 2km from Bergi	48J/6	14	31	2.34	74	24	34.62	UK	5.8m	8m	2m	5m	debris slide	insitu soil	0-5m	Anthropogenic/Rainfall	road cut failure, seepage along fractured and jointed	Slope gradation required	risk to life and property
KA-064	Hegle village area	48J/6	14	32	41.6	74	26	31.98	UK					rock fall	rock	0-5m	Anthropogenic/Rainfall	road cut failure, seepage along fractured and jointed	Slope gradation required	risk to life and property
KA-065	Honnabale village	48J/6	14	36	50.5	74	18	18.06	UK	4m	5m	2m	3m	rock cum debris slide	weatherd granite	0-5m	Anthropogenic/Rainfall	road cut failure, seepage along fractured and jointed	Toe drainage provided for stablization	risk to life and property
KA-066	Honnabale village	48J/6	14	36	49.8	74	18	21.6	UK	4m	15m	2m	3.5m	rock cum debris slide	weatherd granite	0-5m	Anthropogenic/Rainfall	road cut failure, seepage along fractured and jointed	Toe drainage provided for stablization	risk to life and property
KA-067	NH-17 near Amdalli village	48J/6	14	44	48	74	15	2.69	UK	8.5m	5.8m	2m	8m	rock fall	weatherd granite	<0.5m	Anthropogenic/Rainfall	road cut failure, seepage along fractured and jointed	rock bolting required	risk to life and property
KA-068	NH-17 near Amdalli village/Karmanne gudda	48J/6	14	44	48.4	74	15	2.467	UK	6m	6m	1m	10.5m	rock cum debris slide old scar present, mainly rock fall	weatherd granite	<0.5m	Anthropogenic/Rainfall	road cut failure, seepage along fractured and jointed	rock bolting required	risk to life and property
KA-069	Karmanne gudda on NH-17	48J/6	14	44	47	74	15	2.19	UK	7m	87m	2m	5m	3 debris slide	weatherd granite	<0.5m	Anthropogenic/Rainfall	road cut failure, seepage along fractured and jointed	Slope gradation required	risk to life and property
KA-070	Karmanne gudda on NH-17	48J/6	14	44	47.2	74	15	0.84	UK	7m	6m	1.5m	5.5m	2 debris slide	weatherd granite	<0.5m	anthropogenic/weathering and erosion	road cut failure, seepage along fractured and jointed	rock bolting /fencing required	risk to life and property
KA-071	Karmanne gudda on NH-17	48J/6	14	44	48.7	74	15	0.03	UK	9m	13.6m	1.5m	6m	rock fall/relict	weatherd granite	<0.5m	anthropogenic/weathering and erosion	road cut failure, fractured and jointed	rock bolting /fencing required	risk to life and property
KA-072	near gokarna cross on NH-17	48J/6	14	34	48.9	74	22	58.15	UK	10m	7.4m	2.5m	30m	debris slide	weatherd granite and insitu soil	0-5m	anthropogenic/weathering and erosion	road cut failure, fractured and jointed	slope gradtion and benches should be made	risk to life and property
KA-073	near gokarna on NH-17	48J/6	14	34	50.1	74	22	57.9	UK	21m	19m	1.7m	30m	debris slide multiple slide	weathered granite		anthropogenic/weathering and erosion	slope modification	slope gradation and plantation required	risk to life and property
KA-074	near gokarna on NH-17	48J/6	14	34	51.9	74	22	56.9	UK	13m	8m	2m	10.4m	debris slide	schistose rock	0-5m	anthropogenic/weathering and erosion	slope modification	slope gradation and plantation required	risk to life and property
KA-075	near gokarna on NH-17	48J/6	14	34	36.8	74	23	0.8	UK	6m	14m	2.3m	4m	debris slump/slide	weatherd rock	0-5m	anthropogenic/weathering and erosion	slope modification	slope gradation and plantation required	risk to life and property
KA-076	near gokarna on NH-17	48J/6	14	34	35.6	74	23	0.8	UK		10.6m	1m	8.5m	debris slump/slide	weatherd rock	0-5m	anthropogenic/weathering and erosion	slope modification	slope gradation and plantation required	risk to life and property
KA-077	near gokarna on NH-17	48J/6	14	41	7.39	74	24	34.83	UK	12m	10.5m	2.4m	18.5m	debris slide	weatherd rock	0-5m	anthropogenic/weathering and erosion	slope modification	slope gradation and plantation required	risk to life and property
KA-078	near gokarna on NH-17	48J/6	14	35	0	74	20	60	UK	2m	5.5m	2m	3m	debris slide/complex	weatherd rock	0-5m	anthropogenic/weathering and erosion	slope modification	slope gradation and plantation required	risk to life and property
KA-079	near gokarna on NH-17	48J/6	14	35	58.6	74	20	38.4	UK	4m	24.3m	4m	4m	debris slide	weatherd rock	0-5m	anthropogenic/weathering and erosion	slope modification	slope gradation and plantation required	risk to life and property
KA-080	near gokarna on NH-17	48J/6	14	34	53.8	74	22	20.76	UK	5m	7m	3.5m	3.5m	debris slide	weatherd rock	0-5m	anthropogenic/weathering and erosion	slope modification	slope gradation and plantation required	risk to life and property
KA-081	on NH-17 near Kodsani village	48J/6	14	36	11	74	22	49.67	UK	4om	44m	9m	30m	debris slide	laterite+lateritic soil	5-10m	anthropogenic/weathering and erosion/rainfall/wet	road cut failure, fractured and jointed	slope gradation and plantation on natural slope should be done	risk to life and property
KA-082	Near kagal village/Agahanashani	48J/6	14	30	14.8	74	21	41.87	UK	34m	57.7m	6.5m	27m	debris slide	weathered rock, insitu soil, laterite	10-15m	anthropogenic/weathering and erosion/rainfall/wet	road cut failure, fractured and jointed	slope gradation and plantation on natural slope should be done	risk to life and property
KA-083	Near kagal village/Agahanashani	48J/6	14	30	15.8	74	21	43.64	UK	34m	53.4m	7.5m	16.5m	debris slide	weathered rock, insitu soil, laterite	10-15m	anthropogenic/weathering and erosion/rainfall/wet	road cut failure, fractured and jointed	slope gradation and plantation on natural slope should be done	risk to life and property
KA-084	Belekan village	48J/6	14	31	17.5	74	20	47.34	UK	15m	30m	4m	9m	debris slide	weathered rock, insitu soil, laterite	10-15m	anthropogenic/weathering and erosion/rainfall/wet	road cut failure, fractured and jointed	toe part is supported by 1/2m height drainage chute	risk to life and property

ANNEXURE-I

GEO-PARAMETRIC LANDSLIDE INVENTORY DATASHEETS

Slide No	Location	TS no.	Latitude	Longitude	Dist.	Dimension of slide								Type of slide	Overburden material	Overburden thickness(m)	Triggering factor	Geoscientific causes	Remedial measures	Qualitative Risk Assessment Remarks
			Deg	Min	Sec	Deg	Min	Sec		Length(m)	Width(m)	Height(m)	Run out Distance							
KA-085	Mudangi village	48J/6	14	32	11.9	74	20	58.34	UK	18m	30m	5m	15m	2 debris slide	weathered rock, insitu soil	10-15m	anthropogenic/weathering and erosion/rainfall/wet	road cut failure, fractured and jointed	toe part is supported by 1/2m height drainage chute	risk to life and property
KA-086	In and around Kalkeri village/Basti Devsthana(Laterite quarry)	48J/7	14	24	41.9	74	26	5.8	UK	13m	41m	3.8m	11m	debris slide	laterite and lateritic soil	10-15m	Rainfall/Slope modification(Anthropogenic)	laterite Quarry, the exposed cut section are prone to weathering and failure due to watre saturation	benches should be constructed	risk to settlement downslope
KA-087	In and around Kujali village area (Laterite quarry)	48J/7	14	24	27.3	74	26	59.53	UK	15m	40m	4m	10m	debris slide	weathered rock,laterite and lateritic soil	0-5m	Rainfall/Slope modification(Anthropogenic)	laterite Quarry, the exposed cut section are prone to weathering and failure due to watre saturation	slope gradation required	risk to settlement downslope
KA-088	Murur village	48J/7	14	26	15.4	74	28	42.29	UK	10m	15m	1.25m	9m	debris slide	weathered rock	0-5m	Rainfall/Slope modification(Anthropogenic)	slope modification for road construction	plantation on slope	risk to life and property
KA-089	Murur village	48J/7	14	26	19.1	74	28	45.73	UK	3m	7m	1m	4m	debris slump	weathered rock	0-5m	Rainfall/Slope modification(Anthropogenic)	slope modification	slope treatment required	risk to life and property
KA-090	Murur village	48J/7	14	26	22.8	74	28	47.13	UK	12m	16.2m	3.25m	8m	debris slump/slide	weathered rock	10-15m	Rainfall/Slope modification(Anthropogenic)	slope modification	slope treatment required	risk to life and property
KA-091	Murur village	48J/7	14	26	36.9	74	28	8.5	UK	10m	8m	1.6m	8.6m	debris slump/slide	weathered rock	0-5m	Rainfall/Slope modification(Anthropogenic)	slope modification	slope treatment required	risk to life and property
KA-092	Murur village	48J/7	14	26	37.6	74	28	6.7	UK	9m	3.8m	1.5m	7m	debris slump/slide	weathered rock	0-5m	Rainfall/Slope modification(Anthropogenic)	slope modification for road construction	slope treatment required	risk to life and property
KA-093	Murur village	48J/7	14	26	22.4	74	28	1.3	UK	6m	12m	1.5m	4.4m	debris slump/slide	weathered rock	0-5m	Rainfall/Slope modification(Anthropogenic)	slope modification for road construction	slope treatment required	risk to life and property
KA-094	Murur village	48J/7	14	26	27.3	74	28	5.86	UK	13.5m	25m	2m	11.2m	debris slump/slide	laterite and lateritic soil	0-5m	Rainfall/Slope modification(Anthropogenic)	slope modification for road construction	slope treatment required	risk to life and property
KA-095	Murur village	48J/7	14	26	6.78	74	28	16.02	UK	32.5	49.3m	5.5m	27m	debris slump/slide	laterite and lateritic soil	0-5m	Rainfall/Slope modification(Anthropogenic)	slope modification for road construction	slope treatment required	risk to life and property
KA-096	Murur village	48J/7	14	30	48.6	74	24	40.02	UK	12m	49m	2.5m	9.8m	debris slump/slide	laterite and lateritic soil	0-5m	Rainfall/Slope modification(Anthropogenic)	slope modification for road construction	slope treatment required	risk to life and property
KA-097	on NH-17	48J/7	14	28	49.1	74	26	16.08	UK	34m	52.6m	4.5m	28.5m	debris slump/slide	laterite and lateritic soil	5-10m	Rainfall/Slope modification(Anthropogenic)	slope modification for road construction	slope treatment required	risk to life and property
KA-098	APMC Kumta Arc	48J/7	14	25	12.8	74	24	51.52	UK	18m	18m	3m	15m	3 debris slump/slide	laterite and lateritic soil	5-10m	Rainfall/Slope modification(Anthropogenic)	weathering phenomenon, unscientic way of removal of material	slope should be made gentle	risk to building nearby
KA-099	on NH-206	48J/7	14	17	49.3	74	28	17.39	UK	22m	23m	3m	17m	debris slump/slide	laterite and lateritic soil	5-10m	Rainfall/Slope modification(Anthropogenic)	road cut failure	slope treatment required	risk to communication line
KA-100	on NH-206(within 20m from S15)	48J/7	14	17	49.4	74	28	19.36	UK	14.2m	20m	3.3m	10m	debris slump/slide	weatherd rock and insitu soil	0-5m	Rainfall/Slope modification(Anthropogenic)	road cut failure	slope treatment required	risk to communication line
KA-101	on NH-206	48J/7	14	17	49.2	74	28	31.82	UK	8m	23.2m	4.3m	2.5m	debris slump/slide	weatherd rock and lateritic soil	0-5m	Rainfall/Slope modification(Anthropogenic)	road cut failure and weathering	retaining wall constructed	risk to life and property
KA-102	on NH-206	48J/7	14	17	51.2	74	28	32.23	UK	7m	30m	2m	5m	3 multiple debris slide	weatherd rock and lateritic soil	0-5m	Rainfall/Slope modification(Anthropogenic)	road cut failure and weathering	slope gradation required	risk to life and property
KA-103	on NH-206	48J/7	14	18	15.8	74	29	12.8	UK	16.2m	13.5m	2.5m	13.4m	debris slide	weatherd rock and lateritic soil	5-10m	Rainfall/Slope modification(Anthropogenic)	road cut failure and weathering	slope gradation required	risk to life and property
KA-104	on NH-206(next to S19)	48J/7	14	18	5.37	74	29	14.41	UK	12m	20.2m	2.5m	9m	debris slide	weatherd rock and lateritic soil	0-5m	Rainfall/Slope modification(Anthropogenic)	road cut failure and weathering	slope gradation required	risk to life and property
KA-105	on NH-206(next to S19)	48J/7	14	17	55.3	74	28	32.96	UK	13.5m	35m	2.3m	11m	debris slump/slide	laterite and lateritic soil	5-10m	Rainfall/Slope modification(Anthropogenic)	road cut failure and weathering	slope gradation required	risk to life and property
KA-106	Baskeri area	48J/7	14	18	12.6	74	29	1.52	UK	13.4m	24m	4.2m	8m	debris slide	laterite and lateritic soil	0-5m	Rainfall/Slope modification(Anthropogenic)	cut slope failure	slope gradation required	risk to life and property
KA-107	Kasaba Gundibail/Jogmat village	48J/7	14	17	10.2	74	26	55.83	UK	21m	8.5m	2m	17m	debris slide	weatherd rock and soil	10-15m	Rainfall/Slope modification(Anthropogenic)	road cut failure	slope gradation required	risk to life and property
KA-108	1 km from Honavar Areangadi road on NH-17	48J/7	14	17	39.4	74	26	33.81	UK	28m	17.3m	3.8m	23m	debris slide	laterite and weathered rock	10-15m	Rainfall/Slope modification(Anthropogenic)	road cut failure	slope gradation required	downslope settlement is at risk
KA-109	in and around Divgi village	48J/7	14	27	9.16	74	26	50.95	UK	5.5m	3m	2.7m	4.6m	debris slide	laterite and lateritic soil	10-15m	Rainfall/Slope modification(Anthropogenic)	road cut failure/weathering	slope gradation required	downslope settlement is at risk
KA-110	in and around Divgi village	48J/7	14	27	9.34	74	26	52.47	UK	7m	7m	1.25m	4m	debris slide(3slides)	weathered rock and insitu soil	0-5m	Rainfall/Slope modification(Anthropogenic)	road cut failure/weathering/jointed and fractured	slope treatment required	downslope settlement is at risk
																				Qualitative Risk

ANNEXURE-I

GEO-PARAMETRIC LANDSLIDE INVENTORY DATASHEETS

Slide No	Location	TS no.	Latitude	Longitude	Dist.	Dimension of slide								Type of slide	Overburden material	Overburden thickness(m)	Triggering factor	Geoscientific causes	Remedial measures	Assessment Remarks
			Deg	Min	Sec	Deg	Min	Sec		Length(m)	Width(m)	Height(m)	Run out Distance							
KA-111	in and around Divgi village	48J/7	14	21	7.56	74	26	58.42	UK	4.5m	2.6m	1.25m	2.5m	debris slide	weathered rock and insitu soil	0-5m	Rainfall/Slope modification(Anthropogenic)	road cut failure	slope modification required	Downslope settlement is at risk
KA-112	in and around Divgi village	48J/7	14	27	7.47	74	27	0.3	UK	5.5m	2.25m	1m	4.5m	debris slide(2slides)	weathered rock and insitu soil	0-5m	Rainfall/Slope modification(Anthropogenic)	road cut failure	slope modification required	downslope settlement is at risk
KA-113	in and around Divgi village	48J/7	14	27	12	74	27	8.42	UK	9m	5m	2m	8m	debris slide	weathered rock and insitu soil	0-5m	Rainfall/Slope modification(Anthropogenic)	road cut failure	slope modification required	downslope settlement is at risk
KA-114	forest check post 200m sirsi road	48J/7	14	29	11.2	74	29	42.65	UK	8m	8m	1.5m	6.5m	debris slide(3slides)	weathered rock and insitu soil	0-5m	Rainfall/Slope modification(Anthropogenic)	road cut failure	slope modification required	risk to life and property
KA-115	forest check post (near nala)	48J/7	14	29	13.9	74	29	40.47	UK	7.5m	13m	1.25m	6m	3 debris slide	weathered rock and insitu soil	0-5m	Rainfall/Slope modification(Anthropogenic)	weathering phenomenon, nala erosion	afforestation required	risk to life and property
KA-116	forest check post	48J/7	14	29	26	74	29	48.1	UK	6.5m	5m	1.25m	6m	debris slide/slump(3 slides)	weathered rock and insitu soil	0-5m	Rainfall/Slope modification(Anthropogenic)	weathering phenomenon	afforestation required	risk to life and property
KA-117	Shilli village	48J/7	14	28	14.8	74	27	35.23	UK	6.5m	7.3m	1.5m	4.6m	debris slide	insitu soil	0-5m	Rainfall/Slope modification(Anthropogenic)	weatherd rock failed along road cut	afforestation required	risk to life and property
KA-118	chitrang school	48J/7	14	25	50.7	74	24	21.78	UK	13.4m	24m	4.2m	8m	6 debris slide	insitu soil and laterite	5-10m	Rainfall/Slope modification(Anthropogenic)	weathering and removal of material	slope gradation required , loose debris materia has to b eremoved	risk to school, danger on life and property
KA-119	near Chitrang village(school)600 m from school	48J/7	14	26	6.58	74	24	15.92	UK	17m	26m	2.5m	14m	debris slide	laterite and weathered rock soil	10-15m VH	Rainfall/Slope modification(Anthropogenic)	removal of material making vertical cut for open ground	slope gradtion required	risk to life and property
KA-120	Honnavar chruch road	48J/7	14	16	44.2	74	27	22.91	UK	13.5m	20m	7m	30m	debris slide	laterite and weathered schistose rock	10-15m VH	Rainfall/Slope modification(Anthropogenic)	weathering and removal of material	slope gradtion required	risk to life and property
KA-121	Haldipur village	48J/7	14	20	4.48	74	26	7.94	UK	10m	31.6m	1.3m	12.6m	debris slide	laterite and lateritic soil	5-10m(VH)	Rainfall/Slope modification(Anthropogenic)	weathering and Quarry	slope gradtion required	risk to life and property primary health center at risk
KA-122	Ukeri village	48J/7	14	23	22	74	25	54.11	UK	24m	18.5m	8.5m	21.5m	debris slide	laterite and lateritic soil	5-10m(VH)	Rainfall/Slope modification(Anthropogenic)	weathering , railway line nearby may reduce the cohesive and shear strength of weatherd rock	slope gradtion required	risk to settlement, road and railway rack 9life and property)
KA-123	Karki Makki village	48J/7	14	27	20.1	74	28	18.08	UK	7m	8.5m	1.5m	7m	debris slide(3slides)	Weatherd rock, Laterite and in-situ soil	10-15m	Rainfall/Slope modification(Anthropogenic)	weathering and destablization of slope due to road cut	afforestation required	risk to life and property
KA-124	Kallabbe village	48J/7	14	27	20.2	74	28	57.74	UK	7m	18m	1m	9m	debris slide	Weatherd rock, Laterite and in-situ soil	10-15m	Rainfall/Slope modification(Anthropogenic)	weathering and destablization of slope due to road cut	afforestation required	risk to life and property
KA-125	Kallabbe village	48J/7	14	27	15.4	74	29	7.38	UK	13m	14.5m	3.5m	6.8m	debris slide(2slides)	Weatherd rock, Laterite and in-situ soil	10-15m	Rainfall/Slope modification(Anthropogenic)	weathering and destablization of slope due to road cut	afforestation required	risk to life and property
KA-126	Haldipur village(primary health centre)	48J/7	14	21	2.94	74	25	59.82	UK	17m	21m	5m	24.5m	debris slide	Weatherd rock, Laterite and in-situ soil	10-15m	Rainfall/Slope modification(Anthropogenic)	weathering and destablization of slope due to road cut	afforestation required	risk to life and property
KA-127	Suwarnagadde village	48J/7	14	21	27.9	74	25	5.52	UK	22m	35m	4m	18m	debris slide	Weathered rock and laterite	10-15m	Rainfall/weathering and erosional phenomenon	verical road cut, slope modification	retaining wall constructed	Settlement at downslope are at risk, highly unstable zone
KA-128	on NH-17 near Talgere	48J/7	14	28	49.1	74	26	16.08	UK	34m	53m	4.5m	28.5m	2 debris slide	laterite and lateritic soil	10-15m	anthropogenic	slope destablized for road construction	slope angle should be modified	risk to life, lifestock and property
KA-129	on NH-17 in and around Devgiri village	48J/7	14	22	6.1	74	24	37.64	UK	25m	24.7m	2.5m	21.3m	2 debris slide	Weathered rock and laterite	10-15m	anthropogenic	slope modification and excavation for road construction	slope gradation required	risk to communication line, danger to life and property
KA-130	NH-17/Kelaganur	48J/8	14	14	20.2	74	27	27.86	UK	8m	12m	1.5m	6.5m	Shallow multiple debris slide (3 debris slide)	laterite and lateritic soil	10-15m	Rainfall/Slope modification(Anthropogenic)	Slope modification/road cut for road construction	Gradation of slope required for stabilization/benches should be constructed at shorter interval	Extensive vertical road cut of 80m strech are vulnerable to settlement at,downslope.
			Latitude																	**Qualitative Risk Assessment**

ANNEXURE-I

GEO-PARAMETRIC LANDSLIDE INVENTORY DATASHEETS

Slide No	Location	TS no.		Longitude	Dist.	Dimension of slide								Type of slide	Overburden material	Overburden thickness(m)	Triggering factor	Geoscientific causes	Remedial measures	Remarks
			Deg	Min	Sec	Deg	Min	Sec		Length(m)	Width(m)	Height(m)	Run out Distance							
KA-131	NH-17	48J/8	14	14	31.9	74	27	10.49	UK	6m	9m	1m	5m	debris slide	laterite,lateritic soil,weartherd rock	10m	Laterite quarry/Anthropogenic	Unscientific way of excavation/removal of material	Slope gradation required	Church in laterite quarry
KA-132	NH-17	48J/8	14	18	24	74	29	29.3	UK	6.8m	6m	1m	30m	debris slide	weathered rock and laterite	15m	Anthropogenic	Unscientific way of excavation/removal of material	Slope gradation required	Risk to life and property. Electric
KA-133	NH-17	48J/8	14	13	53.8	74	27	42.34	UK	7m	5m	1m	5m	Shallow multiple debris slide (2 debris slide)	weathered rock and laterite	10m	Anthropogenic	weathering phenomenon/Unscientific way of excavation	Slope gradation required	Risk to communication line
KA-134	Kelgin Idgunji	48J/8	14	14	19	74	28	57.72	UK	10.1m	23m	5.5m	4.7m	debris slide	laterite and lateritic soil	5m	Anthropogenic	slope failure due to vertical cut	Slope gradation required	communication line and settlement in valley is at risk.
KA-135	Kelgin Idgunji	48J/8	14	14	49	74	29	9.45	UK	11m	20m	2.3m	7.5m	debris slide	insitu soil	10m	Anthropogenic	slope failure due to vertical cut	Retaining wall constructed for toe support, plantation on slope will impart stability	communication line and settlement in valley is at risk.
KA-136	Melin Idgunji	48J/8	14	14	11.4	74	29	42.38	UK	16m	18m	3m	17m	debris slide	weathered rock and lateritic soil	10m	Natural	Nala erosion by first order drainage	Plantation on natural slope	communication line and settlement in valley part is at risk
KA-137	Melin Idgunji	48J/8	14	13	33	74	29	45.19	UK	16m	11m	1m	15.2m	Shallow multiple debris slide (4 debris slide)	laterite and lateritic soil	8m	Anthropogenic	slope failure due to vertical cut	Slope gradation required	Risk to communication line
KA-138	NH-17	48J/8	14	10	1.91	74	29	37.99	UK	9m	5m	1.5m	7m	debris slide	weathered rock	5m	Anthropogenic	failure along weaker plane/Slope modification/road cut for road construction	Slope gradation required	Risk to communication line
KA-139	Apsarkonda	48J/8	14	14	18.7	74	26	54.95	UK	16.6m	9m	4.5m	7.6m	debris slide	weatherd rock and insitu soil	12m	Anthropogenic	Slope modification/road cut failure	49.6m width and 3m high retaining wall constructed and toe part is supported with proper drainage	communication line and settlement in valley part is at risk
KA-140	Apsarkonda	48J/8	14	14	17.6	74	26	52.49	UK	14m	27m	2m	8m	debris slide	laterite and lateritic soil	12m	Anthropogenic	Slope modification/road cut failure	Slope gradation required	communication line and settlement in valley part is at risk
KA-141	Apsarkonda	48J/8	14	14	16.3	74	26	50.86	UK	14m	30.2m	2m	9m	debris slide (3 debris slide)	laterite and lateritic soil	12m	Anthropogenic	Slope modification/road cut failure	Slope gradation required	communication line and settlement in valley part is at risk
KA-142	Apsarkonda	48J/8	14	14	12.4	74	26	48.81	UK	16.6m	60.4m	2m	8m	debris slide	laterite and lateritic soil	12m	Anthropogenic	weathering phenomenon	60.4m width and 2.5m high retaining wall constructed and toe part is supported with proper drainage	communication line and settlement in valley is at risk
KA-143	Apsarkonda	48J/8	14	13	48.1	74	26	53.22	UK	18.7m	11.5m	1.5m	17.2m	rock cum debris slide/composite slide	weathered rock , laterite and in-situ soil	12m	Natural	Nala erosion	Afforestation required on destablized slope	communication line and settlement in valley is at risk
KA-144	Apsarkonda	48J/8	14	14	18.7	74	26	57.83	UK	15m	42m	1m	17m	natural debris slide	laterite and lateritic soil	12m	Natural	weathering and erosional phenomenon	Plantation on natural slope	risk to life and property
KA-145	NH-17	48J/8	14	14	29	74	27	22.05	UK	6m	9m	1m	5m	old debris slide	laterite and lateritic soil	14.5m	Anthropogenic	Slope modification/road cut failure	Slope gradation required	risk to life and property

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Goa District: South Goa
Tehsil: -- Village: Mashen

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Mashen slide
2.		State/District	South Goa
3.		Toposheet No	48J/1
4.		Important location/Landmark	Near temple
5.		Latitude; Longitude	14°57'35.84"; 74°3'15.58"
6.		Date of occurrence	No information available
7.	Slide type	Type of material involved	Weathered rock and in-situ soil
8.		Type of movement	Advancing, widening and progressive old slide
9.		Type of slide	Translational shallow debris slide
10.		Rate of movement or activity	Slow
11.		History of slide	Palaeo-slide
12.	Slide morphology	Length(m)	19m
13.		Width(m)	8m
14.		Height(m)	2.8m
15.		Run out Distance(m)	16m
17.	Geological details	Geology	Granite
18.		Structural details	--
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope Damp
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall and weathering
22.		Landslide process	Anthropogenic (Road cut failure)
23.		Geological causes	Seepage along joint, fracture
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	No information available
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Life and property/railway track
29.		Agricultural/forest	Nil
30.		Risk	Risk to life and property

ANNEXURE-II

31.	Remedial measures	Remedial measures(brief)	30m width retaining wall constructed. Restoration of plantation on disturbed slope required
32.		Rehabilitation plan(if applicable)	---
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Temple and building nearby at risk, danger to Life and property.
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: -- Village: Karwad

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Karwad 1 slide
2.		State/District	Uttar Kannada
3.		Toposheet No	48J/1
4.		Important location/Landmark	Near Konkan railway track
5.		Latitude; Longitude	14°50'34.56"; 74°10'36.54"
6.		Date of occurrence	Oct 2010
7.	Slide type	Type of material involved	Weathered rock and in-situ soil
8.		Type of movement	Advancing, widening and progressive old slide
9.		Type of slide	Shallow rotational debris slide
10.		Rate of movement or activity	Slow
11.		History of slide	Old Suspended slide
12.	Slide morphology	Length(m)	35m
13.		Width(m)	100m
14.		Height(m)	5m
15.		Run out Distance(m)	300m
17.	Geological details	Geology	Highly weathered jointed and fractured granite
18.		Structural details	Fractured and Jointed
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope Dry
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall and seepage along joint and fracture plane
22.		Landslide process	Natural
23.		Geological causes	Seepage along joint, fracture
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	19 people died
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Life and property/railway track
29.		Agricultural/forest	Nil
30.		Risk	Risk to life and property

ANNEXURE-II

31.	Remedial measures	Remedial measures(brief)	slope gradation required, Plantation in the slide zone with deep rooted plants, Improving drainage connectivity
32.		Rehabilitation plan(if applicable)	Settlement nearby should be removed, slope gradation required
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Life and property is at risk
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: -- Village: Karwad

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Karwad 2 slide
2.		State/District	Uttar Kannada
3.		Toposheet No	48J/1
4.		Important location/Landmark	Near Maruti Nagar
5.		Latitude; Longitude	14°49'59.82"; 74°10'44.86"
6.		Date of occurrence	Oct 2010
7.	Slide type	Type of material involved	Weathered rock and in-situ soil
8.		Type of movement	Advancing, widening and progressive old slide
9.		Type of slide	debris slide
10.		Rate of movement or activity	Slow
11.		History of slide	Old slide
12.	Slide morphology	Length(m)	30m
13.		Width(m)	82m
14.		Height(m)	5m
15.		Run out Distance(m)	178m
17.	Geological details	Geology	Granite
18.		Structural details	Fractured
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope Damp
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall and weathering due water saturation
22.		Landslide process	Natural
23.		Geological causes	Seepage and increased pore water pressure
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	road
29.		Agricultural/forest	Nil
30.		Risk	Risk to life and property

ANNEXURE-II

31.	Remedial measures	Remedial measures(brief)	Slope gradation is done. 5 Benches are constructed at suitable interval.
32.		Rehabilitation plan(if applicable)	Not required
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Life and property is at risk, danger to communication line.
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Goa District: South Goa
Tehsil: -- Village: Agasgalli

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Agasgalli slide
2.		State/District	Goa/South Goa
3.		Toposheet No	48J/1
4.		Important location/Landmark	Near temple
5.		Latitude; Longitude	14°57'14.68"; 74°3'41.4"
6.		Date of occurrence	No information available
7.	Slide type	Type of material involved	Weathered rock and in-situ soil
8.		Type of movement	Advancing, widening and progressive old slide
9.		Type of slide	Shallow debris slide
10.		Rate of movement or activity	Slow
11.		History of slide	Palaeo-slide
12.	Slide morphology	Length(m)	18m
13.		Width(m)	30m
14.		Height(m)	12m
15.		Run out Distance(m)	4m
17.	Geological details	Geology	Granite
18.		Structural details	Fractured and Jointed
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope Dry
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall and weathering
22.		Landslide process	Natural
23.		Geological causes	Seepage along fracture
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	No information available
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Road/railway track nearby
29.		Agricultural/forest	Nil
30.		Risk	Risk to life and property
31.	Remedial measu	Remedial measures(brief)	retaining wall with draining chutes constructed

ANNEXURE-II

32.		Rehabilitation plan(if applicable)	Settlement nearby should be removed.
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Temple beside is at risk, danger to settlement and communication line.
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Taluks: Karwar Village: Chendiye village

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Chendiye slide (2 slides)
2.		State/District	Uttar Kannada
3.		Toposheet No	48J/1
4.		Important location/Landmark	Chendiye village
5.		Latitude; Longitude	14°45'42.00"; 74°11'29.66"
6.		Date of occurrence	--
7.	Slide type	Type of material involved	Weathered rock and in-situ soil
8.		Type of movement	Advancing, widening and progressive old slide
9.		Type of slide	Debris slide
10.		Rate of movement or activity	Slow
11.		History of slide	Active/old slide scars
12.	Slide morphology	Length(m)	28m
13.		Width(m)	35.6m
14.		Height(m)	1.2m
15.		Run out Distance(m)	25m
17.	Geological details	Geology	Highly weathered jointed and fractured granite
18.		Structural details	
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope/piedmont slope Damp
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide	Triggering factor and causes	Rainfall/Nala erosion
22.		Landslide process	Initiation of 1st order stream
23.		Geological causes	Fractured and Jointed
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Nil
29.		Agricultural/forest	Nil
30.		Risk	Risk to settlement and school

ANNEXURE-II

31.	Remedial measures	Remedial measures(brief)	Slope stabilization by plantation on natural slope for anchoring the loose debris.
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	unstable zone, moderate risk to man and material
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: -- Village: Binaga on NH-17

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Binaga on NH-17
2.		State/District	Uttar Kannada
3.		Toposheet No	48J/1
4.		Important location/Landmark	Binaga on NH-17
5.		Latitude; Longitude	14°46'53.34"; 74°8'10.01"
6.		Date of occurrence	Not available
7.	Slide type	Type of material involved	Weathered rock and in-situ soil
8.		Type of movement	Advancing, widening and progressive old slide
9.		Type of slide	Debris slide
10.		Rate of movement or activity	Slow
11.		History of slide	Suspended
12.	Slide morphology	Length(m)	15m
13.		Width(m)	19m
14.		Height(m)	1.3m
15.		Run out Distance(m)	10m
17.	Geological details	Geology	Highly weathered jointed and fractured granite
18.		Structural details	Fractured and Jointed
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope Dry
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall/Human interferences/ slope destabilization due to slope modification for road construction
22.		Landslide process	Anthropogenic
23.		Geological causes	
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Life and property
29.		Agricultural/forest	Nil
30.		Risk	Risk to communication line road

			and electric power line
31.	Remedial measures	Remedial measures(brief)	Retaining wall is constructed with draining holes still for more safety the height of the retaining wall should be increased for reducing the risk factor.
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	The vertical cut made on the slope for road construction has induced high risk to man and material. The settlement and tower on top of the slope should be removed and shifted to stable and safer site.
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: -- Village: Sasanwad slide

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Sasanwad slide
2.		State/District	Uttar Kannada
3.		Toposheet No	48J/1
4.		Important location/Landmark	Makheri
5.		Latitude; Longitude	14°49'15.7"; 74°10'17.62"
6.		Date of occurrence	Not required
7.	Slide type	Type of material involved	Weathered rock
8.		Type of movement	Advancing, widening and progressive old slide
9.		Type of slide	rock slide
10.		Rate of movement or activity	Slow
11.		History of slide	Suspended
12.	Slide morphology	Length(m)	38m
13.		Width(m)	70m
14.		Height(m)	3m
15.		Run out Distance(m)	32m
17.	Geological details	Geology	Highly weathered jointed and fractured granite
18.		Structural details	Fractured and Jointed
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope/mound Dry
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall/Human interferences/ slope destabilization due to slope modification for road construction
22.		Landslide process	Anthropogenic
23.		Geological causes	Seepage along joint, fracture and shear plane
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Life and property
29.		Agricultural/forest	Nil

ANNEXURE-II

30.		Risk	Risk to communication line road and electric power line
31.	Remedial measures	Remedial measures(brief)	Retaining wall is constructed with draining holes for proper drainage, so that the water saturation get reduced as remedies for toe support.
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	The electric poles should be shifted and settlement at down slope and road communication is at risk . Rock bolting and netting may be done as additional safety and debris material should be removed. As plantation on slope may stabilize the slope.
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: -- Village: Shejvada

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Shejvada slide
2.		State/District	Uttar Kannada
3.		Toposheet No	48J/1
4.		Important location/Landmark	Along Shejavada road
5.		Latitude; Longitude	14°48'37.75"; 74°09'23.40"
6.		Date of occurrence	--
7.	Slide type	Type of material involved	Weathered rock
8.		Type of movement	Advancing, widening and progressive old slide
9.		Type of slide	Debris slide
10.		Rate of movement or activity	Slow
11.		History of slide	Suspended
12.	Slide morphology	Length(m)	30m
13.		Width(m)	75m
14.		Height(m)	5m
15.		Run out Distance(m)	125m
17.	Geological details	Geology	Highly weathered jointed and fractured granite
18.		Structural details	Fractured and Jointed
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope Dry
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall/Human interferences (removal of material)
22.		Landslide process	Anthropogenic
23.		Geological causes	Seepage along joint, fracture and shear plane
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Life and property
29.		Agricultural/forest	Nil
30.		Risk	Risk to communication line road and electric power line

ANNEXURE-II

31.	Remedial measures	Remedial measures(brief)	Natural slope gradation required
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Life and property is at risk
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: -- Village: Aligadde slide

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Aligadde slide
2.		State/District	Uttar Kannada
3.		Toposheet No	48J/1
4.		Important location/Landmark	DC office
5.		Latitude; Longitude	14°48'13.22"; 74°07'30.61"
6.		Date of occurrence	--
7.	Slide type	Type of material involved	Weathered rock
8.		Type of movement	Advancing, widening and progressive old slide
9.		Type of slide	rock slide
10.		Rate of movement or activity	Slow
11.		History of slide	Suspended
12.	Slide morphology	Length(m)	25m
13.		Width(m)	32m
14.		Height(m)	2.5m
15.		Run out Distance(m)	22.5m
17.	Geological details	Geology	Highly weathered jointed and fractured granite
18.		Structural details	Fractured and Jointed
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope/mound Dry
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall/Human interferences/ slope destabilization due to slope modification for road construction
22.		Landslide process	Anthropogenic
23.		Geological causes	Seepage along joint, fracture and shear plane
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Life and property

ANNEXURE-II

29.		Agricultural/forest	Nil
30.		Risk	Risk to communication line road and electric power line
31.	Remedial measures	Remedial measures(brief)	Natural slope gradation required
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Life and property is at risk
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: -- Village: Mudarali slide

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Mudarali slide
2.		State/District	Uttar Kannada
3.		Toposheet No	48J/1
4.		Important location/Landmark	Temple Mudarali road
5.		Latitude; Longitude	14°50'48.78"; 74°10'58.48"
6.		Date of occurrence	--
7.	Slide type	Type of material involved	Weathered rock and in-situ soil
8.		Type of movement	Advancing, widening and progressive old slide
9.		Type of slide	debris slide
10.		Rate of movement or activity	Slow
11.		History of slide	Suspended
12.	Slide morphology	Length(m)	27m
13.		Width(m)	26m
14.		Height(m)	2.5m
15.		Run out Distance(m)	25m
17.	Geological details	Geology	Highly weathered jointed and fractured granite
18.		Structural details	Fractured and Jointed
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope Dry
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall/Human interferences/ slope destabilization due to slope modification for road construction
22.		Landslide process	Anthropogenic
23.		Geological causes	Seepage along joint, fracture
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Life and property
29.		Agricultural/forest	Nil

ANNEXURE-II

30.		Risk	Risk to life and property
31.	Remedial measures	Remedial measures(brief)	Retaining wall with chute drains to arrest rain water percolation from slide area is constructed, plantation on disturbed slope will impart stability
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Life and property is at risk
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: -- Village: Arga village

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Arga village
2.		State/District	Uttar Kannada
3.		Toposheet No	48J/1
4.		Important location/Landmark	NH-17
5.		Latitude; Longitude	14°46'14.40"; 74°09'49.02"
6.		Date of occurrence	--
7.	Slide type	Type of material involved	Weathered rock and in-situ soil
8.		Type of movement	Advancing, widening and progressive old slide
9.		Type of slide	debris slide
10.		Rate of movement or activity	Slow
11.		History of slide	advancing
12.	Slide morphology	Length(m)	12m
13.		Width(m)	13.5m
14.		Height(m)	2 m
15.		Run out Distance(m)	12m
17.	Geological details	Geology	Highly weathered jointed and fractured granite
18.		Structural details	Fractured and Jointed
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope Dry
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall and seepage along joint and fracture plane
22.		Landslide process	Natural
23.		Geological causes	Seepage along joint, fracture
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Life and property
29.		Agricultural/forest	Nil
30.		Risk	Risk to life and property

ANNEXURE-II

31.	Remedial measures	Remedial measures(brief)	Plantation on disturbed slope
32.		Rehabilitation plan(if applicable)	Settlement nearby should be removed
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Life and property is at risk
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: Village: Kodsani along NH-17

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Edapally-Panvel Highway(NH-17)
2.		State/District	Karnataka/Uttar Kannada
3.		Toposheet No	48J/6
4.		Important location/Landmark	Beside River
5.		Latitude; Longitude	14°36'11.04"N, 74°22'49.67"E
6.		Date of occurrence	Palaeo-slide
7.	Slide type	Type of material involved	Laterite and Lateritic soil *(insitu-soil)*
8.		Type of movement	slide
9.		Type of slide	Deep rotational Debris slide
10.		Rate of movement or activity	Suspended
11.		History of slide	Paleoslide, scars present
12.	Slide morphology	Length(m)	40m
13.		Width(m)	44
14.		Run out distance	9m
15.		Height(m)	30m
16.		Volume(m^3) with estimated depth	
17.	Geological details	Geology	Granite Gneiss
18.		Structural details	Fractured and Jointed
19.		i. Geomorphology and ii. Hydro-geological	Lowly Dissected Slope Damp
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall, Nala erosion by Ist order drainage
22.		Landslide process	
23.		Geological causes	Fractured and jointed laterite
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Road
29.		Agricultural/forest	Nil
30.		Risk	Risk to road communication and settlement at downslope.

ANNEXURE-II

31.	Remedial measures	Remedial measures(brief)	Slope gradation required, benches should be made at shorter interval fall restricting toe failure, plantation on destabilized natural slope is required
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Proper plan during road construction and slope stabilization should be followed.
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State:Karnataka District: Uttar Kannada
Tehsil: Village: Aghanashani village

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Aghanashani village
2.		State/District	Karnataka/Uttar Kannada
3.		Toposheet No	48J/6
4.		Important location/Landmark	----
5.		Latitude; Longitude	14°30'14.78"N, 74°21'41.87"E
6.		Date of occurrence	-
7.	Slide type	Type of material involved	Laterite, insitu soil, weathered rock(Talc actinolite chlorite schist)
8.		Type of movement	Advancing, progreesive
9.		Type of slide	Shallow debris slide
10.		Rate of movement or activity	Rapid
11.		History of slide	Active
12.	Slide morphology	Length(m)	35m
13.		Width(m)	57.7m
15.		Height(m)	6.5m
16.		Runout	27m
17.	Geological details	Geology	Granite Gneiss
18.		Structural details	Joint and fracture
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope Damp
20.		Land use/Land cover	Sparsely vegetated/Acacia plantation
21.	Landslide causes	Triggering factor and causes	Rainfall and Quarry 100m/excavation vertical cut of 13m height
22.		Landslide process	rainfall augment erosion, seepage along weaker plane
23.		Geological causes	Vertical cut destabilized natural slope, increased weathering phenomenon
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Yes
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure	Nil

		damages (partially or completely)	
28.		Communication	Road
29.		Agricultural/forest	Nil
30.		Risk	Risk to life and property
31.	Remedial measures	Remedial measures(brief)	Slope gradation required, benches should be made at shorter interval
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Nil
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: Village: NH-17

Sl. No.	Data Set6	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	S4
2.		State/District	Karnataka/Uttar Kannada
3.		Toposheet No	48J/6
4.		Important location/Landmark	2.3 km from Handigadde
5.		Latitude; Longitude	14°36'05.14"N, 74°22'01.80"E
6.		Date of occurrence	-
7.	Slide type	Type of material involved	Laterite and Lateritic soil
8.		Type of movement	slide
9.		Type of slide	Debris slide
10.		Rate of movement or activity	
11.		History of slide	Stabilized
12.	Slide morphology	Length(m)	14m
13.		Width(m)	81m
15.		Height(m)	3m
16.		Run out distance	8m
17.	Geological details	Geology	Granite
18.		Structural details	--
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall and road cutting
22.		Landslide process	Nala erosion and slope modification
23.		Geological causes	Road cutting destabilized natural slope
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Yes
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Nil
29.		Agricultural/forest	Nil
30.		Risk	Risk to road communication , life and property
31.	Remedial	Remedial measures(brief)	163.2m width and 5.5m height retaining wall are constructed.

			Plantation on destabilized natural slope is done.
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Nil
35.		Photograph of Slide	Yes
36.			

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41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: Village: NH-17

Sl. No.	Data Set6	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Handigadde village
2.		State/District	Karnataka/Uttar Kannada
3.		Toposheet No	48J/6
4.		Important location/Landmark	2.3km from Handigadde
5.		Latitude; Longitude	14°36'07.23"N, 74°22'04.47"E
6.		Date of occurrence	--
7.	Slide type	Type of material involved	Weathered rock and in-situ soil
8.		Type of movement	slide
9.		Type of slide	Debris slide
10.		Rate of movement or activity	slow
11.		History of slide	Advancing and progreesive
12.	Slide morphology	Length(m)	84m
13.		Width(m)	46m
15.		Height(m)	2.5m
16.		Run out distance	78.6m
17.	Geological details	Geology	Granite
18.		Structural details	--
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall and road cutting
22.		Landslide process	Nala erosion and slope modification
23.		Geological causes	Road cutting destabilized natural slope, removal of material
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Yes
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Nil
29.		Agricultural/forest	Nil
30.		Risk	Risk to road communication , life and property
31.	Remedial	Remedial measures(brief)	163.2m width and 5.5m height retaining wall are constructed.

			Plantation on destabilized natural slope is done.
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Nil
35.		Photograph of Slide	Yes
36.			

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41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: Village: Urkeri village

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Urkeri slide
2.		State/District	Karnataka/Uttar Kannada
3.		Toposheet No	48J/7
4.		Important location/Landmark	Konkan railway track/ along road section
5.		Latitude; Longitude	14°23'21.96"N, 74°24'54.11"E
6.		Date of occurrence	Not required
7.	Slide type	Type of material involved	Laterite, Lateritic soil *(insitu-soil)*
8.		Type of movement	Advancing, progressive and widening
9.		Type of slide	Shallow Debris slide
10.		Rate of movement or activity	Suspended
11.		History of slide	initiation
12.	Slide morphology	Length(m)	24m
13.		Width(m)	18.5m
14.		Run out distance	8.5m
15.		Height(m)	21.5m
17.	Geological details	Geology	Granite Gneiss
18.		Structural details	Fractured and Jointed
19.		iii. Geomorphology and iv. Hydro-geological	Lowly Dissected Slope Dry
20.		Land use/Land cover	Sparsely vegetated/Plantation(LHP)
21.	Landslide causes	Triggering factor and causes	Rainfall and anthropogenic: slope modification for road construction and road widening
22.		Landslide process	
23.		Geological causes	Fractured and jointed laterite
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Road
29.		Agricultural/forest	Nil
30.		Risk	Risk to road communication and settlement at downslope.

ANNEXURE-II

31.	Remedial measures	Remedial measures(brief)	Slope gradation required, benches should be made at shorter interval fall restricting toe failure.
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Proper plan during road construction and slope stabilization should be followed.
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State:Karnataka District: Uttar Kannada
Tehsil: Village: Swarnagadde

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Swarnagadde village
2.		State/District	Karnataka/Uttar Kannada
3.		Toposheet No	48J/7
4.		Important location/Landmark	NH-17
5.		Latitude; Longitude	14°21'27.89"N, 74°25'5.52"E
6.		Date of occurrence	Not required
7.	Slide type	Type of material involved	Laterite and in-situ soil and highly weathered rock
8.		Type of movement	Advancing , progressive
9.		Type of slide	Suspended
10.		Rate of movement or activity	initiation
11.		History of slide	Active
12.	Slide morphology	Length(m)	22m
13.		Width(m)	35m
15.		Height(m)	4m
16.		Volume(m^3) with estimated depth	18m
17.	Geological details	Geology	Granite gneiss
18.		Structural details	--
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected Slope Dry
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall and Quarry of 130m width. Unscientific way of excavation.
22.		Landslide process	
23.		Geological causes	
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Road
29.		Agricultural/forest	Nil
30.		Risk	Risk to road communication

ANNEXURE-II

31.	Remedial measures	Remedial measures(brief)	Retaining wall with side drains to arrest rain water percolation from slide area
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Nil
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State:Karnataka District:Uttar Kannada
Tehsil: Village: Kodigadde

Sl. No.	Data Set5	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	
2.		State/District	Karnataka/Uttar Kannada
3.		Toposheet No	48J/7
4.		Important location/Landmark	Haldipur
5.		Latitude; Longitude	14°21'14.12"N, 74°25'56.03"E
6.		Date of occurrence	Not available
7.	Slide type	Type of material involved	Laterite, insitu soil, weathered rock(Talc actinolite chlorite schist)
8.		Type of movement	Advancing, progressive
9.		Type of slide	Shallow debris slide
10.		Rate of movement or activity	Rapid
11.		History of slide	Active
12.	Slide morphology	Length(m)	65m
13.		Width(m)	63.7mm
15.		Height(m)	6.5m
16.		Runout	60m
17.	Geological details	Geology	Granit Gneiss
18.		Structural details	---
19.		iii. Geomorphology and iv. Hydro-geological	Lowly dissected slope dry
20.		Land use/Land cover	Sparsely vegetated/Acacia plantation
21.	Landslide causes	Triggering factor and causes	Rainfall and quarry
22.		Landslide process	rainfall augment erosion, seepage along weaker plane
23.		Geological causes	Vertical cut destabilized natural slope, increased weathering phenomenon
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Road
29.		Agricultural/forest	Nil
30.		Risk	Community hall should be removed,

ANNEXURE-II

			Risk to road communication and settlement at downslope
31.	Remedial measures	Remedial measures(brief)	Slope gradation required, benches should be made. Retaining wall with side drains to arrest rain water percolation from slide area
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Temple and community hall is at risk, danger to life and property
35.		Photograph of Slide	Yes
36.			

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41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State:Karnataka District: Uttar Kannada
Tehsil: Village: Apsarkonda

Sl. No.	Data Set9	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Apsarkonda
2.		State/District	Karnataka/Uttar Kannada
3.		Toposheet No	48J/8
4.		Important location/Landmark	Apsarkonda
5.		Latitude; Longitude	14°14'18.68"N, 74°26'54.95"E
6.		Date of occurrence	-
7.	Slide type	Type of material involved	Weathered rock and insitu soil
8.		Type of movement	slide
9.		Type of slide	Shallow debris slide
10.		Rate of movement or activity	Suspended and stabilized
11.		History of slide	Old slide
12.	Slide morphology	Length(m)	18m
13.		Width(m)	9m
14.		Run out distance	7.6m
15.		Height(m)	4.5m
16.		Vertical cut	13m
17.	Geological details	Geology	Granite Gneiss
18.		Structural details	--
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope Damp
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall and vertical road cutting
22.		Landslide process	Unscientific way of slope modification, without proper plan
23.		Geological causes	Weathering phenomenon
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Nil
29.		Agricultural/forest	Nil
30.		Risk	Risk to road communication and settlement downslope

ANNEXURE-II

31.	Remedial measures	Remedial measures(brief)	Slope stabilization required, benches should be made at shorter interval
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	The electric pole should be shifted to safer place. Although the retaining wall of 3m height with proper draining hole at toe part provides proper drainage and toe stabilization from further erosion.
35.		Photograph of Slide	Yes
36.			

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41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State:Karnataka District: Uttar Kannada
Tehsil: Village: Apsarkonda

Sl. No.	Data Set9	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Apsarkonda
2.		State/District	Uttar Kannada
3.		Toposheet No	48J/8
4.		Important location/Landmark	Along Apsarkonda road section
5.		Latitude; Longitude	14°14'12.4"N, 74°26'48.81"E
6.		Date of occurrence	-
7.	Slide type	Type of material involved	Weathered rock, laterite and in situ soil
8.		Type of movement	Advancing, progressive
9.		Type of slide	Shallow debris slide
10.		Rate of movement or activity	Active
11.		History of slide	Old slide
12.	Slide morpholog	Length(m)	16.6m
13.		Width(m)	60.4m
14.		Run out distance	2m
15.		Height(m)	8m
17.	Geological details	Geology	Granite Gneiss
18.		Structural details	--
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope Damp
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide causes	Triggering factor and causes	Rainfall and weathering phenomenon
22.		Landslide process	Slope modification for road construction
23.		Geological causes	Weathering phenomenon
24.	Damage and risk due to	Death of person/human Causality/injury	Nil
25.		People affected	Nil
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Nil
29.		Agricultural/forest	Nil
30.		Risk	Risk to road communication and settlement downslope
31.	Re me	Remedial measures(brief)	Plantation on natural slope required

ANNEXURE-II

32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	60.4m width and 2.5m high retaining wall constructed and toe part is supported with proper drainage.
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State:Karnataka District: Uttar Kannada
Tehsil: Village: Aghanashani village

Sl. No.	Data Set5	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Aghanashani village
2.		State/District	Uttar Kannada
3.		Toposheet No	48J/6
4.		Important location/Landmark	----
5.		Latitude; Longitude	14°30'15.83"N, 74°21'43.64"E
6.		Date of occurrence	-
7.	Slide type	Type of material involved	Laterite, lateritic soil, weathered rock
8.		Type of movement	Advancing, progressive
9.		Type of slide	Shallow translational debris slide
10.		Rate of movement or activity	Rapid
11.		History of slide	Active
12.	Slide morphology	Length(m)	27m
13.		Width(m)	53.4m
15.		Height(m)	7.5m
16.		Runout	16.5m
17.	Geological details	Geology	Granit Gneiss
18.		Structural details	
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope dry
20.		Land use/Land cover	Sparsely vegetated/Acacia plantation
21.	Landslide causes	Triggering factor and causes	Rainfall and quarry 100m/excavation vertical cut of 10m height
22.		Landslide process	rainfall augment erosion, seepage along weaker plane
23.		Geological causes	Vertical cut destabilized natural slope, increased weathering phenomenon
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Yes
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Road

ANNEXURE-II

29.		Agricultural/forest	Nil
30.		Risk	Risk to road communication , Downslope settlement
31.	Remedial measures	Remedial measures(brief)	Slope gradation required Retaining wall with side drains to arrest rain water percolation from slide area
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Nil
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State: Karnataka District: Uttar Kannada
Tehsil: Village: Honnebail village

Sl. No.	Data Set6	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Honnebail village
2.		State/District	Karnataka/Uttar Kannada
3.		Toposheet No	48J/6
4.		Important location/Landmark	--
5.		Latitude; Longitude	14°36'49.8"N, 74°18'21.6"E
6.		Date of occurrence	--
7.	Slide type	Type of material involved	Weathered rock and in-situ soil
8.		Type of movement	slide
9.		Type of slide	Composite slide (Rock cum Debris slide)
10.		Rate of movement or activity	Suspended
11.		History of slide	Advancing and progressive
12.	Slide morpholog	Length(m)	4m
13.		Width(m)	15m
15.		Height(m)	2m
16.		Run out distance	3.5m
17.	Geological details	Geology	Granite Gneiss
18.		Structural details	---
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope
20.		Land use/Land cover	Sparsely vegetated
21.	Landslide	Triggering factor and causes	Rainfall and road cutting
22.		Landslide process	Slope modification and weathering
23.		Geological causes	Road cutting destabilized natural slope
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Yes
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Nil
29.		Agricultural/forest	Nil
30.		Risk	Risk to road communication, life and property
31.	Remedial	Remedial measures(brief)	Retaining wall constructed with draining holes to arrest water to prevent toe erosion.

ANNEXURE-II

32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Nil
35.		Photograph of Slide	Yes
36.			

ANNEXURE-II

41- POINT GEO-PARAMETRIC DATA INVENTORY (01 to 23)

State:Karnataka District: Uttar Kannada
Tehsil: Village: Kodigadde village

Sl. No.	Data Set	Geoparameters	Guidelines on the details of information
1.	Location details	Slide No./ID/ Popular name	Kodigadde village
2.		State/District	Uttar Kannada
3.		Toposheet No	48J/6
4.		Important location/Landmark	Govt. hospital/mortuary
5.		Latitude; Longitude	14°21'02.94"N, 74°25'59.82"E
6.		Date of occurrence	-
7.	Slide type	Type of material involved	Laterite, Lateritic soil, weathered rock
8.		Type of movement	Advancing, progressive
9.		Type of slide	Shallow translational debris slide
10.		Rate of movement or activity	Rapid
11.		History of slide	Active
12.	Slide morphology	Length(m)	34m
13.		Width(m)	53.4m
15.		Height(m)	5m
16.		Runout	24.5m
17.	Geological details	Geology	Granit Gneiss
18.		Structural details	
19.		i. Geomorphology and ii. Hydro-geological	Lowly dissected slope dry
20.		Land use/Land cover	Sparsely vegetated/Acacia plantation
21.	Landslide causes	Triggering factor and causes	Rainfall and quarry 100m/excavation vertical cut of 10-15m height
22.		Landslide process	rainfall augment erosion, seepage along weaker plane
23.		Geological causes	Vertical cut destabilized natural slope, increased weathering phenomenon
24.	Damage and risk due to landslide	Death of person/human Causality/injury	Nil
25.		People affected	Yes
26.		Live stock loss	Nil
27.		Buildings/houses/infrastructure damages (partially or completely)	Nil
28.		Communication	Road
29.		Agricultural/forest	Nil
30.		Risk	Risk to road communication, Downslope settlement

ANNEXURE-II

31.	Remedial measures	Remedial measures(brief)	Slope gradation required, loose debris material should be removed.
32.		Rehabilitation plan(if applicable)	Not applicable
33.		Realignment (in case of road communication network)	Nil
34.	Slide documentation	Remarks/ Abstract	Mortuary and communication line at risk
35.		Photograph of Slide	Yes
36.			

Table 1: Details of nature of work, quantum and achievements

Nature of work	Target F.S: 2015-16 in (sq. km)	Achievement F.S: 2015-16 in (sq. km)
1.Pre field map preparation		
Preparation of Thematic maps (in GIS on scale 1:50000)		
a) Slope forming material map	1376 sq. km	1376 sq. km
b) Geomorphology and lineament map	1376 sq. km	1376 sq. km
c) Slope morphometry (slope, aspect & curvature) map	1376 sq. km	1376 sq. km
d) Landuse / Landcover map	1376 sq. km	1376 sq. km
e) Drainage map	1376 sq. km	1376 sq. km
f) Regolith thickness map	1376 sq. km	1376 sq. km
ii) Preparation of landslide inventory map	1376 sq. km	1376 sq. km
2.Field based studies		
i) Field checking of all thematic maps	1376 sq. km	1376 sq. km
ii) Field validation of landslide inventory and collection of recent and historic landslides	1376 sq. km	1377 sq. km
iii) Collection of landslide inventory and damage data as per 41 point geo - parametric sheet	As necessary	23 nos. (Landslides)
iv) Validation of landslide susceptibility map at important locations	1376 sq. km	1376 sq. km
3. Post field studies and modelling		
iii)Updation of thematic and inventory maps in GIS	1376 sq. km	1376 sq. km
iv)Preparation of landslide susceptibility map in GIS	1376 sq. km	1376 sq. km
4.Collection of rainfall data	As necessary	collected

Table 2: LU/LC classes and area under each class in percentage

LU/LC Classes	Area in Percentage (%)
Barren (B)	4.28
Barren Sand (BS)	1.86
Cultivation (CL)	15.11
Extensive Slope Cut (ESC)	0.08
Fallow Land (FL)	2.12
Moderate Vegetation (MV)	17.14
Plantation (HHP)	5.66
Plantation (LHP)	0.003
Quarry (QR)	0.08
Settlement (S)	3.14
Settlement on modified slope (SM)	0.25
Swamp (SW)	2.23
Thick Vegetation (TV)	36.66
Sparse Vegetation (SV)	5.94
Salt Pan (SP)	0.95
Waterbody (WB)	4.504

Table 3: Geomorphology classes and area under each class in percentage

Geomorphology classes	Area covered in percentage (%)
Denudational Slope	0.056
Mound	0.307
Lowly Dissected Slope	24.18
Moderately Dissected Slope	14.058
Highly Dissected Slope	11.08
Piedmont Slope	0.659
Ridge-top	0.01
Tidal Flat	0.1
Water body	4.67
Plateau Top (Flat)	1.96
Rolling Plain	10.54
Valley Fill	0.8
Alluvial Plain	10.52
Beach	0.83
Coastal Plain	2.467
Pediment Pediplain Complex	15.78
Hilltop	2.029

Table 4: Slope angle classes with LOFS rating

I. Pair-wise comparison matrix of Slope Angle classes

Slope Angle	<15°	15-25°	25°-35°	35°-45°	>45°
<15°	1.00	0.33	0.14	0.20	1.00
15°-25°	3.00	1.00	0.20	0.33	3.00
25°-35°	7.00	5.00	1.00	3.00	7.00
35°-45°	5.00	3.00	0.33	1.00	5.00
>45°	1.00	0.33	0.14	0.20	1.00
Cumulative Sum	**17.00**	**9.67**	**1.82**	**4.73**	**17.00**

II. LOFS rating for Slope Angle class

Slope Angle	<15°	15-25°	25-35°	35-45°	>45°	Sum	Frac. Rate	LOFS rating
<15°	0.05882	0.034483	0.078534	0.042254	0.058824	0.272917	0.054583	0.1081
15-25°	0.17647	0.103448	0.109948	0.070423	0.176471	0.63676	0.127352	0.2523
25-35°	0.41176	0.517241	0.549738	0.633803	0.411765	2.524312	0.504862	1.0000
35-45°	0.29412	0.310345	0.183246	0.211268	0.294118	1.293094	0.258619	0.5123
>45°	0.05882	0.034483	0.078534	0.042254	0.058824	0.272917	0.054583	0.1081

Slope Angle class	Rank	LOFS Rating
<15°	**2**	**0.1081**
15°-25°	**4**	**0.2523**
25°-35°	**8**	**1.0000**
35°-45°	**6**	**0.5123**
>45°	**2**	**0.1081**

Table 5: Slope Curvature classes with LOFS rating

I. Pair-wise comparison matrix of Slope Curvature classes

Curvature	Concave	Flat	Convex
Concave	1.00	3.00	0.33
Flat	0.33	1.00	0.20
Convex	3.00	5.00	1.00
Cumulative Sum	4.33	9.00	1.53

II. LOFS rating for Slope Curvature classes

Curvature	Concave	Flat	Convex	Sum rows	Frac. rate	LOFS Rating
Concave	0.230769	0.333333	0.217391	0.781494	0.260498	0.4113
Flat	0.076923	0.111111	0.130435	0.318469	0.106156	0.1676
Convex	0.692308	0.555556	0.652174	1.900037	0.633346	1.0000

CLASS	Rank	LOFS Rating
Concave	4	0.4113
Flat	2	0.1676
Convex	6	1.0000

Table 6: Landuse and Landcover classes with LOFS rating

I. Pair-wise comparison matrix of Landuse-Landcover classes

LULC	B	CL	ESC	FL	MV	HHP	LHP	QR	S	SM	TV	SV
B	1.00	0.50	0.11	1.00	0.20	0.25	0.33	0.20	1.00	0.14	0.25	0.14
CL	2.00	1.00	0.13	2.00	0.25	0.33	0.50	0.25	2.00	0.17	0.33	0.17
ESC	9.00	8.00	1.00	9.00	5.00	6.00	7.00	5.00	9.00	3.00	6.00	3.00
FL	1.00	0.50	0.11	1.00	0.20	0.25	0.33	0.20	1.00	0.14	0.25	0.14
MV	5.00	4.00	0.20	5.00	1.00	2.00	3.00	1.00	5.00	0.33	2.00	0.33
HHP	4.00	3.00	0.17	4.00	0.50	1.00	2.00	0.50	4.00	0.25	1.00	0.25
LHP	3.00	2.00	0.14	3.00	0.33	0.50	1.00	0.33	3.00	0.20	0.50	0.20
QR	5.00	4.00	0.20	5.00	1.00	2.00	3.00	1.00	5.00	0.33	2.00	0.33
S	1.00	0.50	0.11	1.00	0.20	0.25	0.33	0.50	1.00	0.14	0.25	0.14
SM	7.00	6.00	0.33	7.00	3.00	4.00	5.00	3.00	7.00	1.00	4.00	1.00
TV	4.00	3.00	0.17	4.00	0.50	1.00	2.00	0.50	4.00	0.25	1.00	0.25
SV	7.00	6.00	0.33	7.00	3.00	4.00	5.00	3.00	7.00	1.00	4.00	1.00
Cumulative Sum	**49.00**	**38.50**	**3.00**	**49.00**	**15.18**	**21.58**	**29.50**	**15.48**	**49.00**	**6.96**	**21.58**	**6.96**

II. LOFS rating for Landuse-Landcover classes

LULC	B	CL	ESC	FL	MV	HHP	LHP	QR	S	SM	TV	SV	Sum rows	Frac rate	LOFS
B	0.020408	0.012987	0.037022	0.020408	0.013172	0.011583	0.011299	0.012917	0.020408	0.02052	0.011583	0.02052	0.212828	0.017736	0.0626
CL	0.040816	0.025974	0.04165	0.040816	0.016465	0.015444	0.016949	0.016146	0.040816	0.02394	0.015444	0.02394	0.318402	0.026533	0.0937
ESC	0.183673	0.207792	0.333201	0.183673	0.329308	0.277992	0.237288	0.322928	0.183673	0.430917	0.277992	0.430917	3.399356	0.28328	1.0000
FL	0.020408	0.012987	0.037022	0.020408	0.013172	0.011583	0.011299	0.012917	0.020408	0.02052	0.011583	0.02052	0.212828	0.017736	0.0626
MV	0.102041	0.103896	0.06664	0.102041	0.065862	0.092664	0.101695	0.064586	0.102041	0.04788	0.092664	0.04788	0.989888	0.082491	0.2912
HHP	0.081633	0.077922	0.055534	0.081633	0.032931	0.046332	0.067797	0.032293	0.081633	0.03591	0.046332	0.03591	0.675857	0.056321	0.1988
LHP	0.061224	0.051948	0.0476	0.061224	0.021954	0.023166	0.033898	0.021529	0.061224	0.028728	0.023166	0.028728	0.46439	0.038699	0.1366
QR	0.102041	0.103896	0.06664	0.102041	0.065862	0.092664	0.101695	0.064586	0.102041	0.04788	0.092664	0.04788	0.989888	0.082491	0.2912
S	0.020408	0.012987	0.037022	0.020408	0.013172	0.011583	0.011299	0.032293	0.020408	0.02052	0.011583	0.02052	0.232204	0.01935	0.0683
SM	0.142857	0.155844	0.111067	0.142857	0.197585	0.185328	0.169492	0.193757	0.142857	0.143639	0.185328	0.143639	1.91425	0.159521	0.5631
TV	0.081633	0.077922	0.055534	0.081633	0.032931	0.046332	0.067797	0.032293	0.081633	0.03591	0.046332	0.03591	0.675857	0.056321	0.1988
SV	0.142857	0.155844	0.111067	0.142857	0.197585	0.185328	0.169492	0.193757	0.142857	0.143639	0.185328	0.143639	1.91425	0.159521	0.5631

CLASS	Rank	LOFS Rating
Barren	1	0.0626
Barren Sand	0	0.0000
Cultivation	2	0.0937
Extensive Slope Cut	9	1.0000
Fallow Land	1	0.0626
Moderate Vegetation	5	0.2912
Plantation (HHP)	4	0.1988
Plantation (LHP)	3	0.1366
Quarry	5	0.2912
Settlement	1	0.0683
Settlement on modified slope	7	0.5631
Swamp	0	0.0000
Thick Vegetation	4	0.1988
Sparse Vegetation	7	0.5631
Water body	0	0.0000
Salt Pan	0	0.0000

Table 7: Geomorphology classes with LOFS rating

I. Pair-wise comparison matrix of Landuse-Landcover classes

CLASS	DS	ESC	MOUND	CFS	LDS	MDS	HDS	PIED SLOPE
DS	1	8	8	7	6	4	2	6
ESC	0.125	1	1	0.5	0.333333333	0.2	0.142857143	0.333333333
MOUND	0.125	1	1	0.5	0.333333333	0.2	0.142857143	0.333333333
CFS	0.142857143	2	2	1	0.5	0.25	0.166666667	0.5
LDS	0.166666667	3	3	2	1	0.333333333	0.2	1
MDS	0.25	5	5	4	3	1	0.333333333	3
HDS	0.5	7	7	6	5	3	1	5
PIED SLOPE	0.166666667	3	3	2	1	0.333333333	0.2	1
Sum total	2.476190476	30	30	23	17.16666667	9.316666667	4.185714286	17.16666667

II.LOFS rating for Geomorphology classes

CLASS	DS	ESC	MOUND	CFS	LDS	MDS	HDS	PIED SLOPE	Sum Rows	Frac rate	LOFS
DS	0.403846154	0.266667	0.266666667	0.30435	0.349514563	0.429338104	0.4778157	0.34951456	2.8477102	0.35596	1
ESC	0.050480769	0.033333	0.033333333	0.02174	0.019417476	0.021466905	0.034129693	0.01941748	0.2333181	0.02916	0.08193
MOUND	0.050480769	0.033333	0.033333333	0.02174	0.019417476	0.021466905	0.034129693	0.01941748	0.2333181	0.02916	0.08193
CFS	0.057692308	0.066667	0.066666667	0.04348	0.029126214	0.026833631	0.039817975	0.02912621	0.3594079	0.04493	0.12621
LDS	0.067307692	0.1	0.1	0.08696	0.058252427	0.035778175	0.04778157	0.05825243	0.5543288	0.06929	0.19466
MDS	0.100961538	0.166667	0.166666667	0.17391	0.174757282	0.107334526	0.07963595	0.17475728	1.144693	0.14309	0.40197
HDS	0.201923077	0.233333	0.233333333	0.26087	0.291262136	0.322003578	0.23890785	0.29126214	2.072895	0.25911	0.72792
PIED SLOPE	0.067307692	0.1	0.1	0.08696	0.058252427	0.035778175	0.04778157	0.05825243	0.5543288	0.06929	0.19466

GEOMORPHOLOGY CLASSES	Rank	LOFS Rating
Denudational Slope (DS)	9	1.0000
Escarpment(ESC)	2	0.0819
Mound	2	0.0819
Colluvial Footslope(CFS)	3	0.1262
Lowly Dissected Slope(LDS)	4	0.1947
Moderately Dissected Slope(MDS)	6	0.4020
Highly Dissected Slope(HDS)	8	0.7279
Piedmont Slope(PIED SLOPE)	4	0.1947
Ridge-top	0	0
Tidal Flat	0	0
Water body	0	0
Plateau Top (Flat)	0	0
Rolling Plain	0	0
Valley Fill	0	0
Alluvial Plain	0	0
Beach	0	0
Coastal Plain	0	0
Pediment Pediplain Complex	0	0
Hilltop	0	0

Table 8: Slope Forming Material map with LOFS rating

I. Pair-wise comparison matrix of Slope Curvature classes

SFM CLASSES	CSD	INSITU	Col	LSD	R(Type-1)	R(Type-2)	R(Type-3)	TS	WR
CSD	1	0.5	0.333333	0.166667	3	2	0.5	1	0.25
INSITU	2	1	0.5	0.2	4	3	1	2	0.333333
Col	3	2	1	0.25	5	4	2	3	0.5
LSD	6	5	4	1	8	7	5	6	3
R(Type-1)	0.333333	0.25	0.2	0.125	1	0.5	0.25	0.333333333	0.166667
R(Type-2)	0.5	0.333333	0.25	0.142857	2	1	0.333333333	0.5	0.2
R(Type-3)	2	1	0.5	0.2	4	3	1	2	0.333333
TS	1	0.5	0.333333	0.166667	3	2	0.5	1	0.25
WR	4	3	2	0.333333	6	5	3	4	1
SUM	19.83333	13.58333	9.116667	2.584524	36	27.5	13.58333333	19.83333333	6.033333

II. LOFS rating for Slope Forming Material classes

SFM CLASSES	CSD	INSITU	Col	LSD	R(Type-1)	R(Type-2)	R(Type-3)	TS	WR	Sum Rows	Frac rate	LOFS
CSD	0.05042	0.03681	0.036563	0.064486	0.083333333	0.072727273	0.036809816	0.050420168	0.041436	0.473006521	0.052556	0.150594949
INSITU	0.10084	0.07362	0.054845	0.077384	0.111111111	0.109090909	0.073619632	0.100840336	0.055249	0.756598876	0.084067	0.240884562
Col	0.151261	0.147239	0.109689	0.09673	0.138888889	0.145454545	0.147239264	0.151260504	0.082873	1.17063473	0.130071	0.372704538
LSD	0.302521	0.368098	0.438757	0.386918	0.222222222	0.254545455	0.36809816	0.302521008	0.497238	3.140918908	0.348991	1
R(Type-1)	0.016807	0.018405	0.021938	0.048365	0.027777778	0.018181818	0.018404908	0.016806723	0.027624	0.214309818	0.023812	0.068231567
R(Type-2)	0.02521	0.02454	0.027422	0.055274	0.055555556	0.036363636	0.024539877	0.025210084	0.033149	0.307264657	0.034141	0.097826358
R(Type-3)	0.10084	0.07362	0.054845	0.077384	0.111111111	0.109090909	0.073619632	0.100840336	0.055249	0.756598876	0.084067	0.240884562
TS	0.05042	0.03681	0.036563	0.064486	0.083333333	0.072727273	0.036809816	0.050420168	0.041436	0.473006521	0.052556	0.150594949
WR	0.201681	0.220859	0.219378	0.128973	0.166666667	0.181818182	0.220858896	0.201680672	0.165746	1.707661092	0.18974	0.543682006

SFM CLASSES	Rank	LOFS	SFM CLASSES	Rank	LOFS
Compact slide Debris	3	0.1506	Pegmatite	1	0.0682
In-situ soil	4	0.2409	Charnockite	1	0.0682
Colluvium	5	0.3727	Dunite	2	0.0978
Loose slide Debris	8	1.0000	Greywacke	2	0.0978
Banded iron formation	1	0.0682	Peridotite	2	0.0978
Dolerite	1	0.0682	Actinolite-chlorite schist	4	0.2409
Gabbro	1	0.0682	Amphibolite	4	0.2409
Granite gneiss	1	0.0682	Argillite	4	0.2409
Granitoid	1	0.0682	Hornblende-actinolite-chlorite schist	4	0.2409
Limestone	1	0.0682	Laterite	4	0.2409
Metabasalt	1	0.0682	Manganiferous phyllite	4	0.2409
pyroxenite	1	0.0682	Metabasalt (shistose)	4	0.2409
Quartzite	1	0.0682	Talc-chlorite schist	4	0.2409
Vanadiferous titano-magnetite	1	0.0682	Talc-tremolite schist	4	0.2409

SFM CLASSES	Rank	LOFS	SFM CLASSES	Rank	LOFS
Websterite	1	0.0682	Calc granulite	4	0.2409
Grey granite	1	0.0682	Pyroxene granulite	4	0.2409
Granite	1	0.0682	Transported Soil	3	0.1506
Gar-bio-sill gneiss + graphite + kyanite	1	0.0682	Weathered Rock	6	0.5437
Garnet-sillimanite-gneiss + graphite + cordierite	1	0.0682	Salt	0	0.0000
Garnet-sillimanite-kyanite gneiss	1	0.0682	Water body	0	0.0000
Hornblende-diopside gneiss	1	0.0682	Alluvium	0	0.0000
Quartz vein	1	0.0682	Beach Sand	0	0.0000

Table 9: Regolith Thickness classes with LOFS rating

I. Pair-wise comparison matrix of Regolith Thickness classes

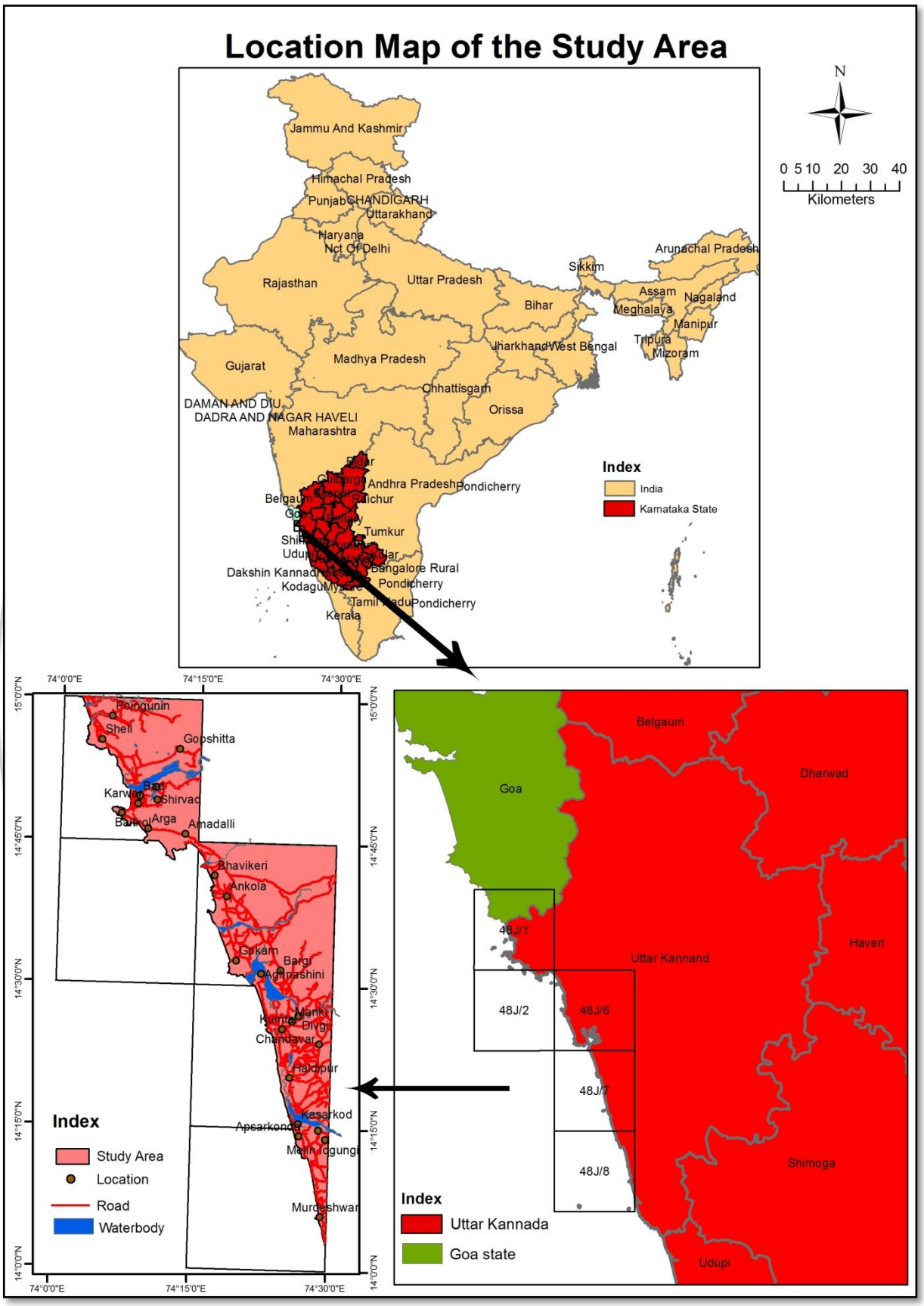
Regolith Thickness	0.5 - 5 m	5 - 10 m	>10 m
0.5 - 5 m	1.00	4.00	6.00
5 - 10 m	0.25	1.00	3.00
>10 m	0.17	0.33	1.00
Sun Clm	1.42	5.33	10.00

II. LOFS rating for Regolith Thickness classes

Regolith Thickness	0.5 - 5 m	5 - 10 m	>10 m	Sum rows	Frac rate	LOFS
0.5 - 5 m	0.705882	0.75	0.6	2.055882	0.685294	1.0000
5 - 10 m	0.176471	0.1875	0.3	0.663971	0.221324	0.3230
>10 m	0.117647	0.0625	0.1	0.280147	0.093382	0.1363

Regolith Thickness classes (in mts)	Rank	LOFS Rating
<0.5m	0	0
0.5-5m	7	1
5-10m	4	0.322961
>10m	2	0.136266

Plate-1


Location Map of the Study Area
N
0 5 10 20 30 40
Kilometers
Jammu And Kashmir
Himachal Pradesh
Punjab
CHANDIGARH
Uttarakhand
Haryana
Nct Of Delhi
Rajasthan
Uttar Pradesh
Sikkim
Arunachal Pradesh
Assam
Nagaland
Meghalaya
Manipur
Tripura
Mizoram
Bihar
Jharkhand
West Bengal
Gujarat
Madhya Pradesh
Chhattisgarh
Orissa
DAMAN AND DIU
DADRA AND NAGAR HAVELI
Maharashtra
Andhra Pradesh
Pondicherry
Belgaum
Tumkur
Bangalore Rural
Kodagu
Tamil Nadu
Kerala
Index
India
Karnataka State
74°0'0"E
74°15'0"E
74°30'0"E
15°0'0"N
14°45'0"N
14°30'0"N
14°15'0"N
14°0'0"N
Poingunin
Sheli
Gopshitta
Karwar
Shirvad
Arga
Amadalli
Bhavikeri
Ankola
Gokarn
Bargi
Aganashini
Chandavar
Haldipur
Kasarkod
Apsarkonda
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Study Area
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Road
Waterbody
Belgaum
Goa
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Haveri
Uttar Kannand
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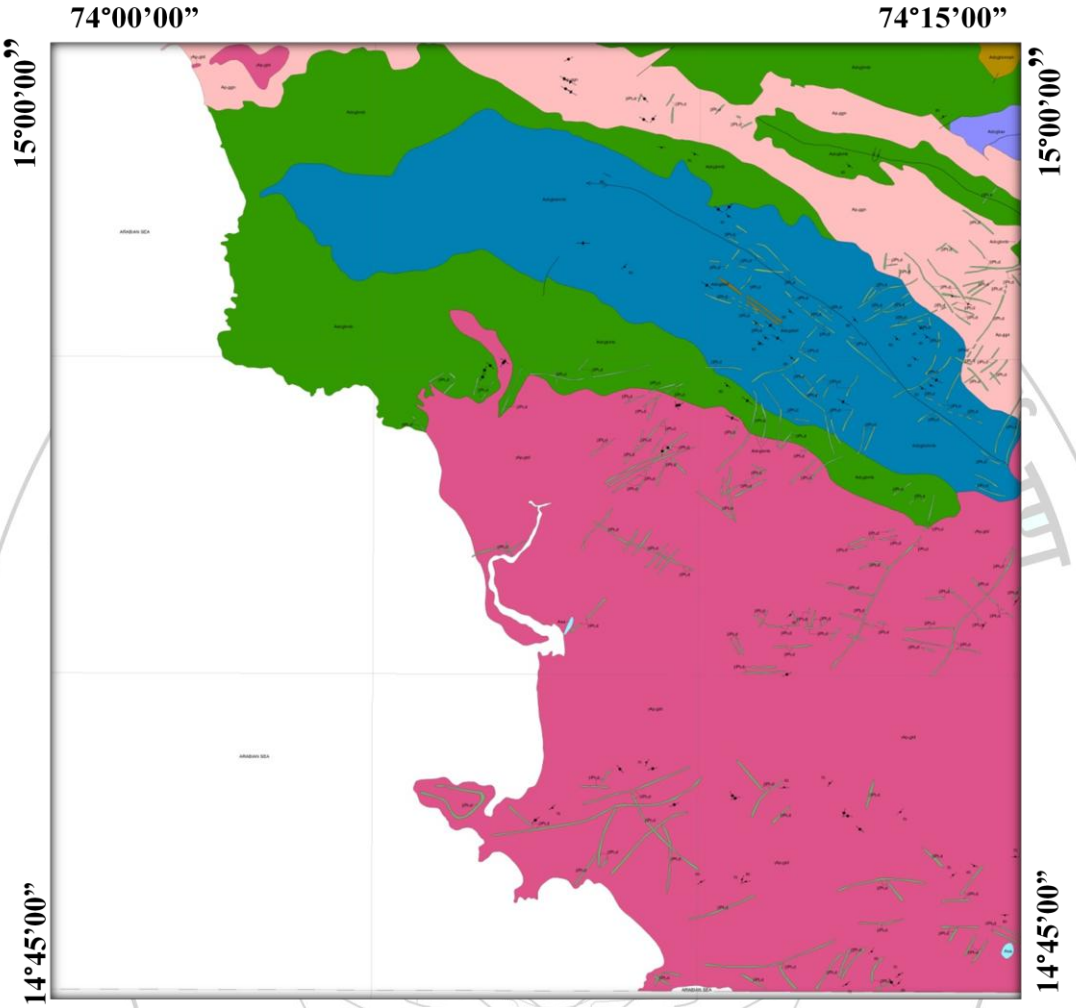
48J/2
48J/6
48J/7
48J/8
Shimoga
Udupi
Index
Uttar Kannada
Goa state

Plate-2

GEOLOGICAL MAP OF TS NO. 48J/1 OF UTTAR KANNADA DISTRICT, KARNATAKA



	Formation	Group	Supergroup	Age
βPt₁d Dolerite	Basic intrusives	Younger intrusives		Palaeoproterozoic
Adcgbimnph Manganiferous phyllite	Bicholim	Chitradurga(Goa)	Dharwar	Archaean
Adcgbav Acid volcanics	Barcem			
Adcgbbif Banded iron formation				
Adcgbshmb Metabasalt(schistose)				
Adcgbmb Metabasalt				
γAp₁gtd Granitoid	Granitoids	Peninsular Gneiss-I	Peninsular Gneissic Complex	
γAp₁gtd Granitoid(Karwar)				
Ap₁ggn Granite gneiss	Gneisses			
Asa Amphibolite		Sargur		

STRUCTURAL SYMBOLS

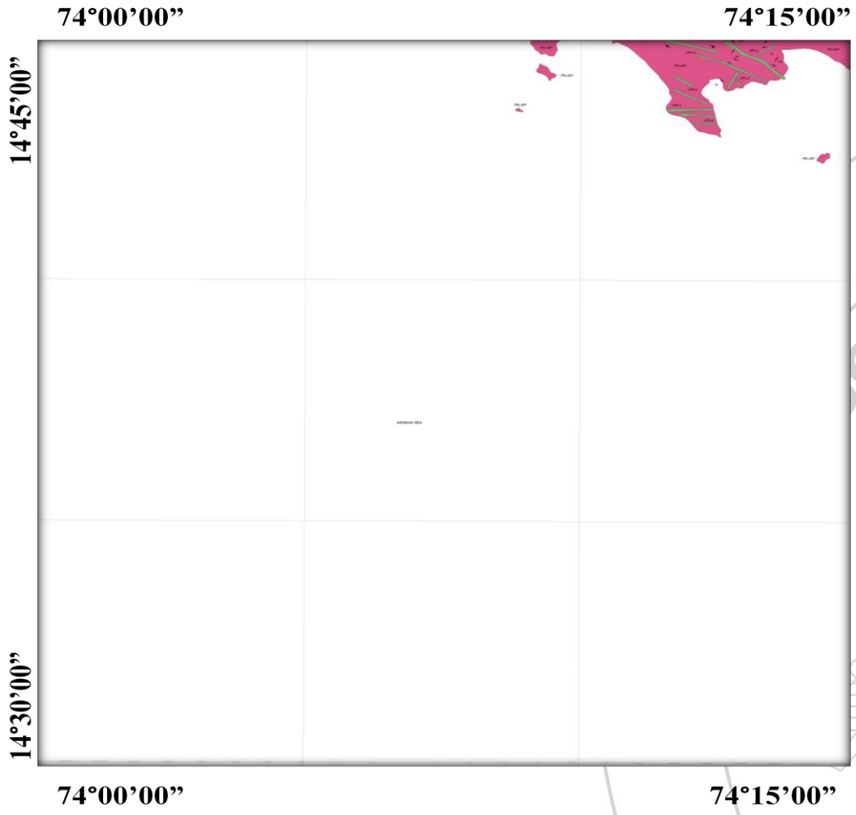
20 Bedding | 30 Foliation | Vertical foliation | 20 Joint | Vertical joint | F Fault

30 Plunging syncline | Overturned syncline

Source: GSI, SU:K&G, Geodata

Plate-3

GEOLOGICAL MAP OF TS NO. 48J/2 OF UTTAR KANNADA DISTRICT, KARNATAKA



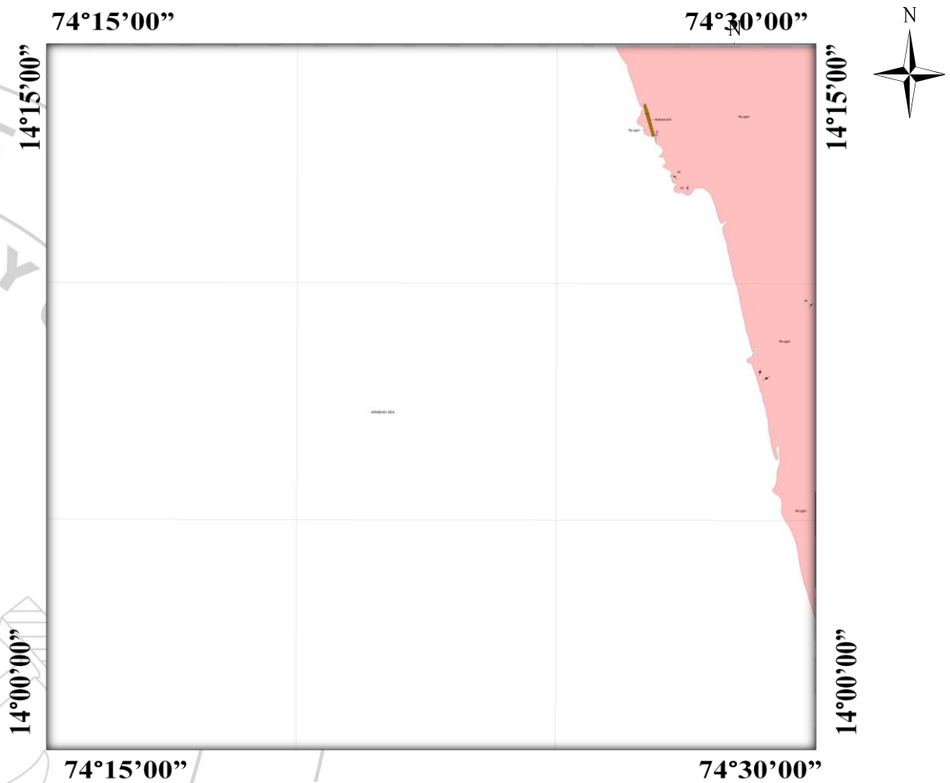
1:50,000 scale

	Formation	Group	Supergroup	Age
βPt₁d Dolerite	Basic intrusives	Younger intrusives		Palaeoproterozoic
γAp₁gtd Granitoid(Karwar)	Granitoids	Peninsular Gneiss-I	Peninsular Gneissic Complex	Archaean

STRUCTURAL SYMBOLS

30 Foliation 20 Joint Vertical joint

GEOLOGICAL MAP OF TS NO. 48J/8 OF UTTAR KANNADA DISTRICT, KARNATAKA



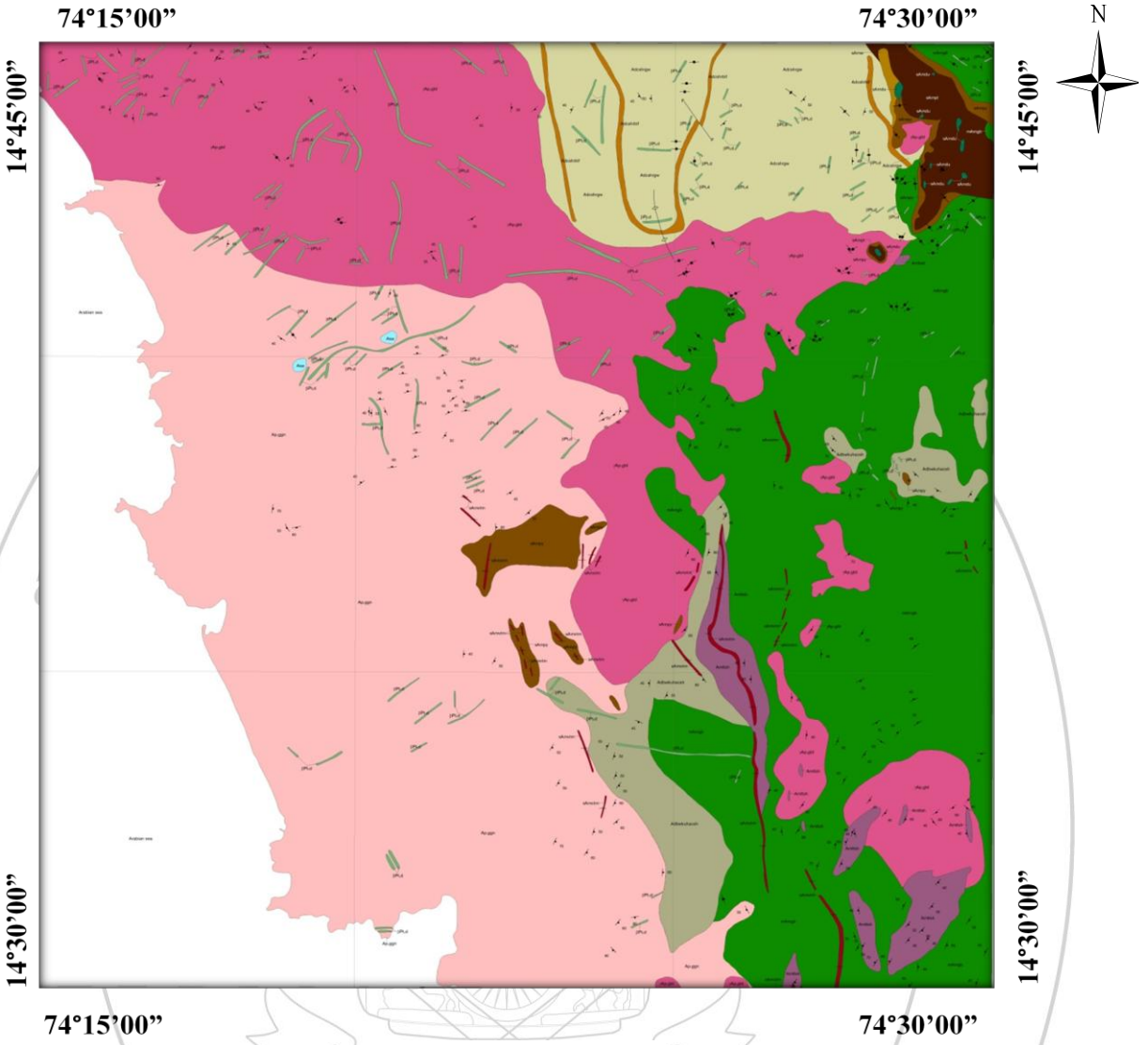
1:50,000 scale

	Formation	Group	Supergroup	
Adbwkubif Banded iron formation	Kudremukh	Bababudan (Western ghat)	Dharwar	Arc
Ap₁ggn Granite gneiss	Gneisses	Peninsular Gneiss-I	Peninsular Gneissic Complex	

Source: GSI, SU:K&G, Geodata

Plate-4

GEOLOGICAL MAP OF TS NO. 48J/6 OF UTTAR KANNADA DISTRICT, KARNATAKA



1:50,000 scale

		Formation	Group	Supergroup	Age
jPt-d	Dolerite	Basic intrusives	Younger intrusives		Palaeoproterozoic
mAmgb	Gabbro	Motimakki ultramafites	Layered Ultramafic Complex		Archaean
sAmw	Websterite				
sAmvtm	Vanadiferous titano-magnetite				
Amtsh	Talc-tremolite schist				
sAmpt	Peridotite				
sAmpy	Pyroxenite				
sAmdu	Dunite				
Adcshrbif	Banded iron formation	Ranibennur	Chitradurga (Shimoga)	Dharwar	
Adcshrgw	Graywacke				
Adbwkuhacsh	Hornblende-actinolite -chlorite schist	Kudremukh	Bababudan (Western ghat)		
yAp-gtd	Granitoid(Karwar)	Granitoids	Peninsular Gneiss-I	Peninsular Gneissic Complex	
Ap-ggn	Granite gneiss	Gneisses			
Asa	Amphibolite		Sargur		

STRUCTURAL SYMBOLS

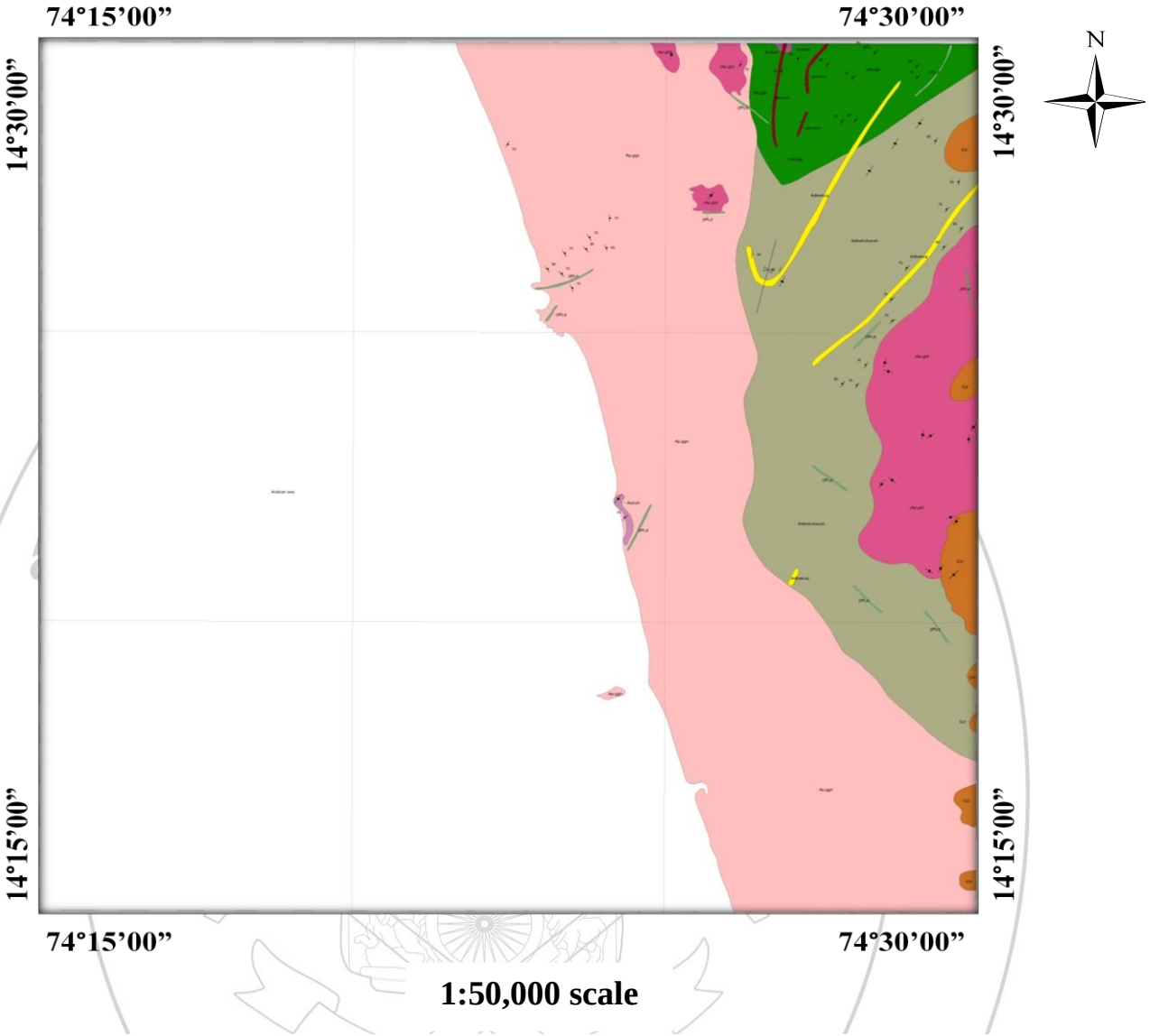
30 Foliation | Vertical foliation | 20 Joint | Vertical joint | F Fault

Axial trace of anticline

Source: GSI, SU:K&G, Geodata

Plate-5

GEOLOGICAL MAP OF TS NO. 48J/7 OF UTTAR KANNADA DISTRICT, KARNATAKA



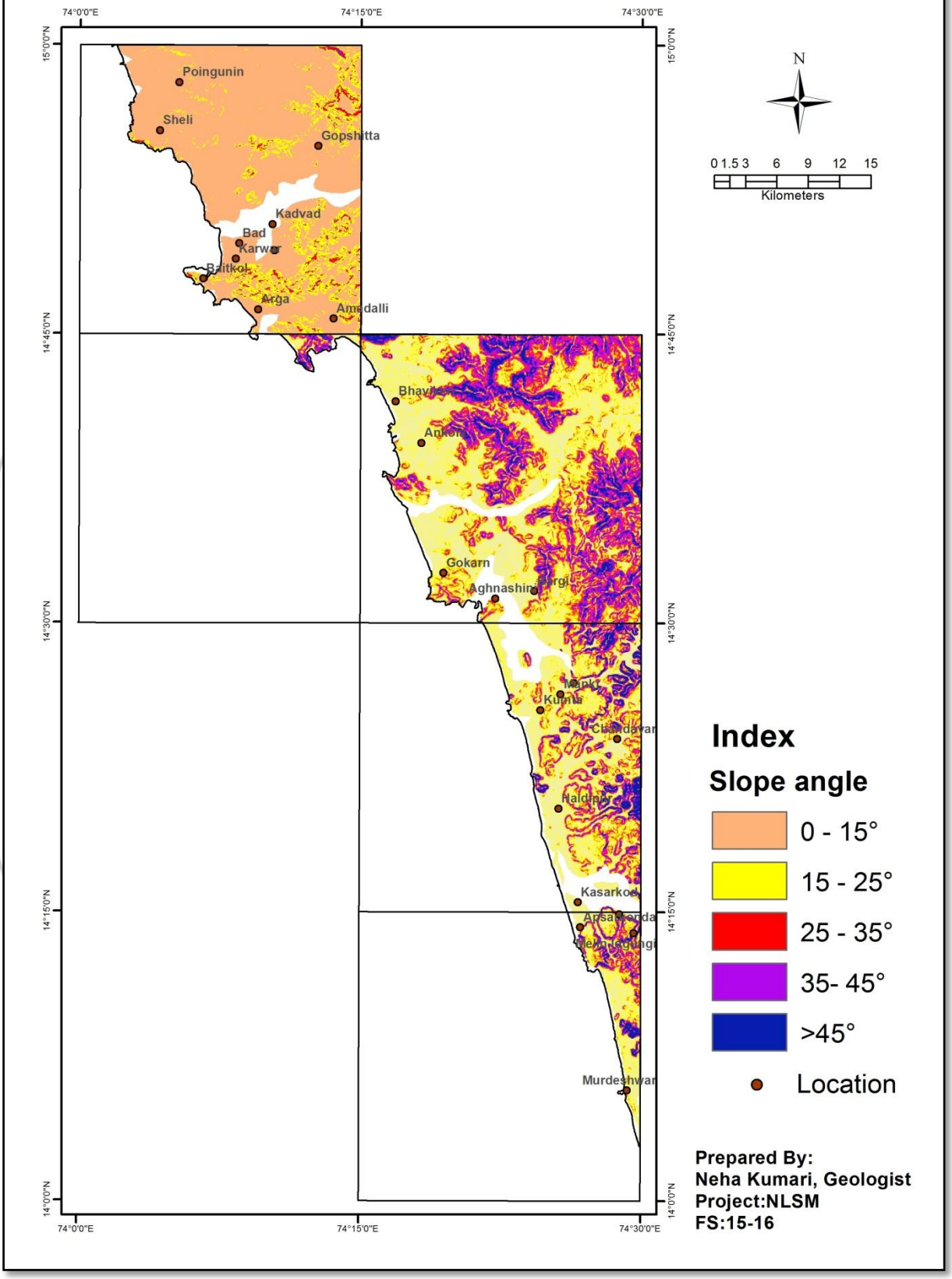
1:50,000 scale

		Formation	Group	Supergroup	Age
Czl	Laterite				Cenozoic
βPt₁d	Dolerite	Basic intrusives	Younger intrusives		Palaeoproterozoic
mAmgb	Gabbro	Motimakki ultramafites	Layered Ultramafic Complex		Archaean
sAmvtm	Vanadiferous titano -magnetite				
Amttsh	Talc-tremolite schist				
Adbwkuq	Quartzite	Kudremukh	Bababudan (Western ghat)	Dharwar	
Adbwkuhacsh	Hornblende-actinolite -chlorite schist				
γAp₁gtd	Granitoid(Karwar)	Granitoids	Peninsular Gneiss-I	Peninsular Gneissic Complex	
Ap₁ggn	Granite gneiss	Gneisses			
Astcsh	Talc-chlorite schist		Sargur		

Source: GSI, SU:K&G, Geodata

Plate-6

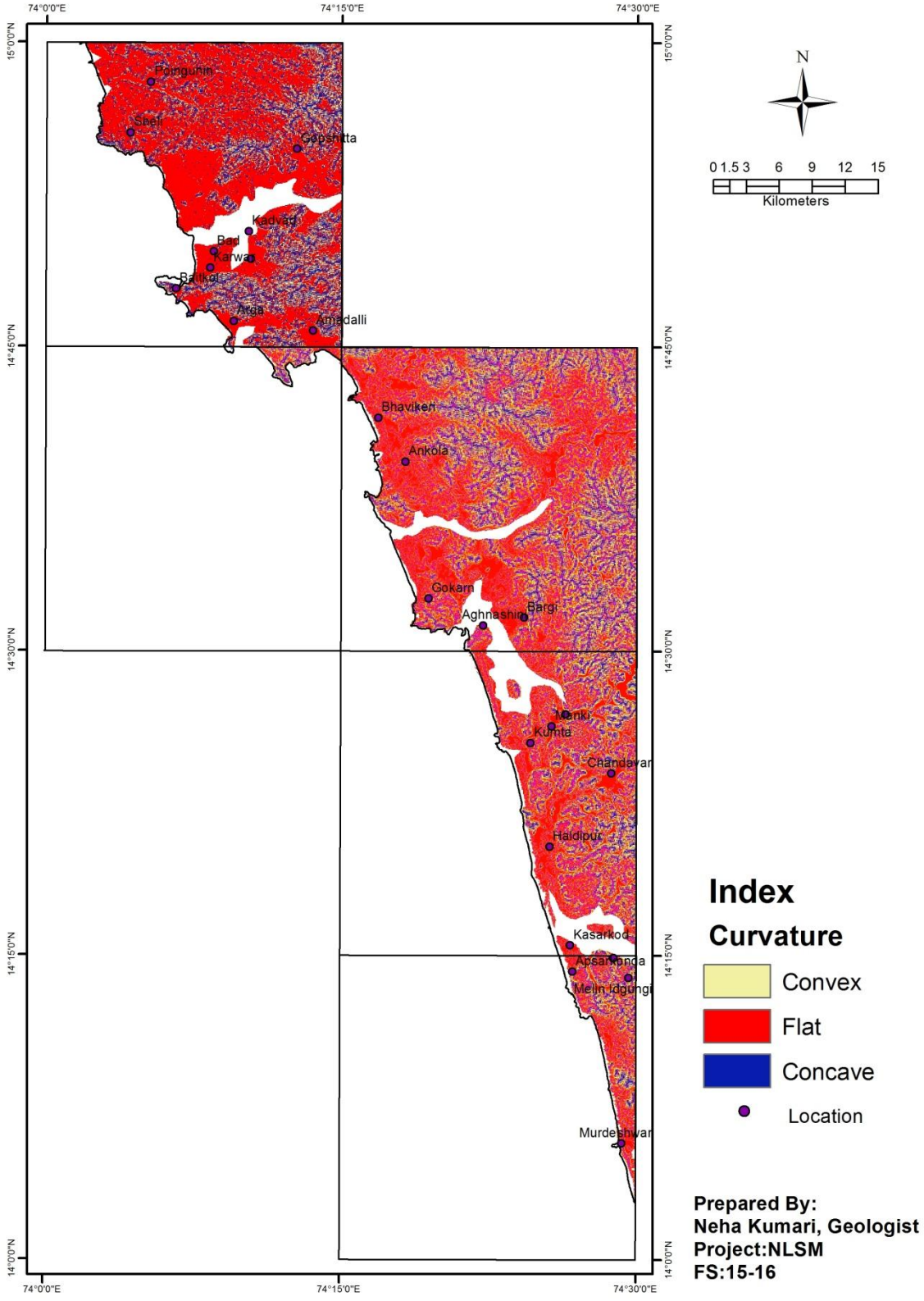
Slope angle Map of TS nos. 48J/1,J/2,J/6,J7 & J8 of Uttar Kannada District, Karnataka



Prepared By:
Neha Kumari, Geologist
Project:NLSM
FS:15-16

Plate-7

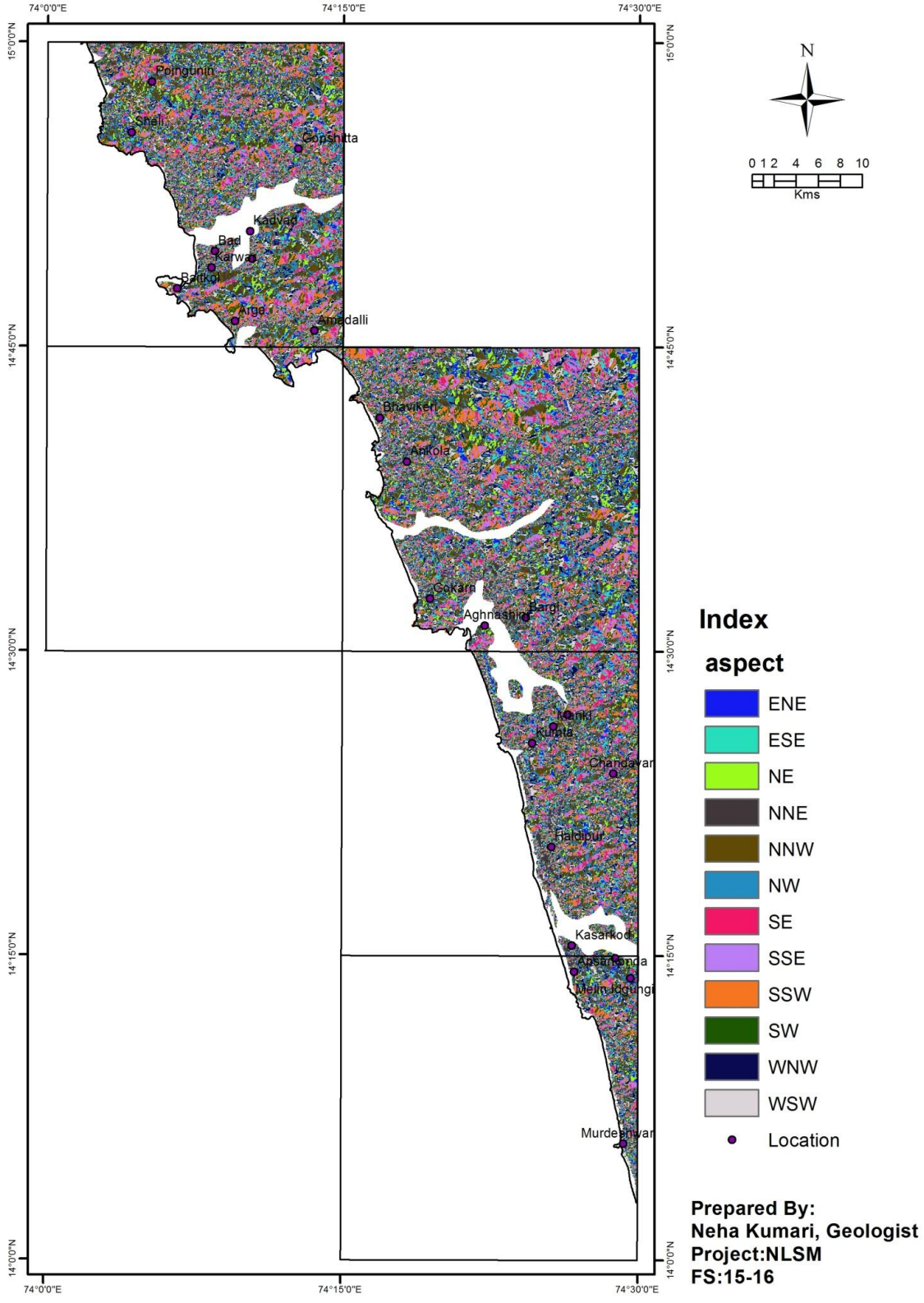
Slope Curvature Map of TS nos. 48J/1,J/2,J/6,J7 & J8 of Uttar Kannada District, Karnataka



Prepared By:
Neha Kumari, Geologist
Project:NLSM
FS:15-16

Plate-8

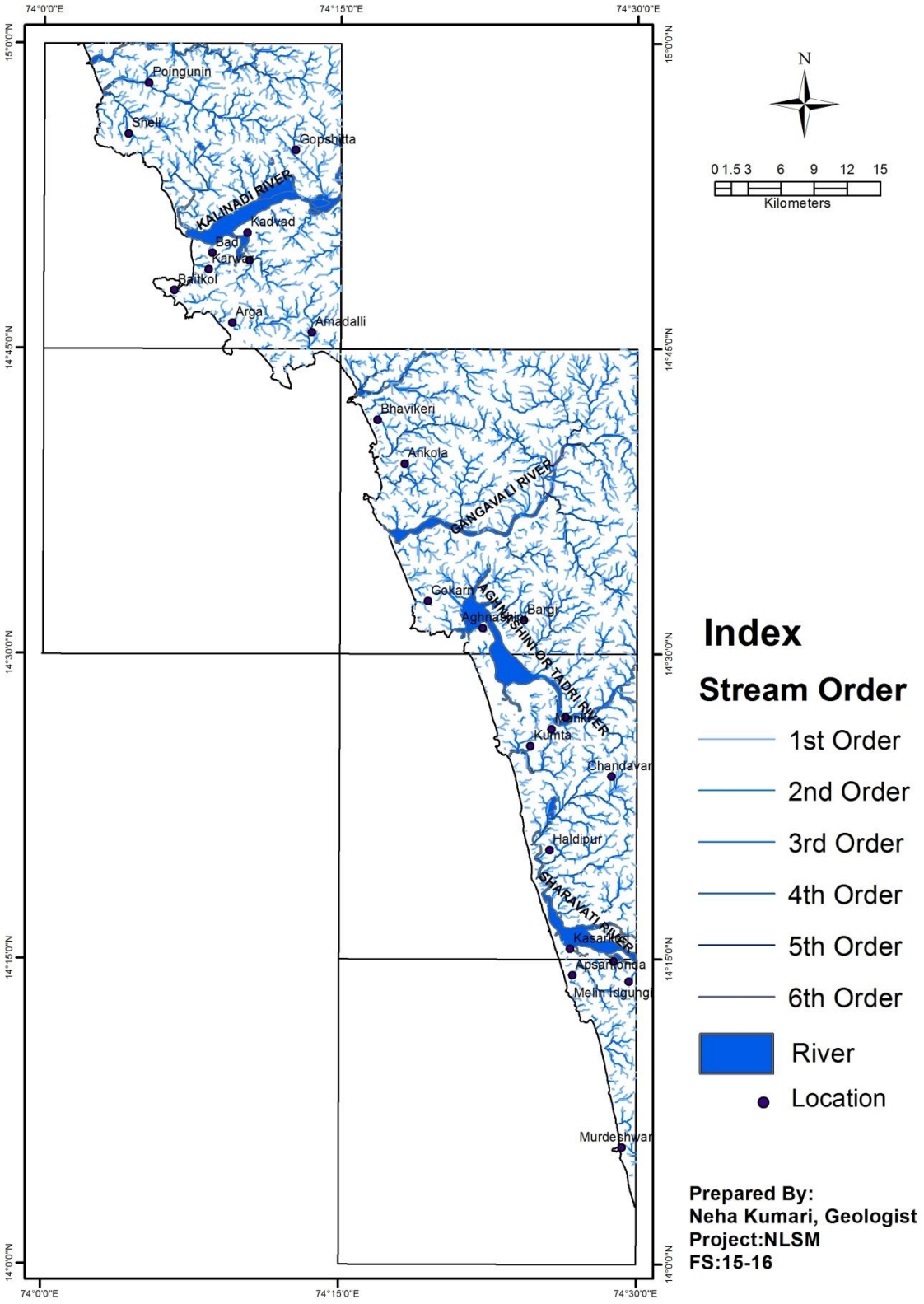
Slope Aspect Map of TS nos. 48J/1,J/2,J/6,J7 & J8 of Uttar Kannada District, Karnataka



Prepared By:
Neha Kumari, Geologist
Project:NLSM
FS:15-16

Plate-9

Drainage Map of TS nos. 48J/1,J/2,J/6,J7 & J8 of Uttar Kannada District, Karnataka



Prepared By:
Neha Kumari, Geologist
Project:NLSM
FS:15-16

Plate-10

Landslide Inventory Map of TS nos. 48J/1,J/2,J/6,J7 & J8 of Uttar Kannada District, Karnataka

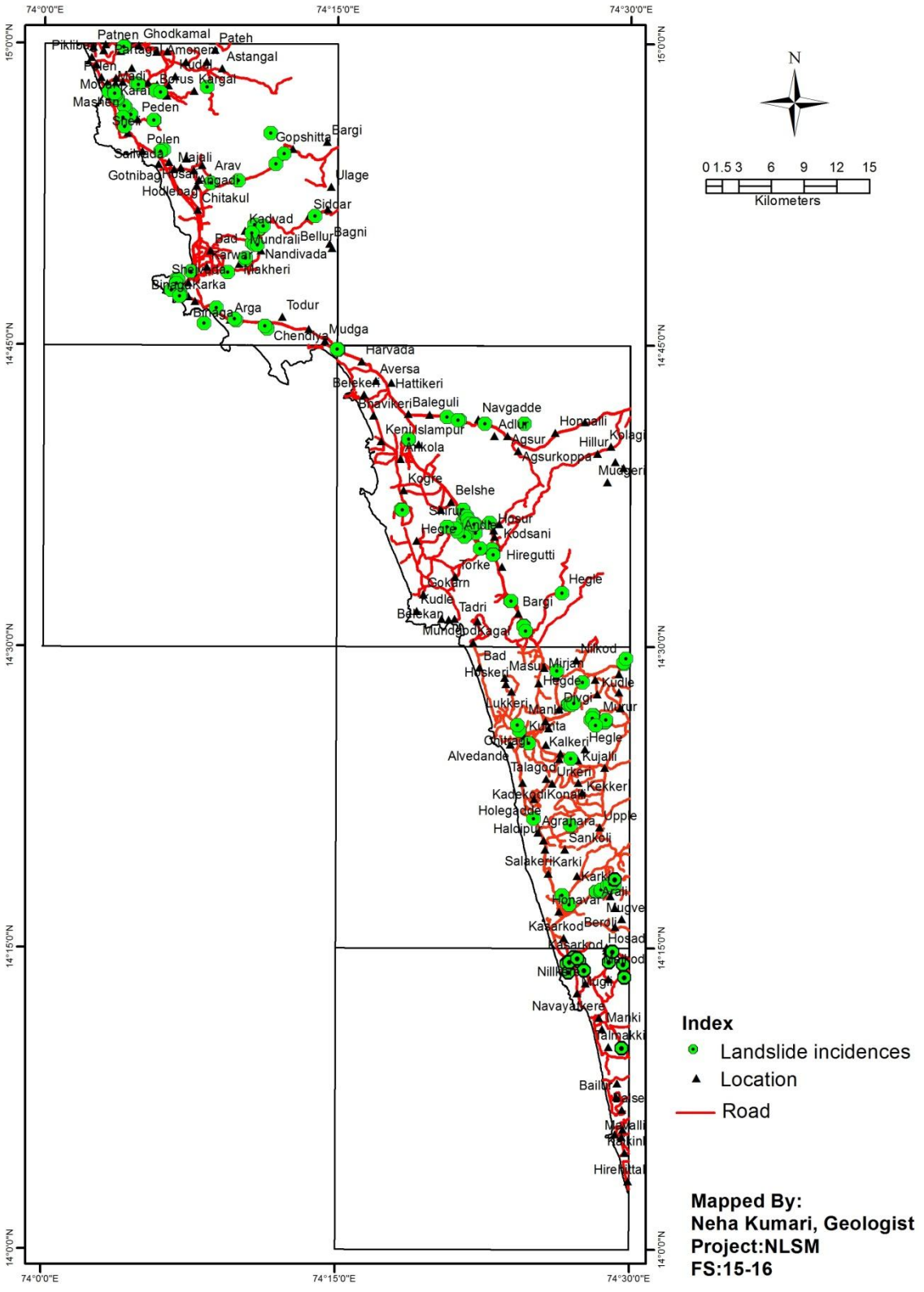
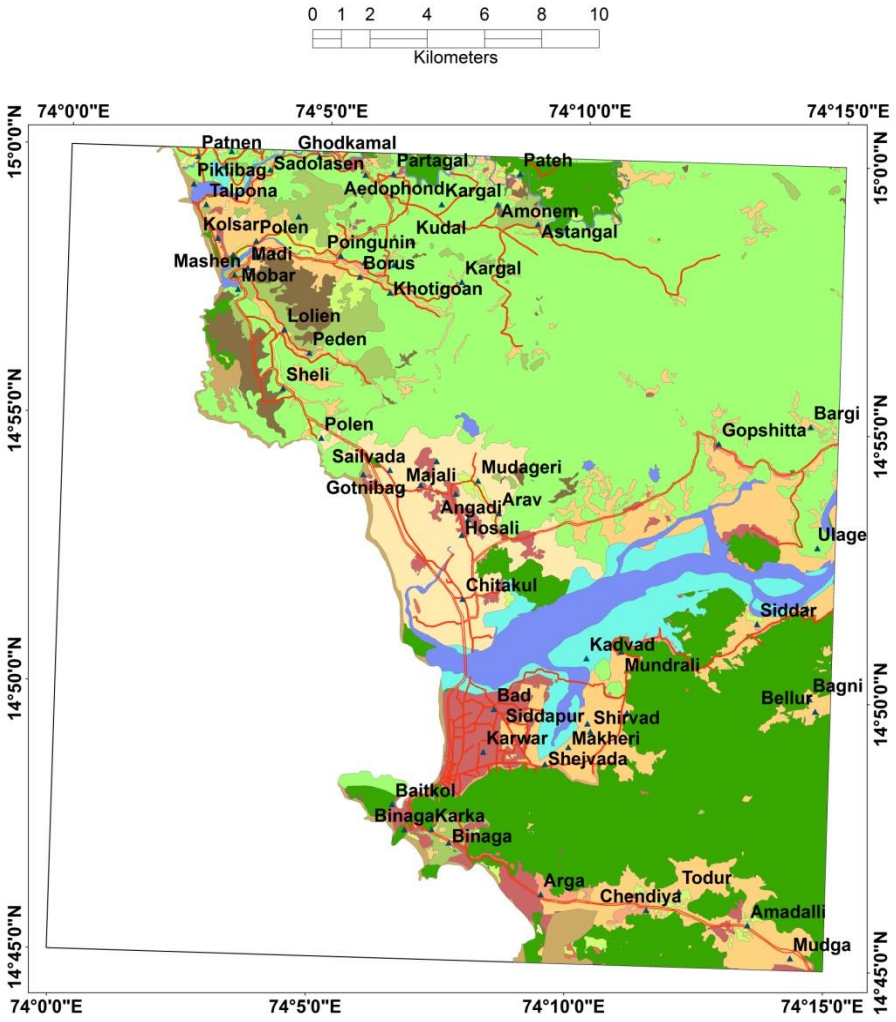


Plate-11

Landuse & Landcover Map of TS no. 48J/1 of Uttar Kannada District, Karnataka



Index

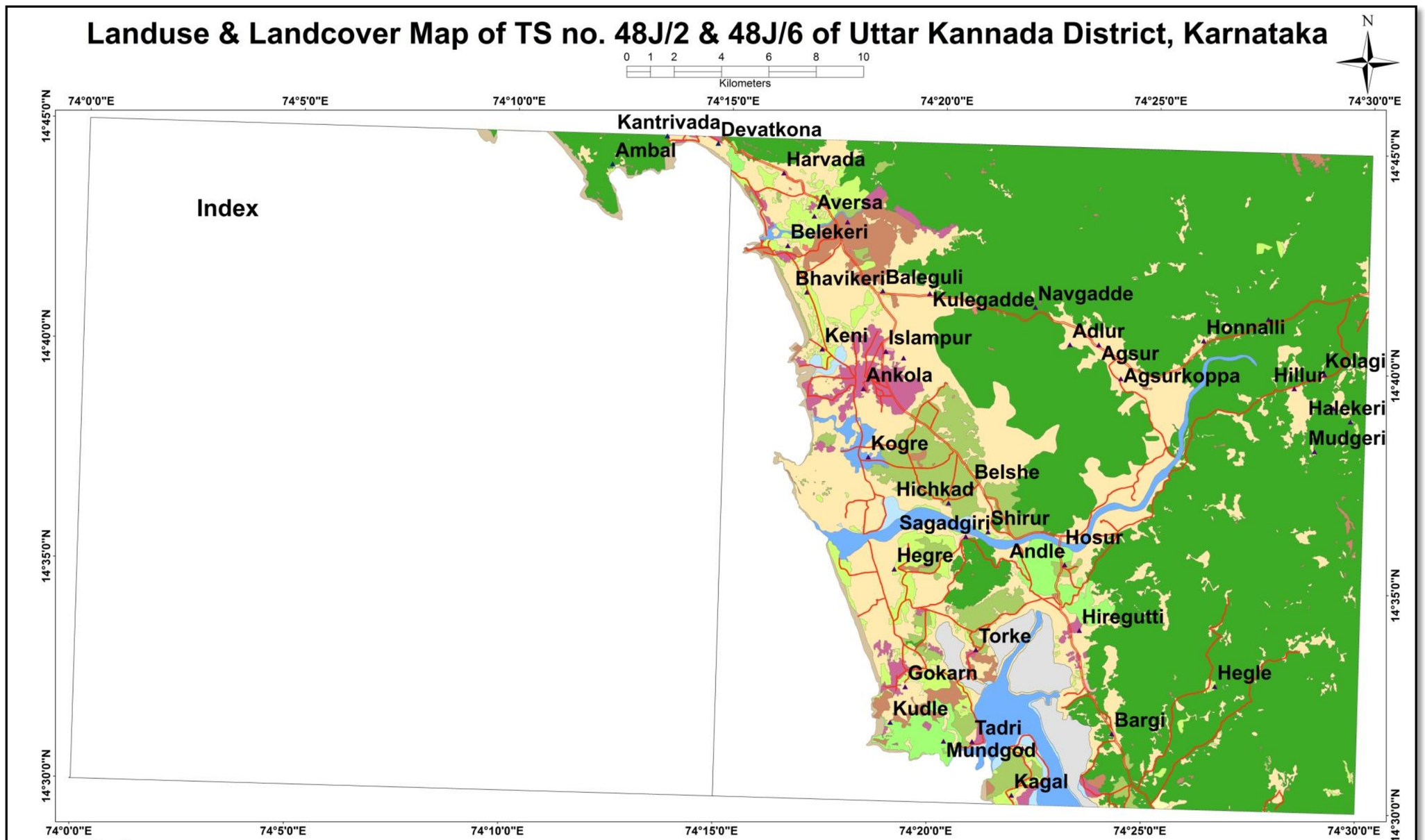
- Thick Vegetation
- Moderate Vegetation
- Sparse Vegetation
- Plantation (HHP)
- Cultivation
- Fallow Land
- Extensive Slope Cut
- Settlement on modified slope
- Barren
- Barren Sand
- Quarry
- Settlement
- Swamp
- Water body
- Location
- Road

Prepared by:
Tanvi Gupta & Neha Kumari, Geologists

Project:NLSM
FS:15-16

Plate-12

Landuse & Landcover Map of TS no. 48J/2 & 48J/6 of Uttar Kannada District, Karnataka

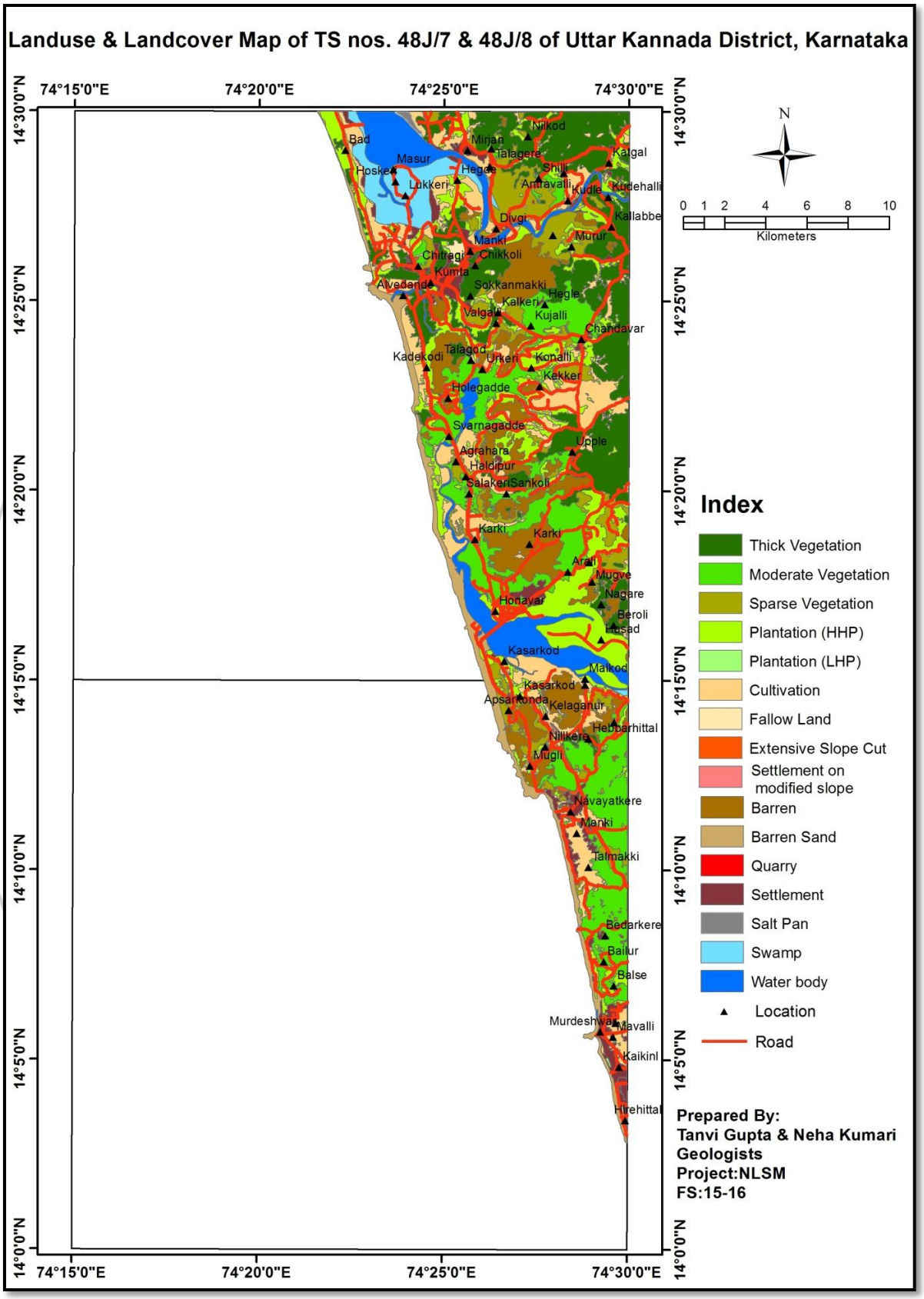


Index

- Thick Vegetation
- Moderate Vegetation
- Sparse Vegetation
- Plantation (HHP)
- Cultivation
- Fallow Land
- Extensive Slope Cut
- Settlement on modified slope
- Barren
- Barren Sand
- Quarry
- Settlement
- Swamp
- Saltpan
- Water body
- Location
- Road

Prepared by:
Tanvi Gupta & Neha Kumari
Geologists
Project:NLSM
FS:15-16

Plate-13


Landuse & Landcover Map of TS nos. 48J/7 & 48J/8 of Uttar Kannada District, Karnataka
74°15'0"E
74°20'0"E
74°25'0"E
74°30'0"E
14°30'0"N
14°25'0"N
14°20'0"N
14°15'0"N
14°10'0"N
14°5'0"N
14°0'0"N
N
0 1 2 4 6 8 10
Kilometers
Nilkod
Bad
Mirjan
Talagere
Kalgal
Masur
Hoske
Hegde
Shiji
Lukkeri
Anttavalli
Kudle
Kudehalli
Kallabbe
Divgi
Murur
Manki
Chikkoli
Chitragi
Kumta
Alvedande
Sokkanmakki
Hegle
Kalkeri
Valgali
Kujalli
Chandavar
Kadekodi
Talagod
Urkeri
Konalli
Kekker
Holegadde
Svarnagadde
Upple
Agrahara
Haldipur
Salakari
Sankoli
Karki
Karki
Arali
Mugve
Nagare
Honavar
Beroli
Kasarkod
Malkod
Kasarkod
Apsarkonda
Kelaganur
Hebbarhittal
Nilikera
Mugli
Navayatkere
Manki
Talmakki
Bedarkere
Bailur
Balse
Murdeshwar
Mavalli
Kaikini
Hirehittal
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Thick Vegetation
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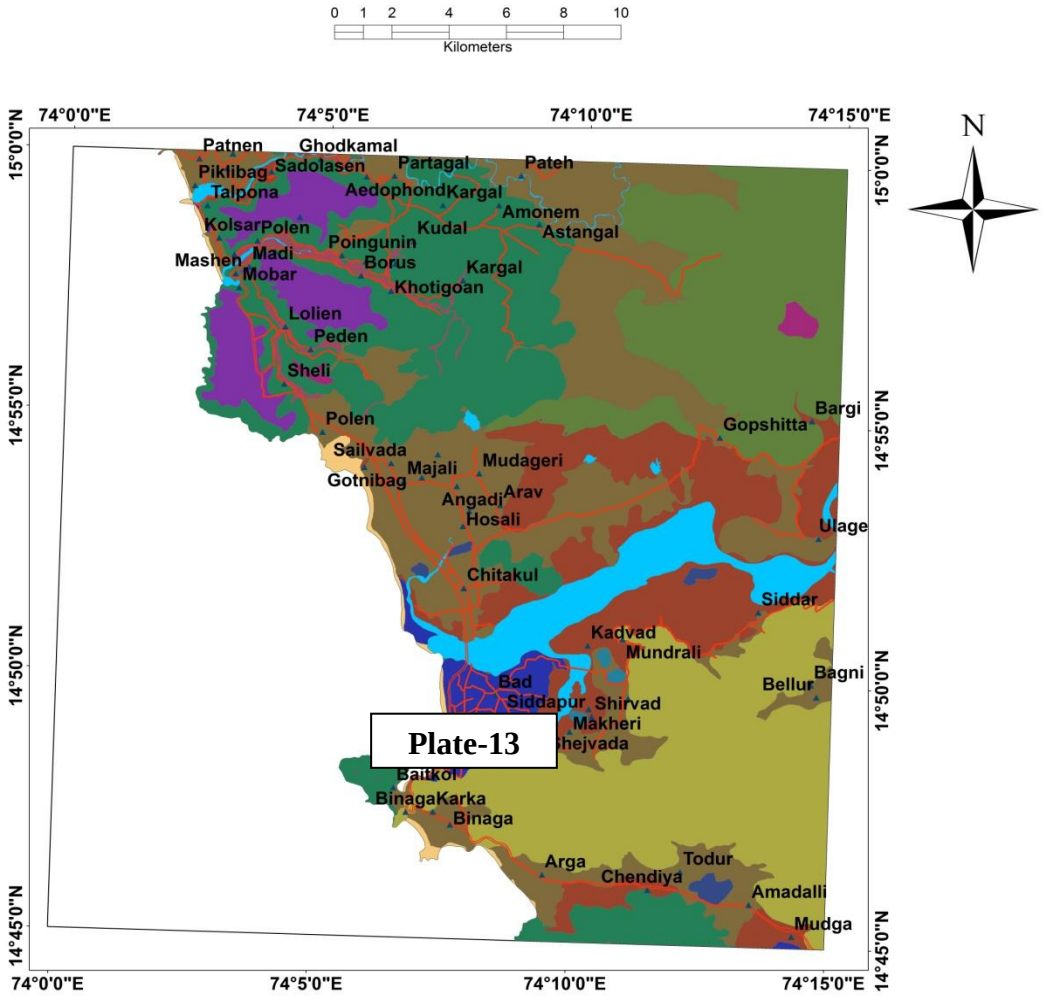
Plantation (LHP)
Cultivation
Fallow Land
Extensive Slope Cut
Settlement on modified slope
Barren
Barren Sand
Quarry
Settlement
Salt Pan
Swamp
Water body
Location
Road
Prepared By:
Tanvi Gupta & Neha Kumari
Geologists
Project:NLSM
FS:15-16

Plate-14

Geomorphology Map of TS no. 48J/1 of Uttar Kannada District, Karnataka



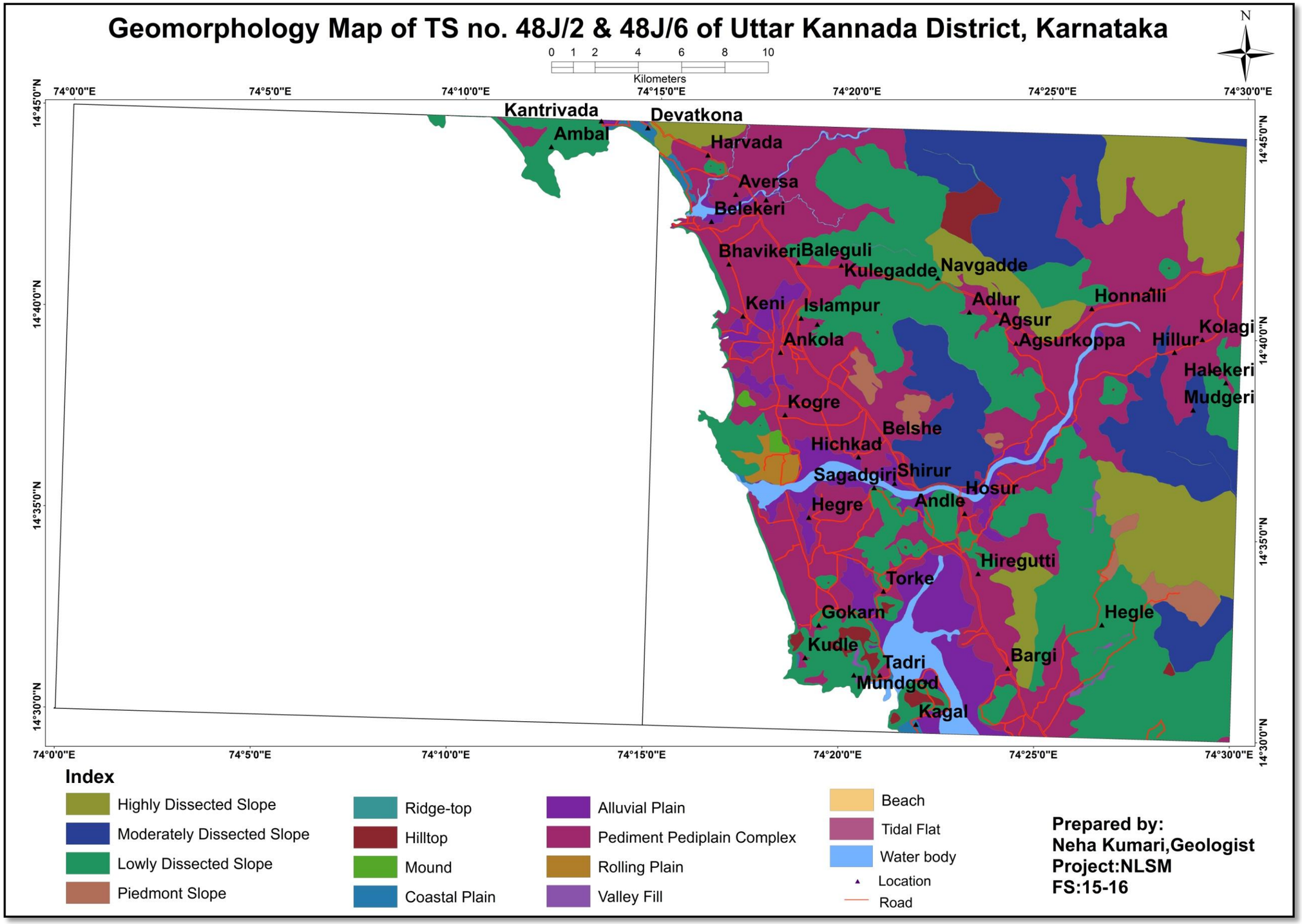
Index

- Highly Dissected Slope
- Lowly Dissected Slope
- Denudational Slope
- Hilltop
- Mound
- Plateau Top (Flat)
- Coastal Plain
- Alluvial Plain
- Pediment Pediplain Complex
- Rolling Plain
- Valley Fill
- Beach
- Water body
- Location
- Road

Prepared by:
Neha Kumari, Geologist
Project:NLSM
FS:15-16

Plate-15

Geomorphology Map of TS no. 48J/2 & 48J/6 of Uttar Kannada District, Karnataka



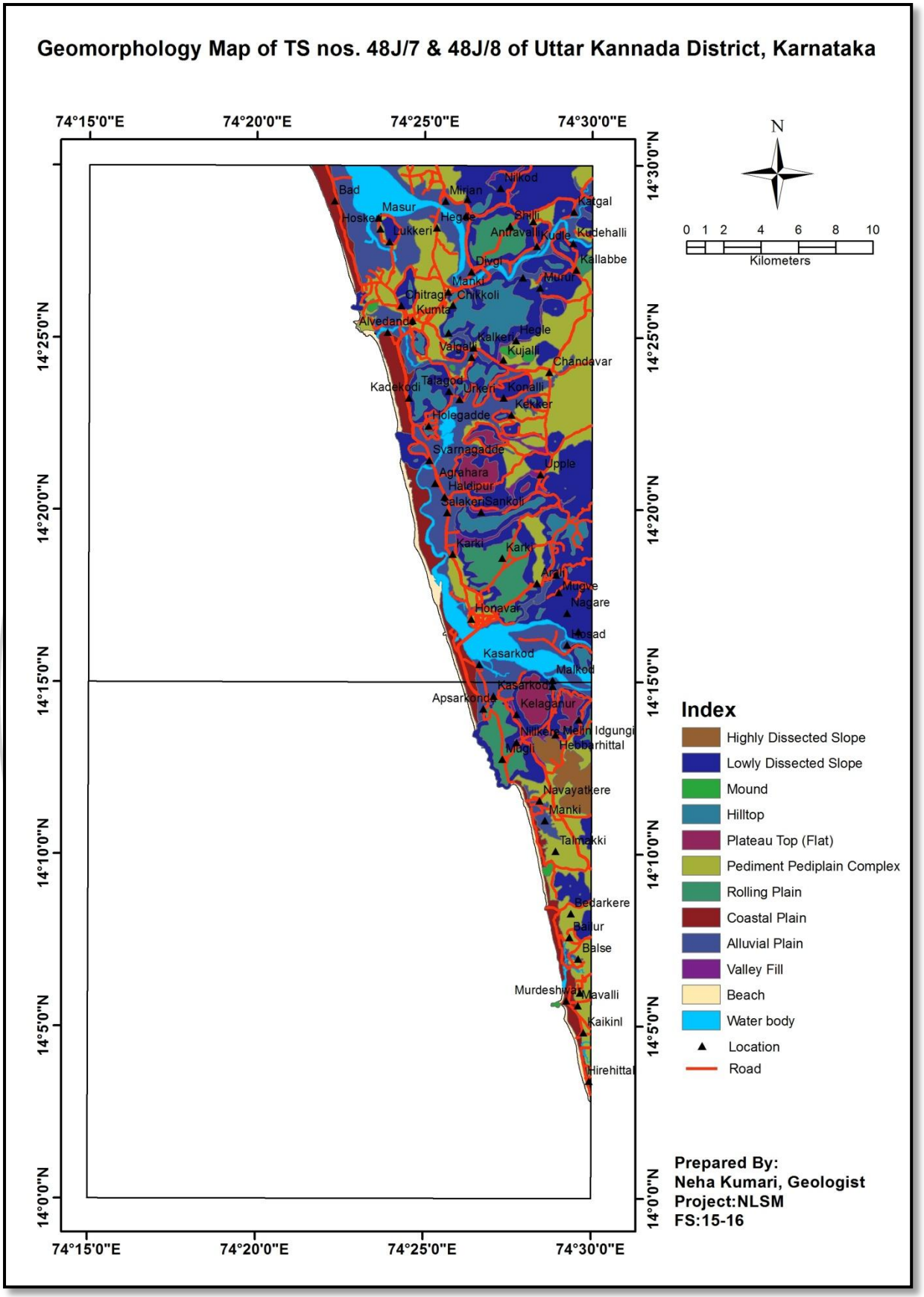
Index

- Highly Dissected Slope
- Moderately Dissected Slope
- Lowly Dissected Slope
- Piedmont Slope
- Ridge-top
- Hilltop
- Mound
- Coastal Plain
- Alluvial Plain
- Pediment Pediplain Complex
- Rolling Plain
- Valley Fill
- Beach
- Tidal Flat
- Water body
- Location
- Road

Prepared by:
Neha Kumari,Geologist
Project:NLSM
FS:15-16

Plate-16

Geomorphology Map of TS nos. 48J/7 & 48J/8 of Uttar Kannada District, Karnataka



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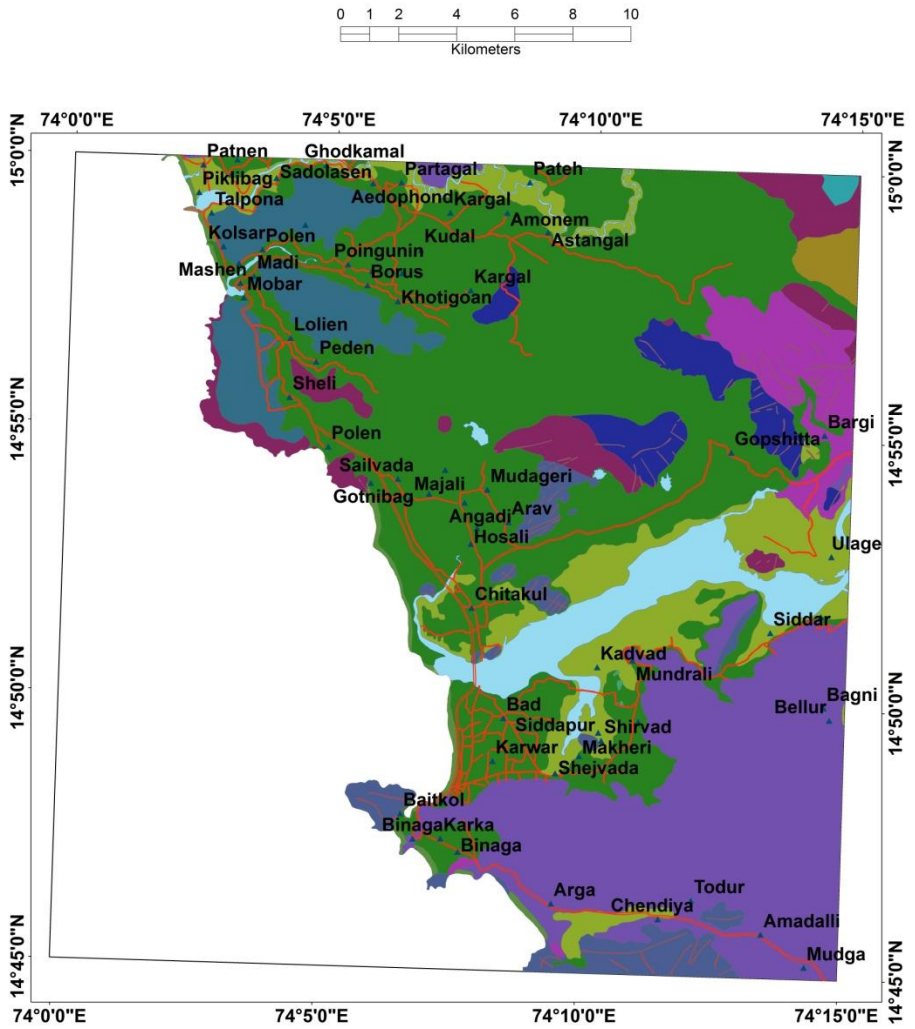
Neha Kumari, Geologist
Project:NLSM
FS:15-16

Plate-17

Slope Forming Material Map of TS no. 48J/1 of Uttar Kannada District, Karnataka



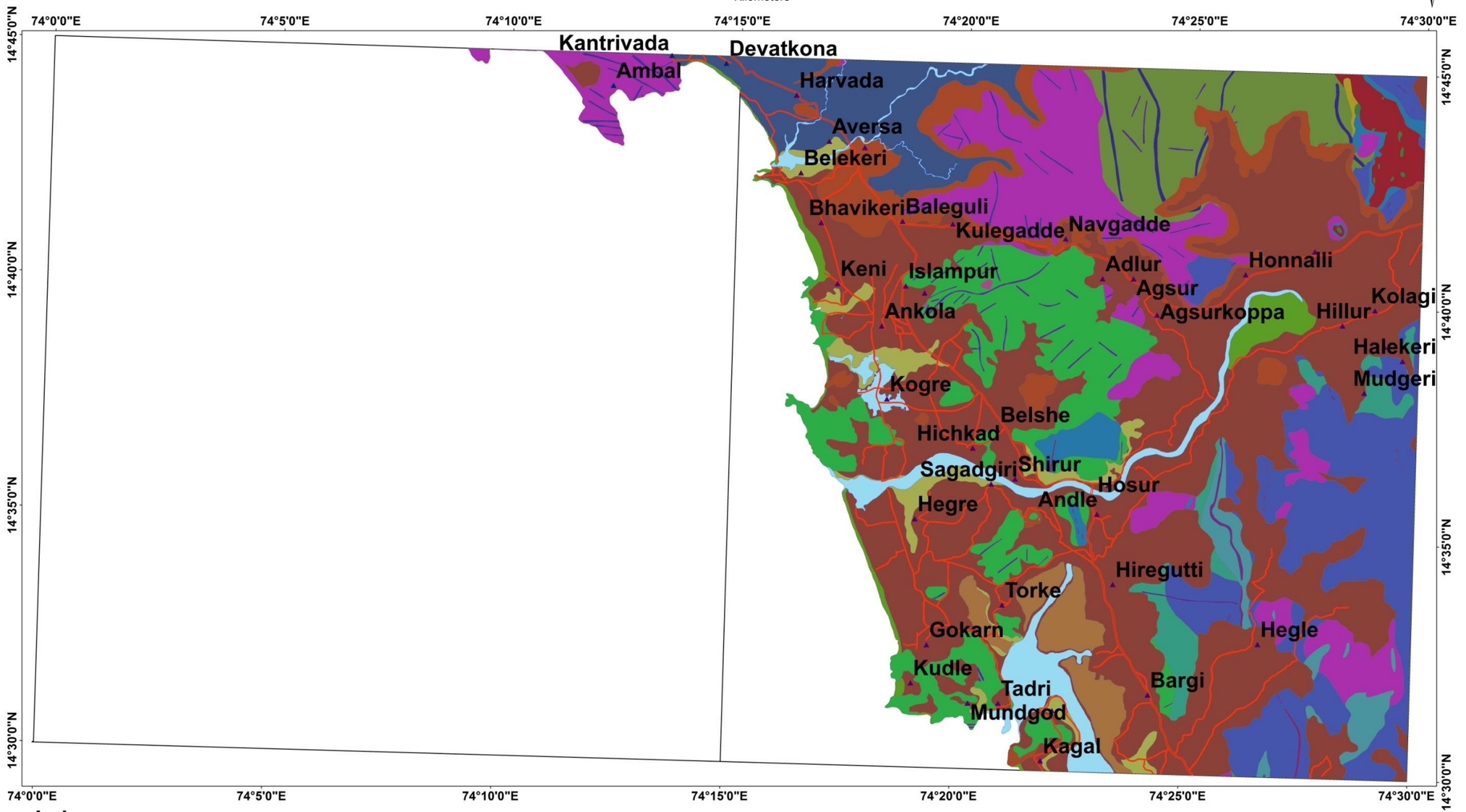
Index

- Alluvium
- Amphibolite
- Beach Sand
- Dolerite
- Granite gneiss
- Granitoid
- In-situ soil
- Laterite
- Loose slide Debris
- Manganiferous phyllite
- Metabasalt
- Metabasalt (shistose)
- Transported Soil
- Vanadiferous titano-magnetite
- Weathered Rock
- Water body
- Location
- Road

Prepared by:
Neha Kumari, Geologist
Project:NLSM
FS:15-16

Plate-18

Slope Forming Material Map of TS no. 48J/2 & 48J/6 of Uttar Kannada District, Karnataka

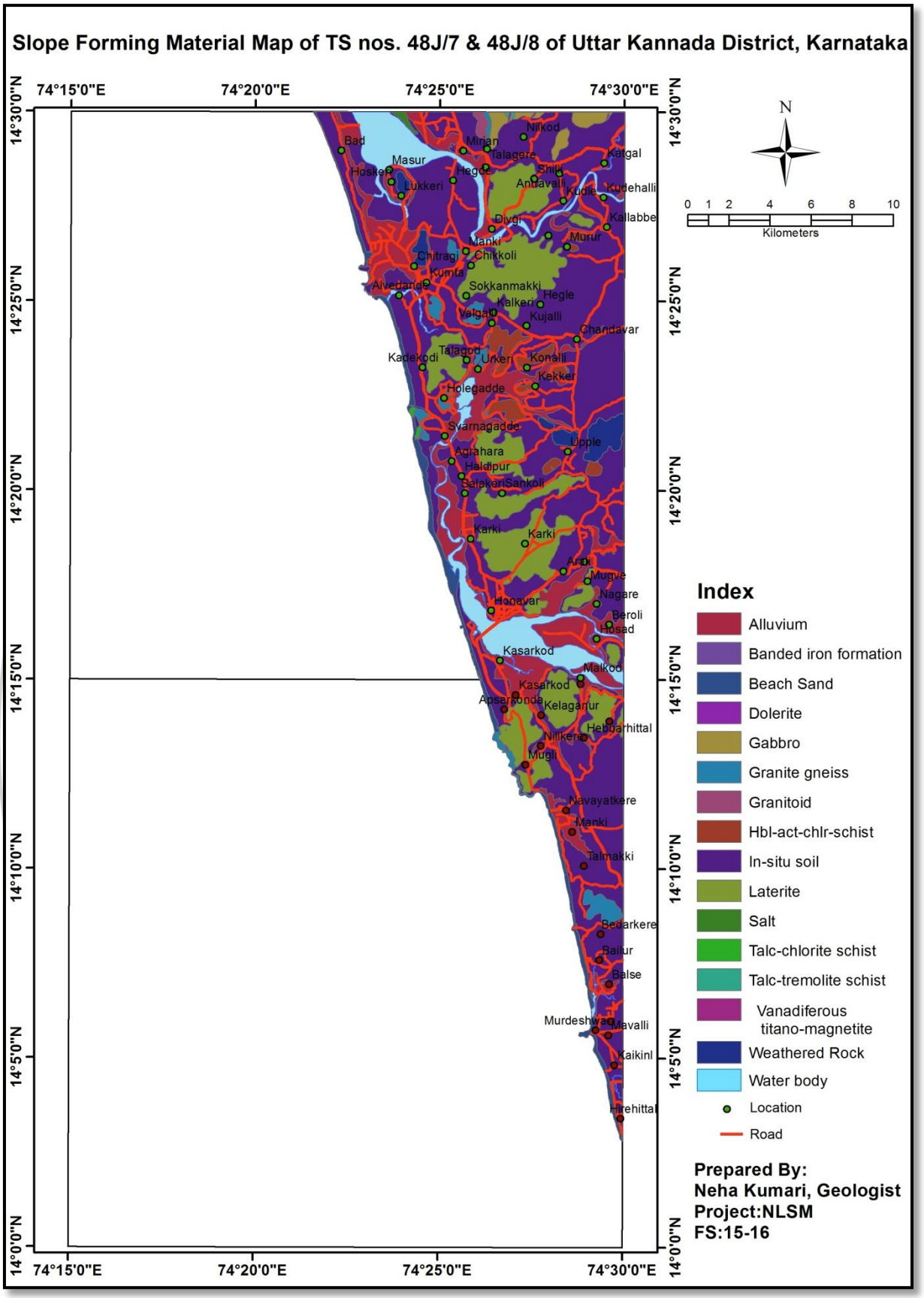


Index

- Alluvium
- Amphibolite
- Banded iron formation
- Beach Sand
- Dolerite
- Dunite
- Gabbro
- Granite gneiss
- Granitoid
- Greywacke
- Hornblende-actinolite-chlorite schist
- In-situ soil
- Peridotite
- Salt
- Talc-tremolite schist
- Transported Soil
- Vanadiferous titano-magnetite
- Weathered Rock
- Websterite
- pyroxenite
- Water body
- Location
- Road

Prepared by:
Neha Kumari,Geologist
Project:NLSM
FS:15-16

Plate-19


Slope Forming Material Map of TS nos. 48J/7 & 48J/8 of Uttar Kannada District, Karnataka
74°15'0"E
74°20'0"E
74°25'0"E
74°30'0"E
14°30'0"N
14°25'0"N
14°20'0"N
14°15'0"N
14°10'0"N
14°5'0"N
14°0'0"N
N
0 1 2 4 6 8 10
Kilometers
Index
Alluvium
Banded iron formation
Beach Sand
Dolerite
Gabbro
Granite gneiss
Granitoid
Hbl-act-chlr-schist
In-situ soil
Laterite
Salt
Talc-chlorite schist
Talc-tremolite schist
Vanadiferous titano-magnetite
Weathered Rock
Water body
Location
Road
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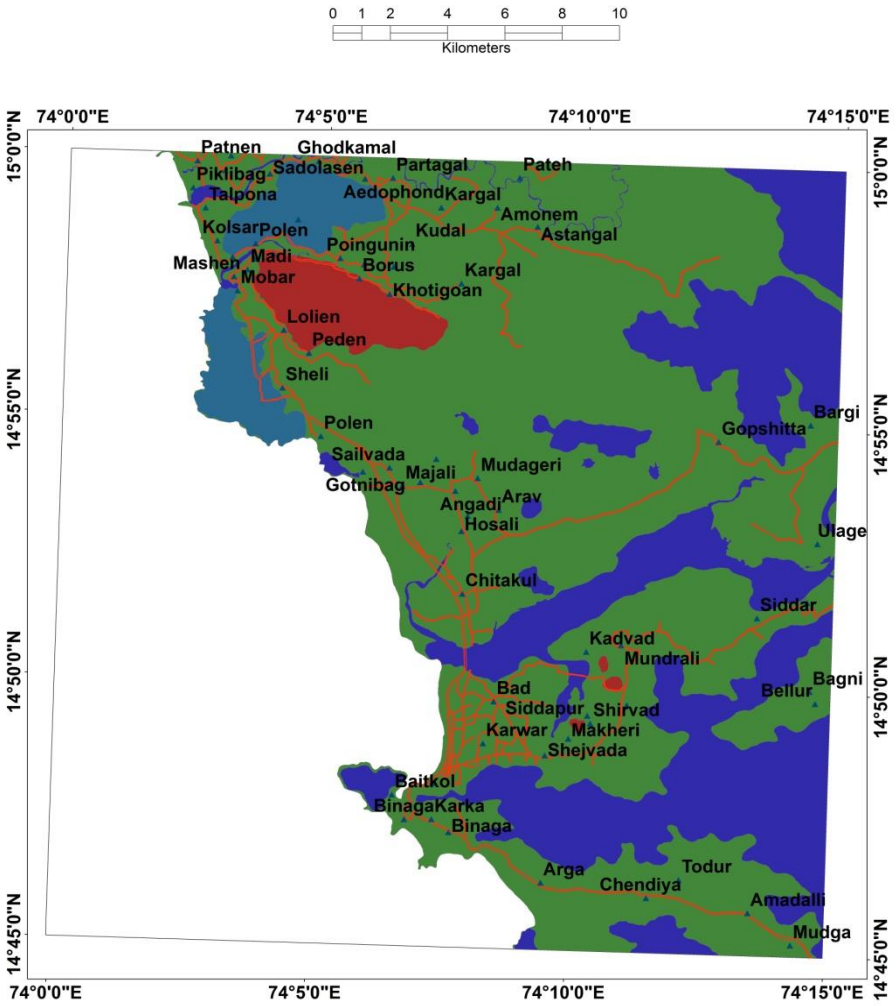
FS:15-16

Plate-20

Regolith Thickness Map of TS no. 48J/1 of Uttar Kannada District, Karnataka



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Regolith Thickness

- <0.5m
- 0.5-5m
- 5-10m
- >10m
- Location
- Road

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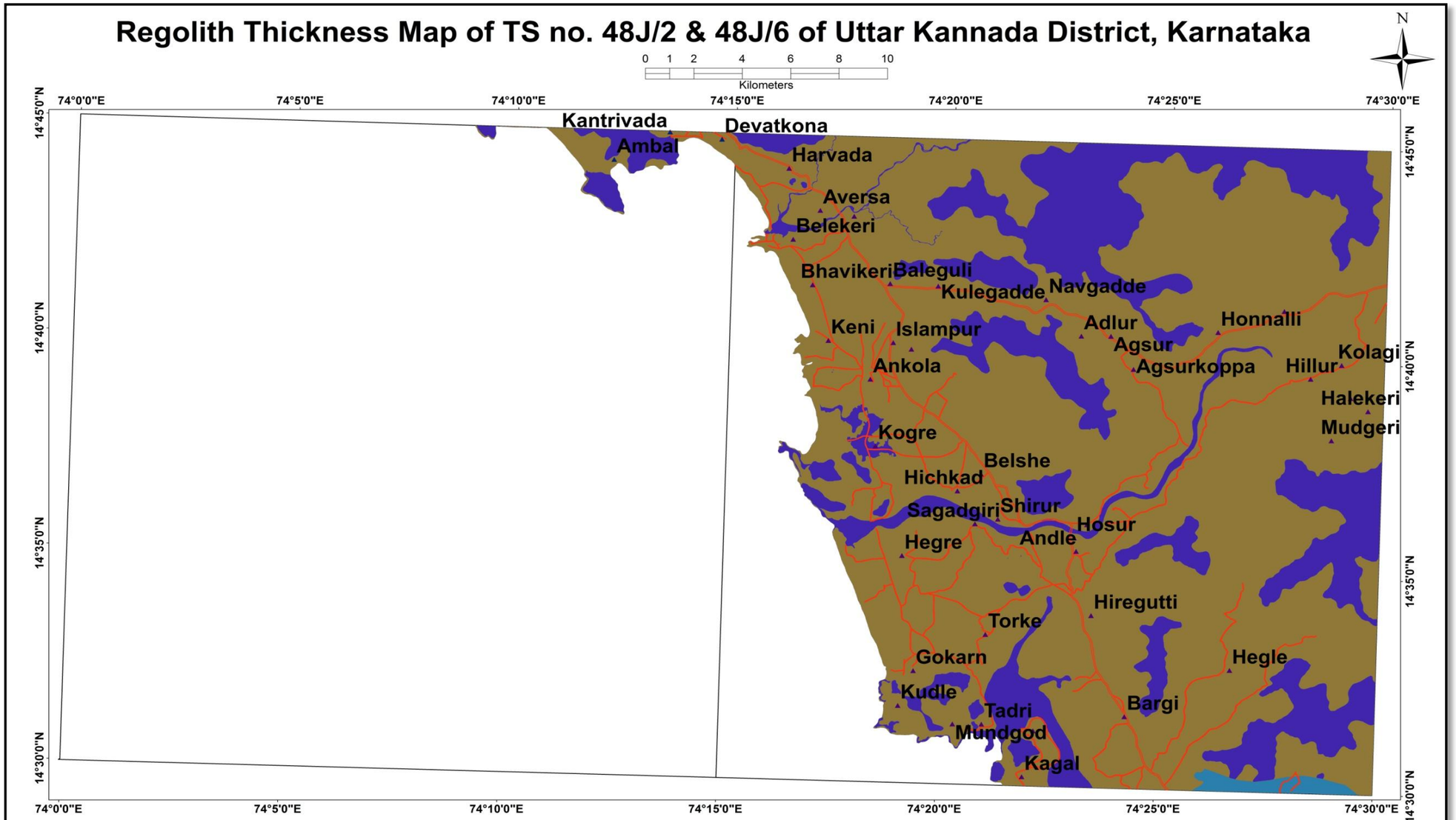
Plate-21

Regolith Thickness Map of TS no. 48J/2 & 48J/6 of Uttar Kannada District, Karnataka



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Regolith Thickness

- <0.5m
- 0.5-5m
- >10m
- Location
- Road

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Plate-22

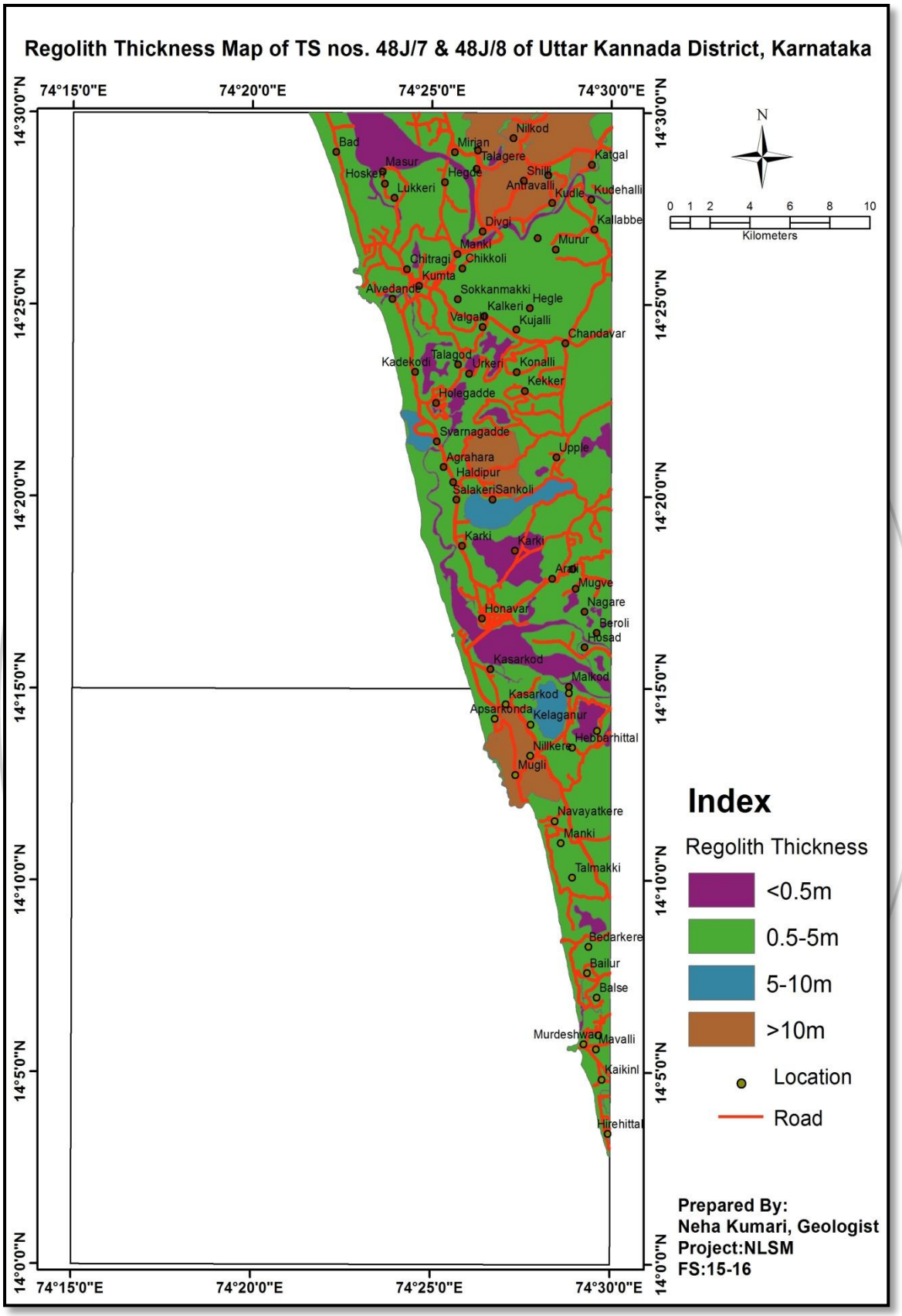
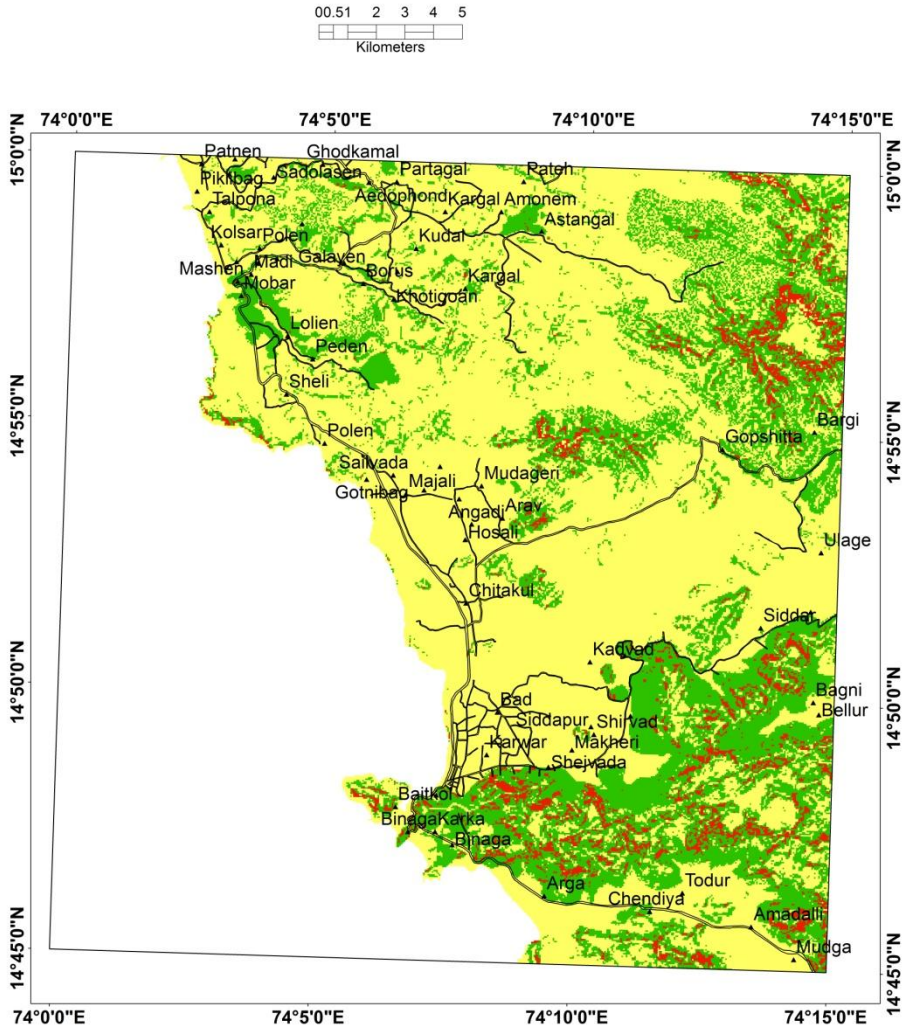

Regolith Thickness Map of TS nos. 48J/7 & 48J/8 of Uttar Kannada District, Karnataka
74°15'0"E
74°20'0"E
74°25'0"E
74°30'0"E
14°30'0"N
14°25'0"N
14°20'0"N
14°15'0"N
14°10'0"N
14°5'0"N
14°0'0"N
N
0 1 2 4 6 8 10
Kilometers
Nilkod
Bad
Mirjan
Talagere
Katgal
Masur
Hoskeri
Hegde
Shilli
Antravalli
Kudle
Kudehalli
Lukkeri
Kallabbe
Divgi
Murur
Manki
Chitragi
Chikkoli
Kumta
Alvedande
Sokkanmakki
Hegle
Kalkeri
Valgalli
Kujalli
Chandavar
Kadekodi
Talagod
Urkeri
Konalli
Kekker
Holegadde
Svarnagadde
Upple
Agrahara
Haldipur
SalakeriSankoli
Karki
Karki
Aradi
Mugve
Nagare
Honavar
Beroli
Hosad
Kasarkod
Malkod
Kasarkod
Apsarkonda
Kelaganur
Hebbarhittal
Nillkeri
Mugli
Navayatkere
Manki
Talmakki
Bedarkere
Bailur
Balse
Murdeshwar
Mavalli
Kaikini
Hirehittal
Index
Regolith Thickness
<0.5m
0.5-5m
5-10m
>10m
Location
Road
Prepared By:
Neha Kumari, Geologist
Project:NLSM
FS:15-16

Plate-23

Landslide Susceptibility Map of TS no. 48J/1 of Uttar Kannada District, Karnataka



Index

- High
- Moderate
- Low
- Location
- Road

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Plate-24

Landslide Susceptibility Map of TS no. 48J/2 & 48J/6 of Uttar Kannada District, Karnataka

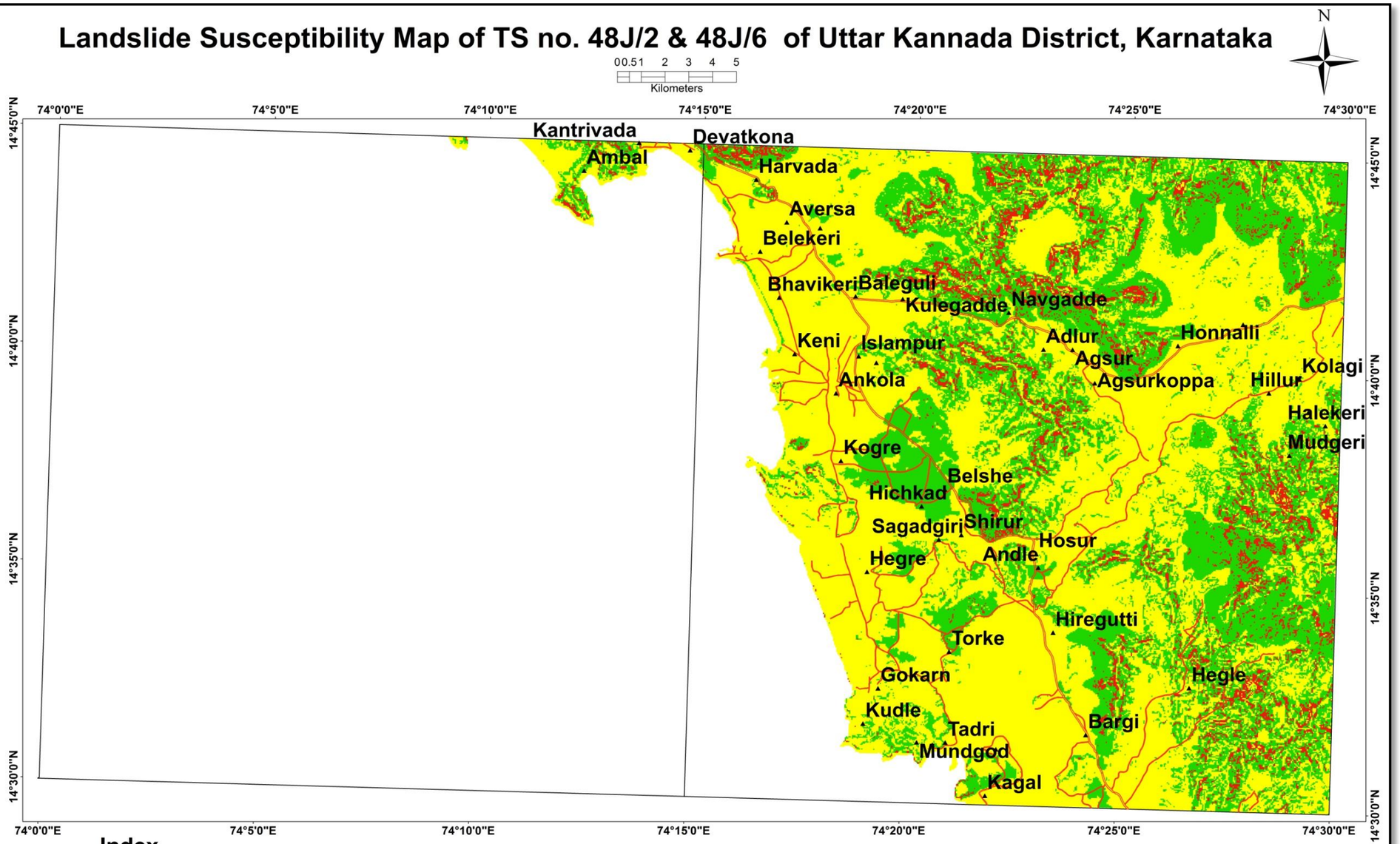

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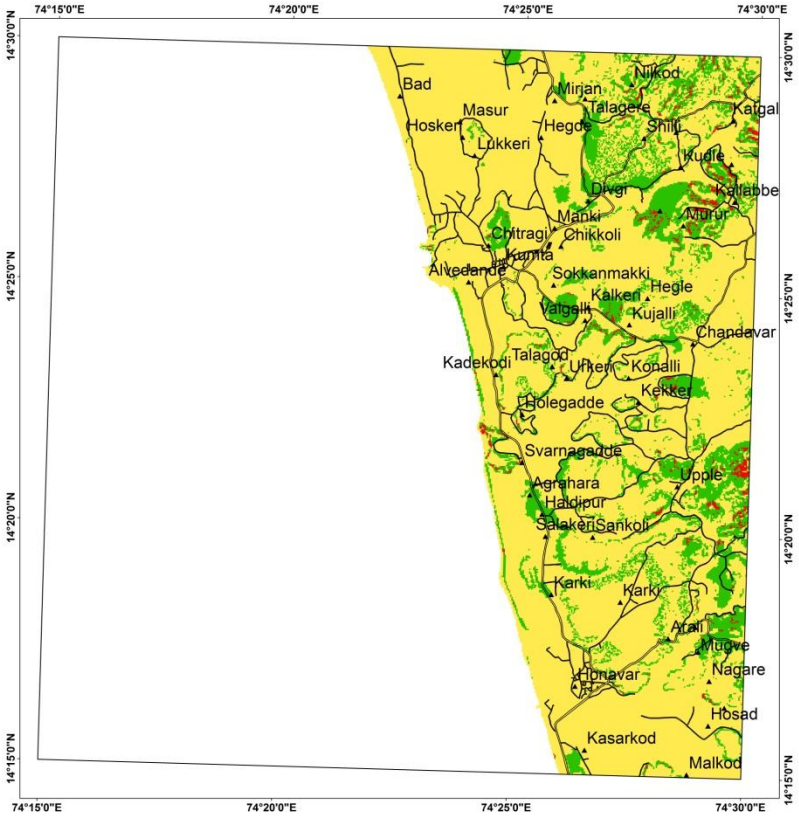
Plate-25

Landslide Susceptibility Map of TS no. 48J/7 of Uttar Kannada District, Karnataka

0 1 2 4 6 8 10
Kilometers



Index

- High
- Moderate
- Low
- Location
- Road

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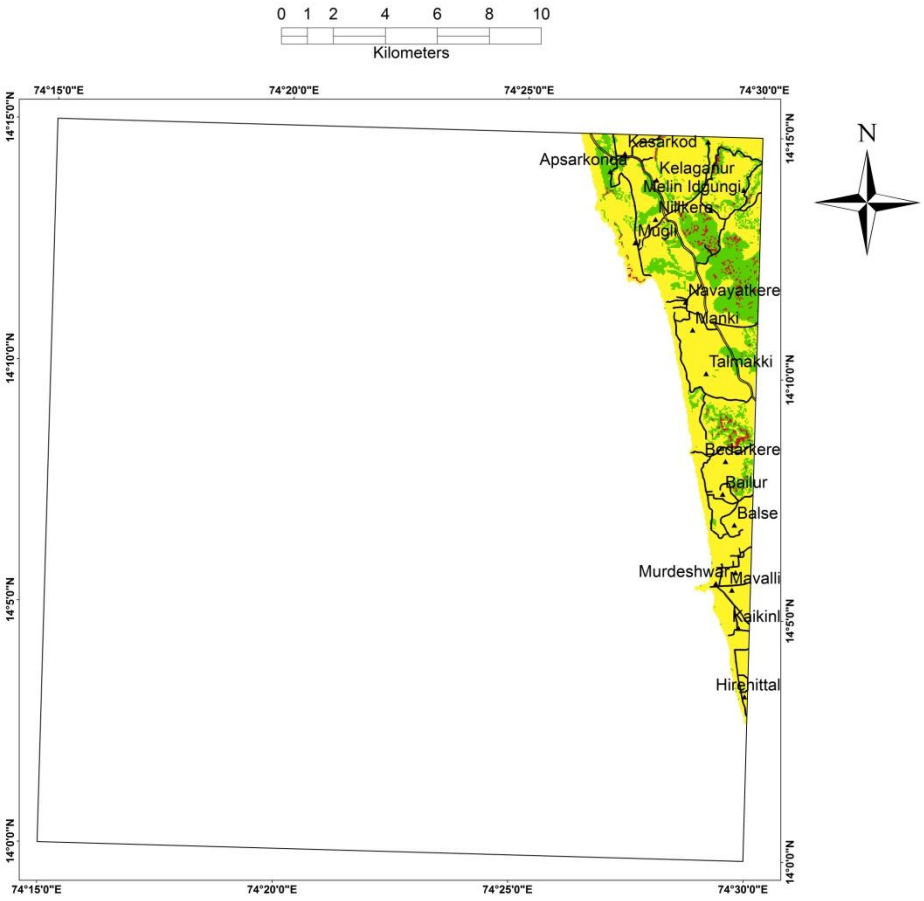
Plate-26

Landslide Susceptibility Map of TS no. 48J/8 of Uttar Kannada District, Karnataka



Index

- High
- Moderate
- Low
- Location
- Road

Prepared by:
Neha Kumari, Geologist
Project:NLSM
FS:15-16